Investigation of US Political Donation Data

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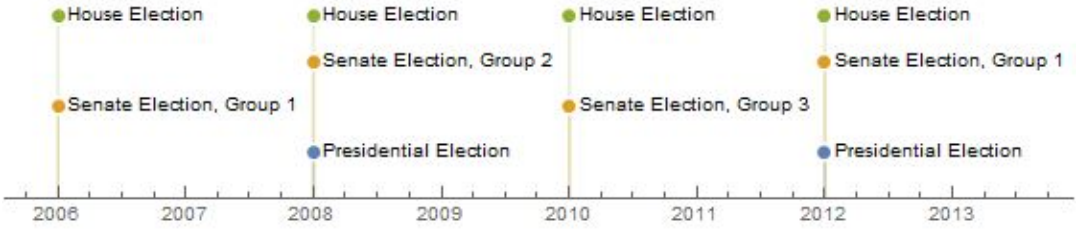
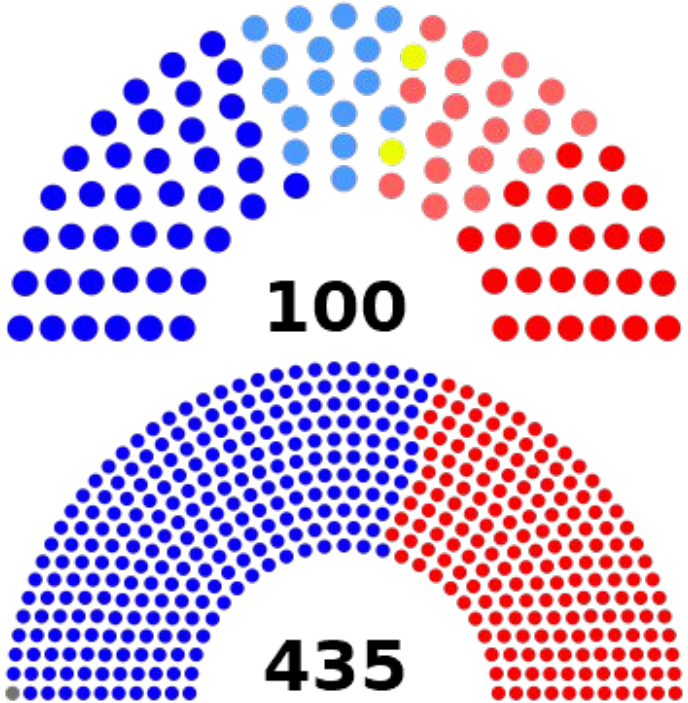
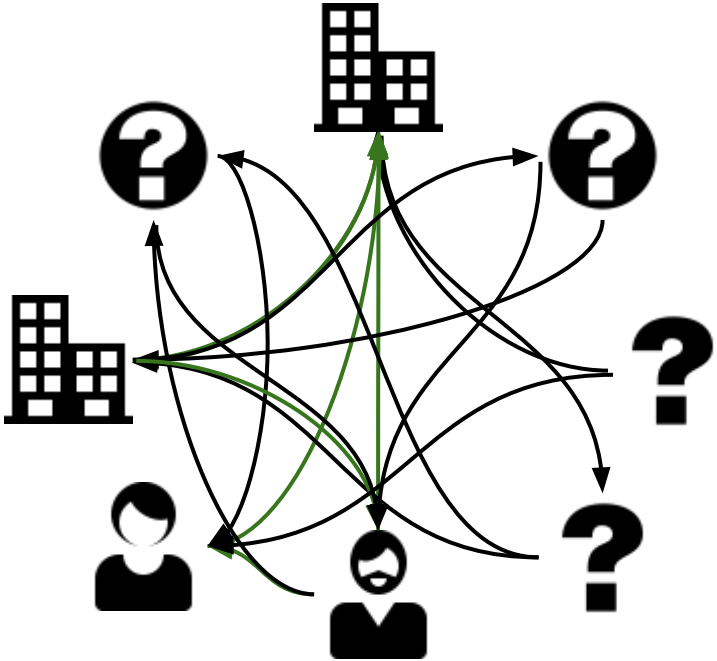
Background


House Election
Senate Election, Group 1
Presidential Election
House Election
Senate Election, Group 2
Presidential Election
House Election
Senate Election, Group 3
House Election
Senate Election, Group 1
Presidential Election
2006
2007
2008
2009
2010
2011
2012
2013

