# Using Algorithms to Detect Gerrymandering and Improve Legislative Redistricting:
## Cases from the United States and Japan

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# Motivation

- Today's world for quantitative social science:
  1. increasing availability of granular data
  2. rapid methodological advancement
- Social scientists can and should solve problems of the real world!

- Redistricting as a major policy decision
- How can we use data and algorithms to evaluate redistricting plans?
  - traditional methods: comparison across states and time periods
  - confounded by state-specific political geography and rules

- Use of simulation algorithms
  1. obtain a representative sample of redistricting plans under constraints
  2. compare the enacted plan with this baseline distribution
- Technological solution to detecting gerrymandering
- Tool for analyzing redistricting

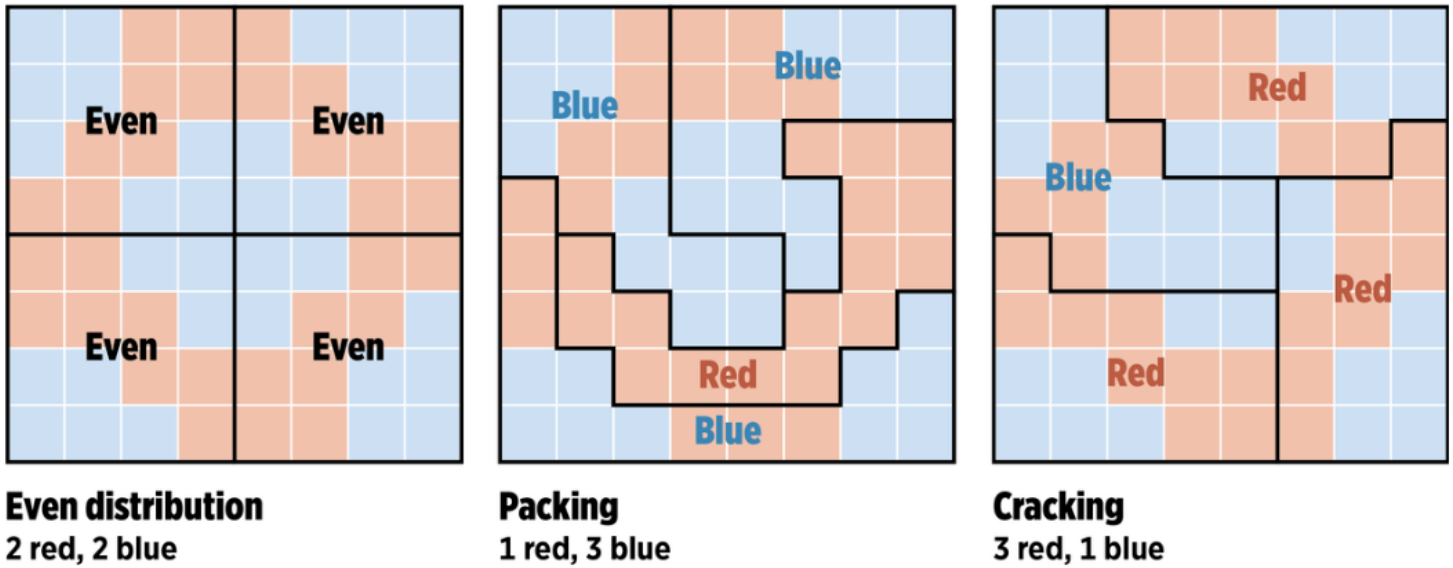
# ALgorithm-Assisted Redistricting Methodology (ALARM)


- What we do:
  1. develop efficient and flexible simulation algorithms
  2. build open-source software packages for the entire workflow
  3. evaluate redistricting plans in the United States and elsewhere

- Goal: empower researchers, policy makers, data journalists, and citizen data scientists with powerful tools

# Redistricting Basics

- Classic gerrymandering strategies: packing and cracking




- What has changed:
  - availability of granular data
  - mapping software (e.g., Maptitude, Dave's Redistricting app)
- US Congressional redistricting
  - racial gerrymandering: *Allen v. Milligan*
  - partisan gerrymandering: *Rucho v. Common Cause*

# Why Use Simulation Algorithm for Redistricting Evaluation?

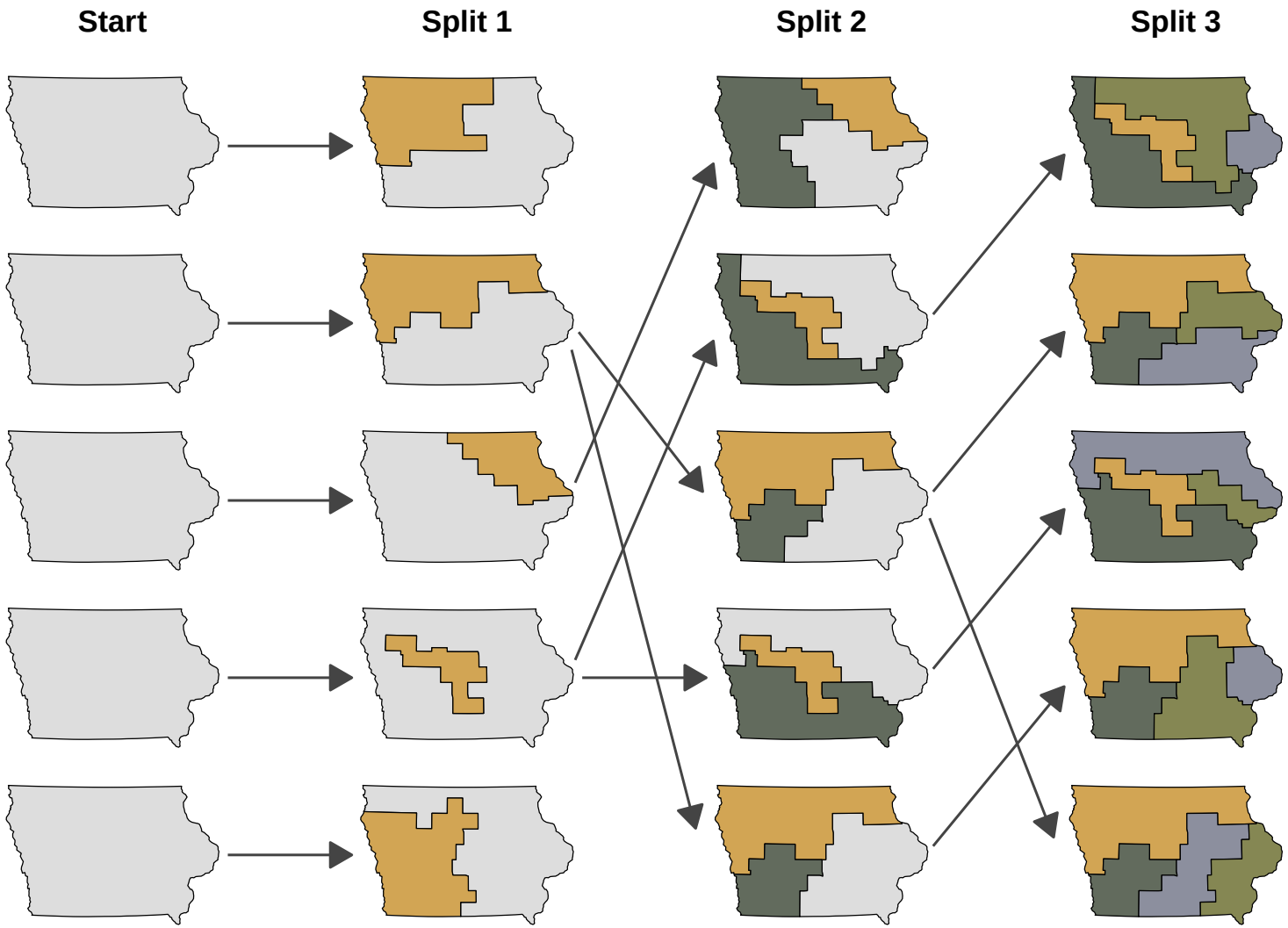
- Traditional redistricting evaluation
  1. compute various fairness metrics
  2. compare them across states and over time
- Confounded by differences in political geography and redistricting rules

