# Mapping the Money

*An exploration of how campaign contributions shape political connections*

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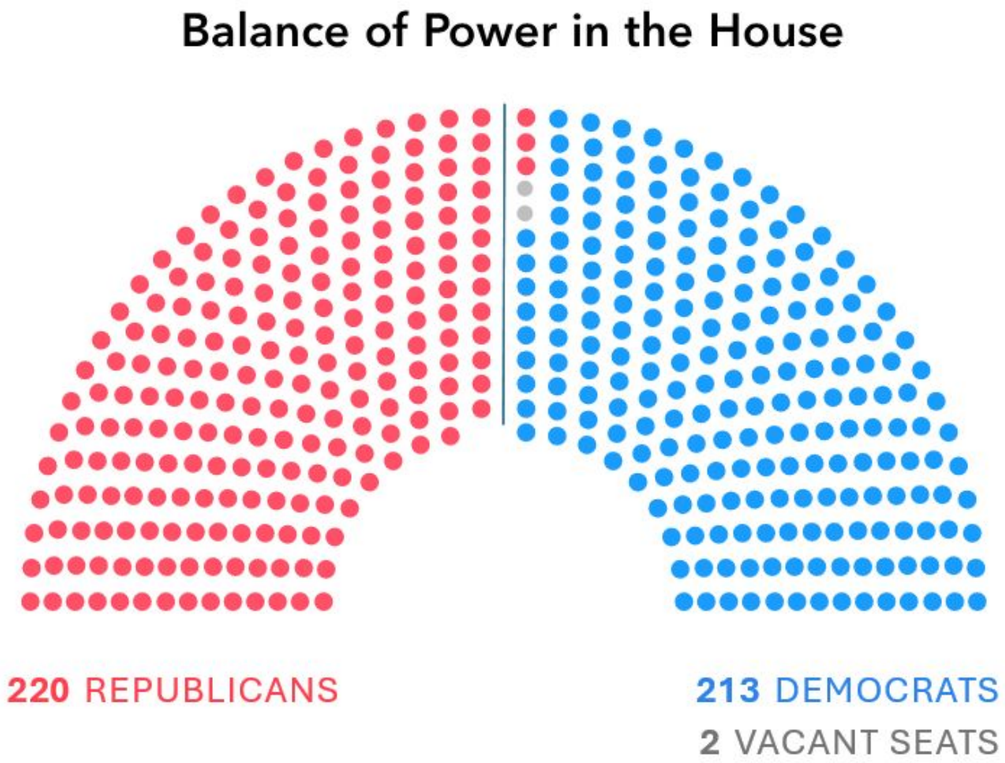
# Introduction

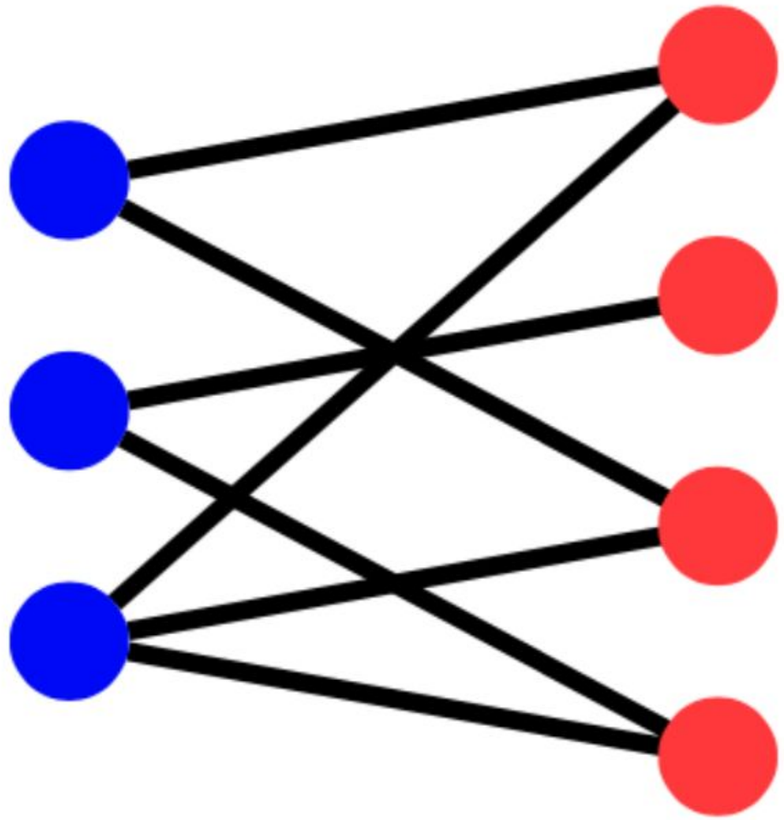



**What are Congressional Networks?**

- Congressional networks model relationships between politicians based on shared behaviors or affiliations
- Prior studies focus on co-voting behavior, bill co-sponsorship, or committee overlap to uncover ideological coalitions.
- These networks often show strong partisan clustering, with Democrats and Republicans forming distinct communities

# Our Approach - Mapping Donor Influence

- Build a **bipartite network** between senators and their top 100 donors
- Project into **senator-senator** and **donor-donor** networks
- Apply **community detection** and **centrality analysis**
- Focus on how shared financial backers reflect or reinforce partisanship
- Explore how donor overlap patterns reveal structural polarization



# Mathematical Background

- We performed community detection through **modularity optimization**
- Modularity:

$$Q(G,g) := \frac{1}{2m} \sum_{i,j} \left( A_{ij} - \frac{k_i k_j}{2m} \right) \delta_{g_i, g_j}$$

- Our network is weighted.
- By Newman (*Analysis of Weighted Networks, 2004*), this definition, as well as the interpretation of the terms, generalizes to weighted networks.

