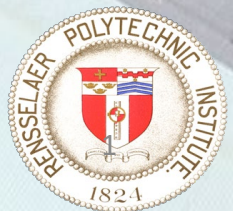# Political Polarization in Legislative Branches

Presenter: **Boleslaw Szymanski**

Co-authors: Xiaoyan   Lu, Jianxi Gao

NeST Center & SCNARC
Department of Computer Science
Department of Physics, Applied Physics and Astronomy
Rensselaer Polytechnic Institute, Troy, NY 12180

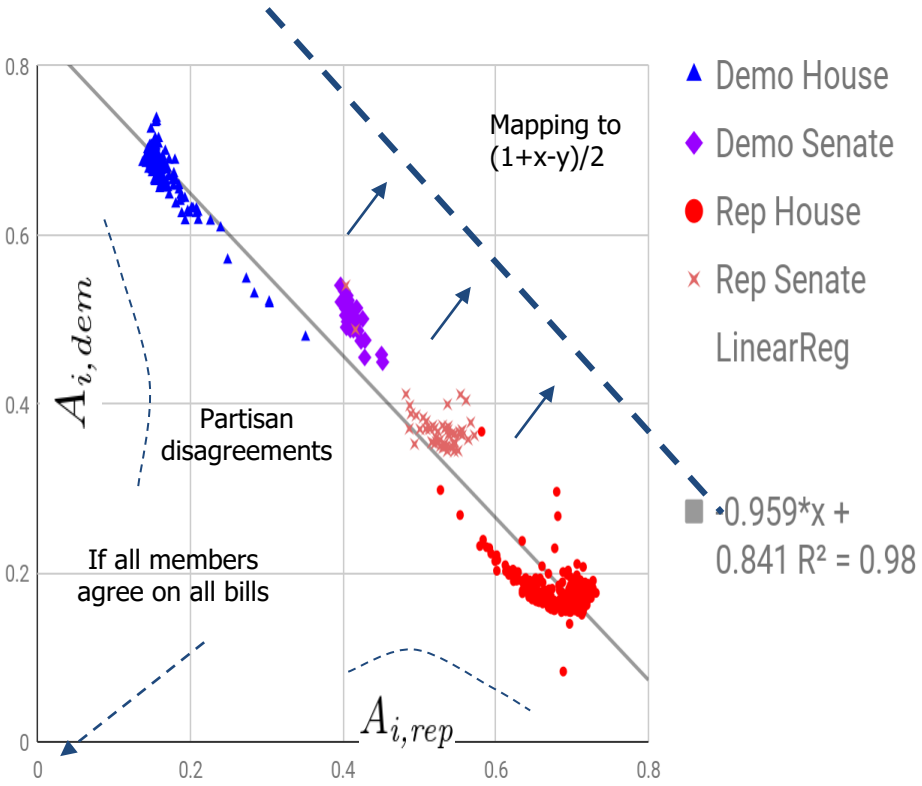Political Polarization Workshop, Princeton University, August 9. 2019

Introduction

➤ Research objective: How does the social and political polarization evolve over time?
➤ Data-driven analysis:
  ○ We collect congress/parliament voting data of the countries including *Sweden* (2.4M votes), *UK* (3M votes) and *USA* (3.5M votes)
➤ Quantifying the social choices of competition and collaboration by mathematical models.
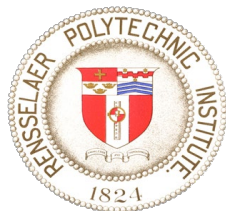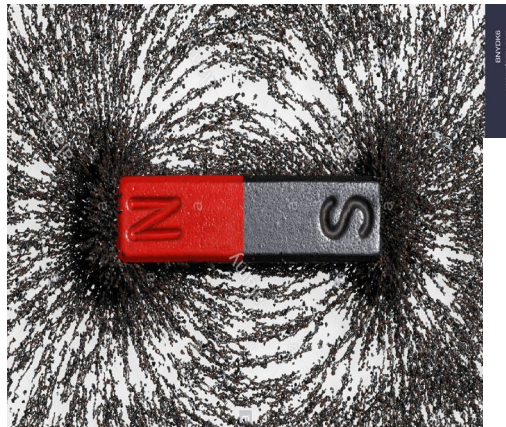
*Similar results for other countries are in the making

Partisan Alignment of Members of the U.S. Congress (2015)

Demo House
Demo Senate
Rep House
Rep Senate
LinearReg

Mapping to (1+x-y)/2

Partisan disagreements

If all members agree on all bills

$A_{i,dem}$

$A_{i,rep}$

•0.959*x + 0.841 R² = 0.98

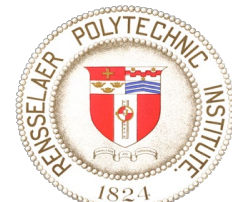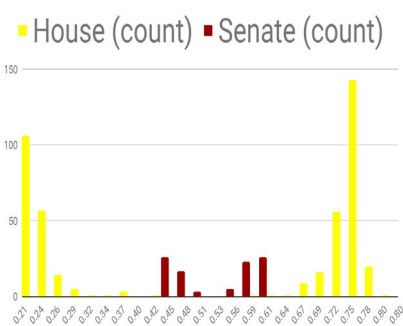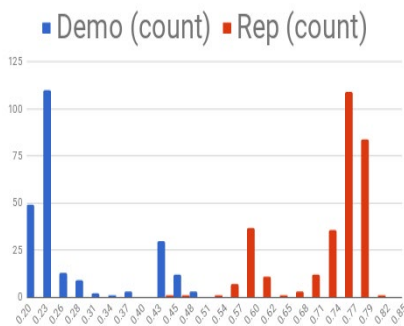Demo (count)   Rep (count)

House (count)   Senate (count)

Partisan alignment measured by the distance to a party's centroid:

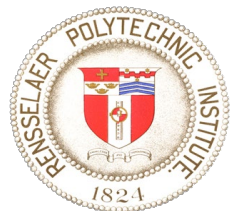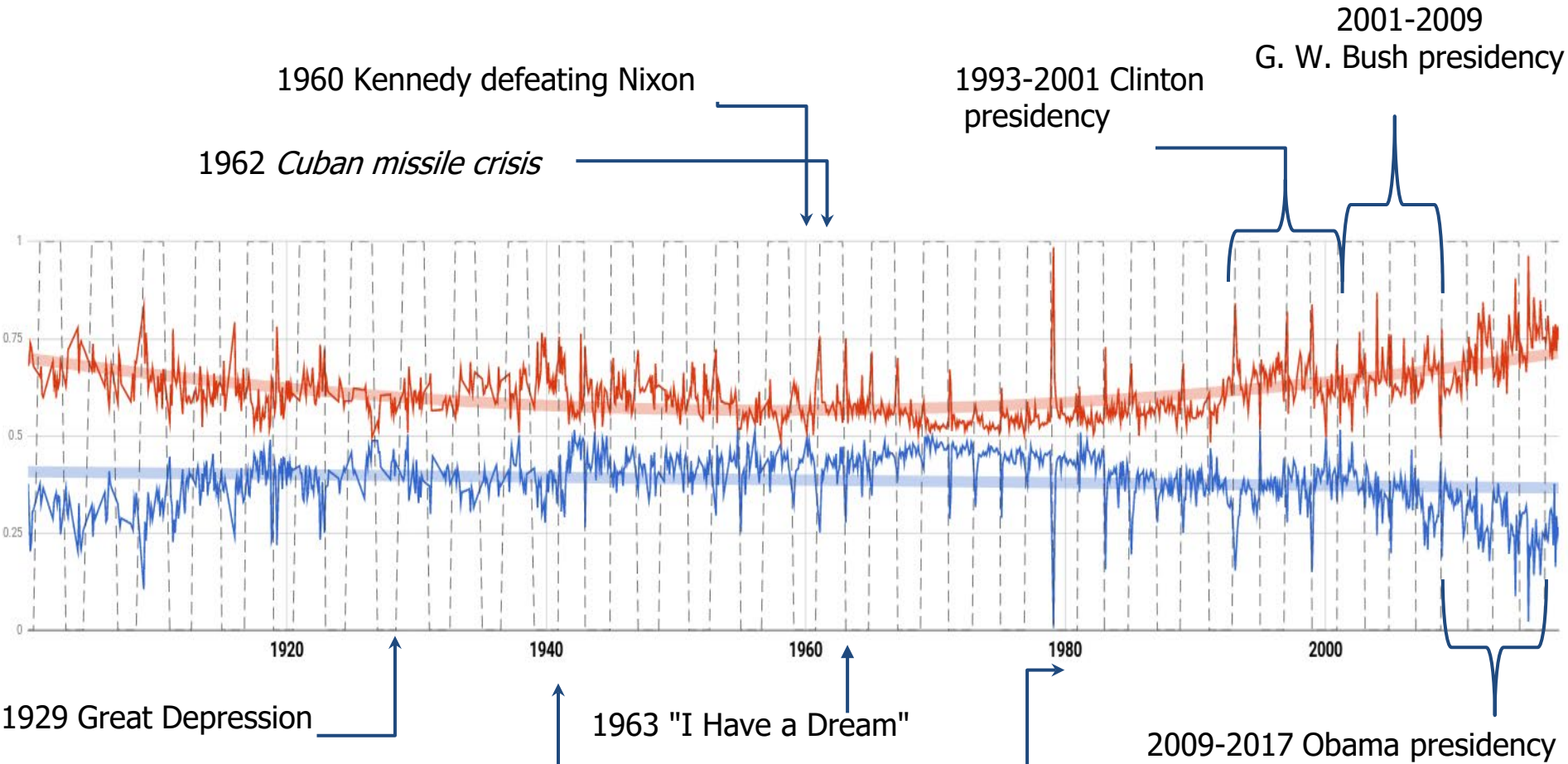$$A_{i,p} = \mathbb{E}_b |\mathbb{E}_i[V_i^{(b)} \delta_{i,p}] - V_i^{(b)}|$$

$V_i^{(b)}$ is member i's vote on a bill b among the year 2015's bills.

- Relative measure: if one party deviates then both should move to the poles, but not exactly symmetric due to the non-uniform population distribution.

- Members' loyalty to the party does **NOT** alway lead to polarization. Parties could align with each other on certain bills themselves.

- Mapping $(A_{i,dem}, A_{i,rep})$ to the diagonal, which is equivalent to **PCA** reducing the dimension from two to one.

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Evolution of the Average Partisan Polarization

1900-2018 Monthly

2001-2009
G. W. Bush presidency

1960 Kennedy defeating Nixon

1993-2001 Clinton presidency

1962 *Cuban missile crisis*

1929 Great Depression

1963 "I Have a Dream"

.941 Pearl Harbor

1980 Reagan defeating Carter

2009-2017 Obama presidency

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Evolution of the Average Partisan Polarization

Polarization increases as a general trend, but it decreases **within** each congress in the 70s and 80s.

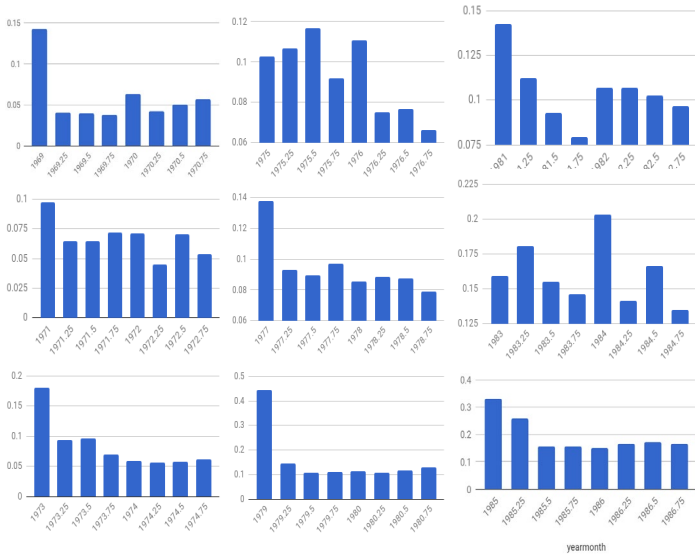The evolution of polarization from 1968/01/01 to 2018/01/01 (monthly)
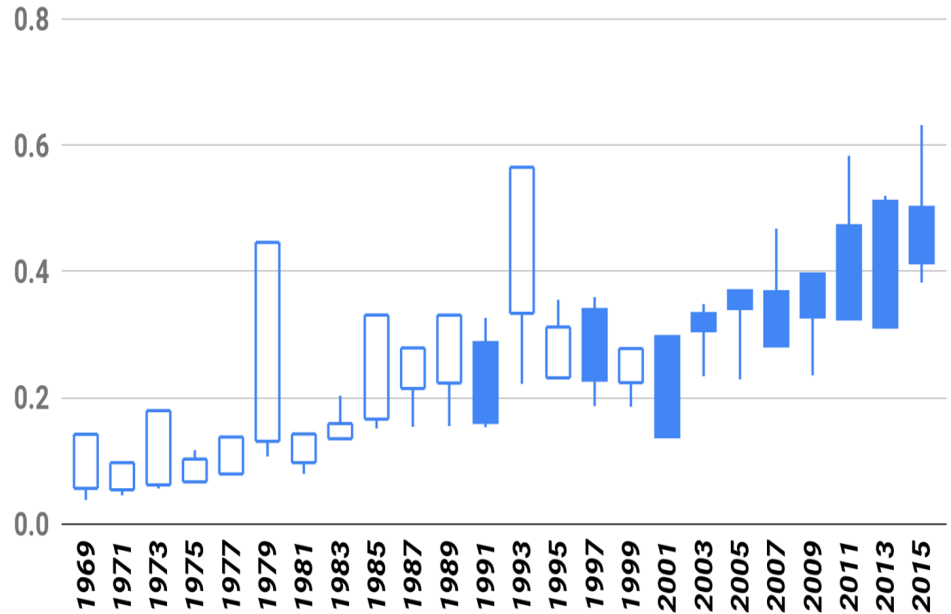