- Simulation-based redistricting evaluation
  1. generate many alternative plans under a set of redistricting criteria
  2. compare them with a proposed plan to evaluate its properties

- Benefits of simulation approach
  1. can control for state-specific political geography and redistricting rules
  2. transparency and ability to isolate a relevant factor
  3. mathematical properties $\rightsquigarrow$ representative sample of alternative plans

# Sequential Monte Carlo (SMC) Algorithm (McCartan and Imai, 2020)

- Start with a blank state in parallel, sample a district at a time, resample with weights at each step



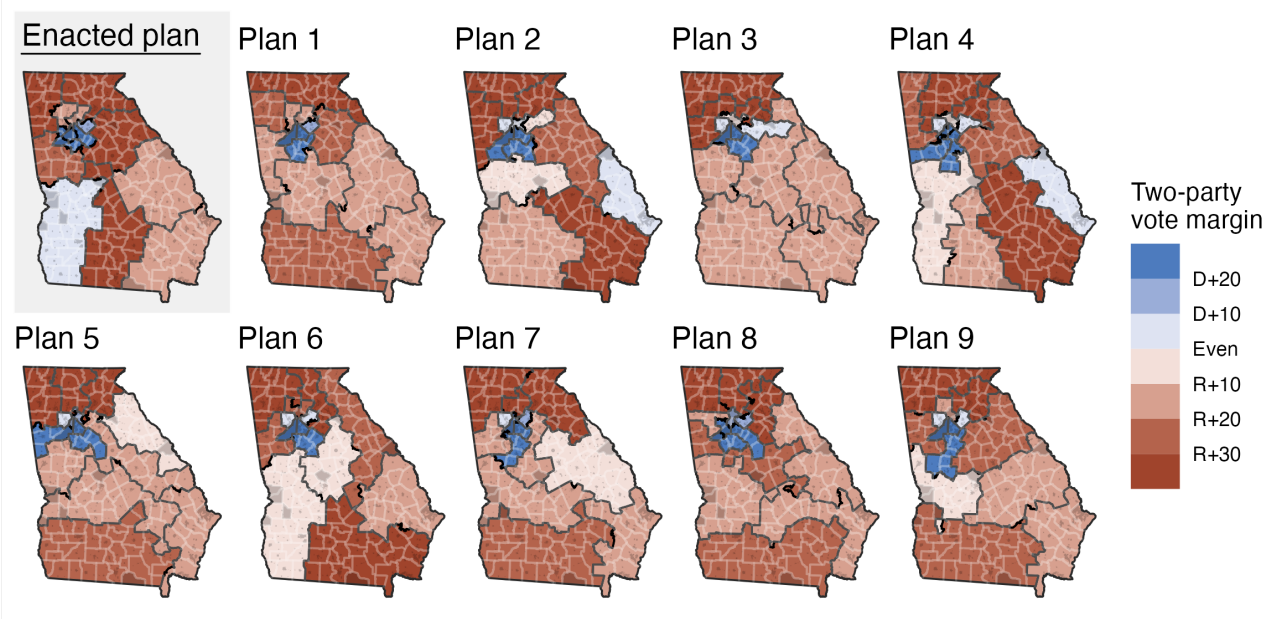
# 50 State Redistricting Simulations Project


Comprehensive project to simulate alternative congressional redistricting plans for all fifty states.

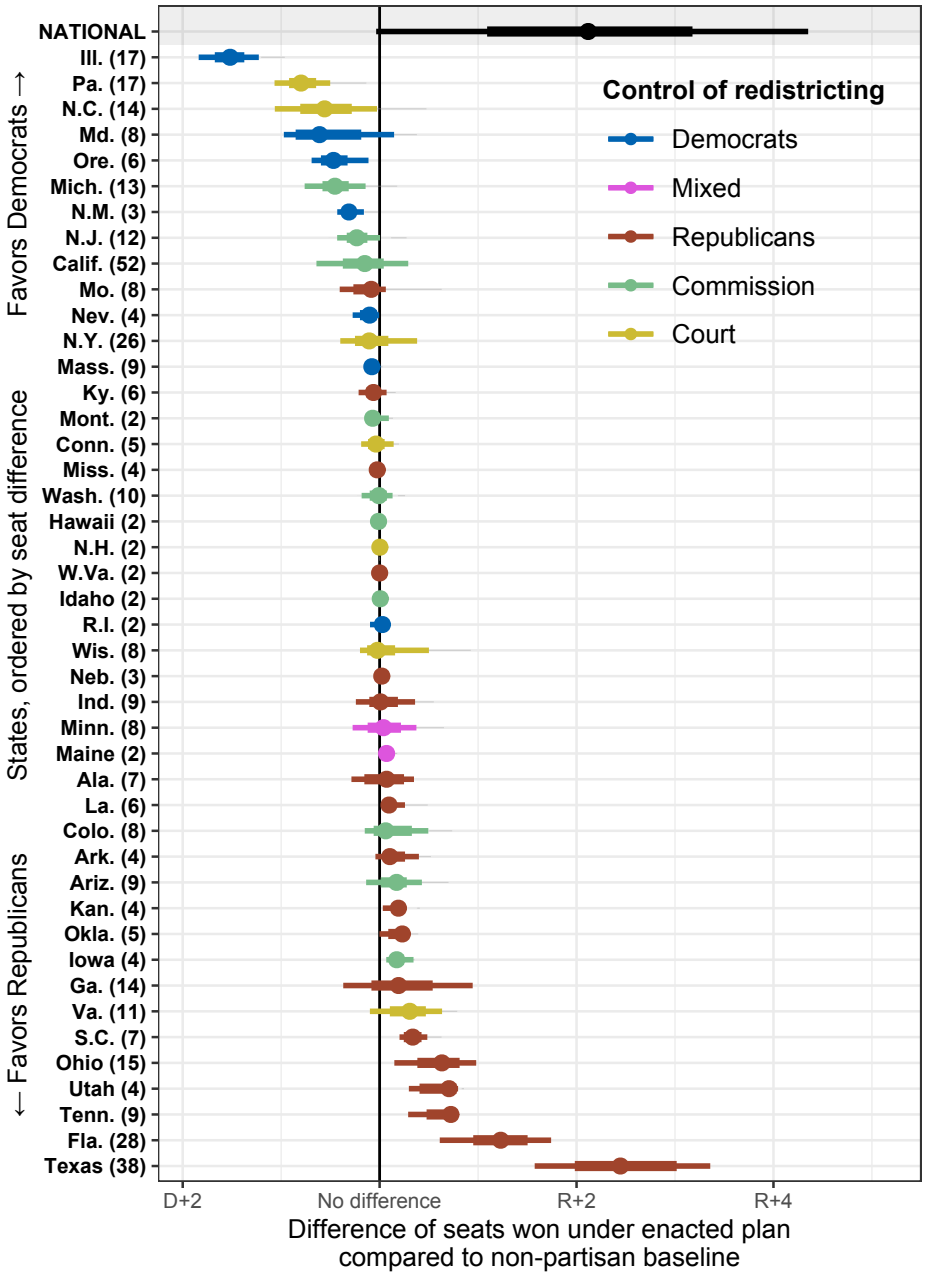
- tidied 2020 Census plus statewide election data from the VEST
- collect state-specific redistricting requirements
- construct algorithmic constraints based on these and traditional redistricting criteria
- 5,000 simulation plans based on SMC
- code and data are available at the Harvard Dataverse

