Combatting Gerrymandering with Social Choice: the Design of Multi-member Districts

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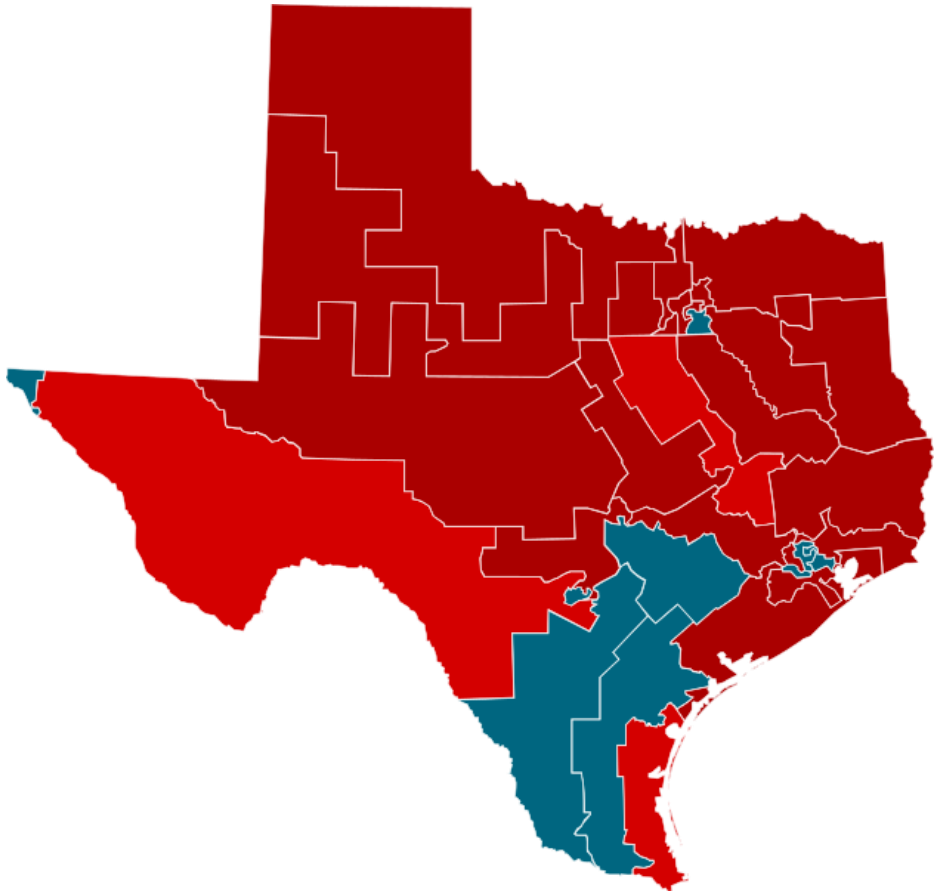
Re-districting basics

- In district-based representative democracies (like the US), voters are partitioned into districts
- Each district runs independent elections to elect representatives
- District boundaries are redrawn semi-regularly, potentially by political actors
- *How* boundaries are drawn matters
- Re-districting is a graph partitioning challenge



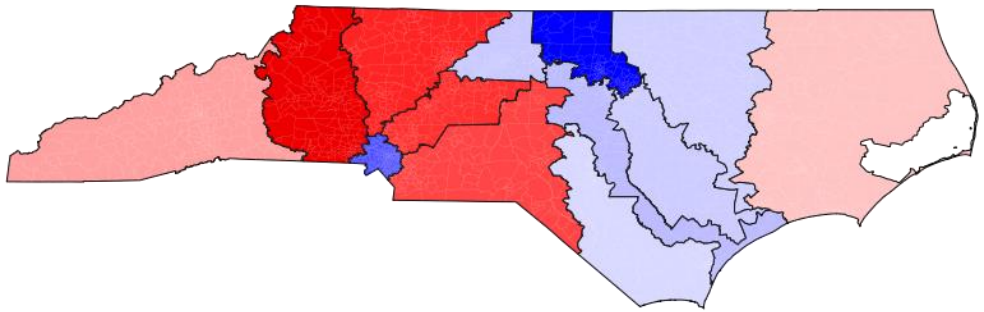
This bill requires (1) that ranked choice voting . . . be used for all elections for Members of the House of Representatives, (2) that states entitled to six or more Representatives establish districts such that three to five Representatives are elected from each district, and (3) that states entitled to fewer than six Representatives elect all Representatives on an at-large basis

—Fair Representation Act, H.R. 4000, 2019

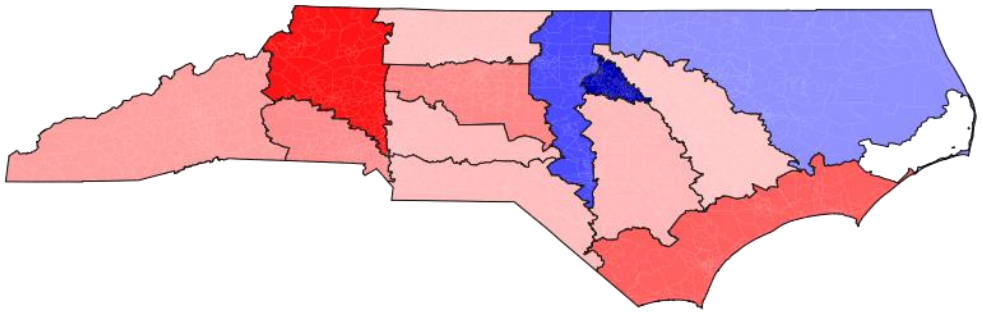
Why are *multi-member districts* a good idea, and how does one (computationally) study such a thing?

Re-districting potential desiderata

- Proportional: party vote share v_p is close to winner seat share w_p
- Compact: districts reflect geographically cohesive communities
  - "Local": Representatives live close to the communities they represent



