

Political Polarization in Legislative Branches II

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Dynamic Social Competition Model^[1]

$x \in [0, 1]$ measures the current polarization, so the collaboration is measured by the complementary fraction of x , i.e. $y = 1 - x$

$$\frac{dx}{dt} = \overbrace{yP_{yx}(x, u_x)}^{\text{increased competition}} - \overbrace{xP_{xy}(x, u_x)}^{\text{lost competition}}$$

simple symmetric
transition functions:

$$\begin{aligned} P_{yx}(x, u_x) &= P_{xy}(1 - x, 1 - u_x) \\ &= c \cdot x^a \cdot u_x \end{aligned}$$

= **Evolution speed** $\times$ Impact of **population belief** on the change of polarization $\times$ **Perceived utility of competition**,
(the benefit fighting against the other party on certain bills)

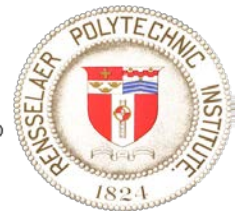
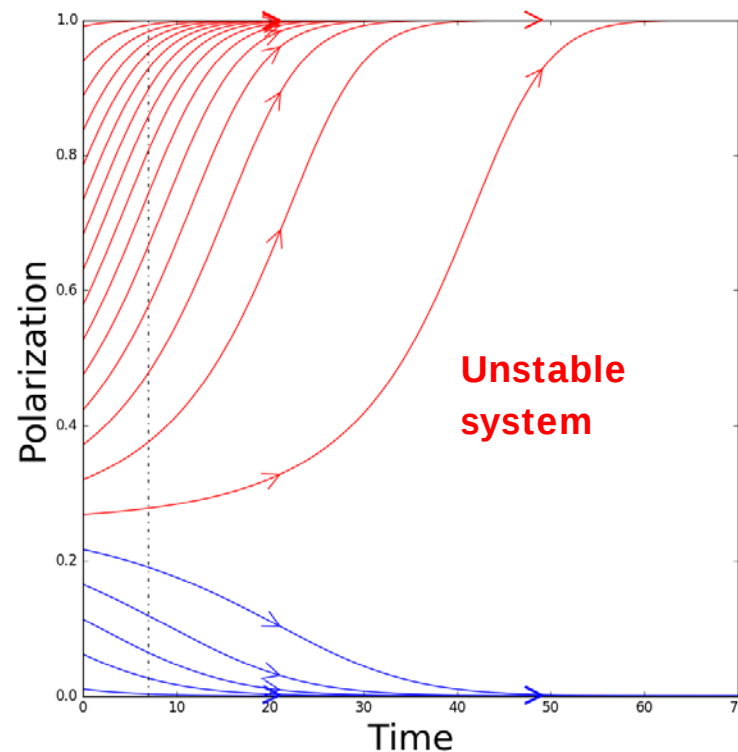
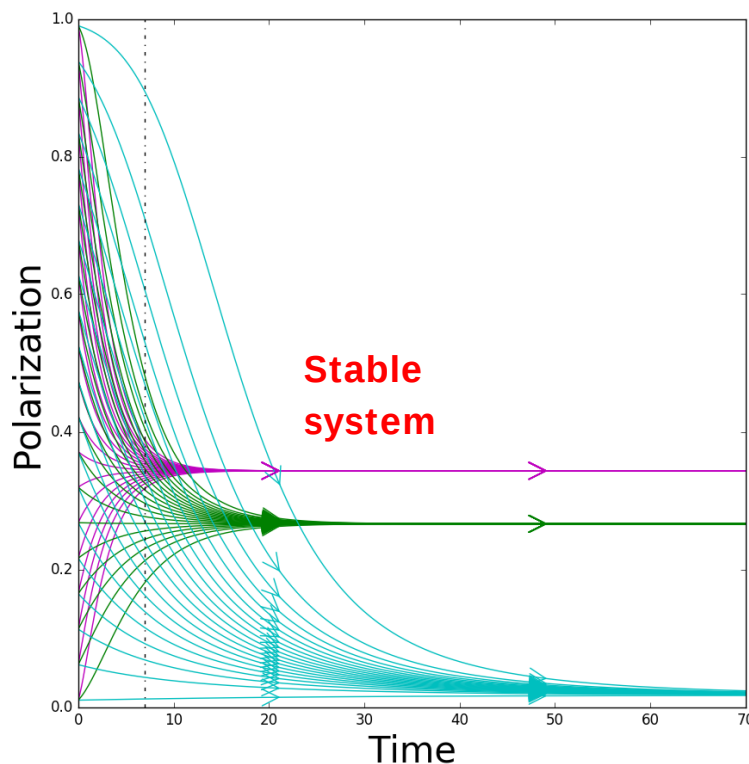
[1] Abrams, D. M., & Strogatz, S. H. (2003). Linguistics: Modelling the dynamics of language death. *Nature*, 424(6951), 900.