# Georgia Example

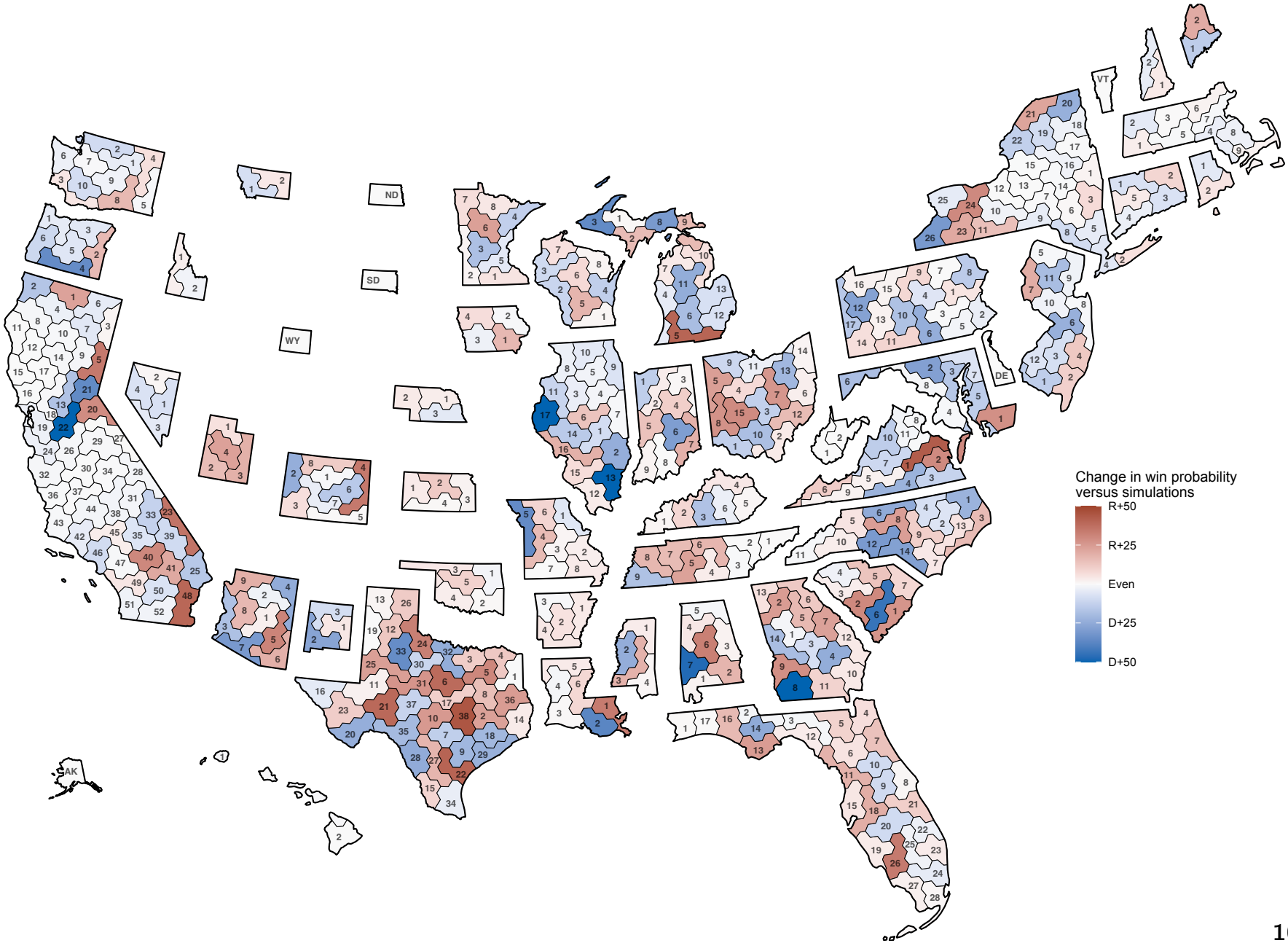
- 14 Congressional districts
- According to Georgia's House Legislative and Congressional Reapportionment Committee, districts must:
  1. be contiguous
  2. have equal populations
  3. be geographically compact
  4. preserve county and municipality boundaries as much as possible
  5. avoid the unnecessary pairing of incumbents
- We attempted to account for everything except incumbency constraint
- Voting rights act (VRA) compliance is tricky