# Data Acquisition

- We obtained our data from the OpenSecrets website
- OpenSecrets blocks webscrapers, so we had to download data manually (more on this in the Limitations section). This limited the scope of our project

# Data Acquisition

- For each senator
  - visit senator's OpenSecrets page
  - download data on top 100 donors for 2020 election cycle
- Merge all into one dataframe and keep only the relevant columns

| ... | ultorg | total | pacs | indivs | ... |
|---|---|---|---|---|---|
| | Org 1 | $ | $ | $ | |
| | ⋮ | ⋮ | ⋮ | ⋮ | |
| | Org 100 | $ | $ | $ | |

×100

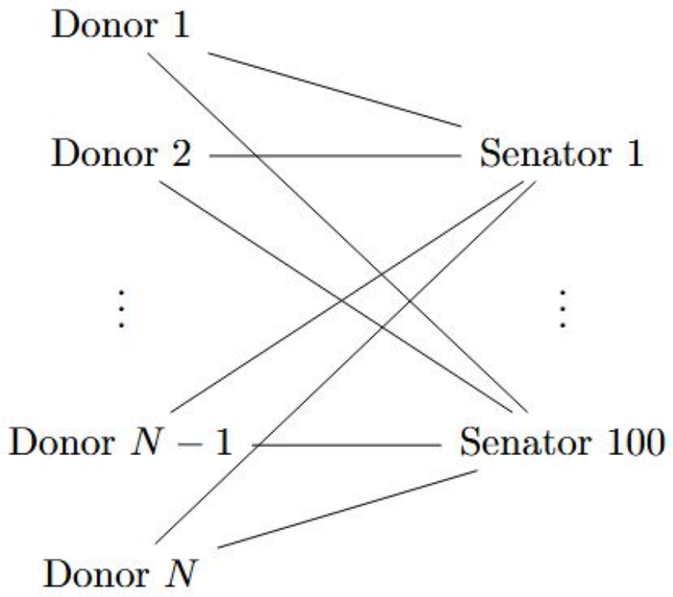
merge ⟹

| Senator | Party | Organization | Contribution |
|---|---|---|---|
| Senator 1 | $(D/I/R)$ | Org (1,1) | $ |
| ⋮ | ⋮ | ⋮ | ⋮ |
| Senator 1 | $(D/I/R)$ | Org (1,100) | $ |
| ⋮ | ⋮ | ⋮ | ⋮ |
| Senator 100 | $(D/I/R)$ | Org (100,1) | $ |
| ⋮ | ⋮ | ⋮ | ⋮ |
| Senator 100 | $(D/I/R)$ | Org (100,100) | $ |

# The Model

## Bipartite structure:

- One collection of nodes represents political donors
- One collection of nodes represents senators




## Assigning edge weights:

- Some senators receive more donations than others. For example:

  Senator Jon Ossoff: $12M

  Senator James Lankford: $2M

- So, we normalize the donor's contribution by total amount received by the senator.
- The incidence matrix B is then

$$B_{ij} = \frac{\text{Dollar amount donated by donor } j \text{ to senator } i}{\text{Total amount received by senator } i \text{ from all of } i\text{'s donors}}$$

# The Model

Weighted adjacency matrices for each projection:

$$A_{\text{senators}} = BB^T$$

$$A_{\text{donors}} = B^T B$$

Loosely speaking...

$(A_{\text{senators}})_{ij}$ : measures the extent to which two senators' donors overlap

$(A_{\text{donors}})_{ij}$ : measures the extent to which two donors' influence over the Senate overlaps

# The Model

Sanity check:

- List pairs of senators based on edge weight (excludes self-edges and pairs with no edge)
- Highest weight is between Senator Duckworth (progressive) and Senator Masto (slightly centrist)
- Lowest weight  is between Bernie Sanders (far left progressive) and Bill Hagerty (staunch conservative)

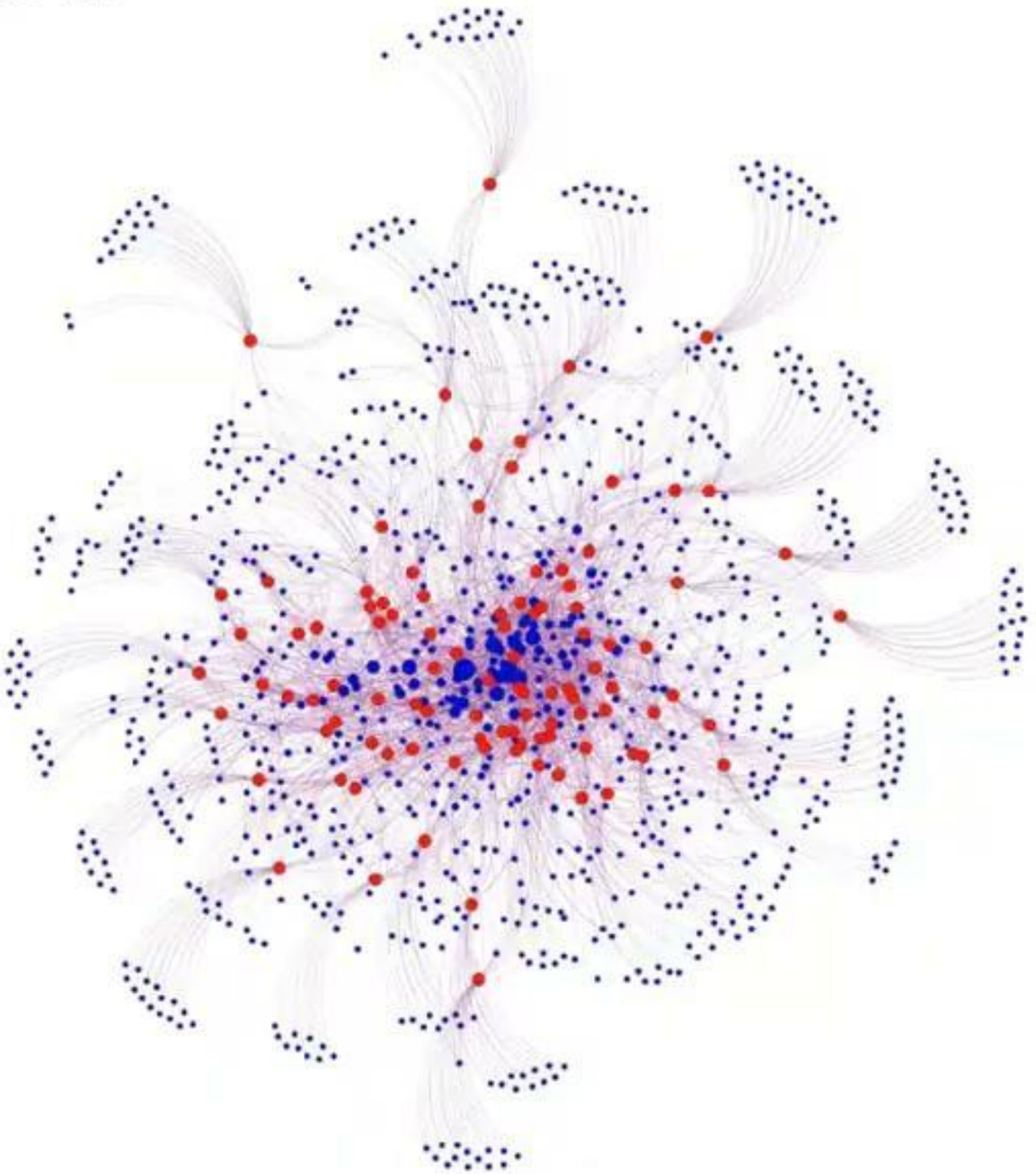
| | Senator Pair | Edge Weight |
|---|---|---|
| 0 | Masto, Catherine Cortez and Duckworth, Tammy | 0.030583 |
| 1 | Rosen, Jacky and Masto, Catherine Cortez | 0.030409 |
| 2 | Rosen, Jacky and Duckworth, Tammy | 0.024096 |
| 3 | Lummis, Cynthia and Hawley, Josh | 0.023394 |
| 4 | Sinema, Kyrsten and Rosen, Jacky | 0.021244 |
| ... | ... | ... |
| 4933 | Tuberville, Tommy and Masto, Catherine Cortez | 0.000044 |
| 4934 | Warren, Elizabeth and Marshall, Roger | 0.000044 |
| 4935 | Markey, Ed and Kennedy, John | 0.00004 |
| 4936 | Johnson, Ron and Cantwell, Maria | 0.000037 |
| 4937 | Sanders, Bernie and Hagerty, Bill | 0.000036 |