Dynamical Model for Polarization Evolution

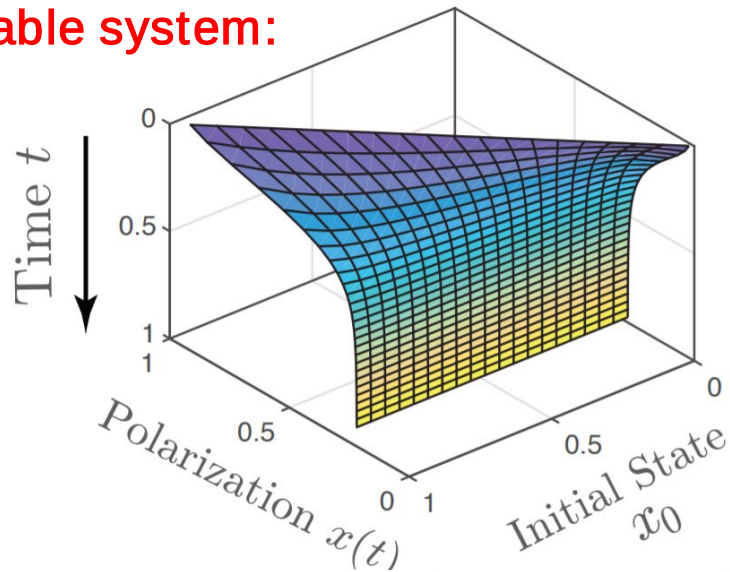
- We assume a social system dominated by two parties. In such a system polarization and collaboration can convert into each other but they maintain their sum constant at 1.