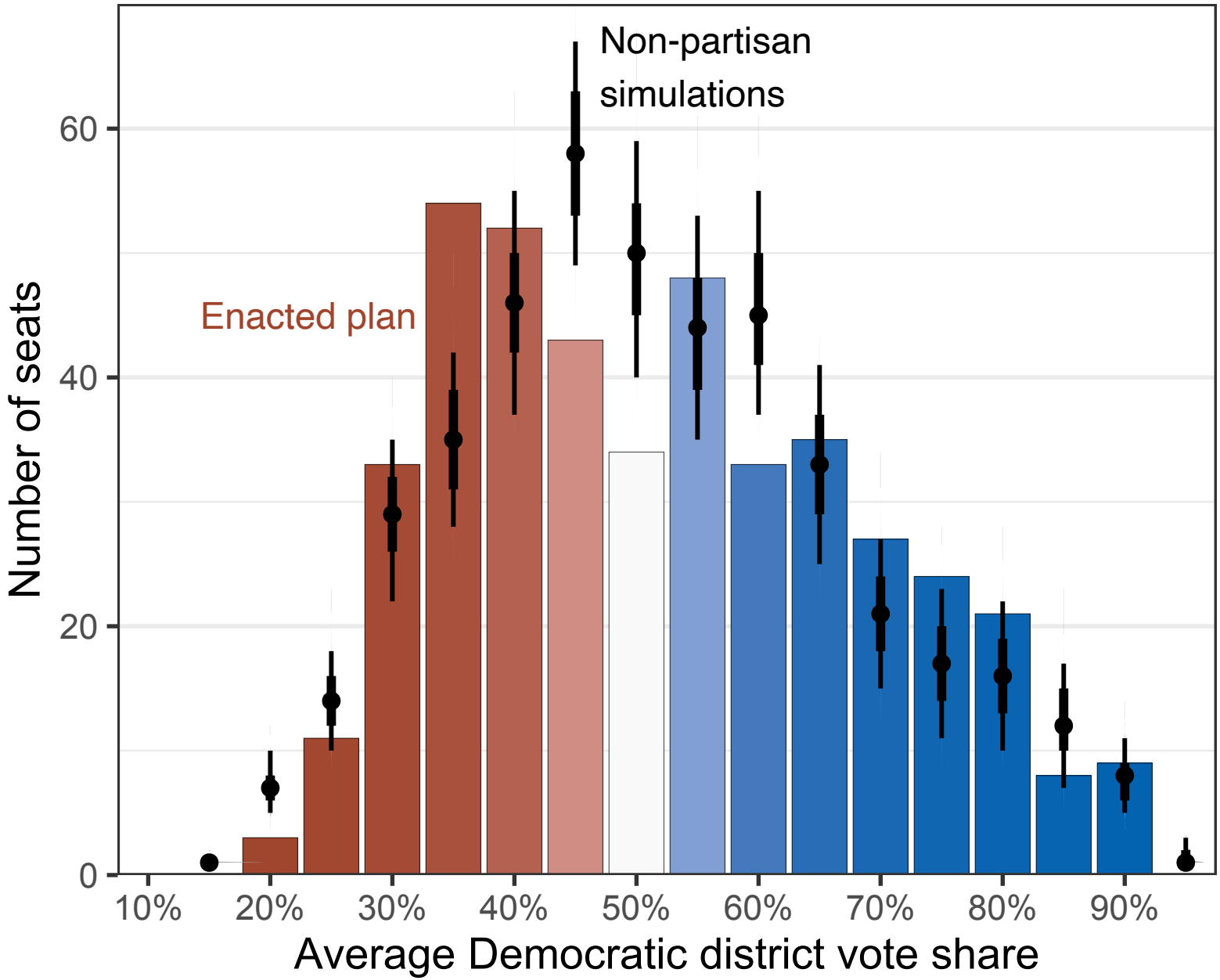
# Widespread Partisan Gerrymandering Cancels Nationally



# Map of Partisan Gerrymandering



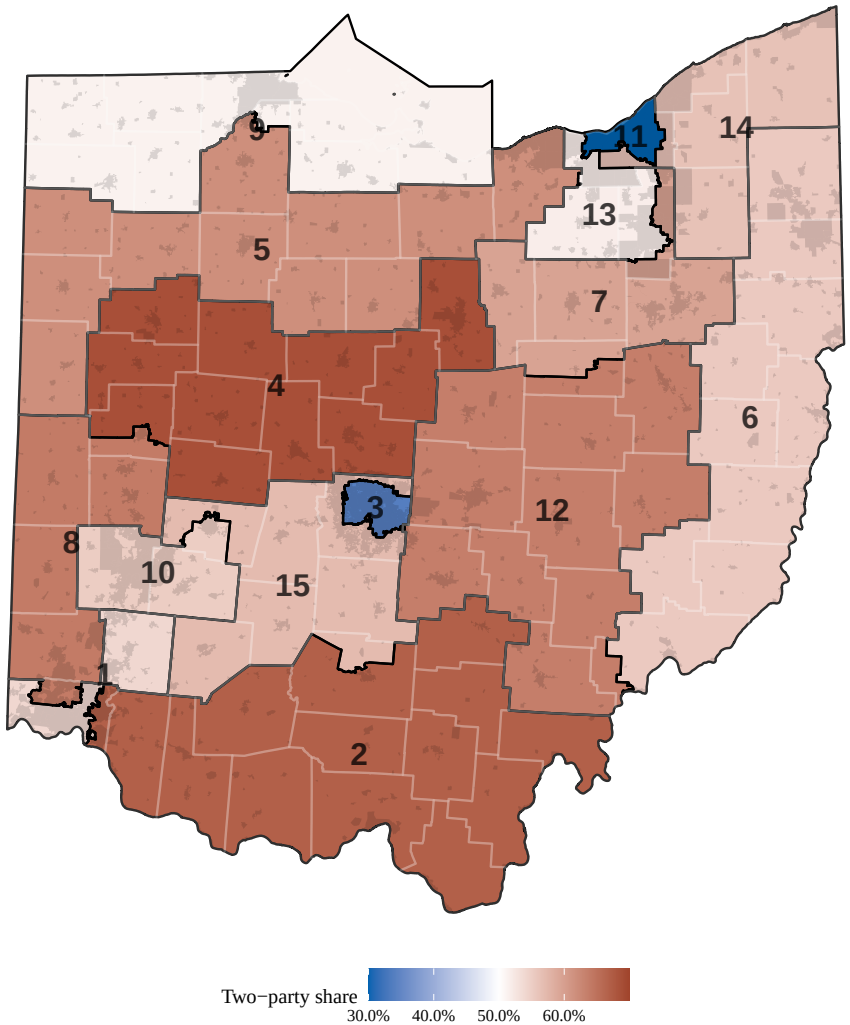
# Partisan Gerrymandering Reduces Competitiveness