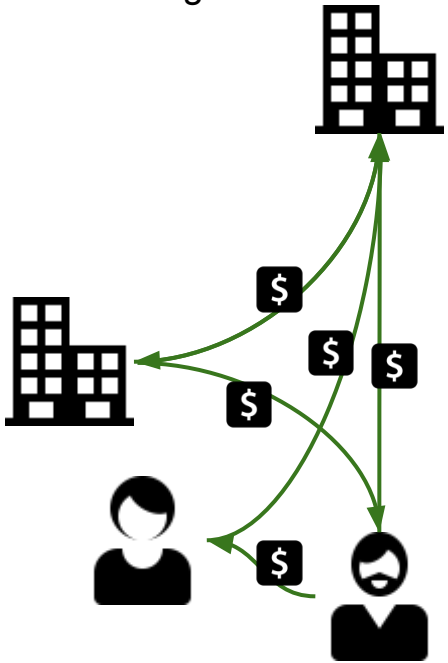

100
435

The Dataset

Federal Election Commission Data



Directed Weighted Network



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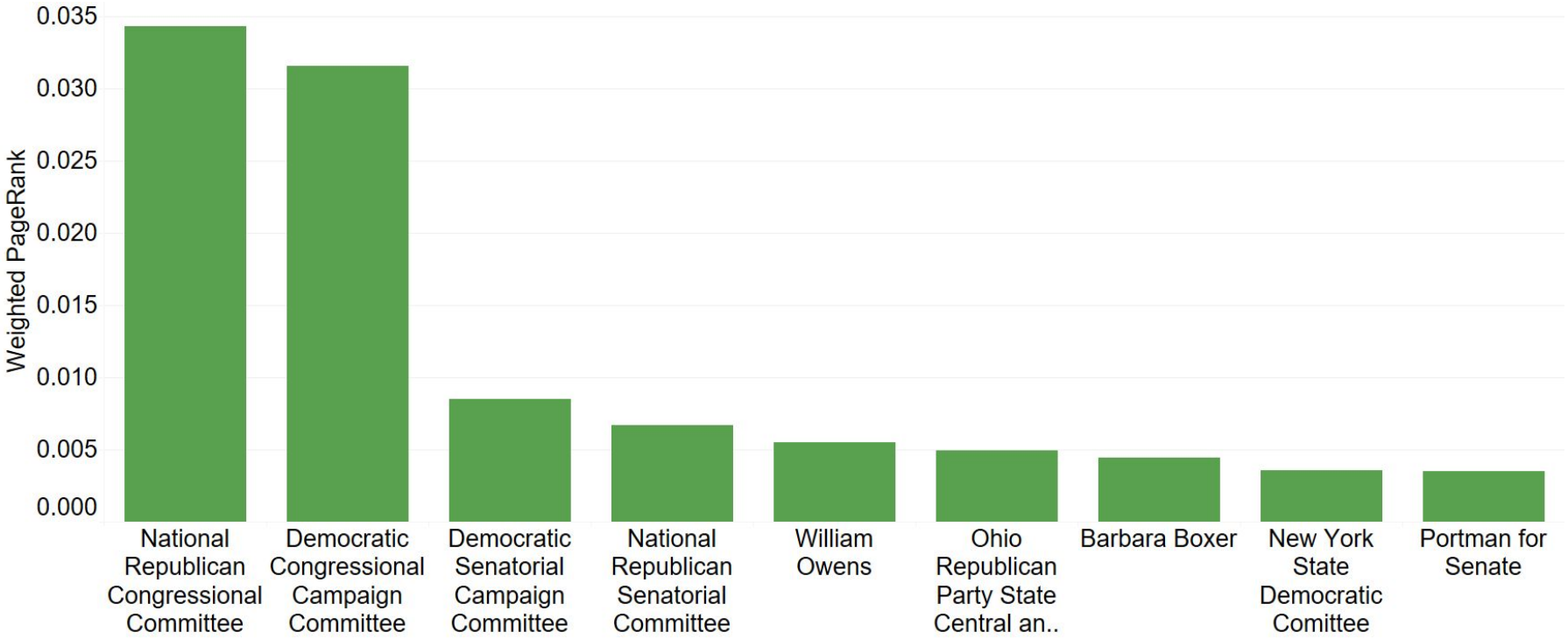
Weighted PageRank



Community Detection

Walktrap Algorithm

- Applicable for directed weighted networks
- Efficient for complex networks
- Maximizes modularity score
- Captures information on the community structure
- The algorithm is based on a random walk

Walktrap Computation

Initialization We start form a partition $\mathcal{P}_1 = \{\{v\} \mid v \in V\}$ of network with n communities and each community has a single vertex. t, a given constant denoting the number of steps in random walk.

For $k = 1, \cdots, n-1$ **iterations**

- Compute the distance between all adjacent vertices using $r_{ij}(k) = \sqrt{\sum_{k=1}^{n} \frac{\left(p_{ik}^t - p_{jk}^t\right)^2}{\deg(k)}}$
- Choose two communities C_1 and C_2 in $\mathcal{P}_k$ and compute the distance between communities

$$r_{C_1,C_2} = \sqrt{\frac{\sum_{k=1}^{n}\left(p_{C_1,k}^t - p_{C_2,k}^t\right)^2}{\deg(k)}},$$

  where p_{ij}^t is the probability of moving from node i to node j in t steps.
- Merge these two communities into a new community $C_3 = C_1 \cup C_2$ by minimizing the mean σ_k of the squared distance

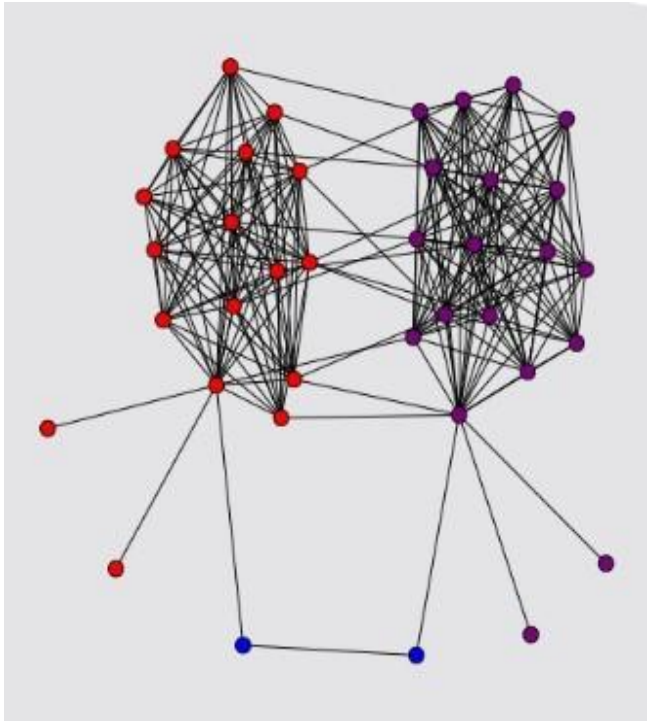
$$\sigma_k = \frac{1}{n} \sum_{C \in \mathcal{P}_k} \sum_{j \in C} r_{j,C}^2$$

  Note: it's a greedy algorithm since it tries to solve the problem of maximizing σ_k for each k
- After merging, it creates a new partition $\mathcal{P}_{k+1} = \left(\mathcal{P}_k \backslash \{C_1, C_2\}\right) \cup \{C_3\}$