$$\frac{dx}{dt} = yP_{yx}(x, u_x) - xP_{xy}(x, u_x)$$

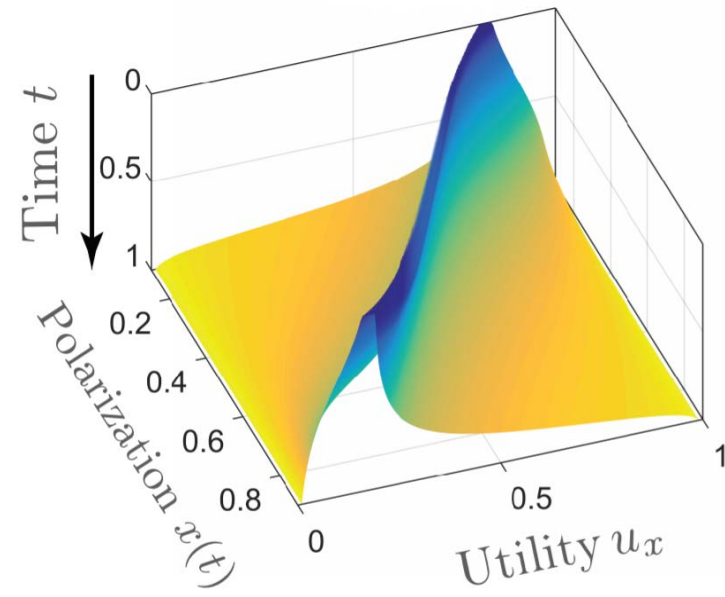
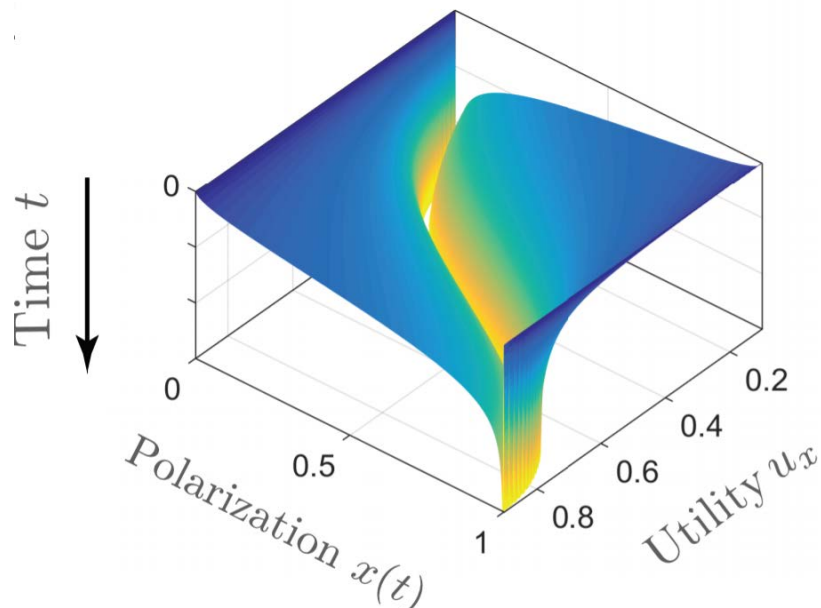
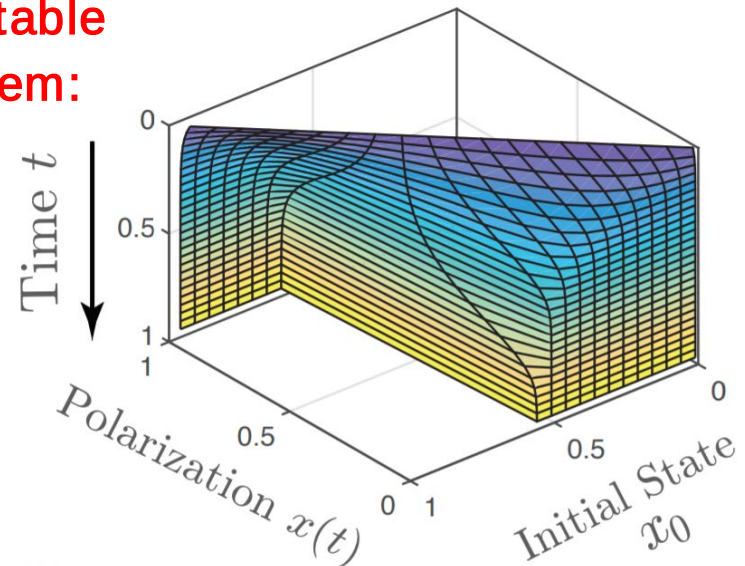


Dynamical Model for Polarization Evolution

Stable system:

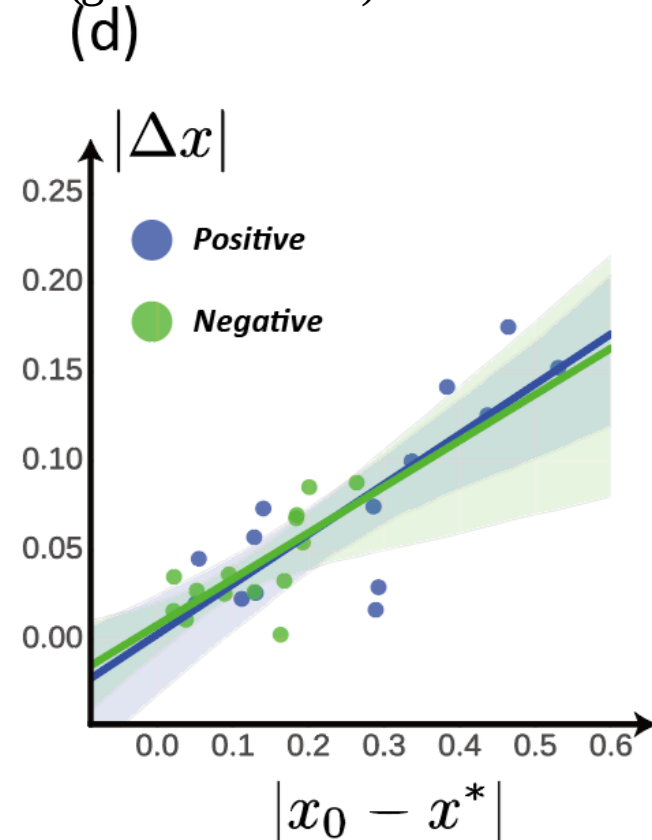
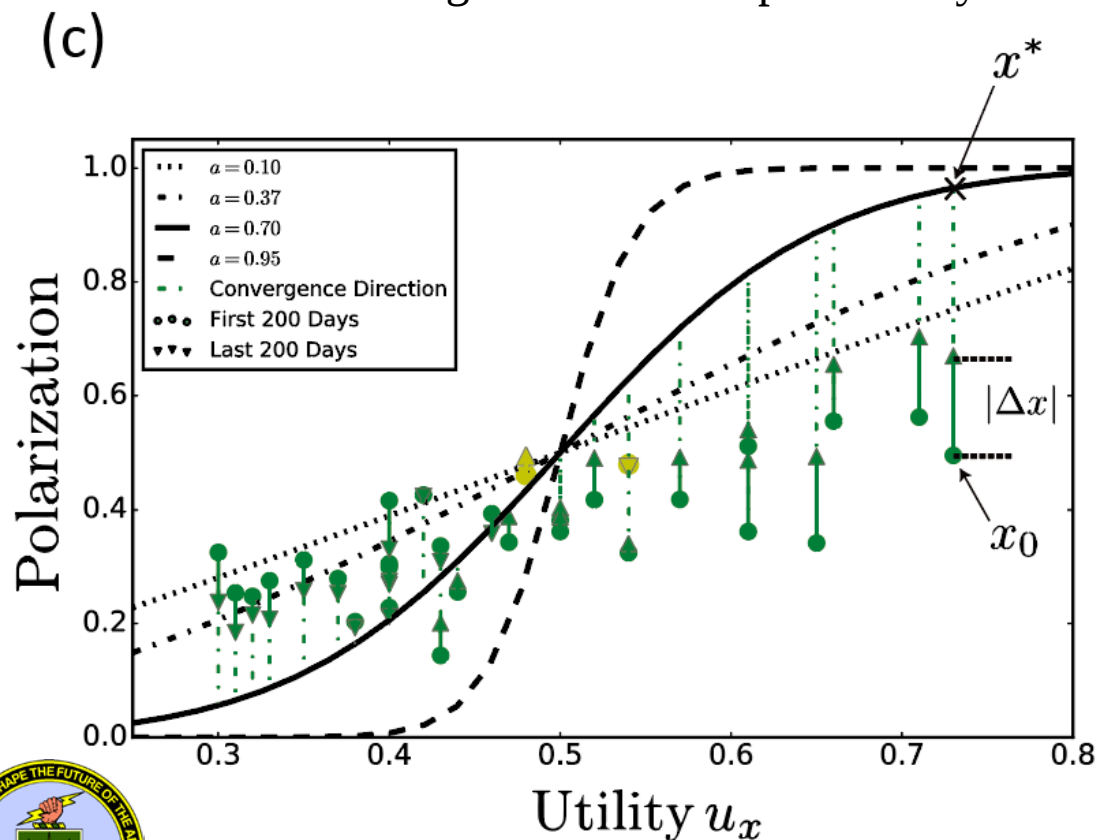


Unstable system:



Direction of Polarization Change

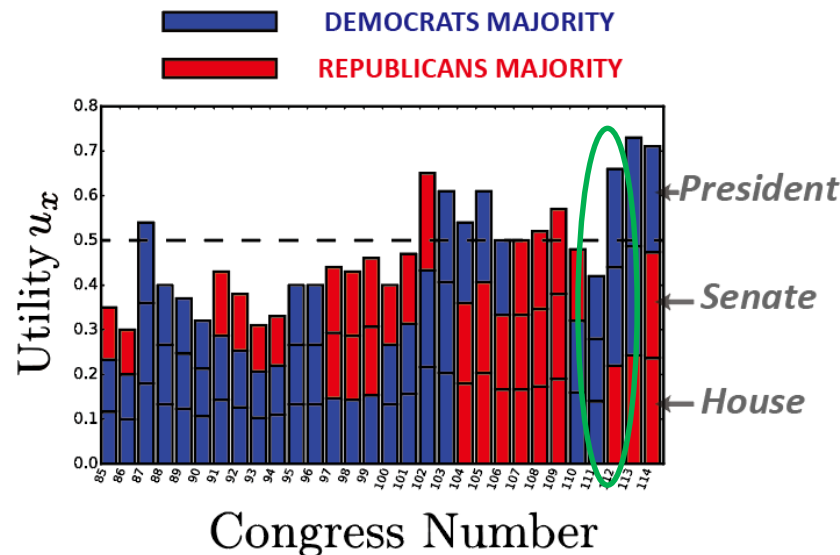
- When the initial polarization level (green cycles) is smaller than the stable polarization level predicted by our model (solid black curve), we observe an increase of polarization within one Congress. The direction of such change in 28 out of all 30 Congresses are explained by the model (green arrows)