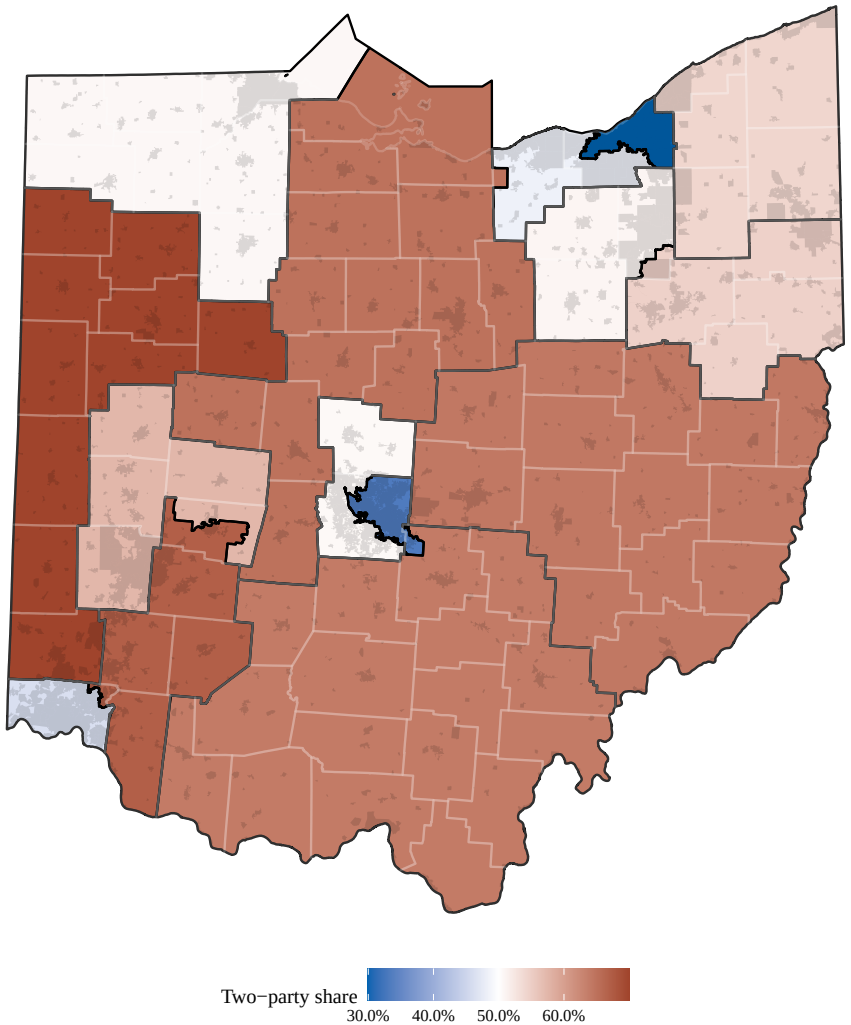


# Application in the Court: Ohio Congressional Redistricting

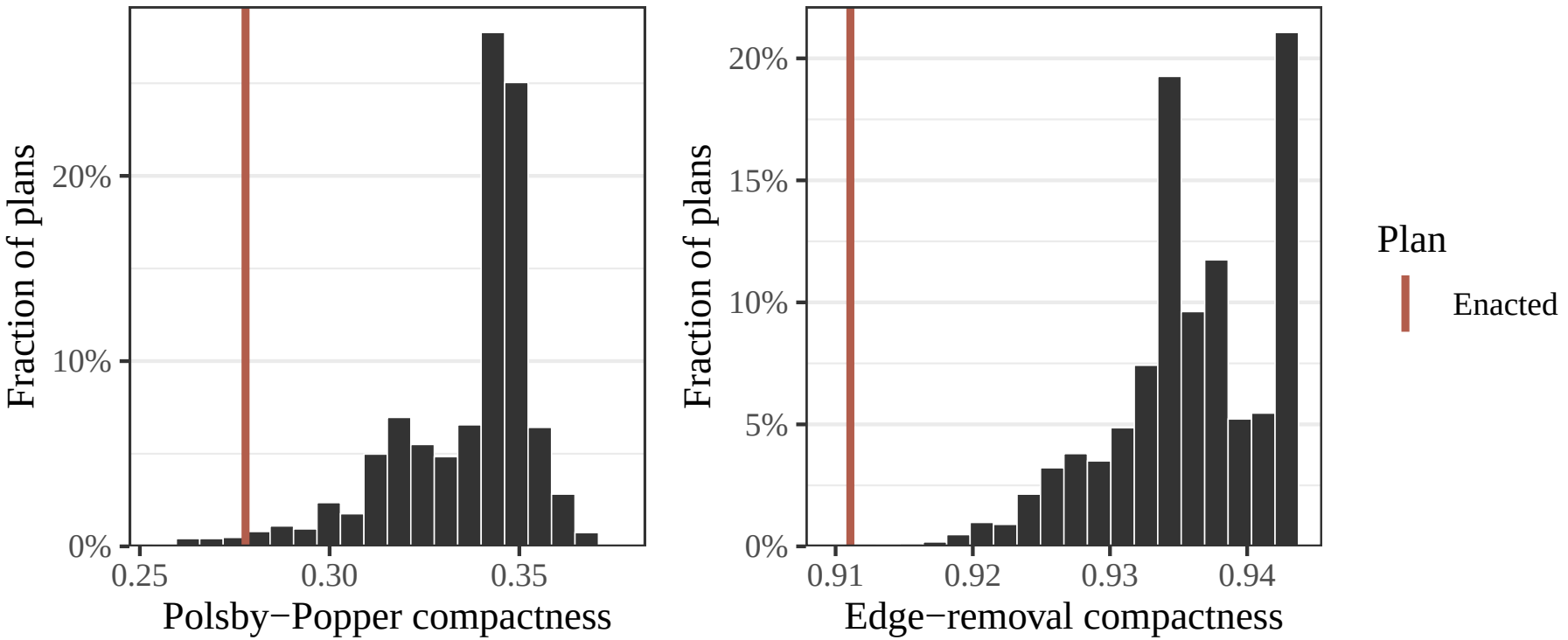
- Currently 16 districts: 4 Democrats and 12 Republicans
- After 2020 Census, the number of seats is reduced to 15 districts
- 2018 Ohio voters passed the constitutional amendment
- I served as an expert witness for Relators: *League of Women Voters of Ohio et al. v. Ohio Redistricting Commission, et al.*
- Simulation analysis
  - 5,000 alternative plans
  - contiguous and compact districts
  - compliant with the Voting Rights Act (Cleveland)
  - several complicated splitting constraints
  - Section 2(B)(5): out of Ohio's 88 counties,
    - at least 65 counties should not be split
    - no more than 18 counties can be split no more than once
    - no more than 5 counties can be split no more than twice