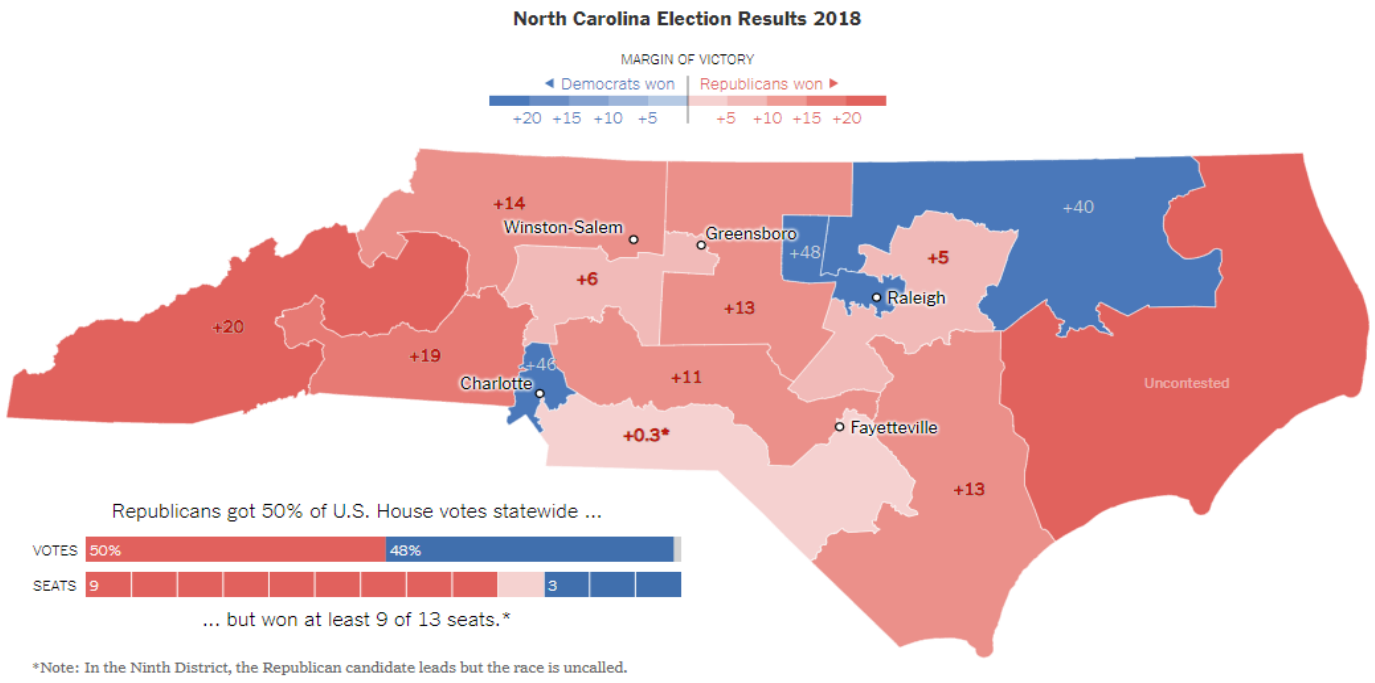
Proportional, not compact



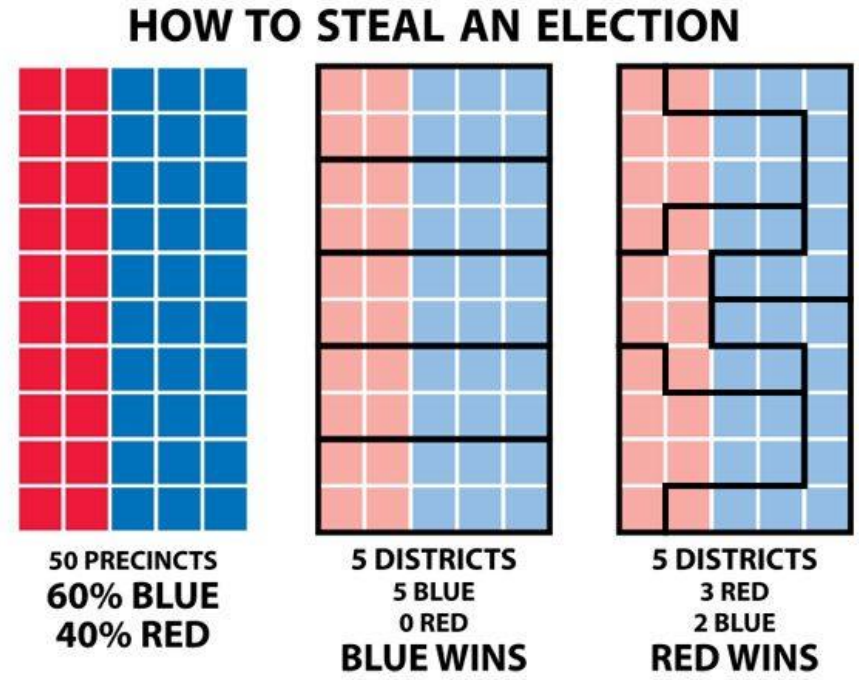
Compact, not proportional

Challenge 1: Intentional gerrymandering

Partisan gerrymanders: *intentional* drawing of maps to favor one party



NYT 2018 (Astor & Lai)



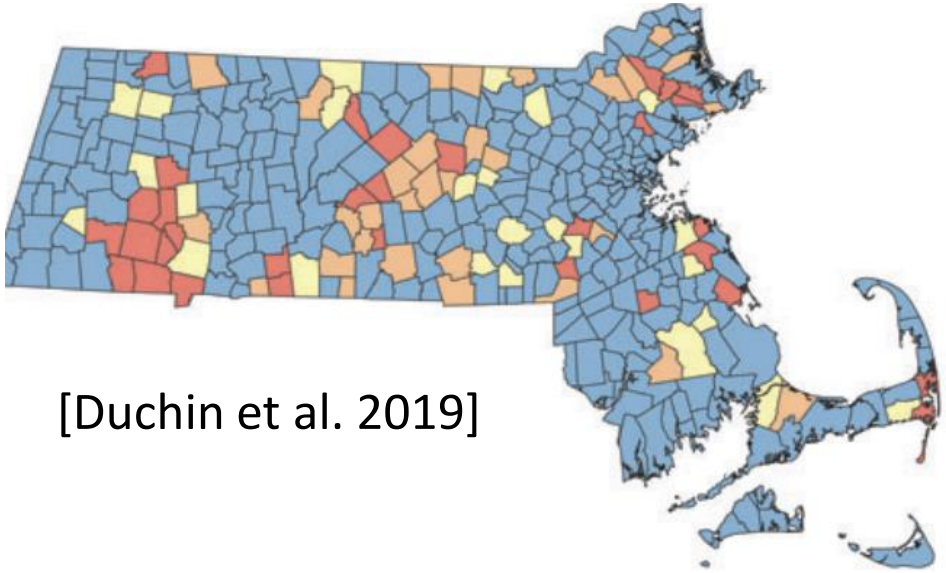
By Steven Nass [CC BY-SA 4.0]

Challenge 2: “Natural” gerrymandering

“Natural” gerrymanders: distribution of voters makes it *impossible* to draw proportional maps – the “Massachusetts problem” [Duchin et al. 2019]

Why? Republicans have 30% of state-wide vote, but need 51% in a single district

=> might need to draw “unnatural” maps to be proportional, if possible



[Duchin et al. 2019]

Social choice & multi-winner elections

Suppose we're electing N people from each district

Winner takes all: Each voter votes for N candidates. Top N vote-getters are elected

STV: Candidates are not elected "independently." Each voter submits a ranking, and candidates are selected sequentially.

Sample Multi-Winner RCV Election					
Candidate	**Round 1**	**Round 2**	**Round 3**	**Round 4**	**Round 5**
Armando Perez Democrat	**27.2%** 2,500 votes	**25.0%** 2,300 votes	**25.0%** 2,300 votes	**25.0%** 2,300 votes	**25.0%** 2,300 votes
Cathy Chan Democrat	**19.0%** 1,750 votes	**20.1%** 1,850 votes	**21.2%** 1,950 votes	**34.8%** 3,200 votes	**25.0%** 2,300 votes
Hannah Murphy Republican	**14.1%** 1,300 votes	**14.3%** 1,320 votes	**20.7%** 1,900 votes	**22.3%** 2,050 votes	**27.2%** 2,500 votes
Charles Lorenzo Republican	**14.1%** 1,300 votes	**14.1%** 1,300 votes	**17.4%** 1,600 votes	**17.9%** 1,650 votes	**18.9%** 1,740 votes
Brad M. Jackson Democrat	**14.7%** 1,350 votes	**15.5%** 1,430 votes	**15.8%** 1,450 votes	**0.0%** 0 votes	**0.0%** 0 votes
June Smith Republican	**10.9%** 1,000 votes	**10.9%** 1,000 votes	**0.0%** 0 votes	**0.0%** 0 votes	**0.0%** 0 votes

Proportional Ranked Choice Voting Example - FairVote

In paper: we study the class of "Thiele" rules, that parameterize decreasing marginal returns for a voter getting multiple candidates that they approve of as part of the winning set.

Intuition: why STV & multi-member districts?