Polarization Utility

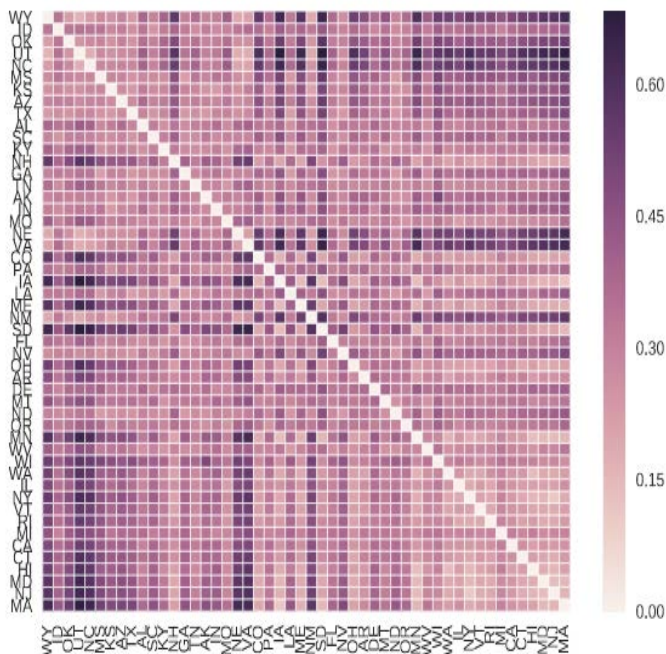
- 6 of 14 Presidential election Congresses started with the polarization utilities at least 0.5 while only 1 of 15 midterm election Congresses achieved such high polarization utility
- The highest polarization utility growth (57.1%) occurs in the 112th Congress (2011-2013).

Super PACs arose following the July 2010 federal court decision

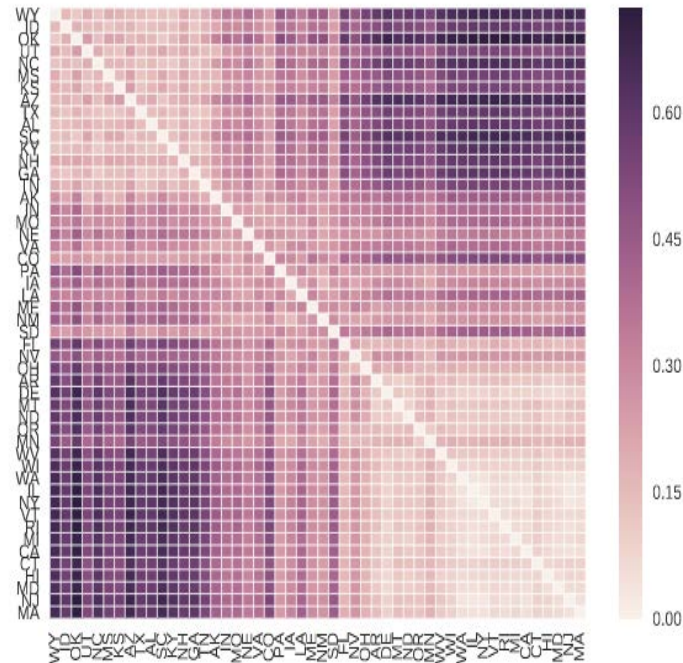


Structural Change of Competition among States

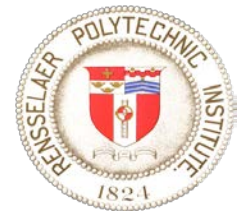
The pairwise disagreements are at similar level while the structure of competition changes significantly.
The order of states is ranked by their one-dimensional PCA projection.