# The Enacted and Example Simulated Plans



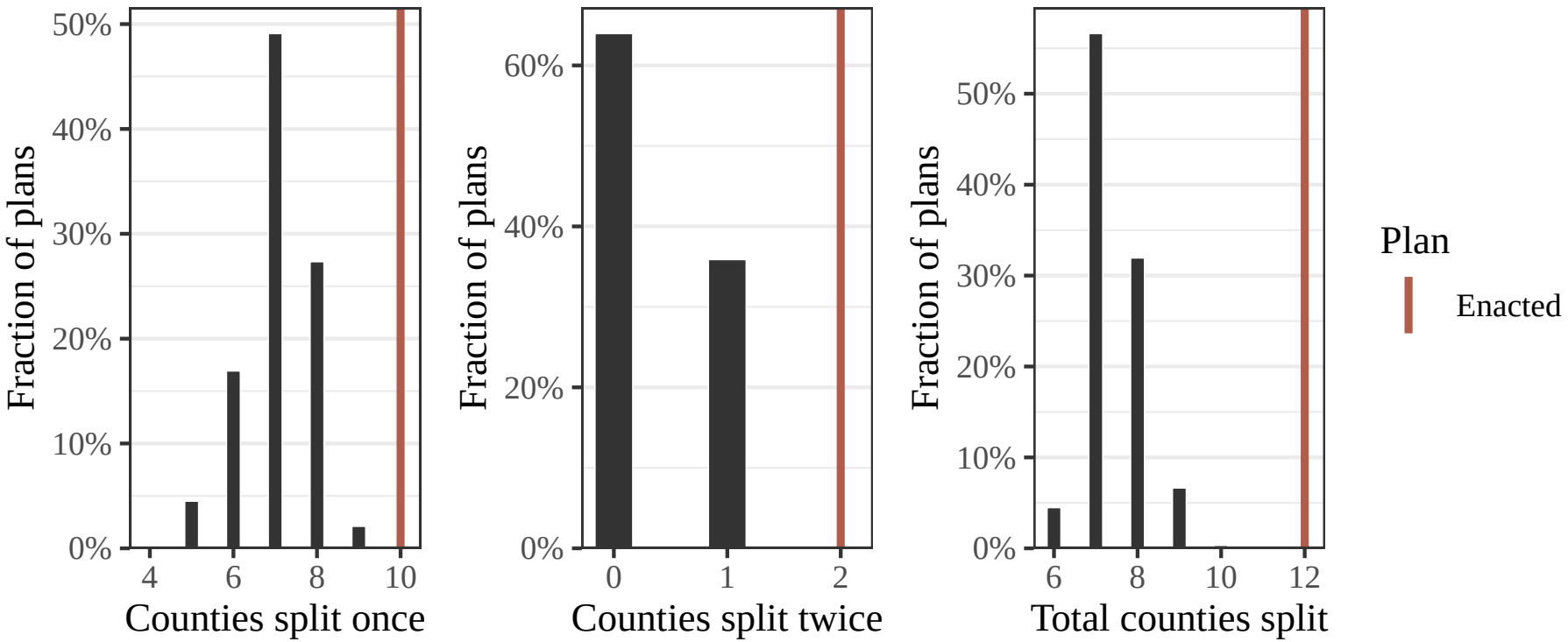



# Compactness

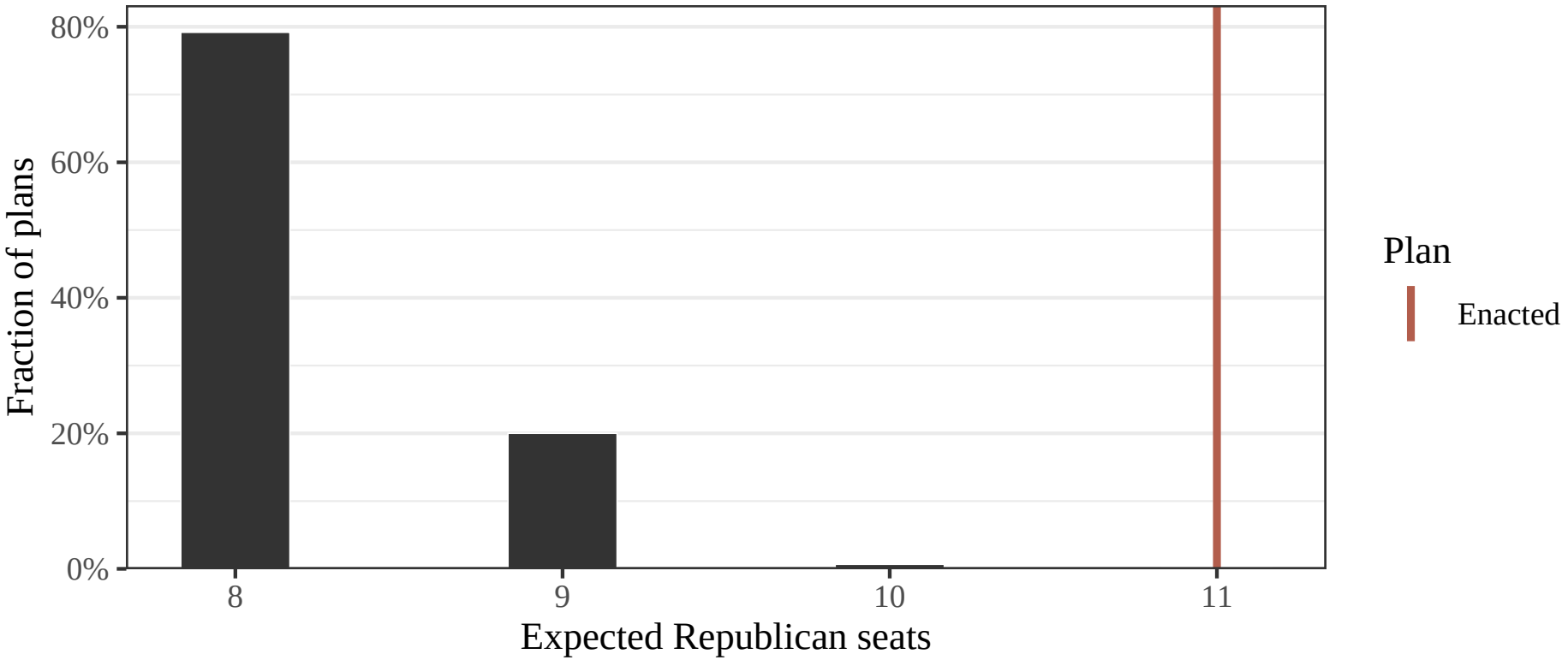



- Polsby-Popper: the ratio of the district area to the area of a circle with the same perimeter
- Edge-removal