demo — rep — • Re-election
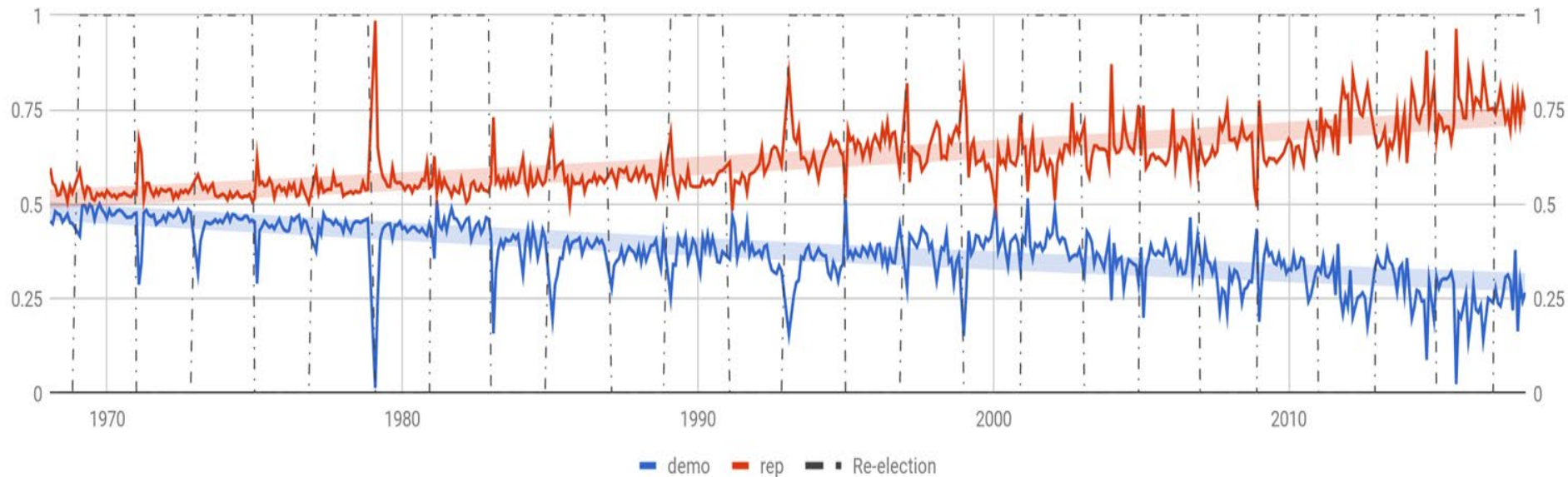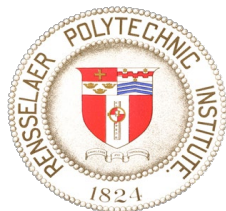
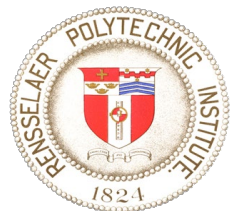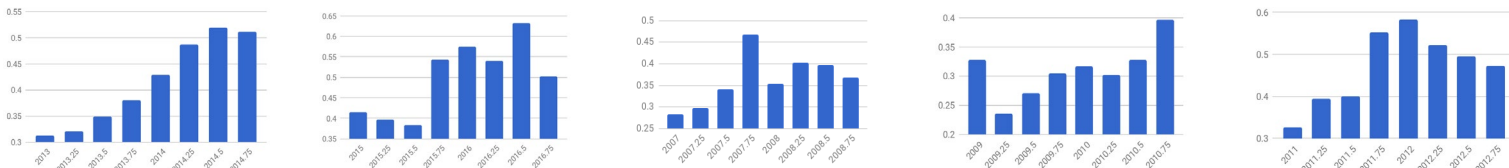# Evolution within Each Congress (2 years term)

Period I (1969-1989) Polarization decreases

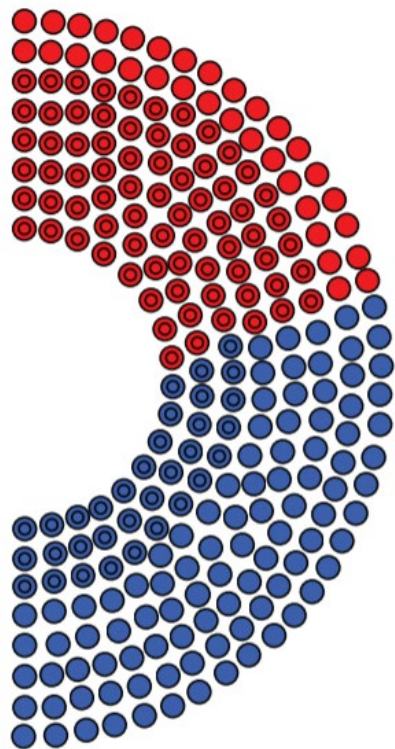Candlestick chart of open, close, max, min polarization of each congress