# Results - Bipartite Network

- Red: senator nodes
- Blue: donor nodes

- Large blue nodes near center indicate prolific donors
- Small blue nodes on periphery have may have more targeted or limited engagement

- Only 3,150 unique donors (which is much smaller than the maximum of 10,000).
- This suggests many donors are shared



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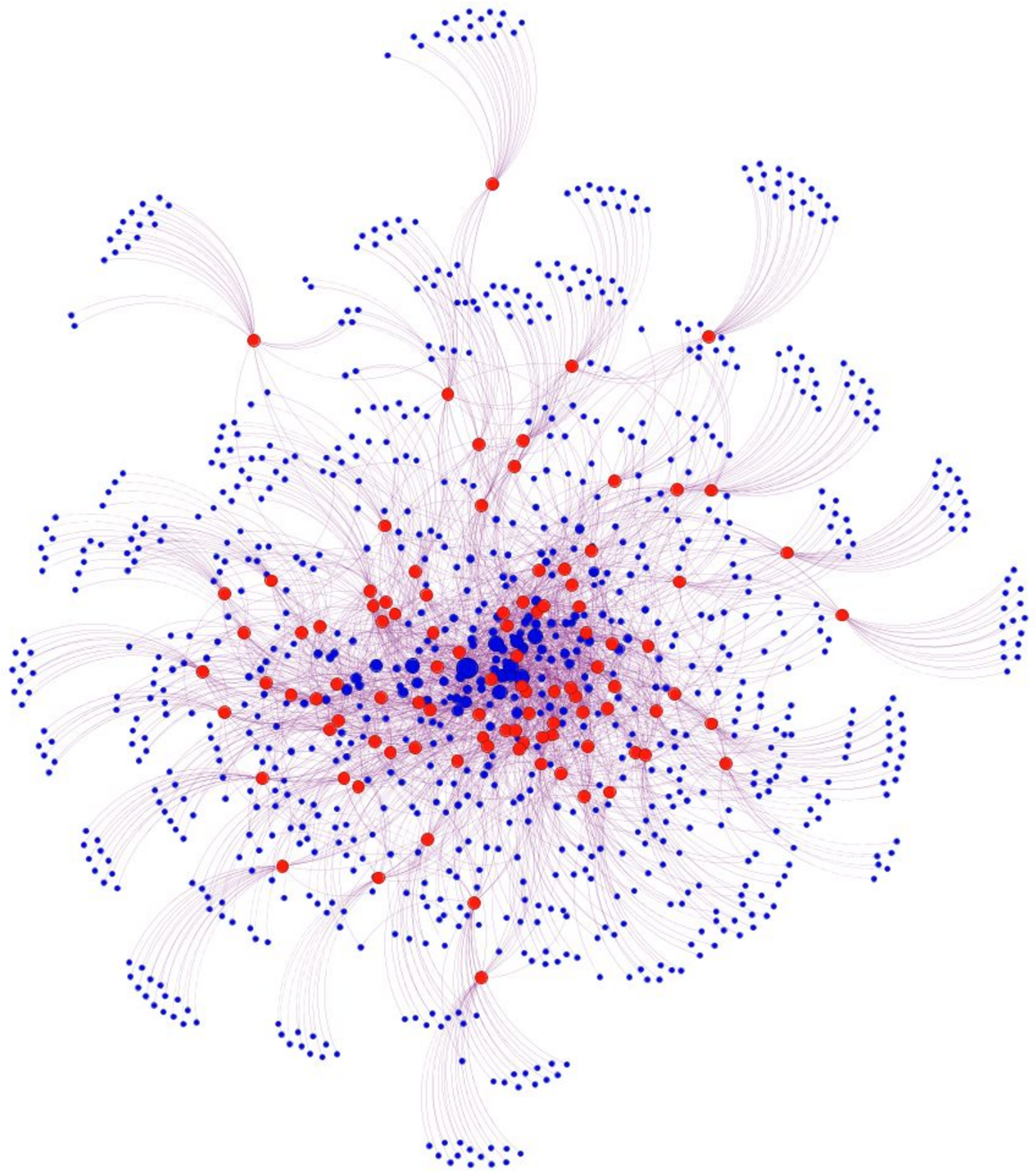
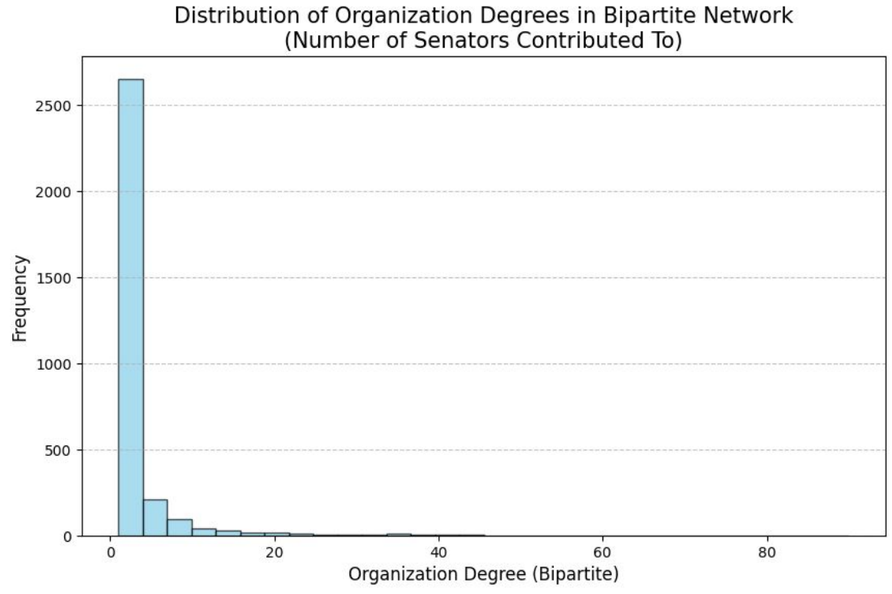
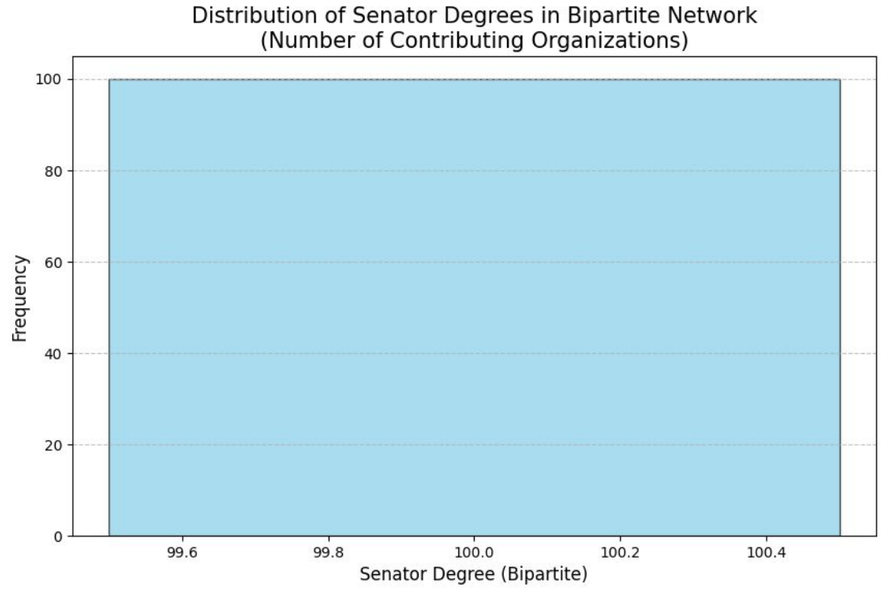