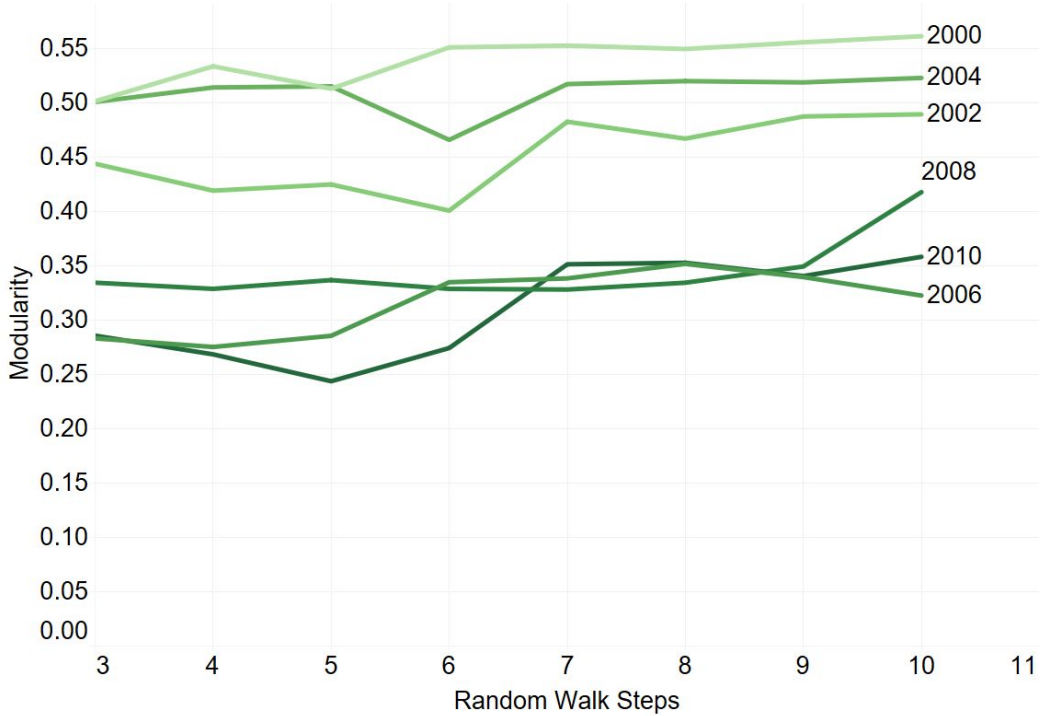
$$\triangle\sigma(C_1, C_2) = \frac{1}{n}\left(\sum_{i \in C_3} r_{j,C_3}^2 - \sum r_{i,C_1}^2 - \sum_{i \in C_2} r_{i,C_2}^2\right)$$

- Update the distance between communities.

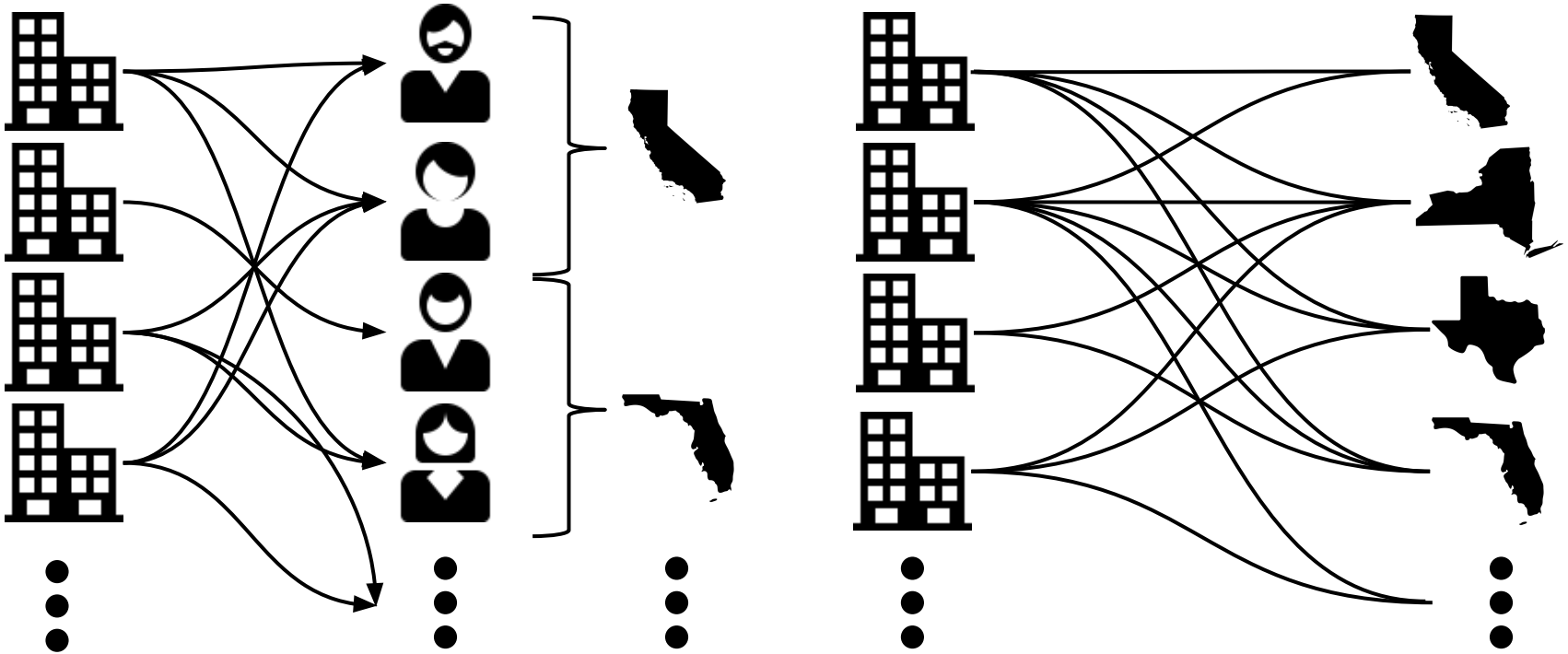
Output $\mathcal{P}_n$.