Theorem (Informal)*: Under a two-party system where within-party candidates are ranked above other-party candidates, STV is *proportional* up to rounding

$$N = 2: \begin{cases} 0 - 33\% \rightarrow 0 \text{ seats} \\ 33 - 66.6\% \rightarrow 1 \text{ seat} \\ > 66.6\% \rightarrow 2 \text{ seats} \end{cases}$$

Computational benefit: Don't have to construct individual rankings, which would be $\Theta(|\text{Voters}||\text{Candidates}|)$

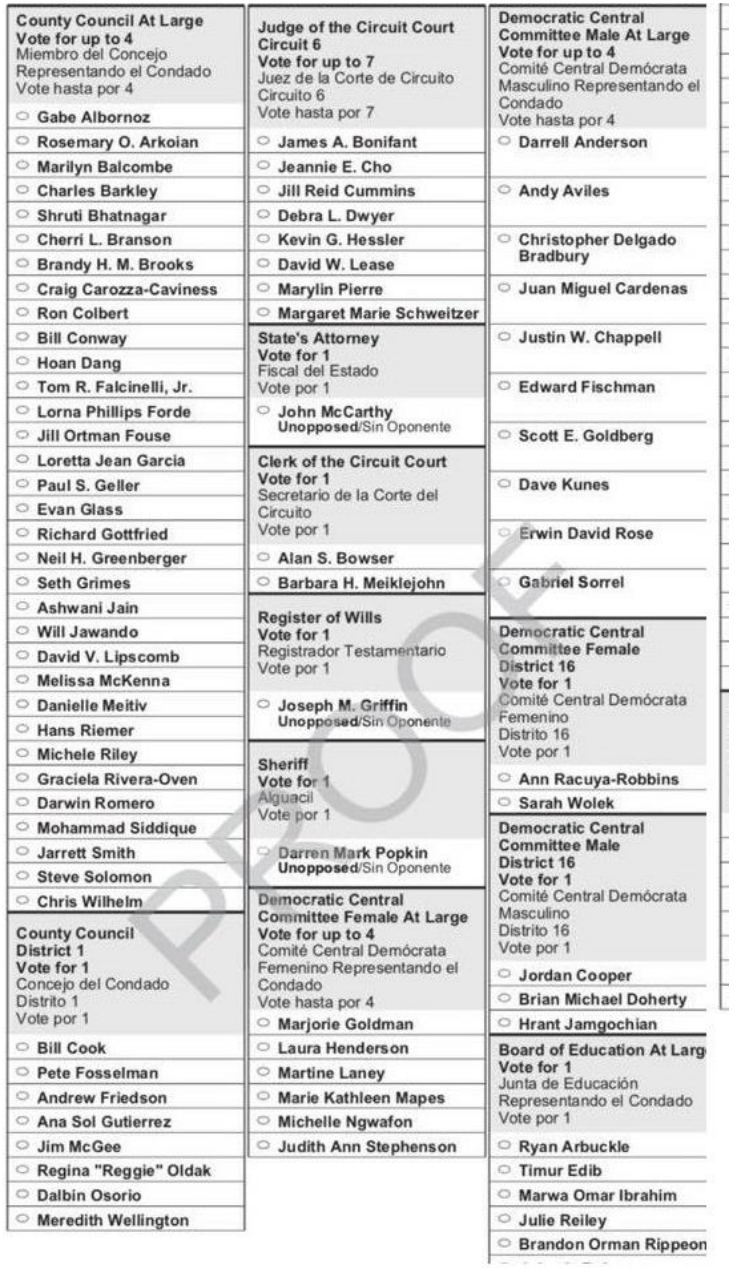
*Dummett 1985, *Voting Procedures.*

Problem solved?

Why not just elect all members in single district with STV?

- California has 53 seats – can't ask voters to rank that many candidates
- "Local representation" – want winners to represent a cohesive set of people

Medium solution: have multiple districts, each with a few members each



County Council At Large
Vote for up to 4
Miembro del Concejo Representando el Condado
Vote hasta por 4

- Gabe Albornoz
- Rosemary O. Arkoian
- Marilyn Balcombe
- Charles Barkley
- Shruti Bhatnagar
- Cherri L. Branson
- Brandy H. M. Brooks
- Craig Carozza-Caviness
- Ron Colbert
- Bill Conway
- Hoan Dang
- Tom R. Falcinelli, Jr.
- Lorna Phillips Forde
- Jill Ortman Fouse
- Loretta Jean Garcia
- Paul S. Geller
- Evan Glass
- Richard Gottfried
- Neil H. Greenberger
- Seth Grimes
- Ashwani Jain
- Will Jawando
- David V. Lipscomb
- Melissa McKenna
- Danielle Meitiv
- Hans Riemer
- Michele Riley
- Graciela Rivera-Oven
- Darwin Romero
- Mohammad Siddique
- Jarrett Smith
- Steve Solomon
- Chris Wilhelm

County Council District 1
Vote for 1
Concejo del Condado Distrito 1
Vote por 1

- Bill Cook
- Pete Fosselman
- Andrew Friedson
- Ana Sol Gutierrez
- Jim McGee
- Regina "Reggie" Oldak
- Dalbin Osorio
- Meredith Wellington

Judge of the Circuit Court Circuit 6
Vote for up to 7
Juez de la Corte de Circuito Circuito 6
Vote hasta por 7

- James A. Bonifant
- Jeannie E. Cho
- Jill Reid Cummins
- Debra L. Dwyer
- Kevin G. Hessler
- David W. Lease
- Marylin Pierre
- Margaret Marie Schweitzer

State's Attorney
Vote for 1
Fiscal del Estado
Vote por 1

- John McCarthy **Unopposed**/Sin Oponente

Clerk of the Circuit Court
Vote for 1
Secretario de la Corte del Circuito
Vote por 1

- Alan S. Bowser
- Barbara H. Meiklejohn

Register of Wills
Vote for 1
Registrador Testamentario
Vote por 1

- Joseph M. Griffin **Unopposed**/Sin Oponente

Sheriff
Vote for 1
Alguacil
Vote por 1

- Darren Mark Popkin **Unopposed**/Sin Oponente

Democratic Central Committee Female At Large
Vote for up to 4
Comité Central Demócrata Femenino Representando el Condado
Vote hasta por 4

- Marjorie Goldman
- Laura Henderson
- Martine Laney
- Marie Kathleen Mapes
- Michelle Ngwafon
- Judith Ann Stephenson

Democratic Central Committee Male At Large
Vote for up to 4
Comité Central Demócrata Masculino Representando el Condado
Vote hasta por 4

- Darrell Anderson
- Andy Aviles
- Christopher Delgado Bradbury
- Juan Miguel Cardenas
- Justin W. Chappell
- Edward Fischman
- Scott E. Goldberg
- Dave Kunes
- Erwin David Rose
- Gabriel Sorrel

Democratic Central Committee Female District 16
Vote for 1
Comité Central Demócrata Femenino Distrito 16
Vote por 1

- Ann Racuya-Robbins
- Sarah Wolek

Democratic Central Committee Male District 16
Vote for 1
Comité Central Demócrata Masculino Distrito 16
Vote por 1

- Jordan Cooper
- Brian Michael Doherty
- Hrant Jamgochian

Board of Education At Large
Vote for 1
Junta de Educación Representando el Condado
Vote por 1

- Ryan Arbuckle
- Timur Edib
- Marwa Omar Ibrahim
- Julie Reiley
- Brandon Orman Rippeon

Research questions

How do multiple multi-member districts (MMDs) affect the distribution of possible outcomes, under either adversarial gerrymanders or neutral re-districting?

- What is the role of the social choice function used?
- How big is “big enough”? Do we need 8-member districts?
- How do MMDs affect intra-party measures, such as geographic and political diversity of winners?

Contributions

Methodologically, we provide a scalable methodology to algorithmically study partisan gerrymandering and fair redistricting under MMDs, and in particular under STV

Applications-wise, we show that 2- or 3-member districts with STV are enough to both *inhibit partisan gerrymanders* and *eliminate natural gerrymanders,* without sacrificing “representative” democracy

No discrepancy between “natural” and proportional maps!

Summary of related literature

Gerrymandering

- Technical work in optimization and sampling
- Methods to evaluate and audit maps
- Everything Moon Duchin has written

Social choice

- Properties of multi-winner election rules
- Empirical effects of implementing RCV + other reforms

Multi-member districts

- Long history of MMDs in the United States (Klain 1955)
- At large elections + MMDs with Winner Takes All rules harm minorities
- Recent Duchin work: RCV with MMDs for city councils (evaluate non-partisan effects)

Comparative politics

- Many other methods to achieve proportionality (especially within parliamentary systems)

Methods

Technical challenge

Goal: calculate political outcomes under counterfactual maps.