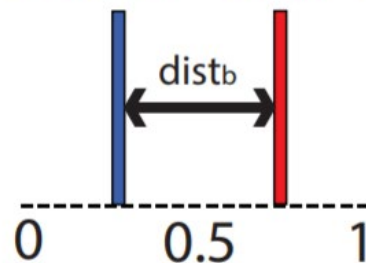Period III (2001-2017) Polarization increases (seasonal plot)

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The evolution of polarization in the legislative branch of government

VOTES   **Yes**   **Else**

110
REPUBLICANS

130
DEMOCRATS

Ratio of YES votes:
33/130   77/110

dist_b

0   0.5   1

➢ We analyze millions of roll-call votes cast in the U.S. Congress over the past six decades to identify evolution of political polarization patterns

➢ Using the roll-call vote results, we quantify the level of polarization in the legislative branch of government over the last six decades

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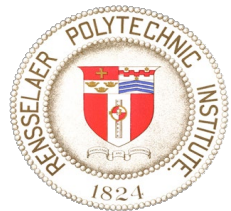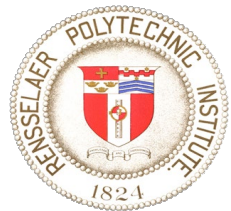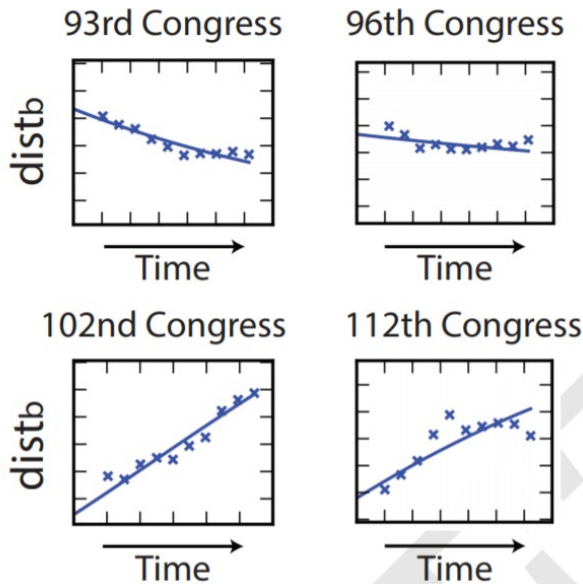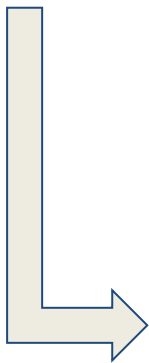
The evolution of polarization in the legislative branch of government
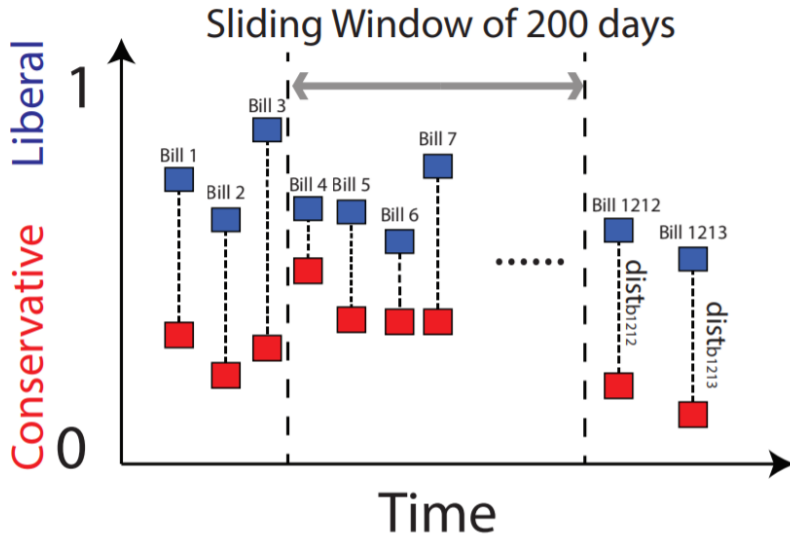
Long-term polarization pattern
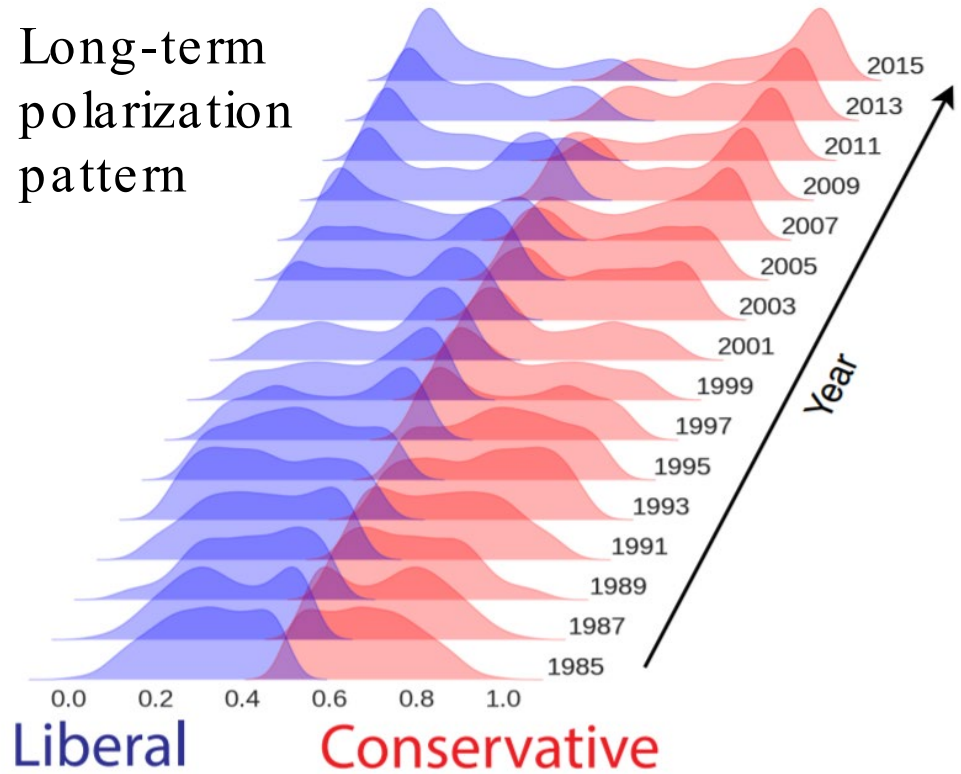
The political polarization levels at ten evenly-distributed sampled time points exhibit an evolution of polarization patterns from one type of behavior to another