Walktrap Algorithm Result



The Senate Network



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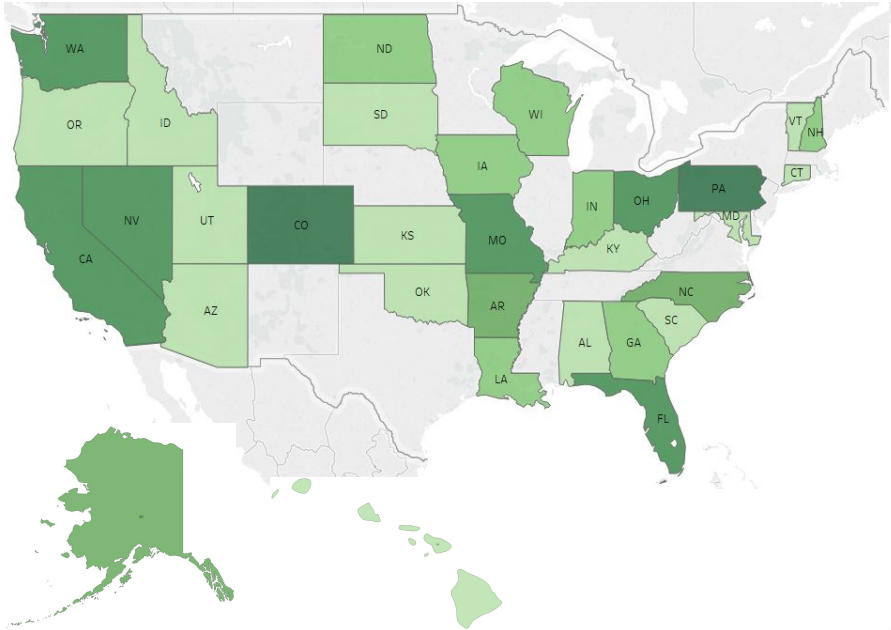
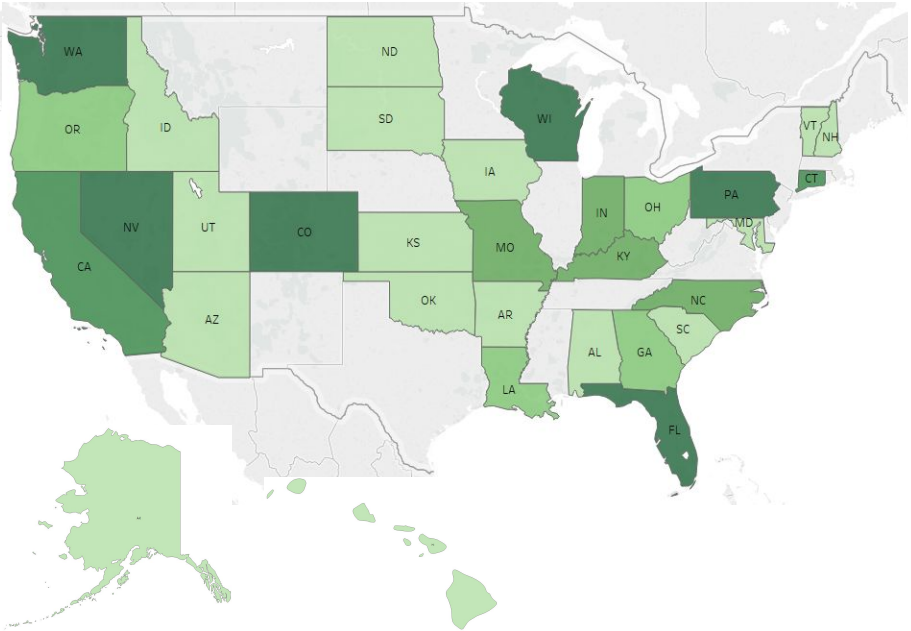
Close Elections

Weighted PageRank (2010)

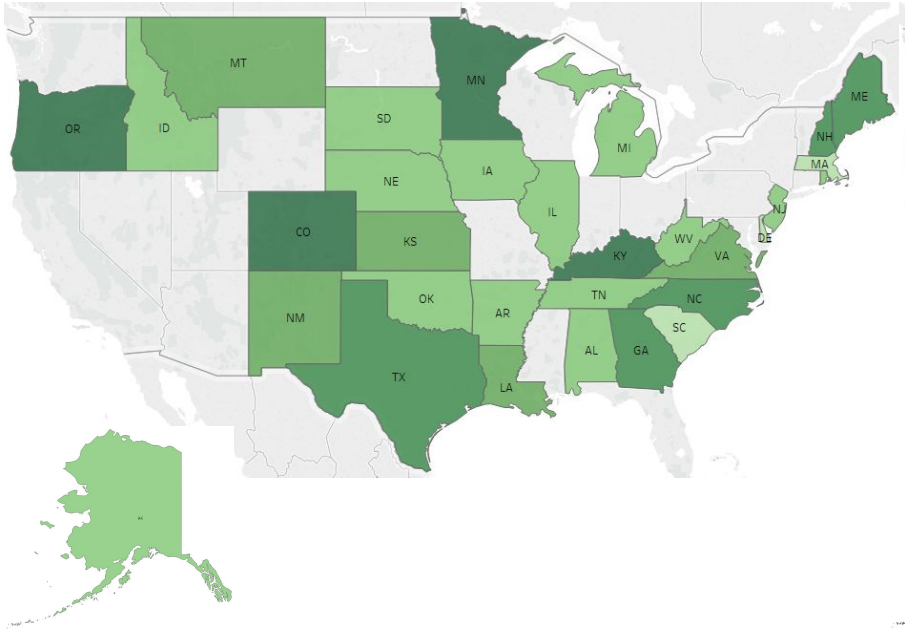


Winning Margin (2010)