# Centralities in the Bipartite Network(Senators)




-The distribution is highly right-skewed. Most organizations donate to only 1–2 senators.

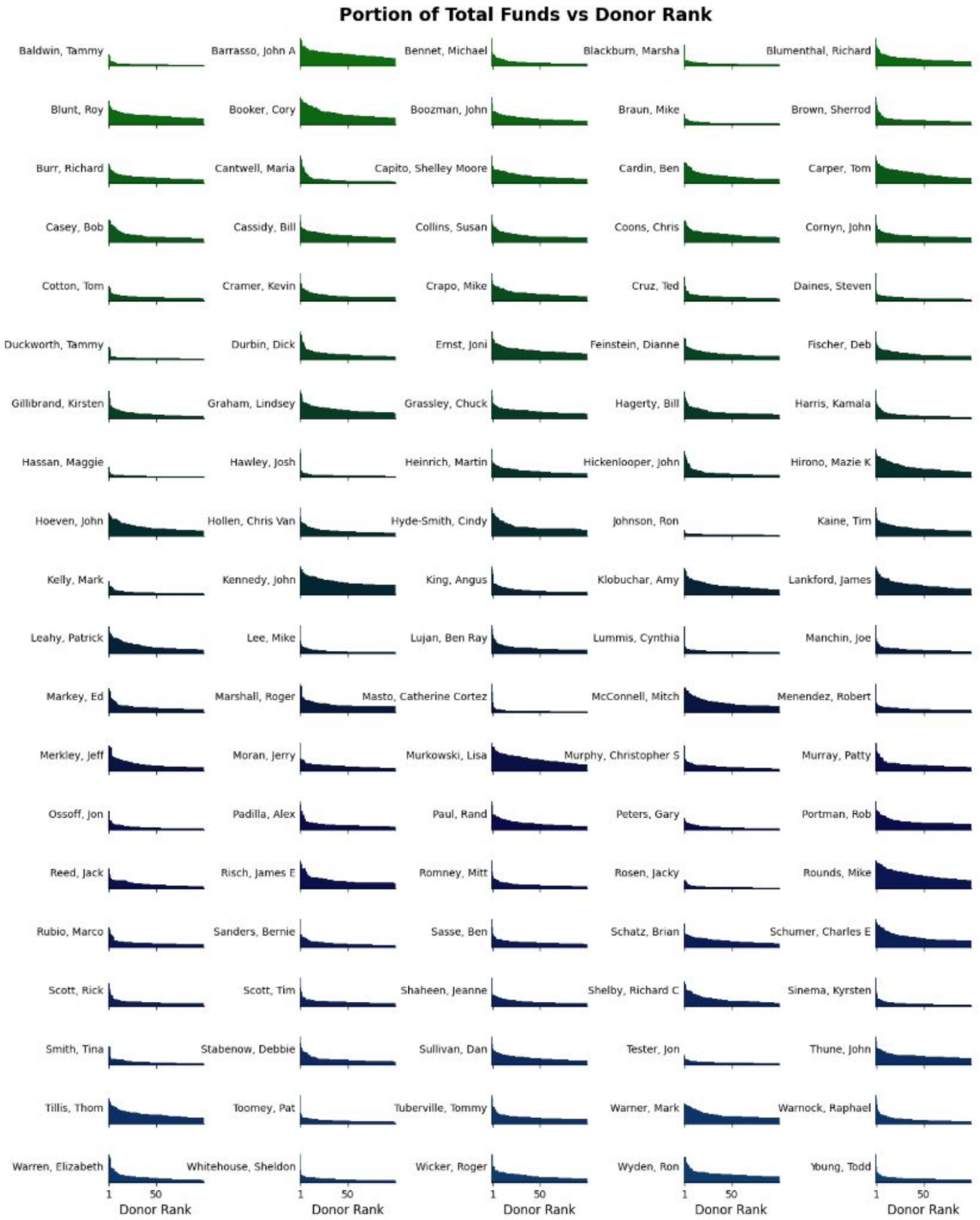
-A small number of organizations contribute to many senators. This indicates the centralizing power of well-funded organizations.