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. $y = 1 - x$

increased competition   lost competition

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

simple symmetric transition functions:

$$P_{yx}(x, u_x) = P_{xy}(1 - x, 1 - u_x)$$

$$= c \cdot x^a \cdot u_x$$

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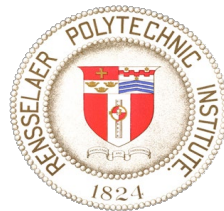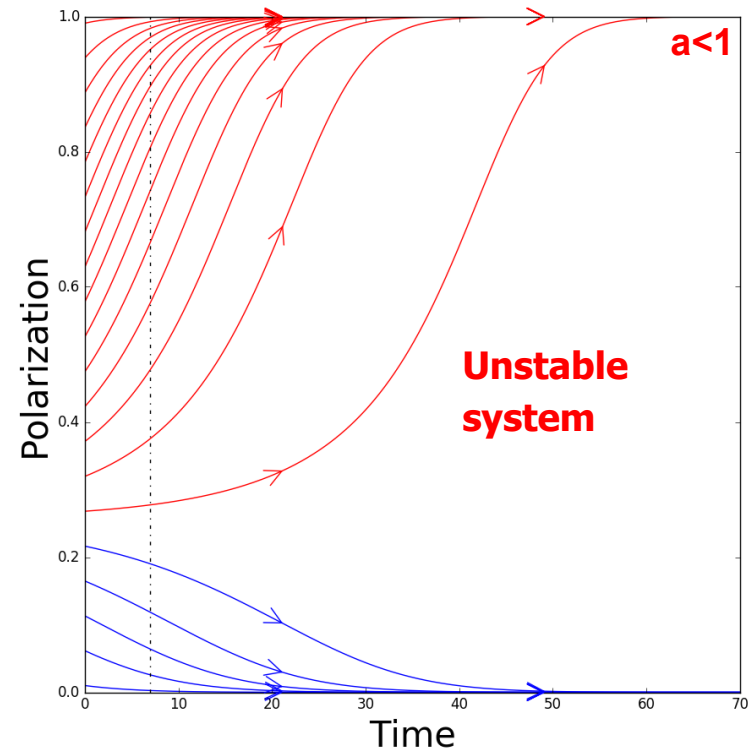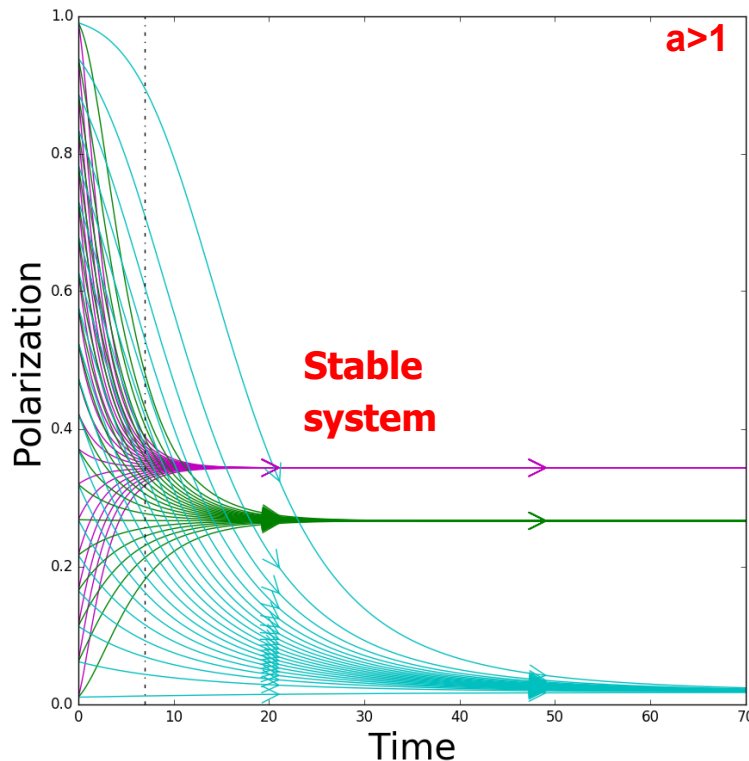
[1] Abrams, D. M., & Strogatz, S. H. (2003). Linguistics: Modelling the dynamics of language death. *Nature*, *424*(6951), 900.
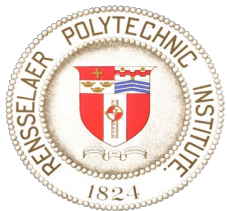
Dynamical Model for Polarization Evolution