# Administrative Boundary Splits

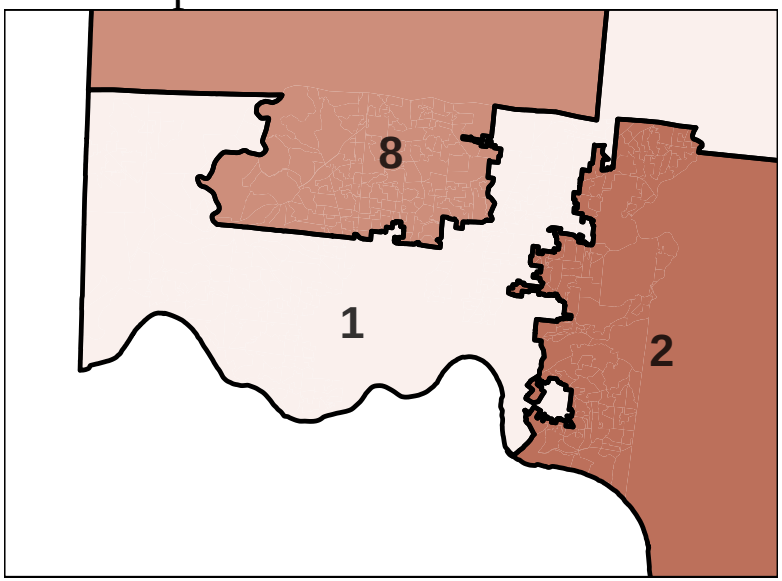


# Expected Number of Republican Seats

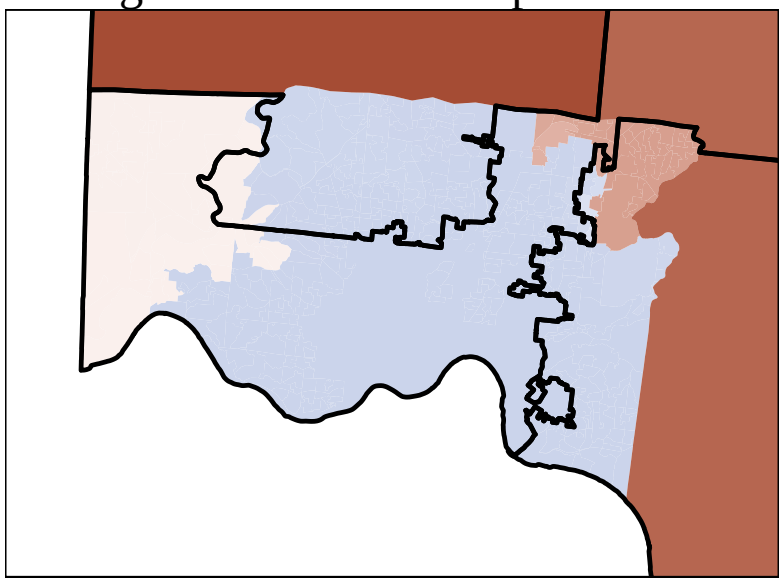


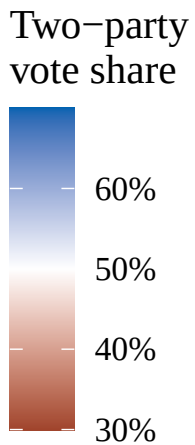
# Cracking: Hamilton County (Cincinnati Area)

Enacted plan

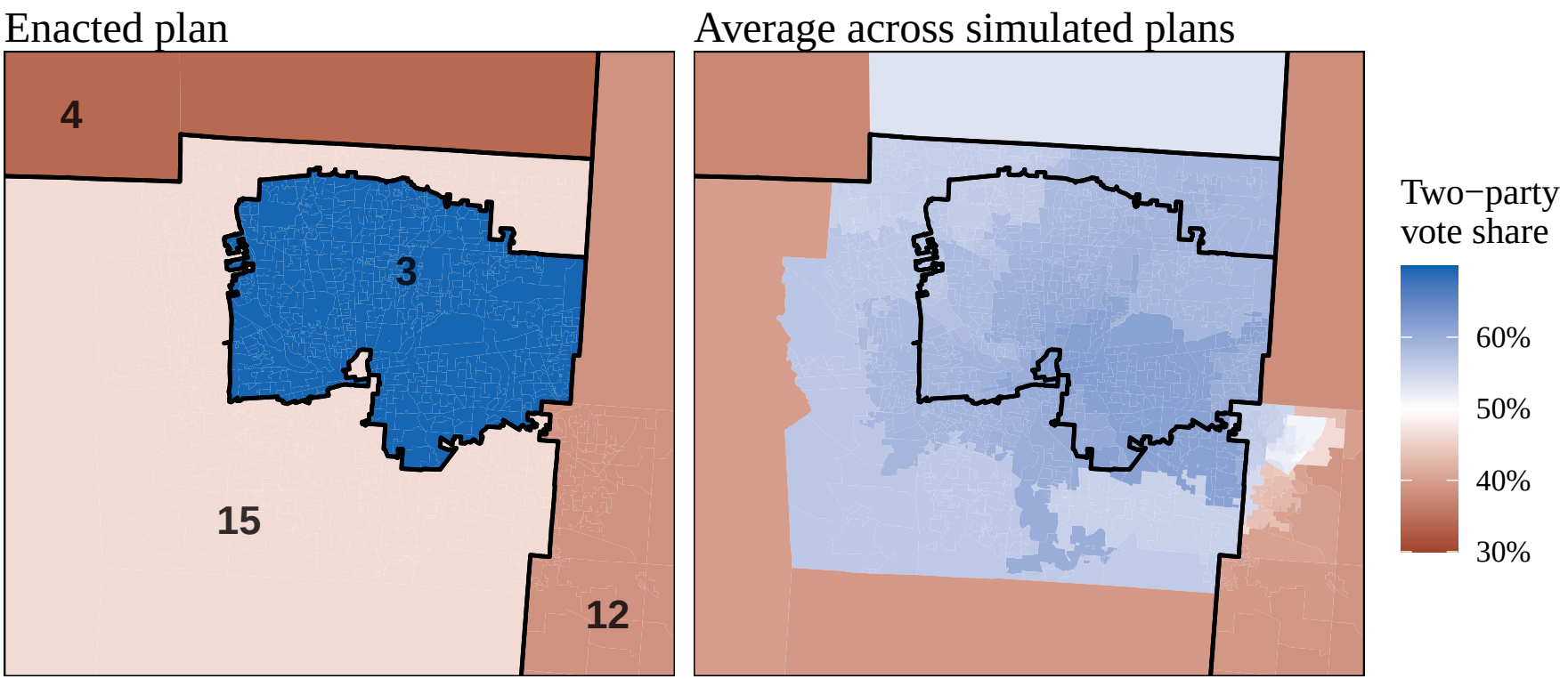



Average across simulated plans





# Packing: Franklin County (Columbus Area)



# Ohio Supreme Court Strikes Down the Enacted Map

# The Court Opinion

*Id.* at Section 1(C)(3)(a). The above evidence, particularly Dr. Imai's conclusion that the enacted plan will result in, on average, 2.8 more Republican seats than are warranted, shows that the General Assembly's decision to shift what could have been—under a neutral application of Article XIX—Democratic-leaning areas into competitive districts, i.e., districts that give the Republican Party's candidates a better chance of winning than they would otherwise have had in a more compactly drawn district, resulted in a plan that unduly favors the Republican Party and unduly disfavors the Democratic Party.