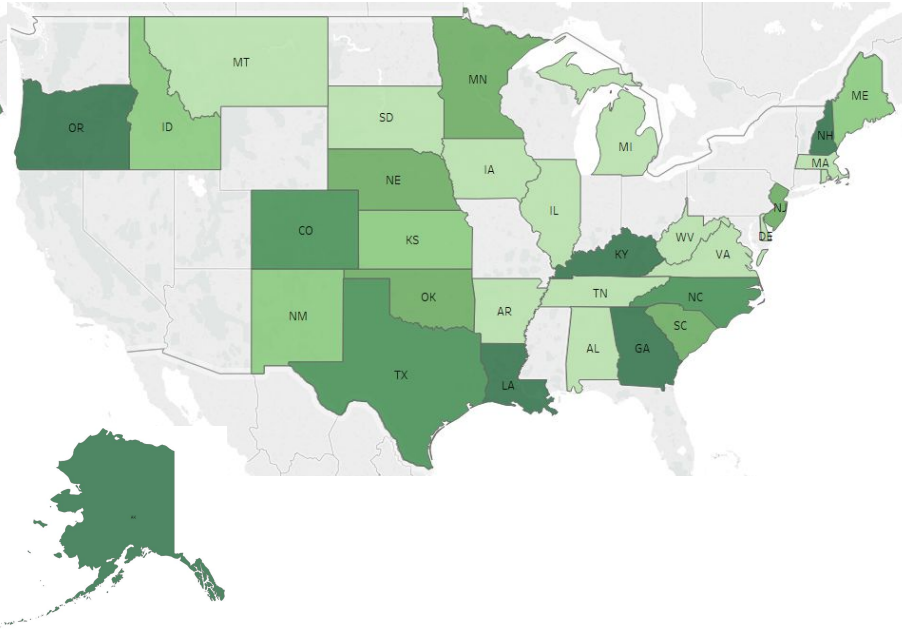


Close Elections

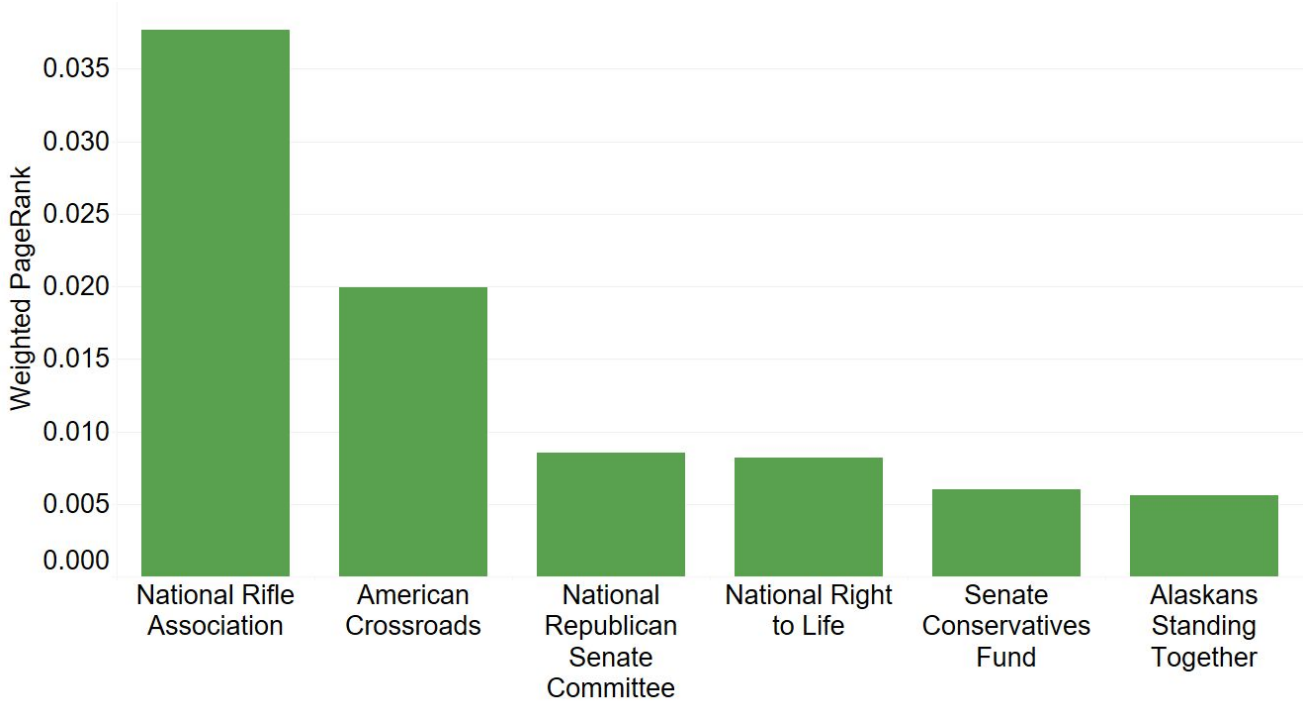
Weighted PageRank (2008)



Winning Margin (2008)



Important PACs by Weighted PageRank (2010)



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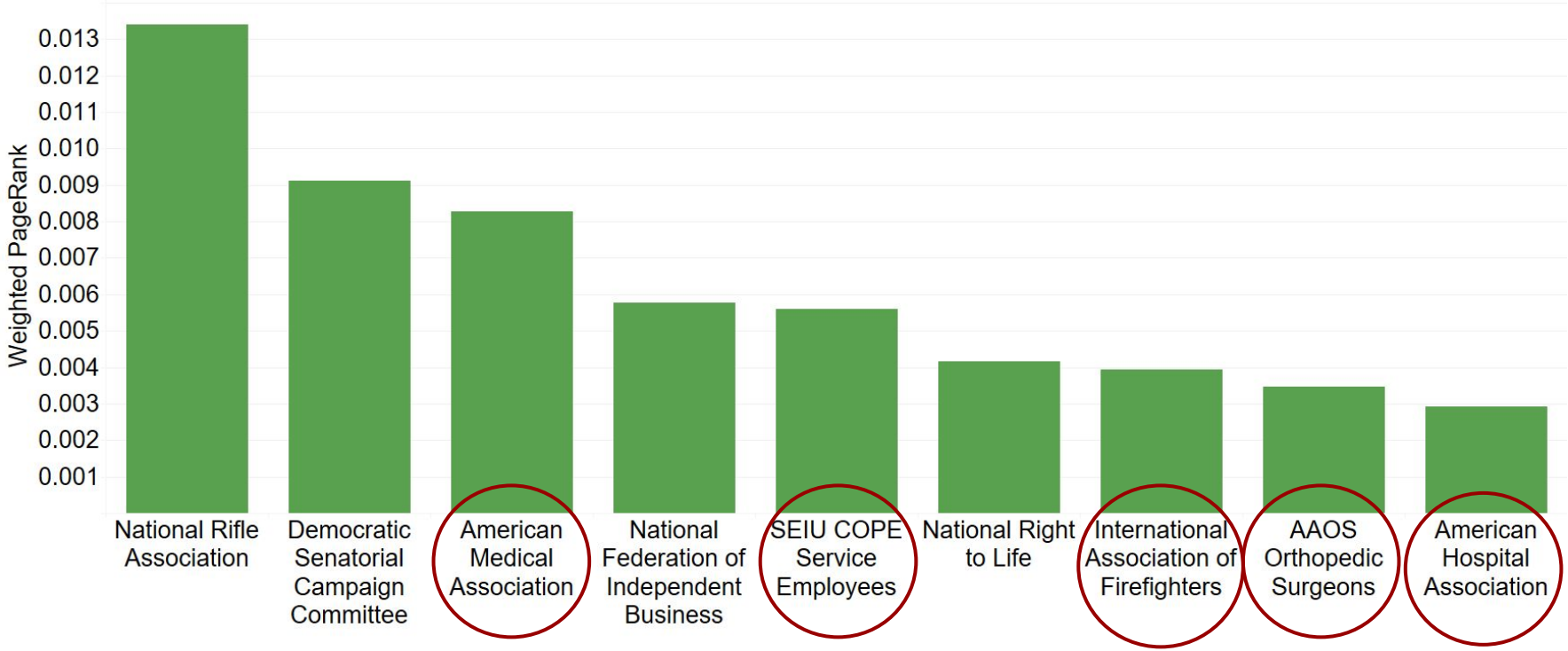
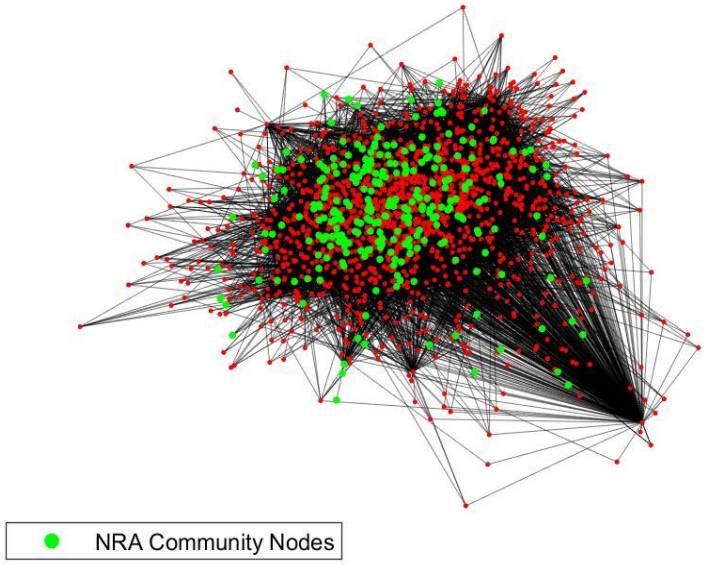
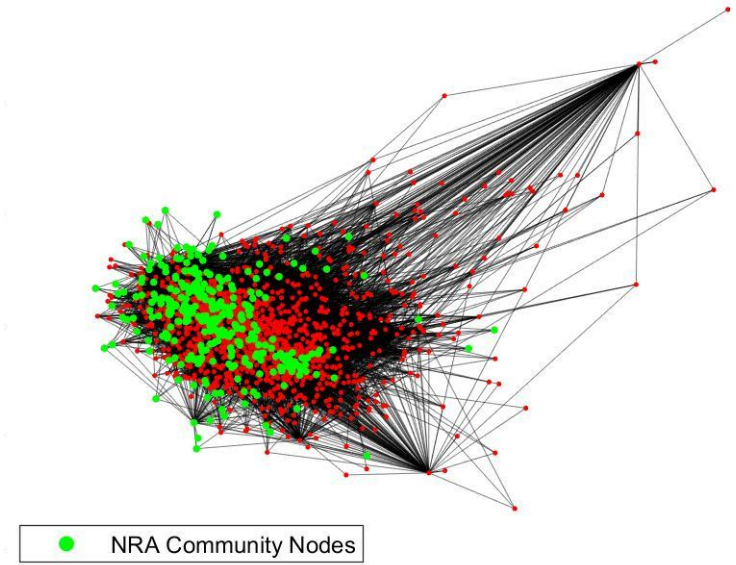