➤ 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.
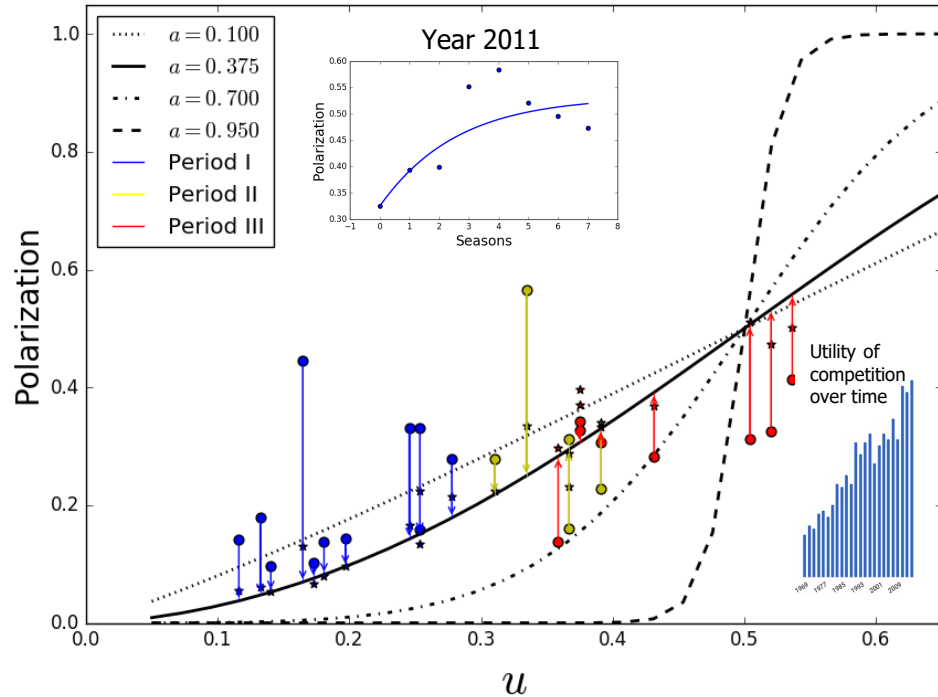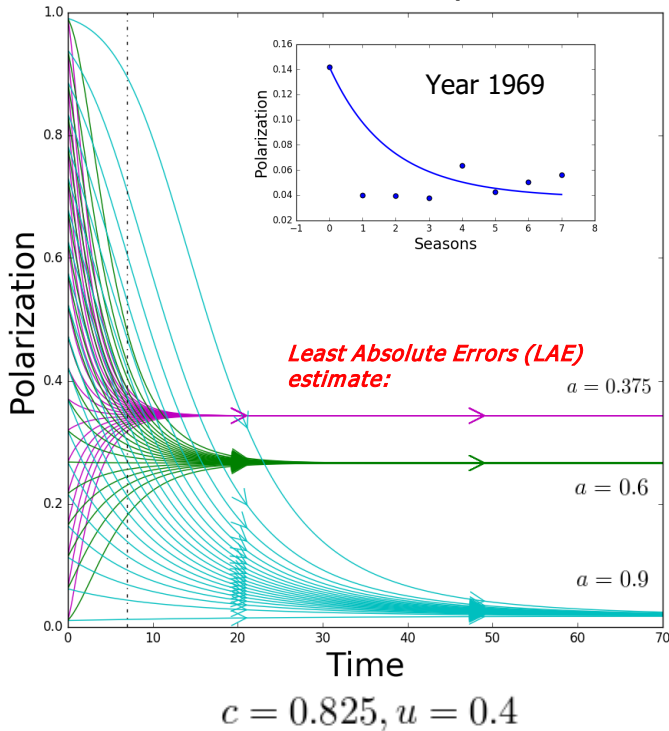
$$\frac{dx}{dt} = yP_{yx}(x, u_x) - xP_{xy}(x, u_x)$$
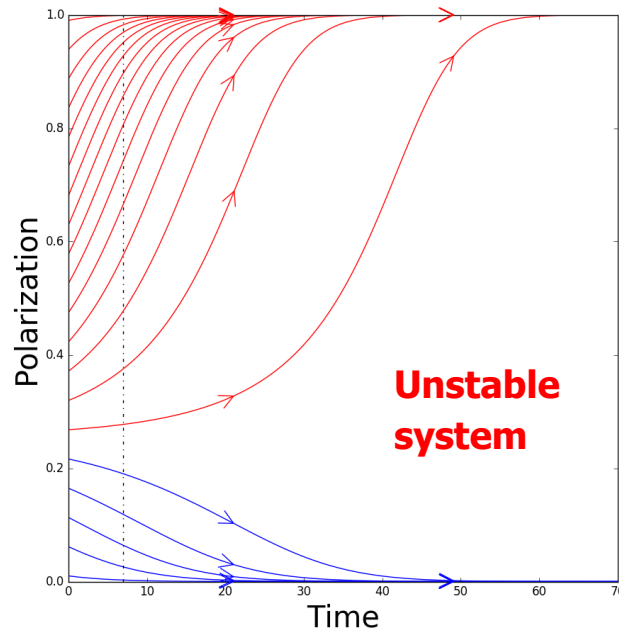
How to Reduce Social Polarization?

The stable states of the dynamical system when $a < 1$: **convergence** at some polarization level

We assume that u_r is unique for each congress, but c and a are universal at all times.
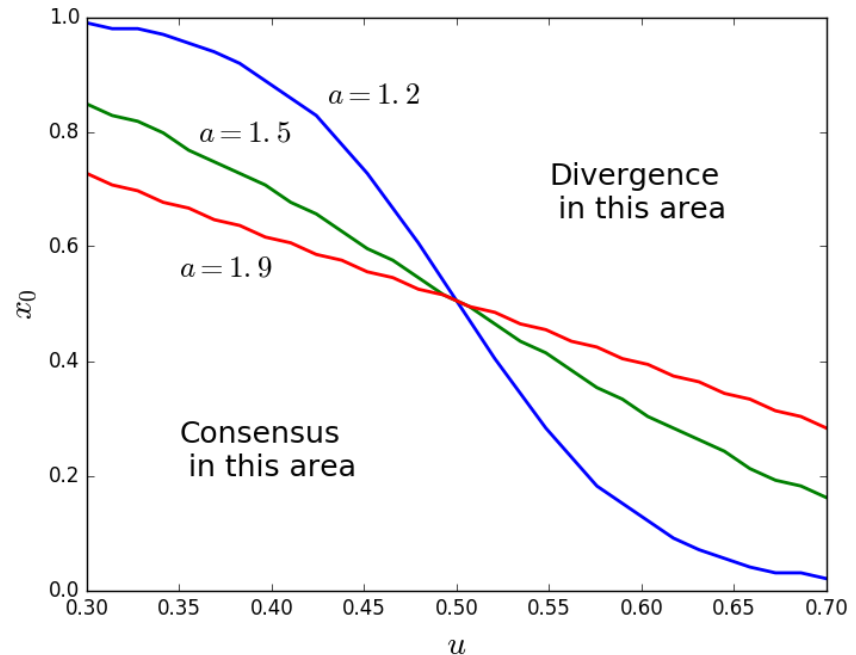

$c = 0.825, u = 0.4$

How to Reduce Social Polarization?