Need to generate maps that are *optimized* for political outcomes

- Intentionally gerrymandered for one party or the other
- Intentionally made as proportional as possible
- “Neutral” maps that are unaware of underlying political geography

Challenge: Hard combinatorial optimization problem!

Data

Historical *vote shares* for each party for each census tract

- Averaged across Senate, Congressional, and Presidential elections
- Use both average vote share and standard deviation
- This is all we need for the inter-party measures

Individual voter data – from a national voter file

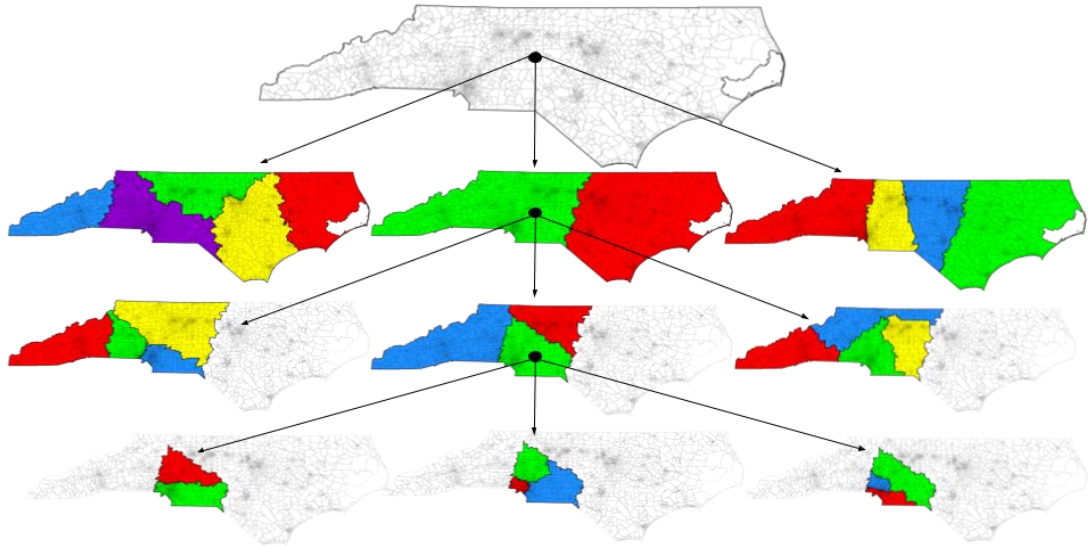
- List of individual voters by census block
- Estimated opinions on a variety of dimensions
  - Party preference, *strength* of partisan preference
  - Ideology scores on 20+ dimensions (economy, criminal justice, environment, taxes, etc)
- Necessary for intra-party measures

Fairmandering: tree-based optimization

Step 1: Hierarchically generate districts in a tree structure

Step 2: Calculate outcomes for districts in the leaf nodes

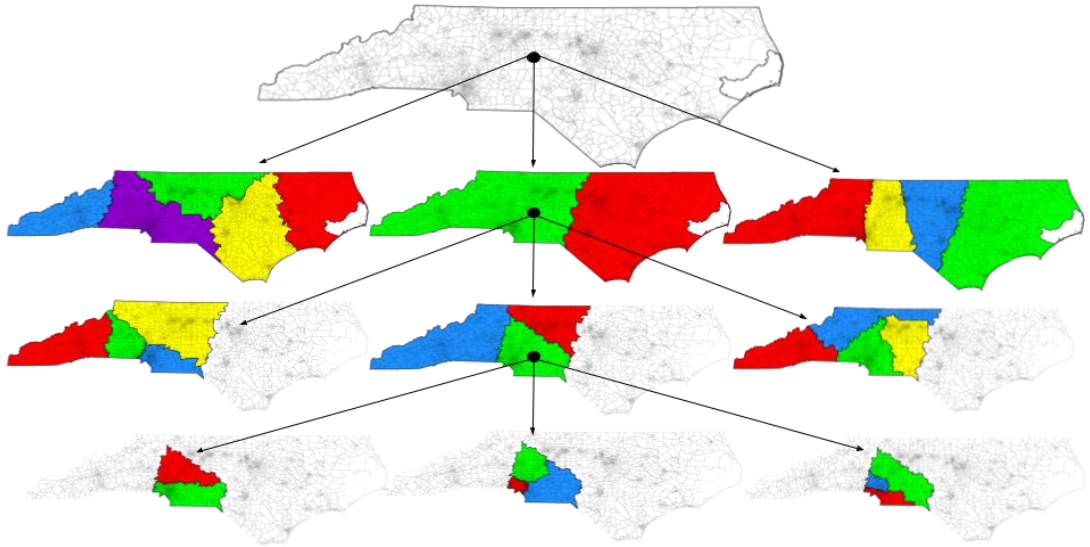
Step 3: Use a dynamic program (or an IP) to aggregate into maps



Wes Gurnee and David Shmoys. "*Fairmandering: A Column Generation Heuristic for Fairness-Optimized Political Redistricting*"

Tree-based optimization for MMDs

- This work: extend the method such that intermediate and leaf nodes can be different sizes
  - Recombination methods would require separate optimization for each combination of district sizes
- Step 2: Calculate outcomes for districts: needs to be efficient!
  - Cannot run STV as a sub-routine to the optimization



"(2) that states entitled to six or more Representatives establish districts such that three to five Representatives are elected from each district" – Fair Representation Act

Method overview

For each parameter set, generate many possible maps

Most gerrymandered maps

Most “fair” (proportional) maps

“Neutral” maps – those drawn without knowledge of partisan distribution

For each map, calculate outcomes of interest

- Proportionality, competitiveness, compactness (just need party vote share)
- Intra-party measures, such as geographic or opinion diversity

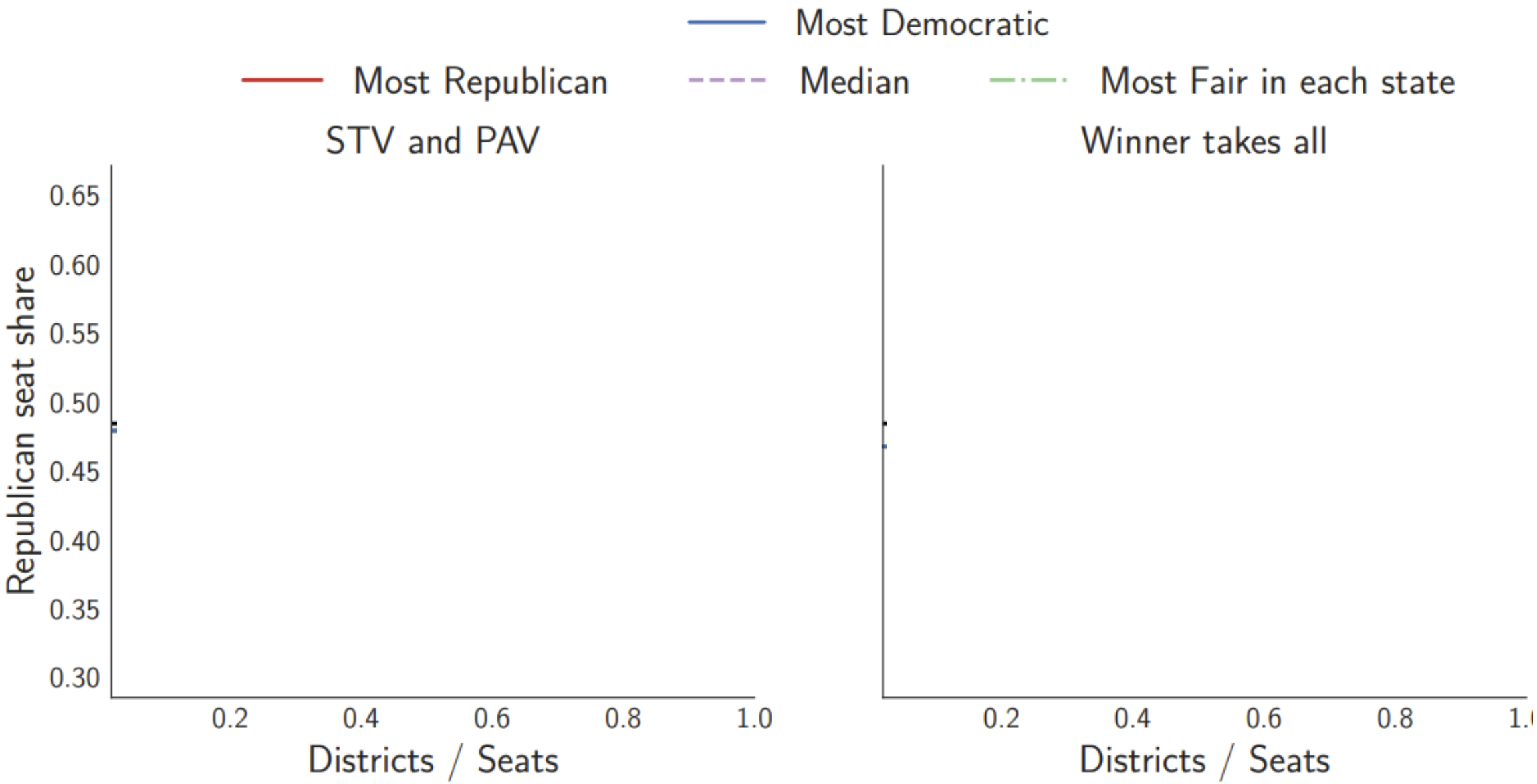
  Need to construct counterfactual voter rankings & simulate STV