NRA Louvain Communities

2010

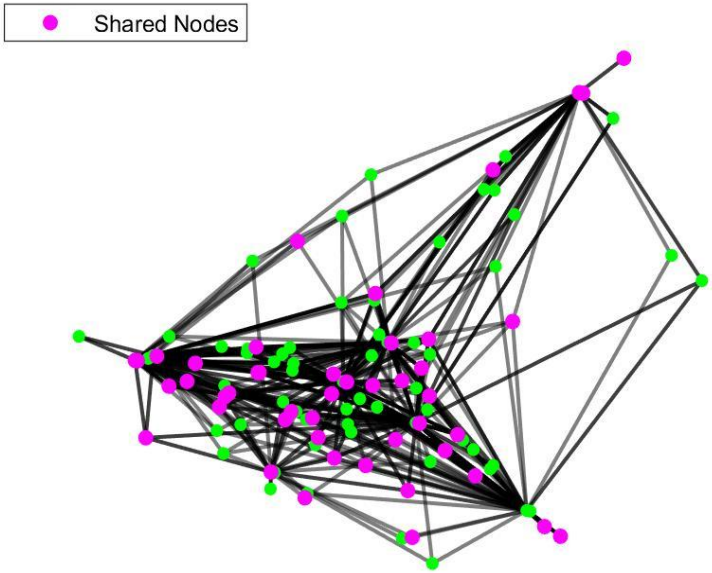


2008

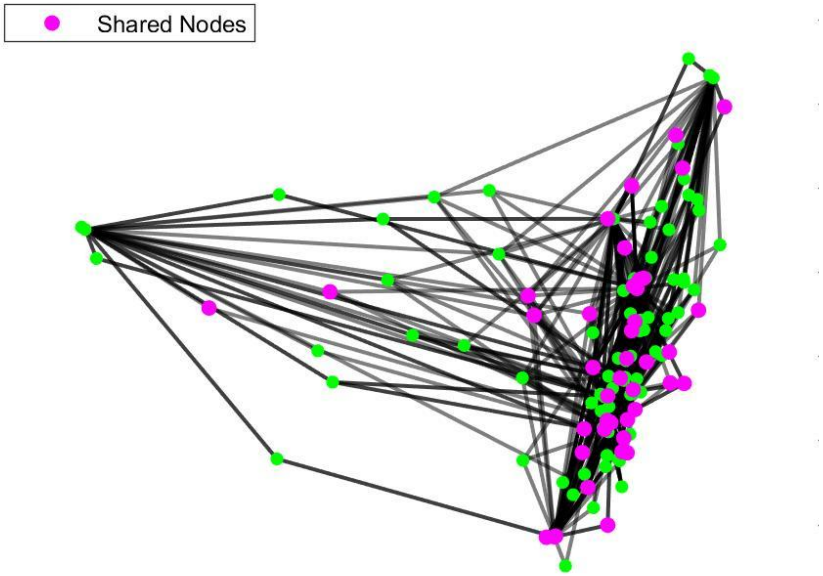


Shared NRA Community

2010

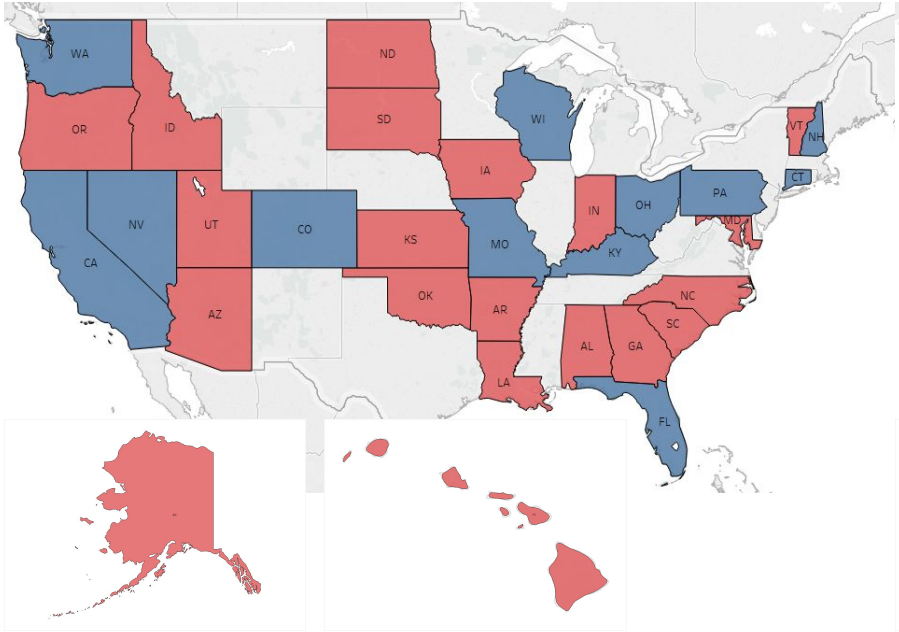


2008

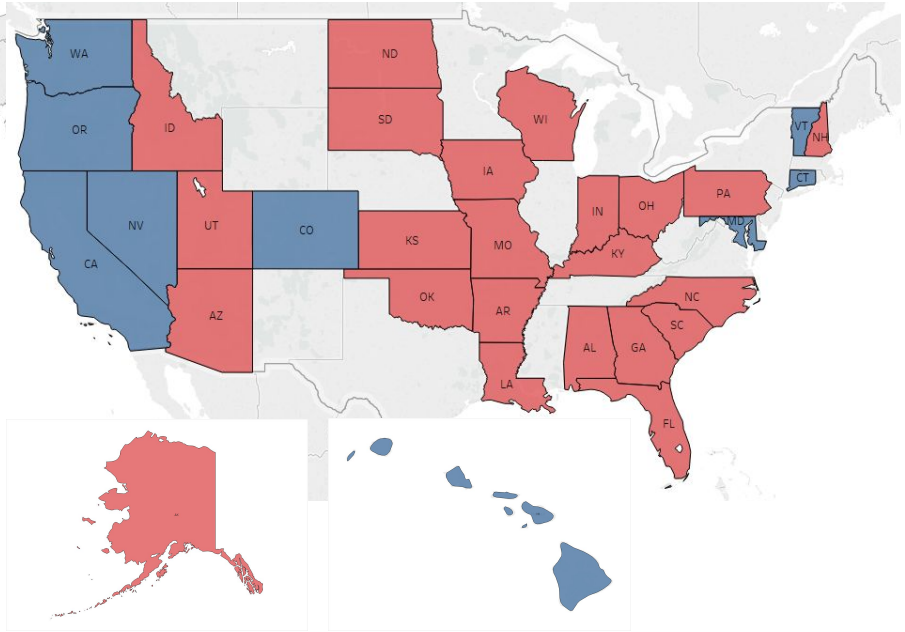


Community Detection on States

Modularity (2010)