The stable states of the dynamical system when $a > 1$: either consensus or divergence

Unstable system

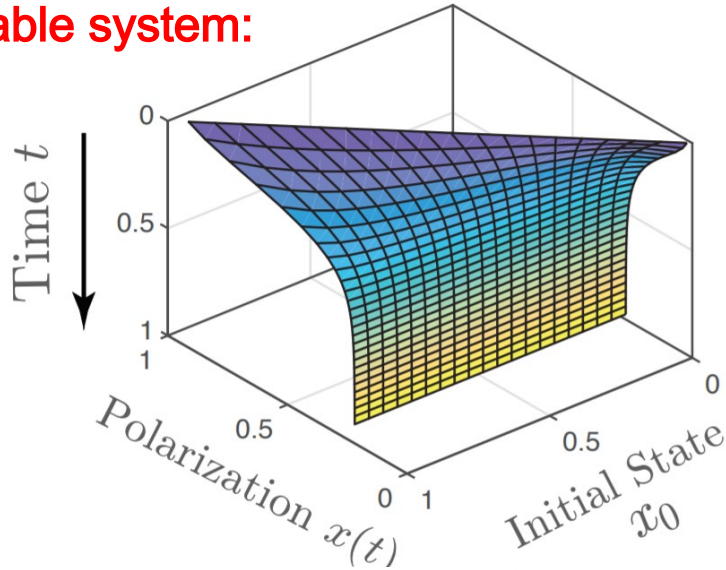$c = 0.6, \quad a = 1.38, \quad u_x = 0.6$