Entire process used about ~100s CPU-weeks

Results

Proportionality and other inter-party measures

Inhibiting partisan gerrymandering



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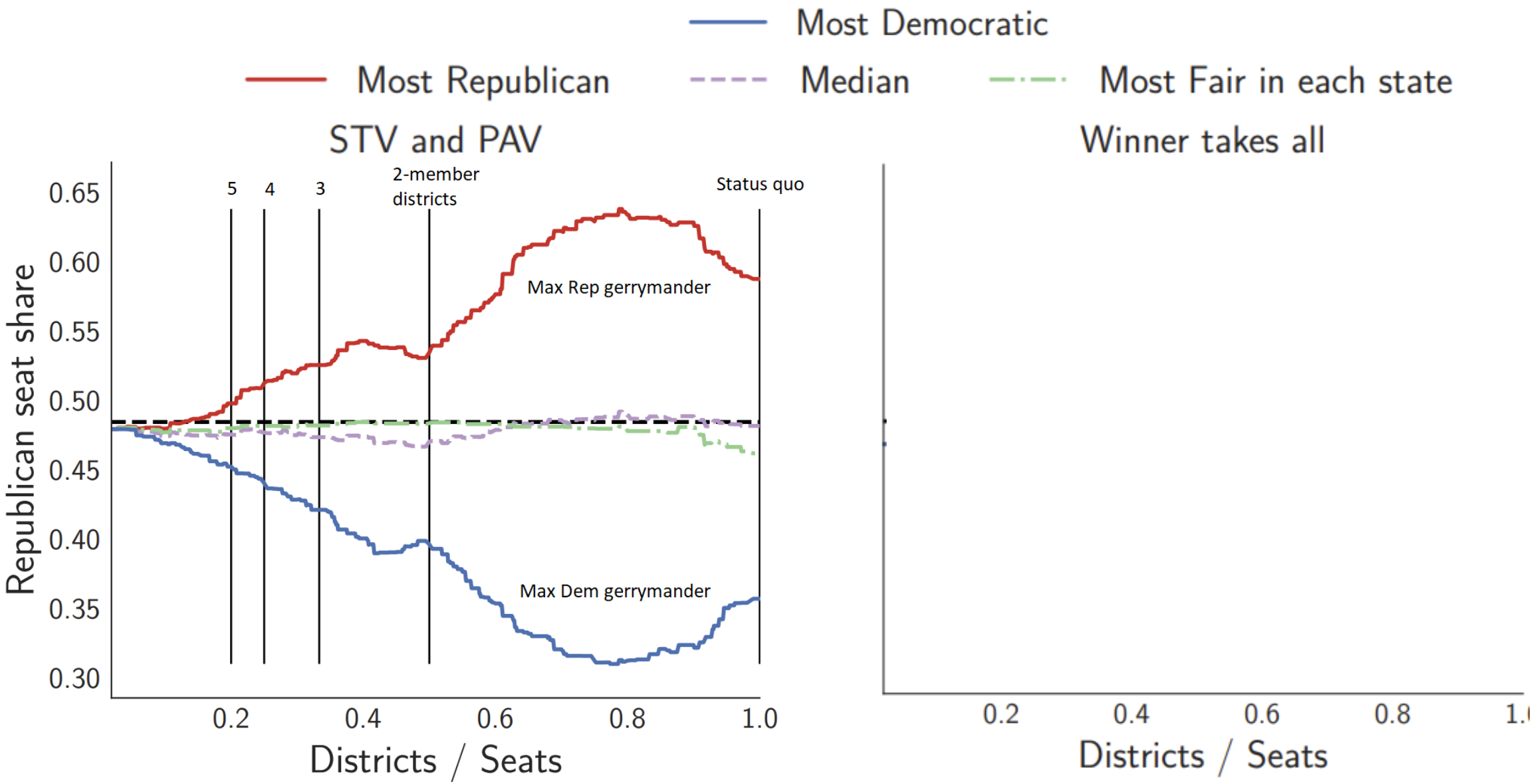