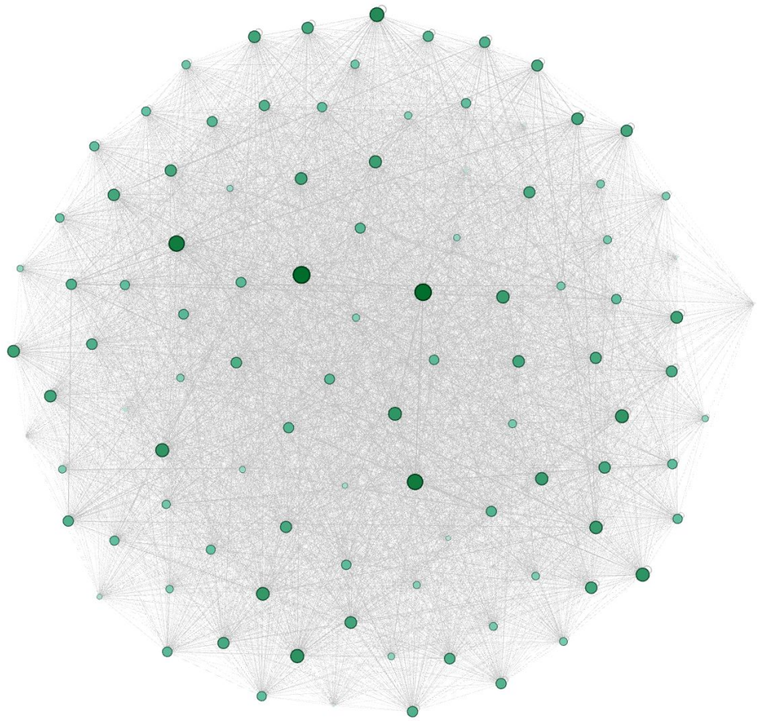

-The degree distribution is uniform by design. Every senator receives donations from exactly 100 organizations. This ensures comparability across senators for further analysis.

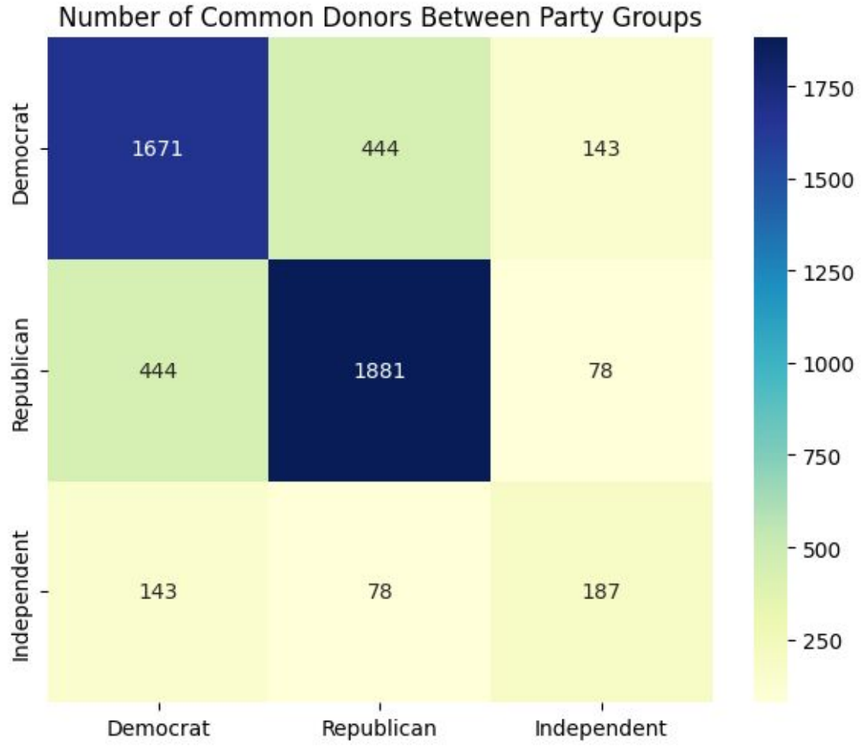
# Results - Bipartite Network

- Each subplot demonstrates how evenly a senator's funds are distributed across their top 100 donors
- Skewed plot means more funds from a small selection of donors
- Uniform plot means funds are about evenly distributed across the donors



# Results - Senator Projection Network



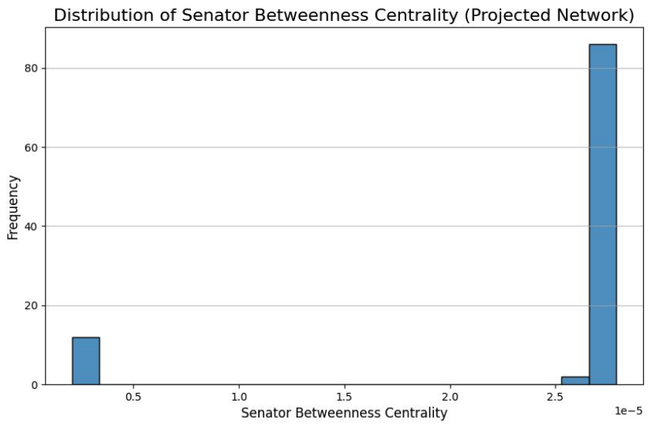


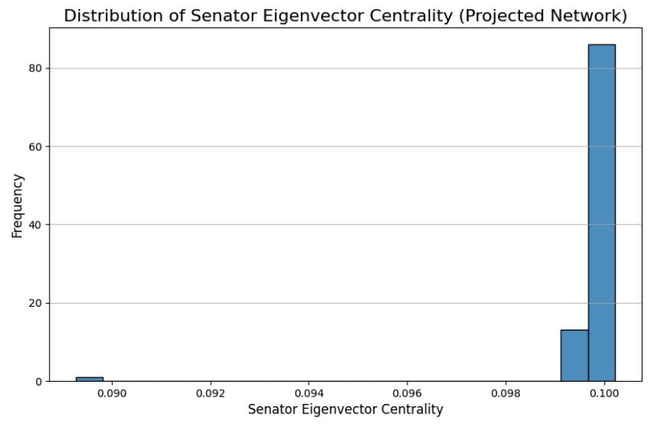

- Densely connected network
- Lots of edges → lots of common donors between senators

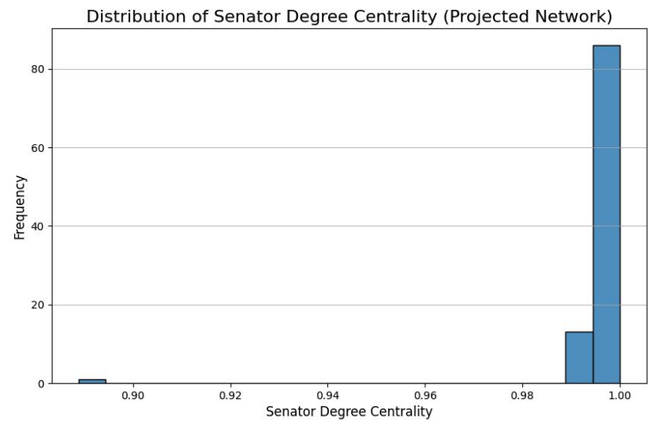
Does political party determine the # of common donors?