$a = 1.2$

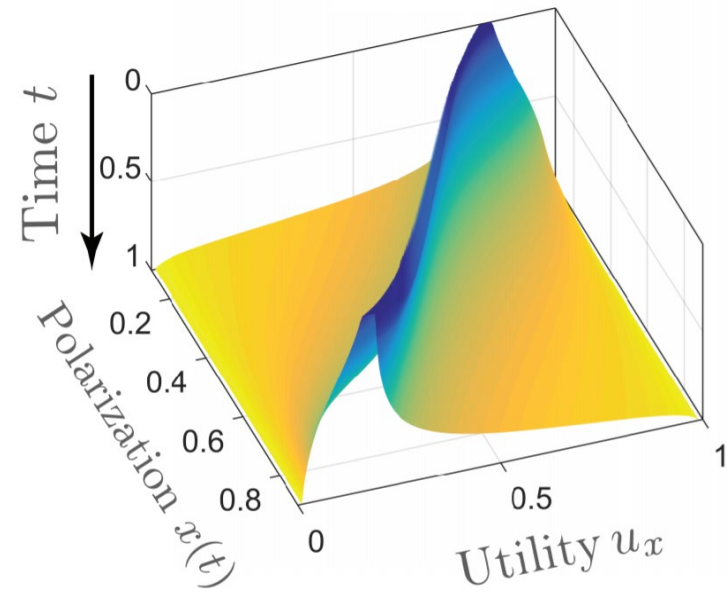$a = 1.5$

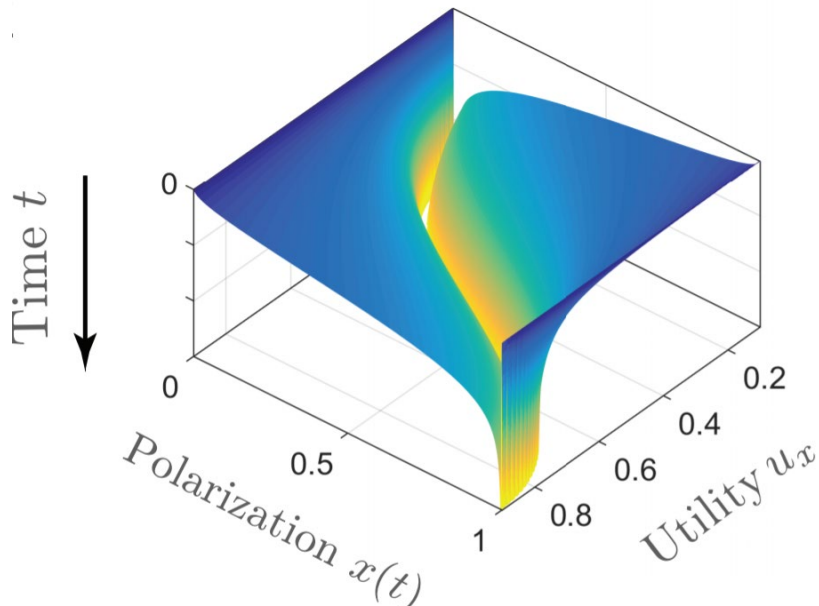$a = 1.9$

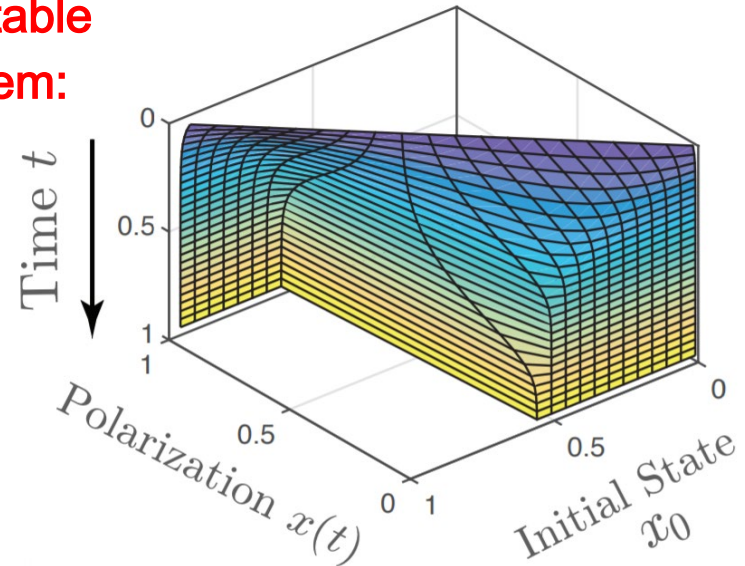Divergence in this area

Consensus in this area

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)
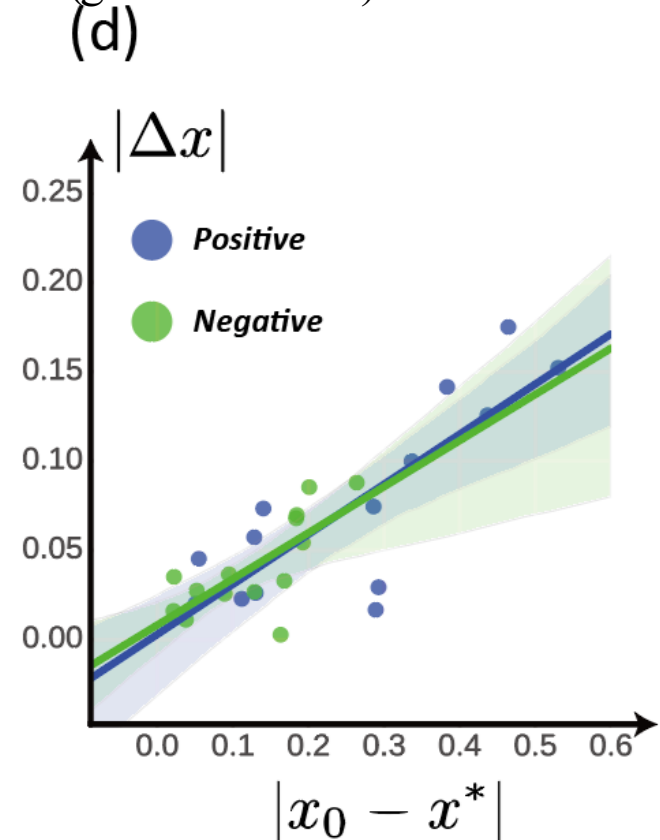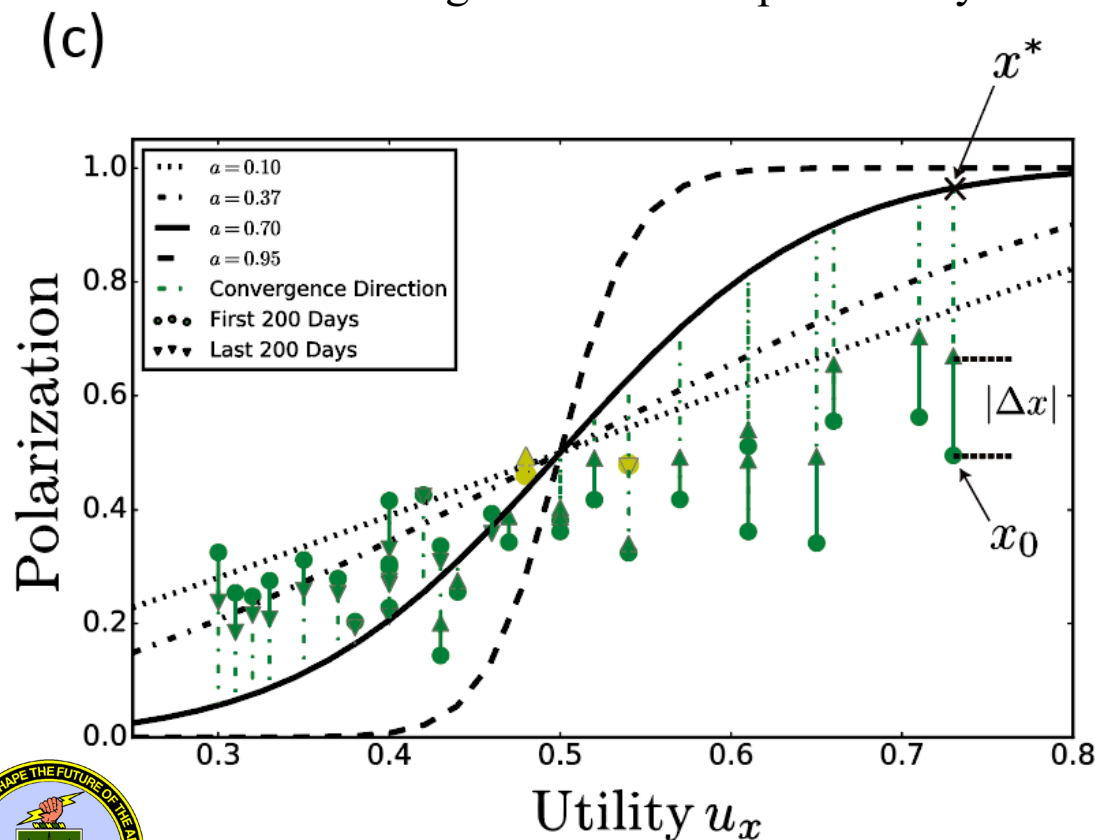
Polarization Utility

➢ 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

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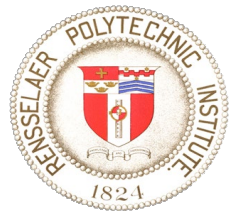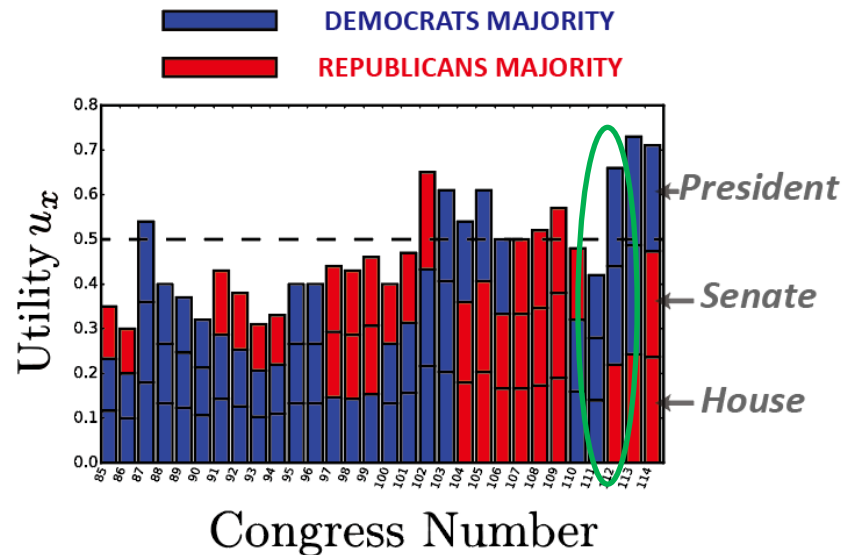
Contributions

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.

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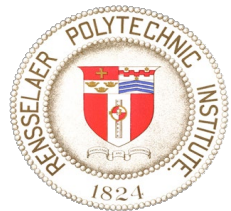
Thanks

Questions?

Reference:

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