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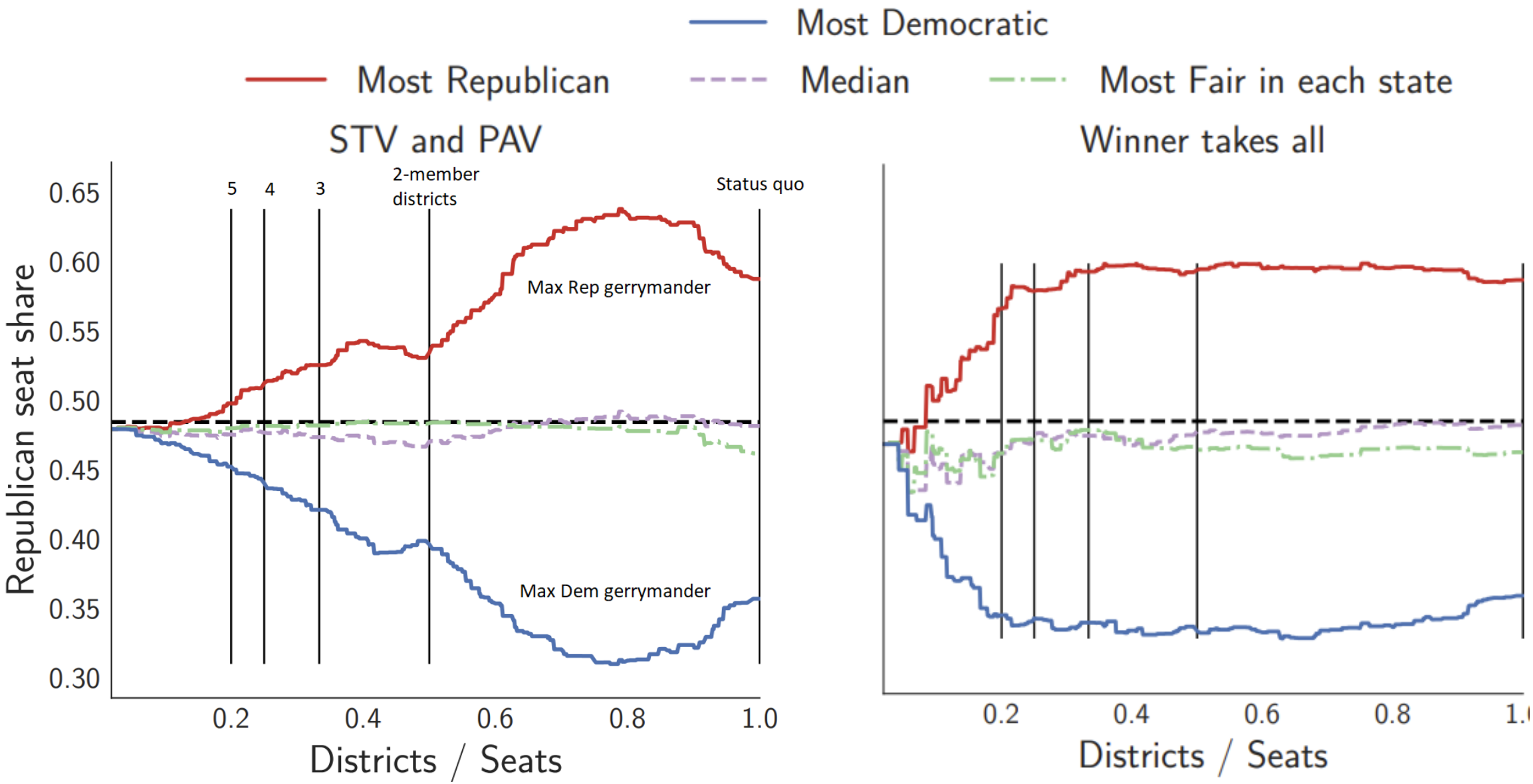
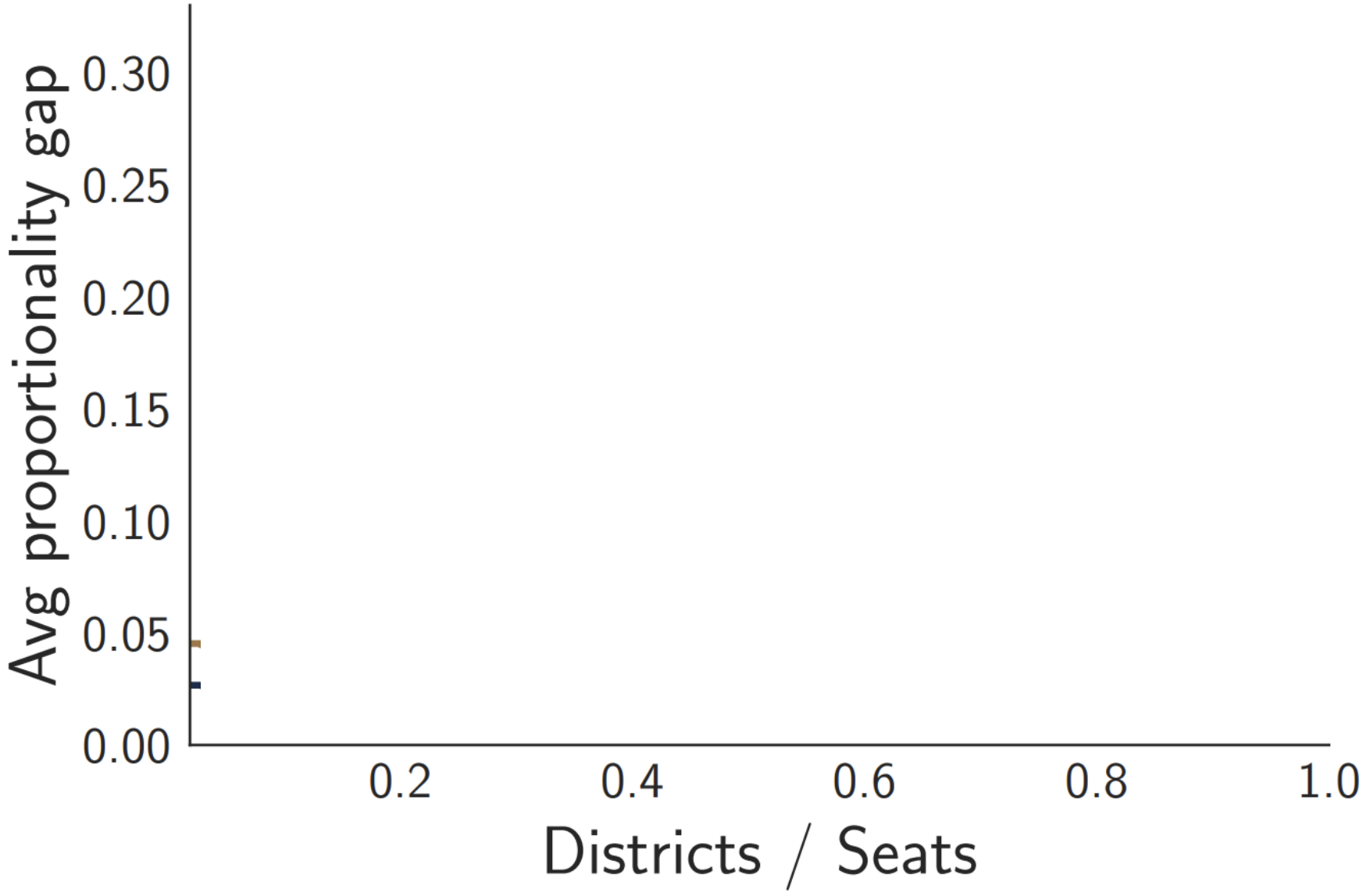