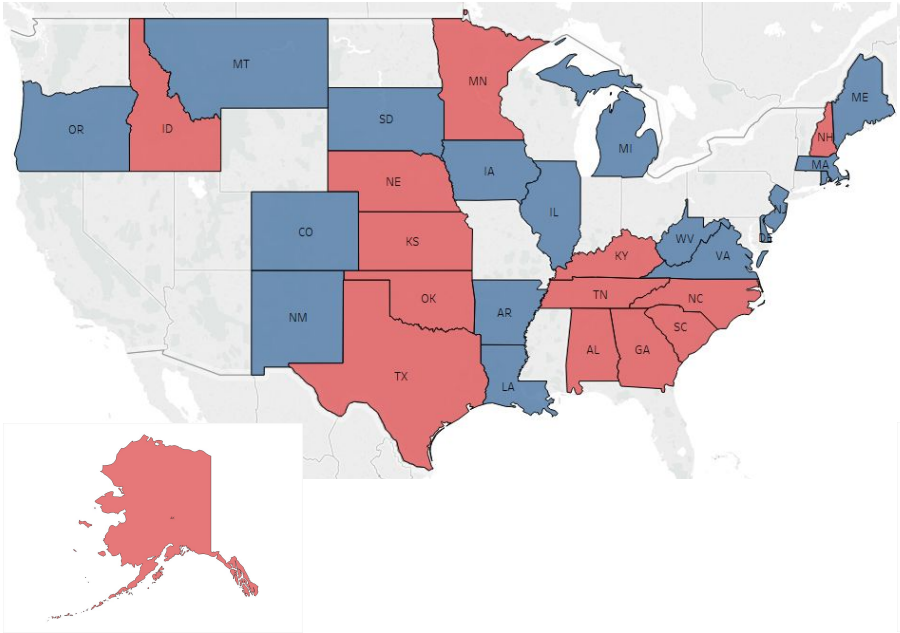


Election Result (2010)



Community Detection on States

Modularity (2008)



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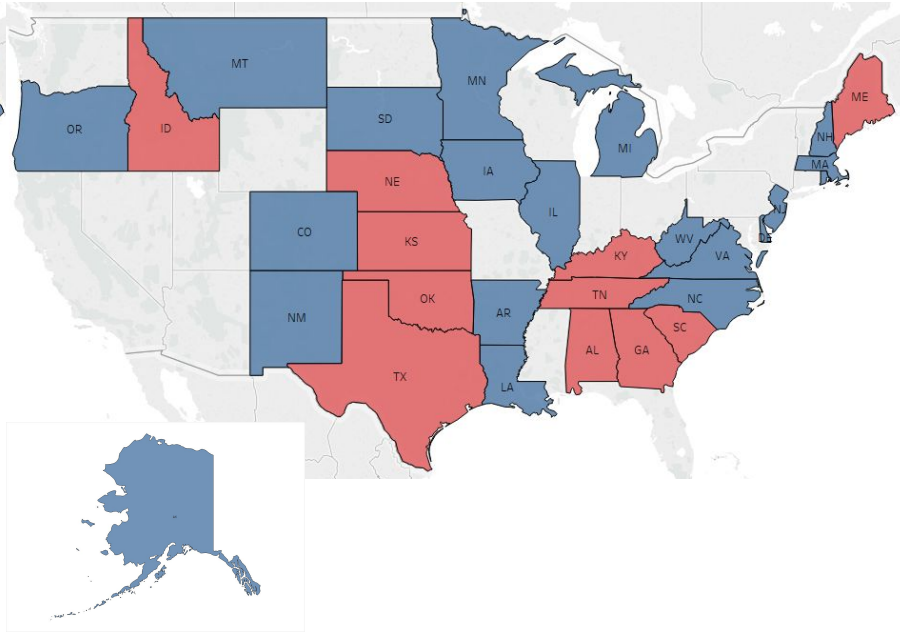
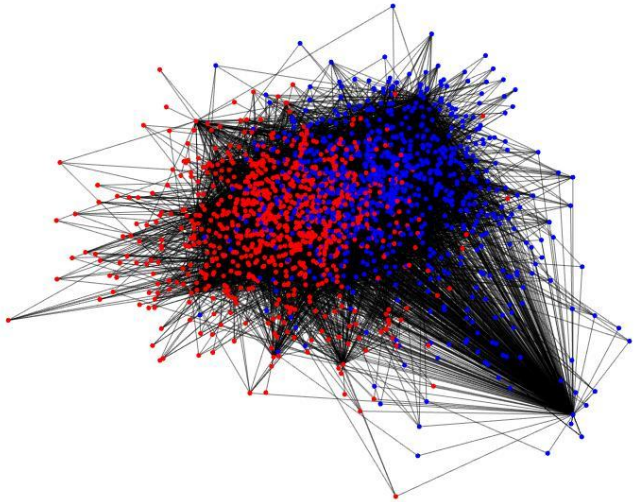
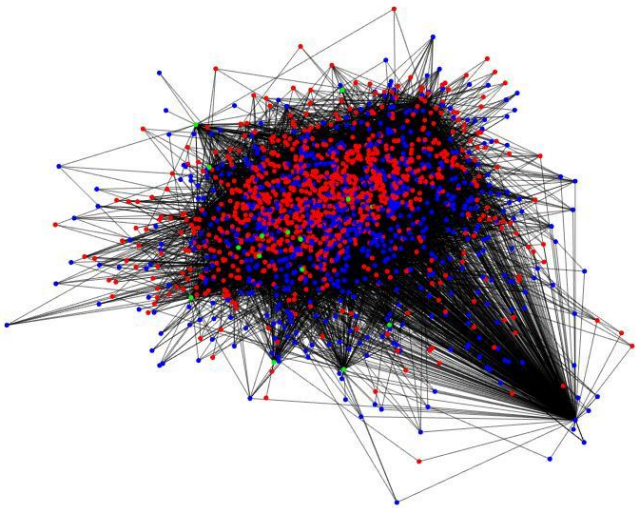