To a great degree, yes! → lots of common edges between Dem-Dem senator nodes and Rep-Rep senator nodes

# Centralities in the Senator Network



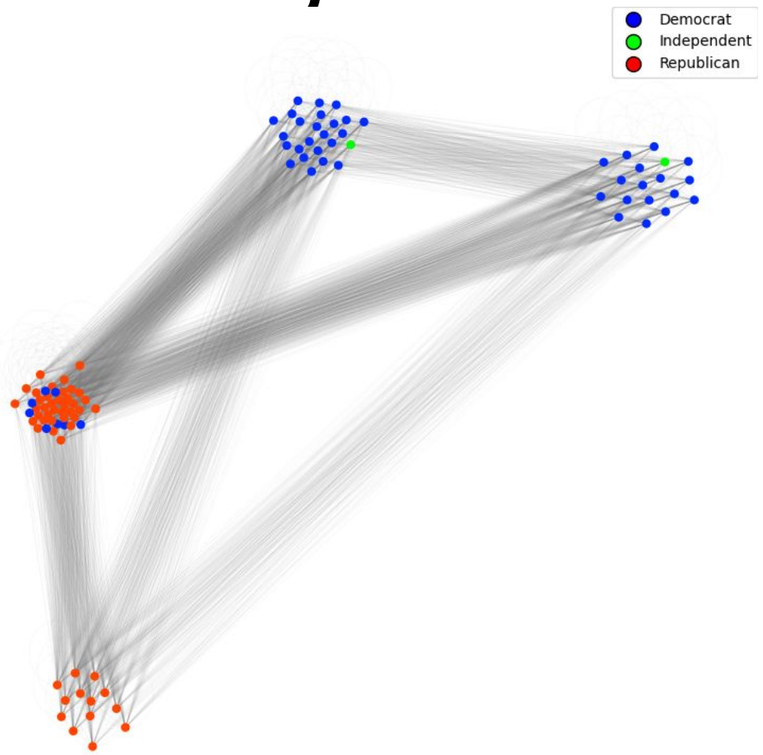



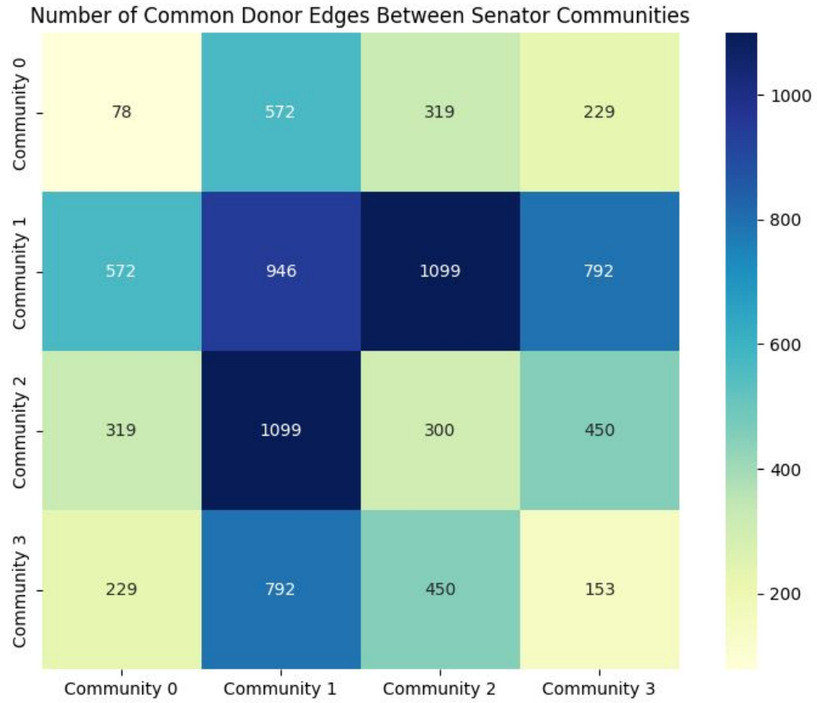

About 80% of senators have a high degree centrality → they connect donors between different communities, probably because of their moderate ideologies

Only a few senators have high eigenvector centrality → these senators are very influential because they are connected to other influential senators

High degree centrality of most nodes → senators have a lot of donor overlap

# Community Detection in the Senator Network



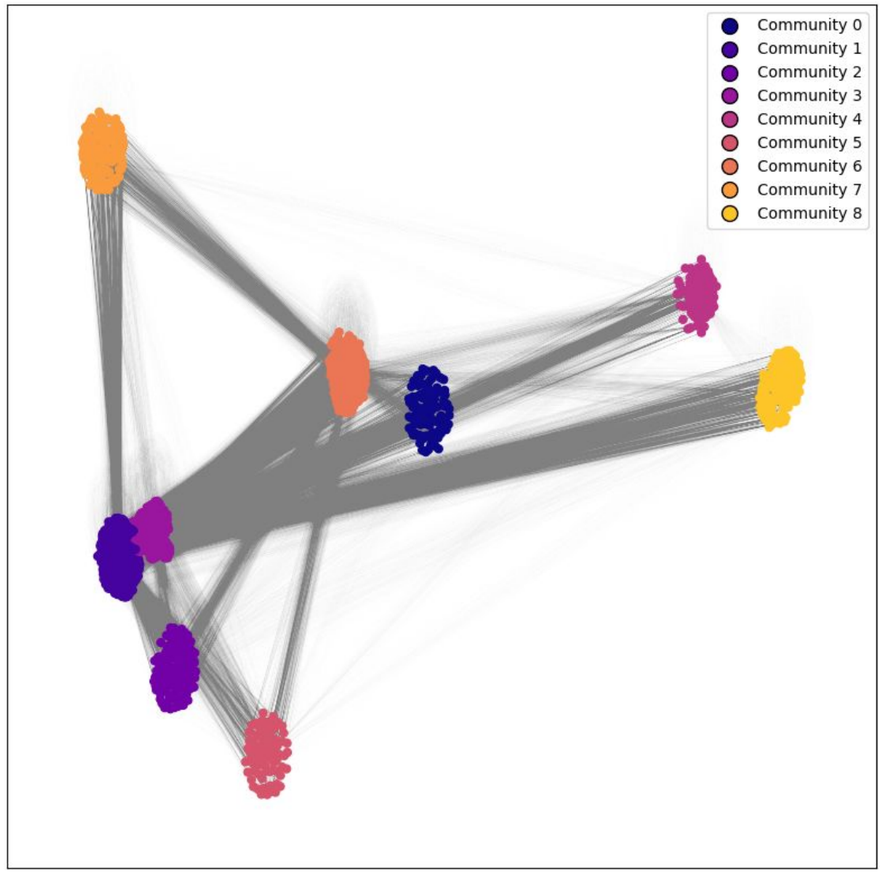




- We see 4 distinct communities
- Communities do not exactly align with political parties
- Democrats and Republicans diverge into 2 communities each

Lot of common edges between:

- Communities 1 and 2
- Communities 1 and 3

# Results - Donor Projection Network

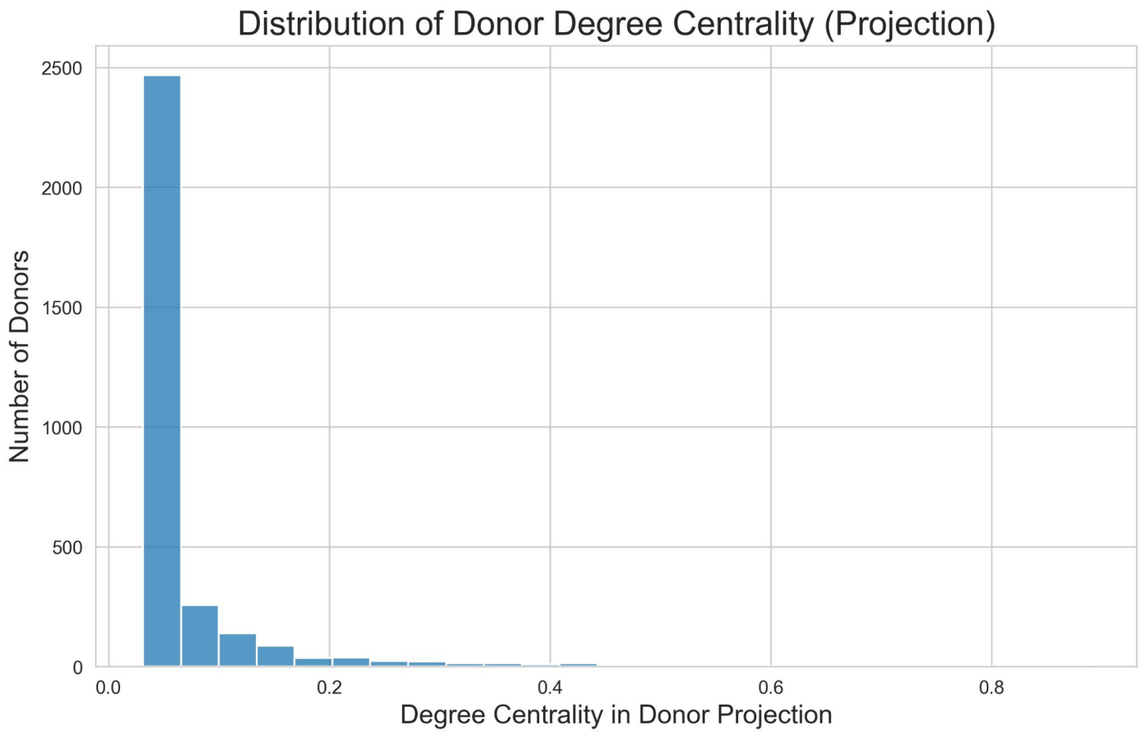



| | | Percent Contributed To | | |
|---|---|---|---|---|
| Community | Size | Democrats | Independents | Republicans |
| 0 | 94 | **0.809** | 0 | 0.191 |
| 1 | 814 | 0.387 | 0.005 | **0.608** |
| 2 | 131 | 0.387 | 0.003 | **0.610** |
| 3 | 645 | 0.061 | 0.002 | **0.937** |
| 4 | 110 | 0.143 | 0.003 | **0.854** |
| 5 | 70 | 0.263 | 0 | **0.737** |
| 6 | 1017 | **0.923** | 0.012 | 0.065 |
| 7 | 120 | **0.797** | 0.081 | 0.122 |
| 8 | 149 | 0.036 | 0 | **0.964** |

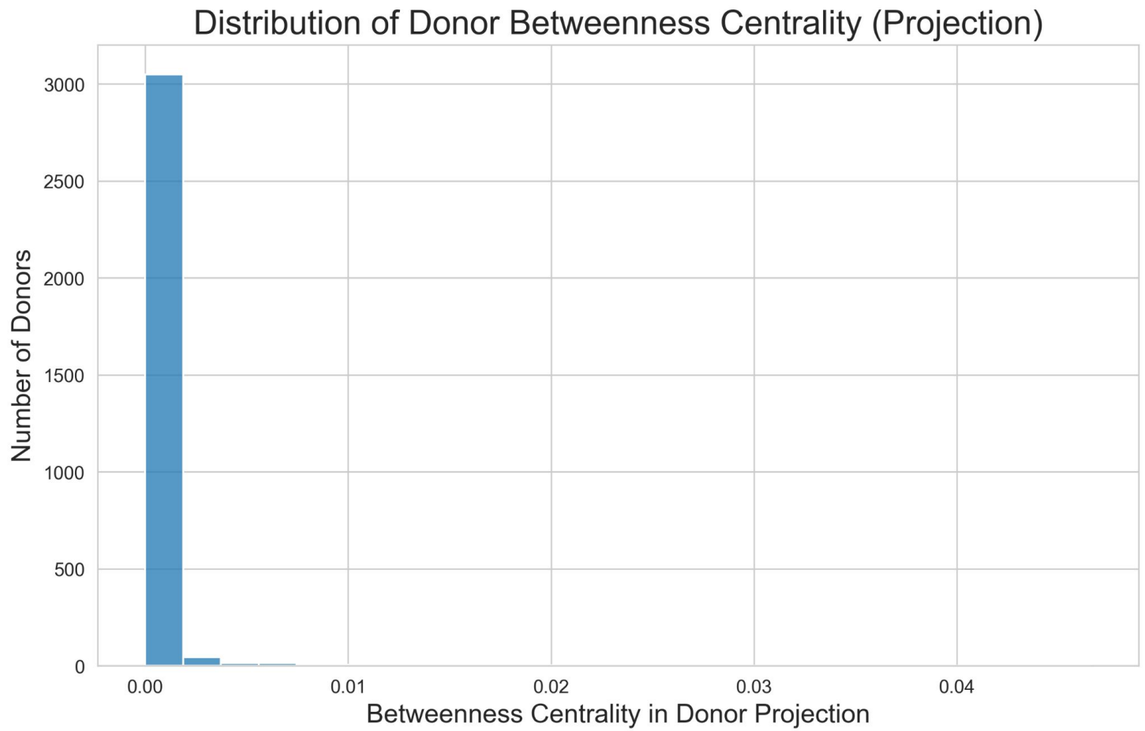
- 9 distinct communities
- High amount of inter-community edges

- Lack of ground-truth and meta data on donors makes this hard to interpret
- But, communities appear to have clear party preferences

# Centralities in the Donor Projection Network




- Majority of donors have low degree centrality, meaning they share senators with only a few other donors.
- A small number of donors have high degree centrality, indicating they are connected to many others in the network.