Eliminating “natural” gerrymanders



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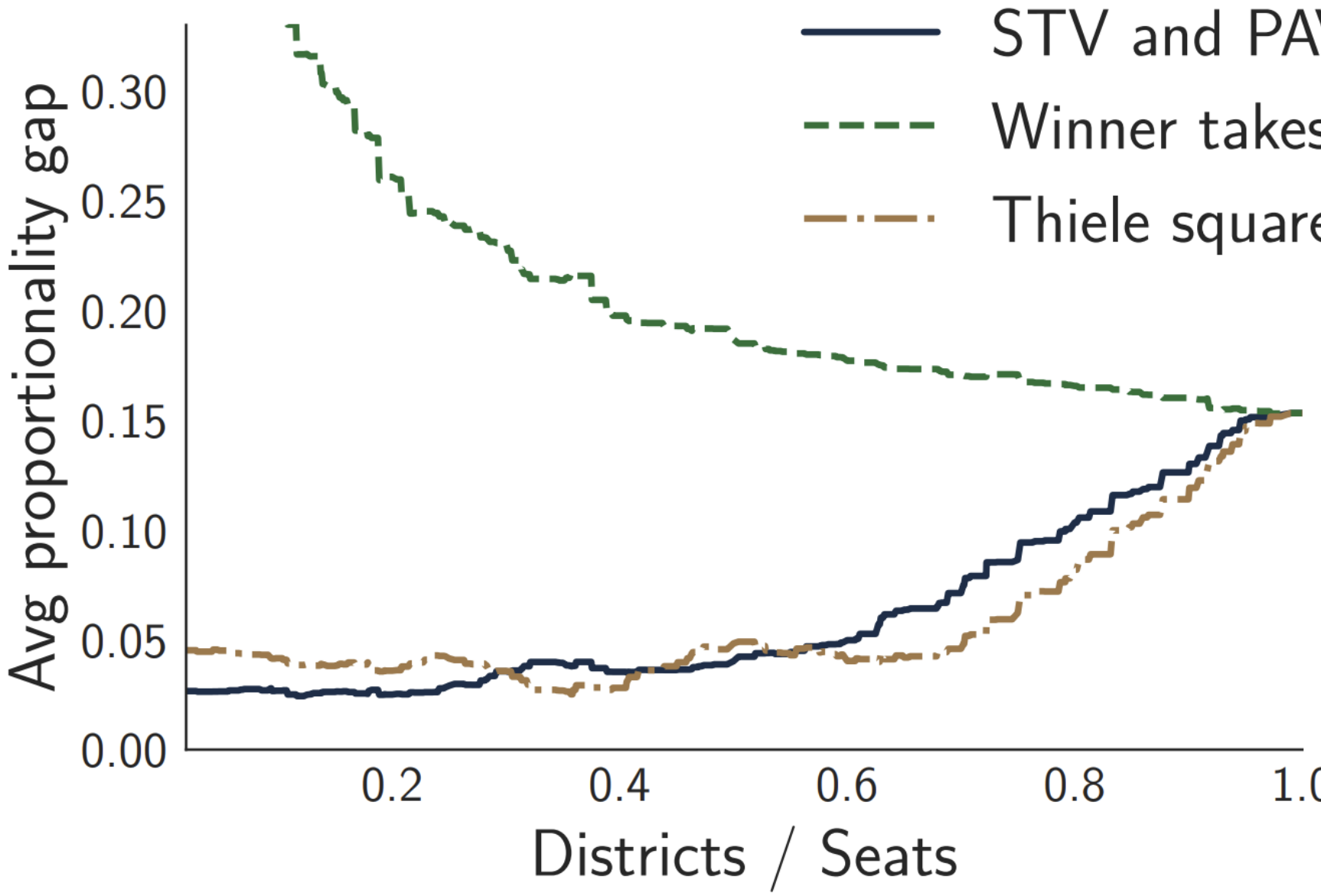
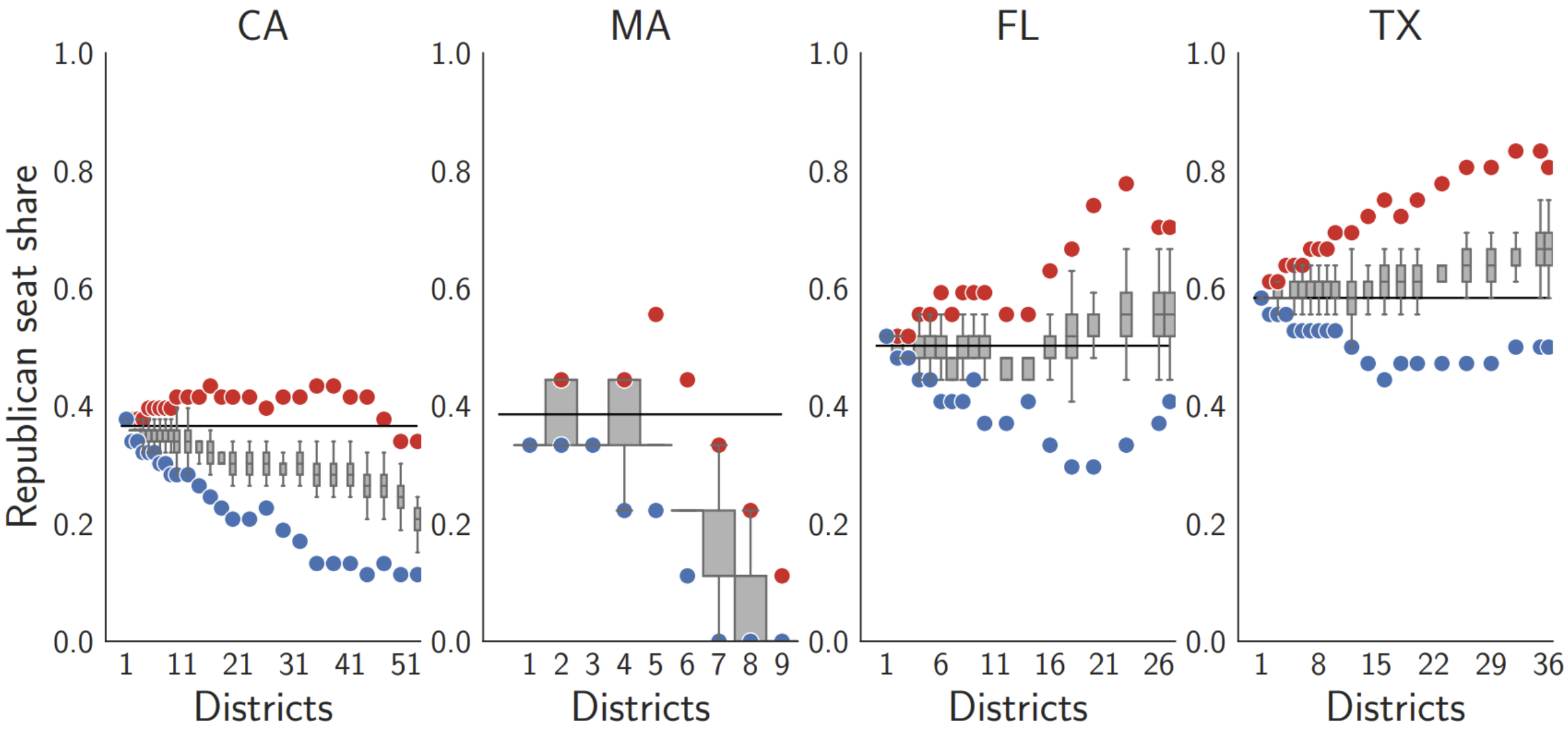


Even 2 member districts solve the “Massachusetts problem”!

Eliminating “natural” gerrymanders



Other inter-party results + recommendations

- Fair Representation Act analysis
- Competitiveness: Multi-member districts and STV increase competitiveness, monotonically in district size
- Analysis of various Thiele rules

Design recommendations:

- Three member districts effective in most states in mitigating gerrymandering
- Larger districts needed in smaller and more partisan states

Methods & results: Intra-party effects

Research questions + challenge

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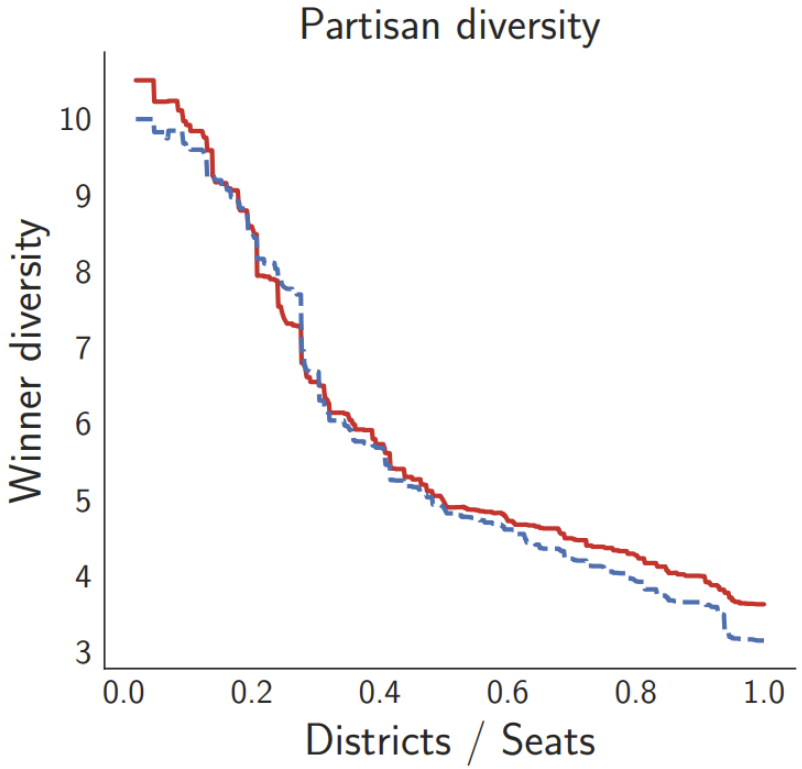
- Do STV and MMDs enable minority ideologies within parties?
- Do they ruin geographic “representation”?
- Challenge: constructing voter rankings
  - For above results, we don’t need to construct voter rankings or simulate STV: only need party vote shares (Theorem)
  - Now, we need assumptions for how voters rank candidates within a party
  - Simulate STV after constructing rankings
- Our assumptions: voters either rank