Community Detection on States and Committees

Modularity (2010)

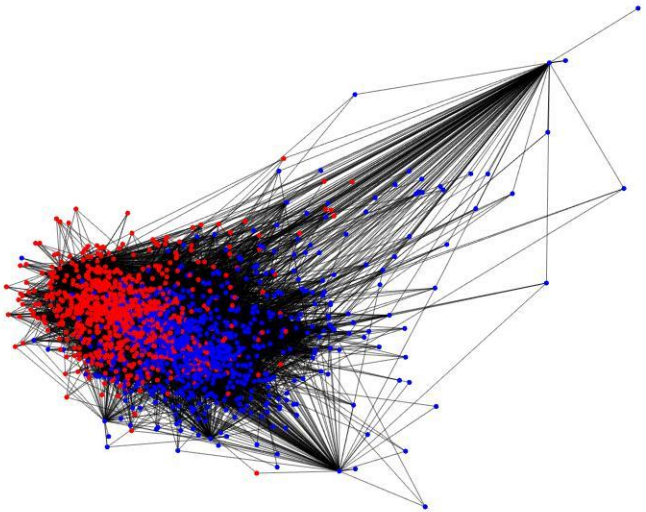


Party Affiliation (2010)

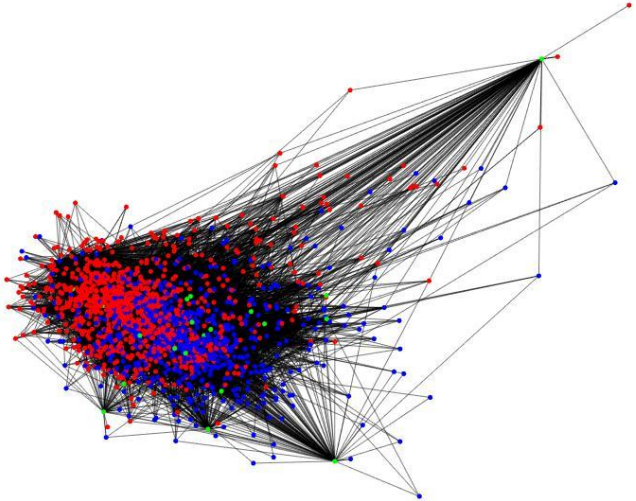


Community Detection on States and Committees

Undirected Modularity (2008)

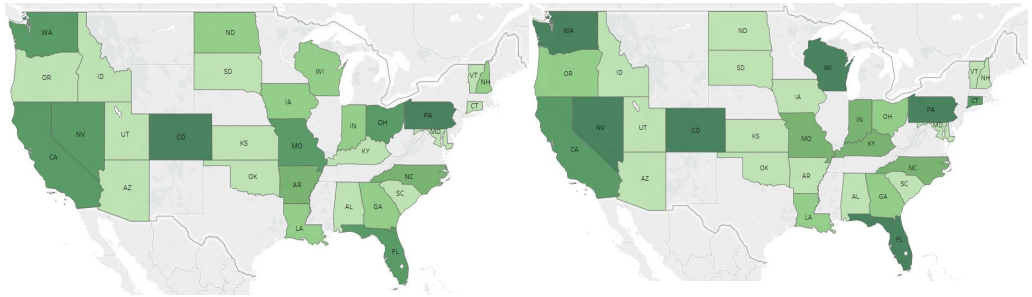


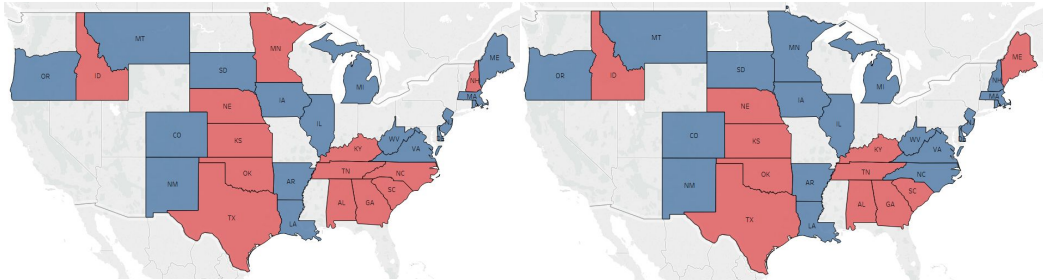
Party Affiliation (2008)



Conclusions

- Identify close elections
- Predict voting outcome solely from donation data





Future Research

Application of other aspects of the dataset

- More recent years
- Other types of elections, including: presidential, House, and primaries
- Effect of independent candidates on the network

Investigate underlying structure

- Co-citation and co-donation
- Preferential attachment

Thank You

- Federal Election Commission (FEC)
- Andrew Waugh
- Professor Porter

Visualizations were made in MATLAB and Tableau