95th Congress (1977-1978)



110th Congress(2007-2008)

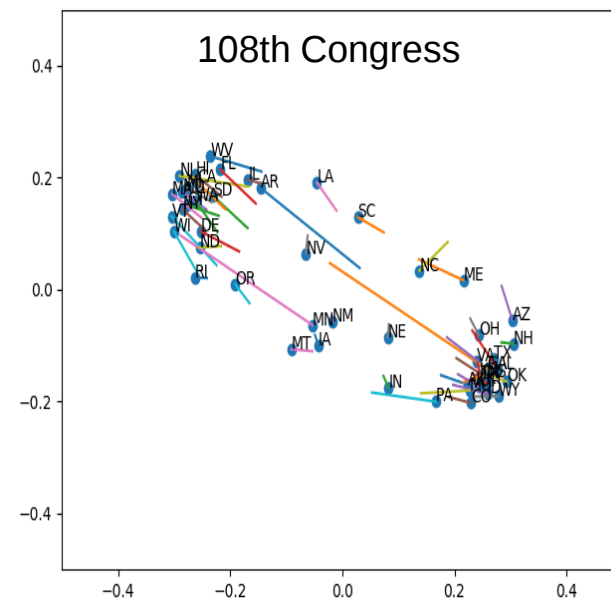
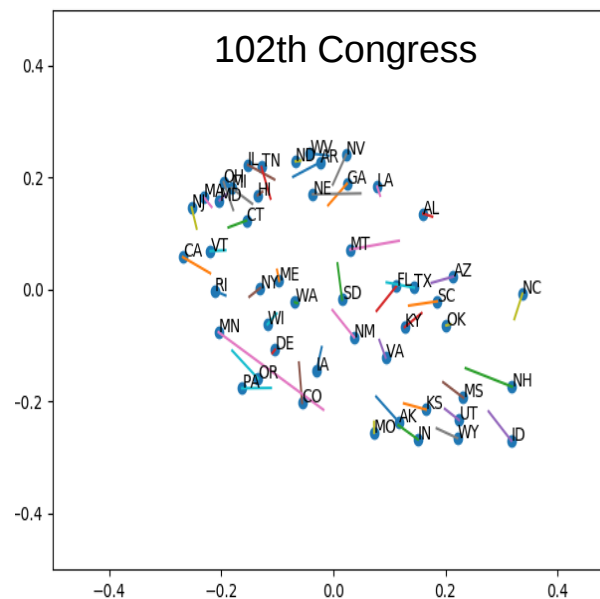
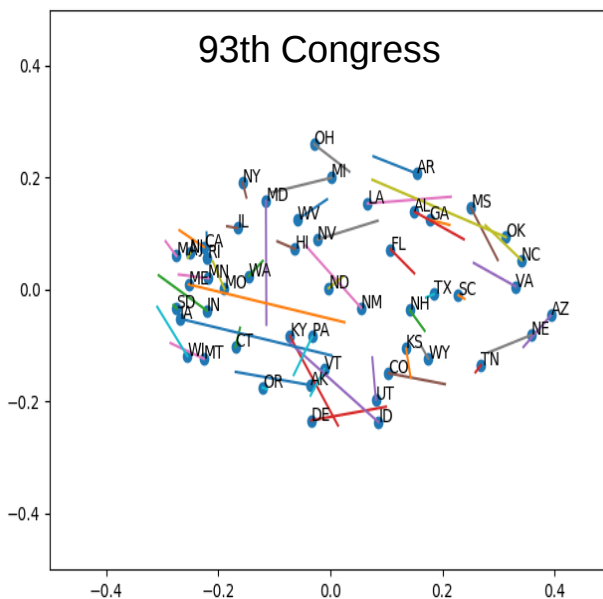
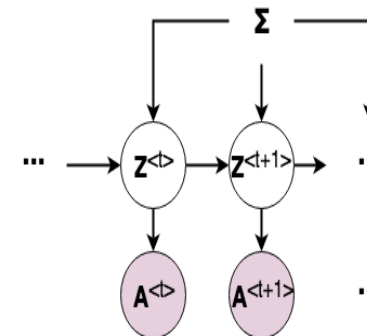