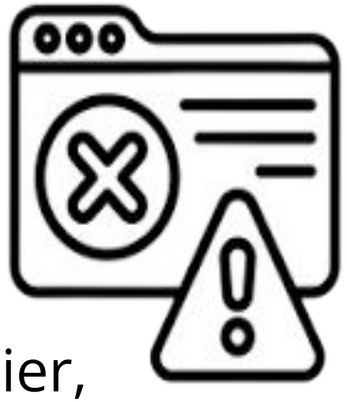



- Almost every Donor has 0 betweenness centrality
- This suggests that donors  are only connected within a specific political or financial cluster

# Discussion

- **Partisan Clustering**: Louvain community detection showed that senators cluster strongly by political party, indicating donor networks reinforce party divisions.
- **High Modularity**: The senator-senator projection exhibited high modularity, with minimal cross-party connections, especially among top donors.
- **Donor Overlap Patterns:** Shared donors tend to cluster within parties; while some cross-party links exist, they are relatively rare and often involve moderates.
- **Centrality Insights**: Senators with high degree and betweenness centrality often act as key fundraising hubs or bridges within donor networks, suggesting strategic influence from donors and politicians.
- **Polarized Financial Ecosystem**: Despite a few exceptions, the overall donor network reflects a polarized landscape with limited bipartisan financial overlap.

# Limitations



- **Data Acquisition**: downloading the data manually, as mentioned earlier, limited our analysis to just one Senate term. With only one election cycle studied, we were unable to track changes in donor networks over time.
- **Incomplete Donor Coverage**: The dataset includes only the top 100 donors per senator, leaving out smaller donations from regular citizens that can still play a big role in supporting a candidate.
- **Lack of Donor Metadata**: Absence of industry, location, or donor type information limited our ability to interpret the significance of donor connections.
- **Projection Information Loss**: Senator-senator projection simplified the network, potentially masking nuanced differences in donor overlap.
- **Methodological Constraints**: Louvain detection was chosen for its clarity, but it may miss finer or hierarchical patterns that more advanced models (e.g., stochastic block models) could capture.

# Conclusions

**Campaign finance networks are highly polarized**
Donor relationships strongly align with party identity, reinforcing partisan divides

**Donor overlap is limited across parties**
Shared donors tend to support senators within the same party; cross-party links are rare and often involve moderates

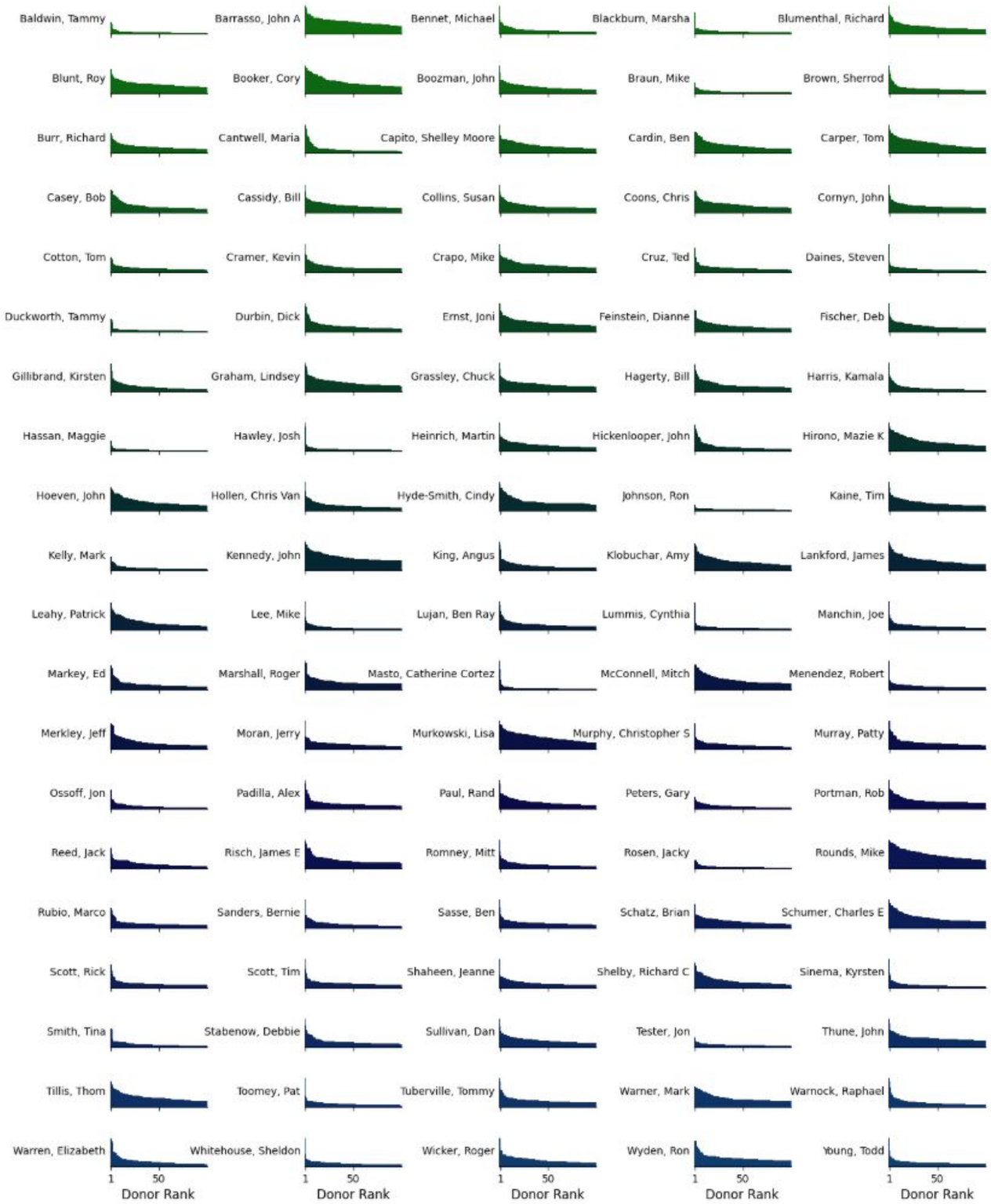
**Opens doors for deeper future research**
Industry labels, donor types, or multi-term analysis could reveal deeper patterns of political influence

# Acknowledgements

We thank Professor Tymochko for all her guidance and encouragement throughout this project!

We also thank our peer reviewers for their valuable feedback and suggestions!

## Portion of Total Funds vs Donor Rank



# Mathematical Background

- Def for unweighted networks:

$$Q(G,g) := \frac{1}{2m}\sum_{i,j}\left(A_{ij} - \frac{k_i k_j}{2m}\right)\delta_{g_i,g_j}$$

- In *Analysis of Weighted Networks* (*2004*), Newman extends this to integer-weighted networks by viewing these networks as multi-graphs (i.e. graphs with self-edges and multiple edges).
- Given a rational-weighted network, scale the edges uniformly to get an integer-weighted network.