  Based on *partisan score* (single dimensional strength of Dem-Rep)

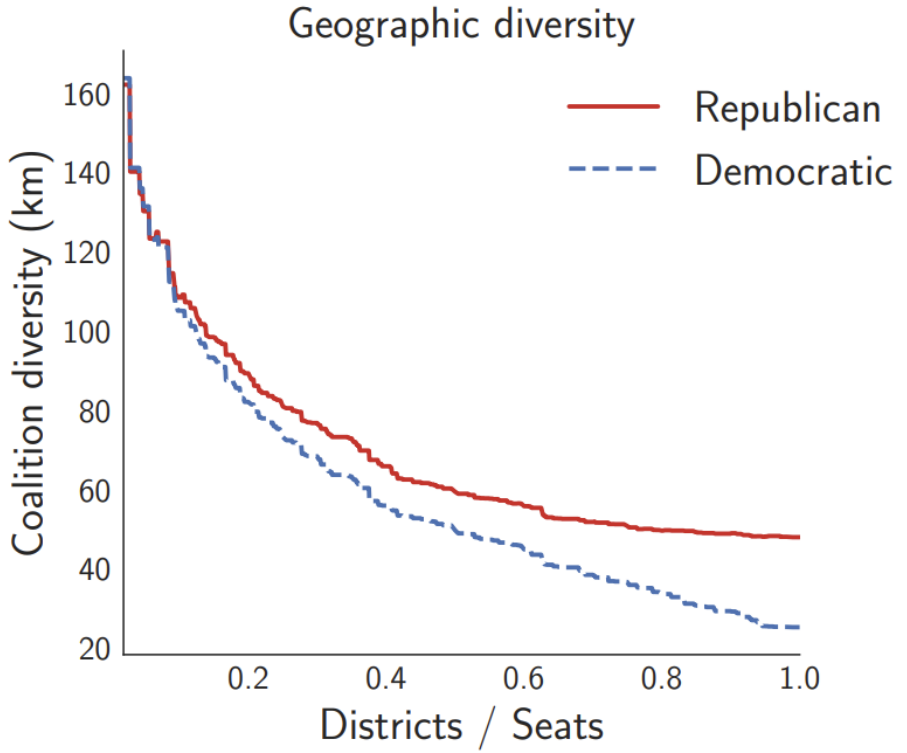
  Or based on *geographic distance*

Suppose voters rank by partisan scores…

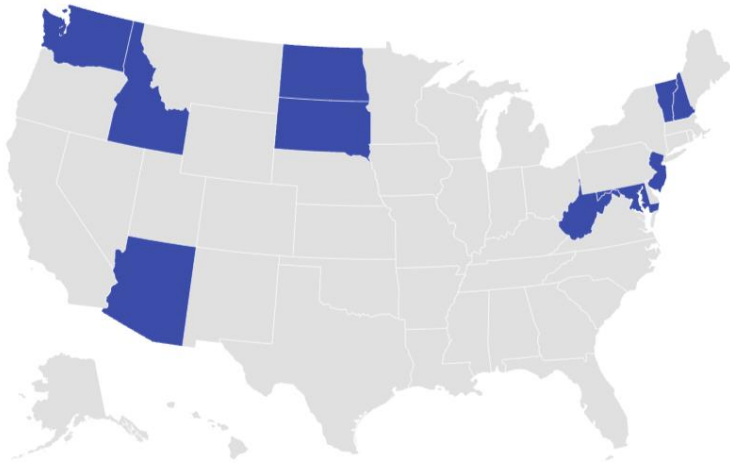
Minority ideologies supported: diversity of winners increases



Some cost to geographic cohesion: winners draw support from different areas



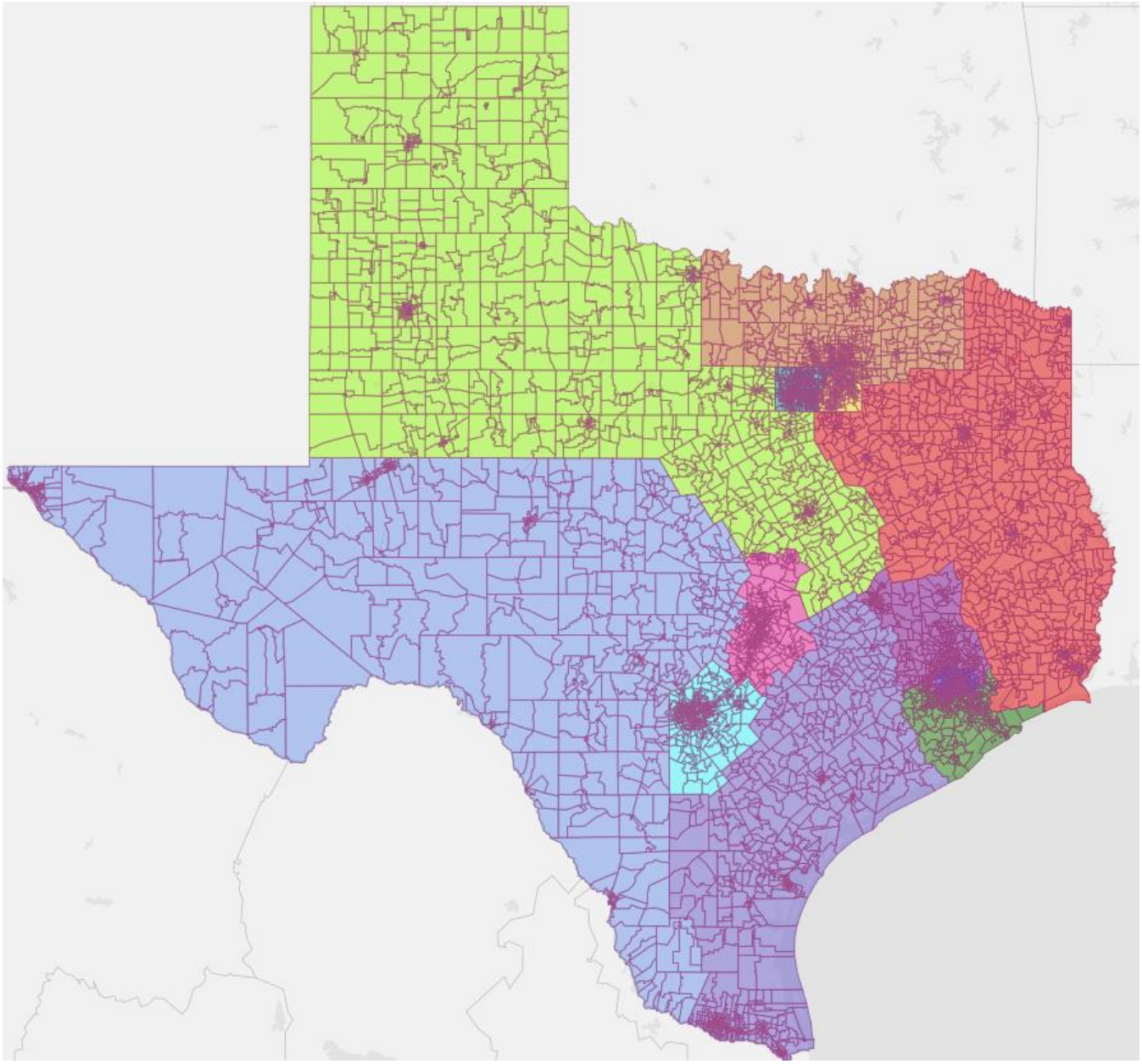
Parting thoughts



- Not (just) a pipedream! 10 states have MMDs
- Rich research agenda in gerrymandering + social choice
  - Can we prove proportionality guarantees for multiple MMDs?
  - What are the effects at the city level, with non-partisan elections, single party dominance, or many third parties?
  - Emergence of third-party winners?

Computational scientists have much to contribute to understanding and solving pressing challenges in politics and governing

Questions?



Texas with 12 three-member districts