Social Flocks Model (Extended Boids Model)

The three rules of social flocks movement in latent space $\mathbf{Z}$:

1. *Separation*: steer to the opposite direction of competitors
2. *Cohesion*: steer to move toward the average position of local flockmates
3. *Gravity*: steer towards the most neural position (origin)

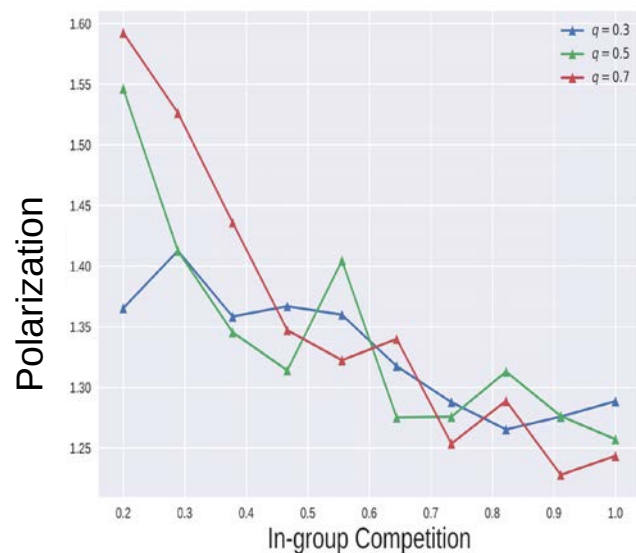
The Euclidean distance matrix $\mathbf{A}_{ij}$ follows Gaussian with mean $|\mathbf{Z}_i - \mathbf{Z}_j|$



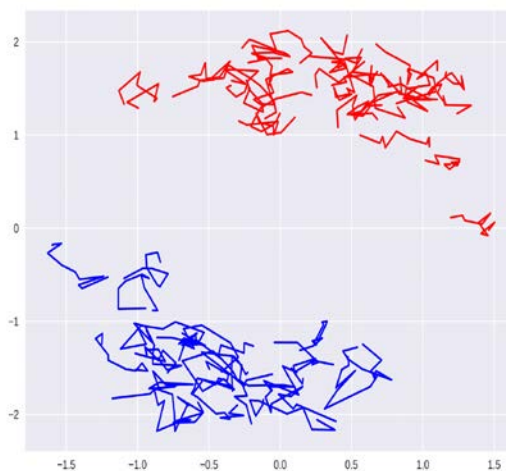
Competition Structure Matters

The network structure of competitors impacts the final polarization level.

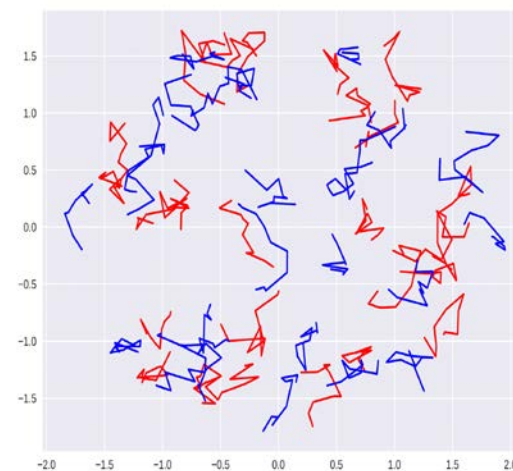
We simulate the evolution of polarization using a competition graph generated by planted partition model with intra-group edge probability q and inter-group edge probability p .



$q=0.2, p=0.7$



$q=0.8, p=0.3$



Contributions

Theory: We define a dynamical model **quantifying the evolution of polarization** in the U.S. Congresses elected in the past six decades.

The hidden model parameter, polarization utility, correlates well with significant political or legislative changes happening at the same time.

Algorithm: We implemented a predictor based on the model that successfully predicts the direction of polarization changes in 28 out of 30 elected U.S. Congresses.

The hidden model parameter, polarization utility, correlates well with significant political or legislative changes happening at the same time.



Thanks

Questions?

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Reference:

X. Lu, J. Gao, B. K. Szymanski, “The evolution of polarization in the legislative branch of government,” *Royal Society Interface*, **16**:20190010, 2019



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