# United States Supreme Court: *Alexander v. NAACP et al.*

- South Carolina racial gerrymandering case argued on Oct 11, 2023
- Served as an expert witness for the plaintiffs
- Used simulation to provide evidence that a disproportionately large number of Black voters are packed into District 6

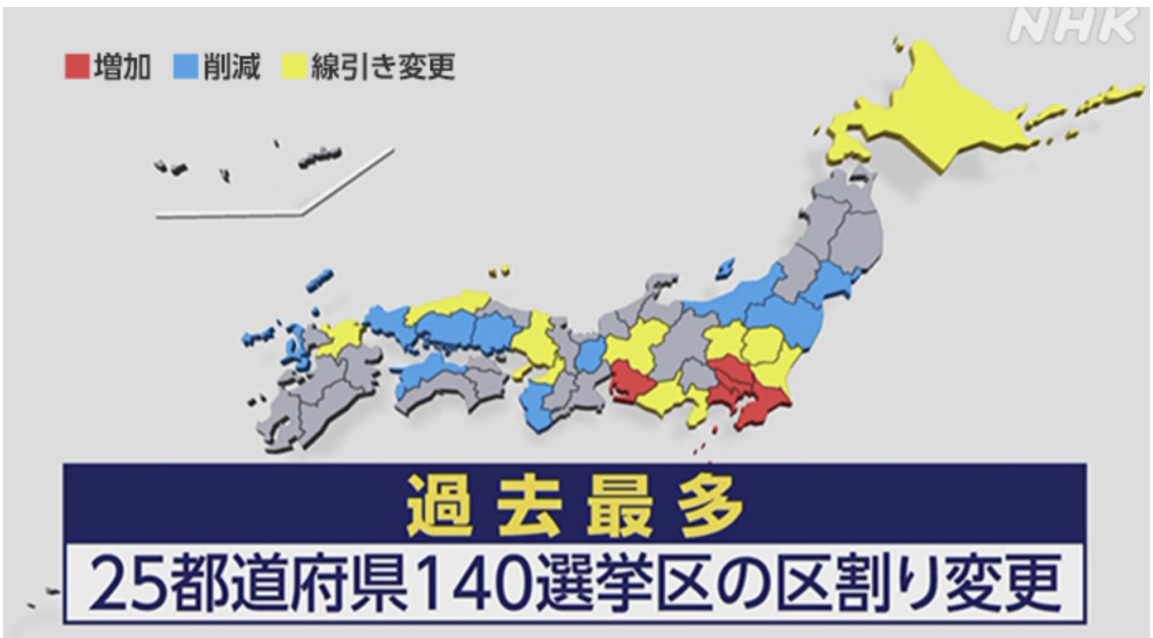
**Justice Alito:** Did Dr. Imai run a simulation using the political data as well but then decide to shelve it when the results were not favorable to your client?

**Ms. Aden:** That is not what I believe the record reflects, Your Honor.

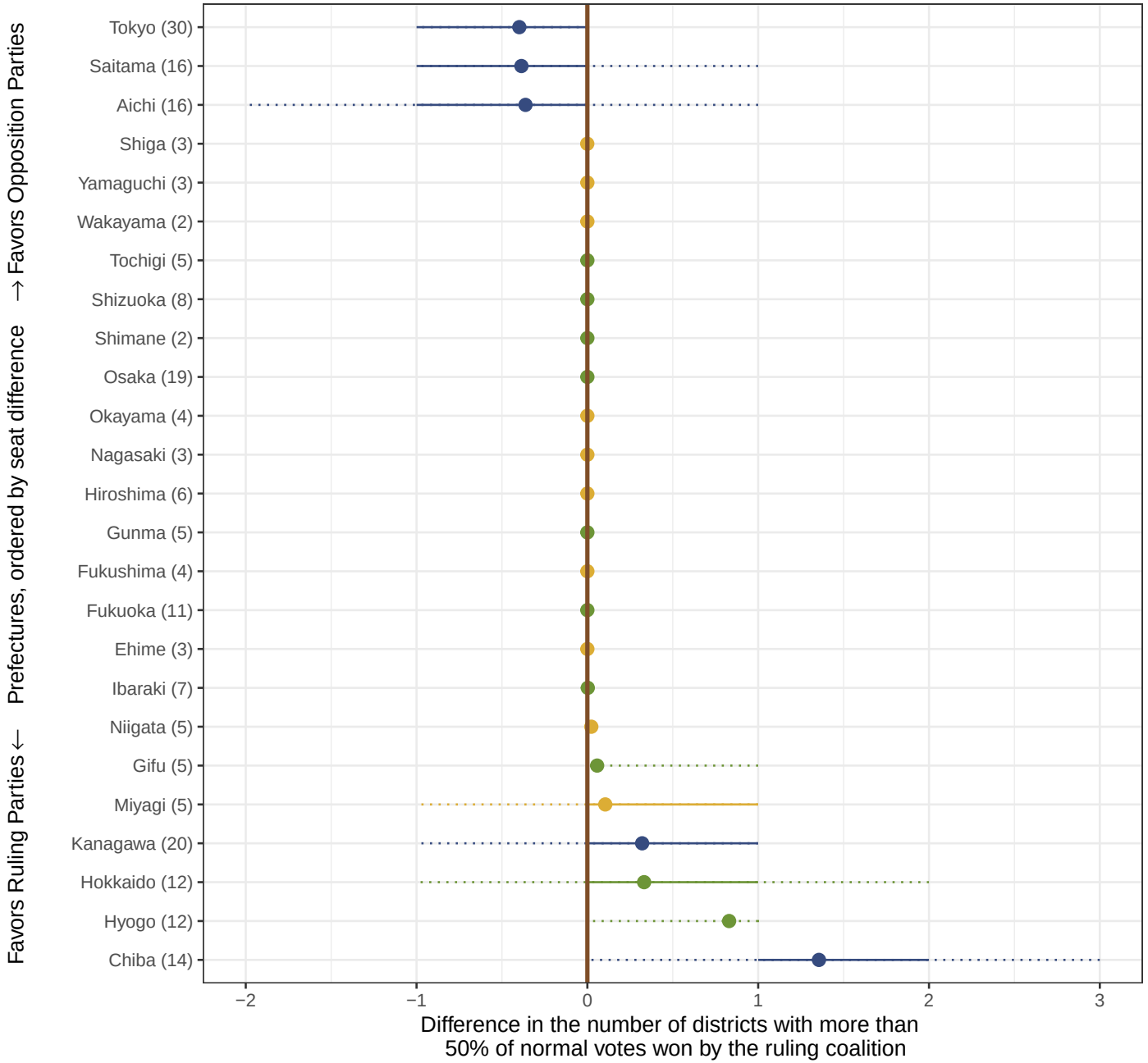
**Justice Alito:** It just never occurred to him that politics might have something to do with this?

# Is There Partisan Bias in Japanese Redistricting?

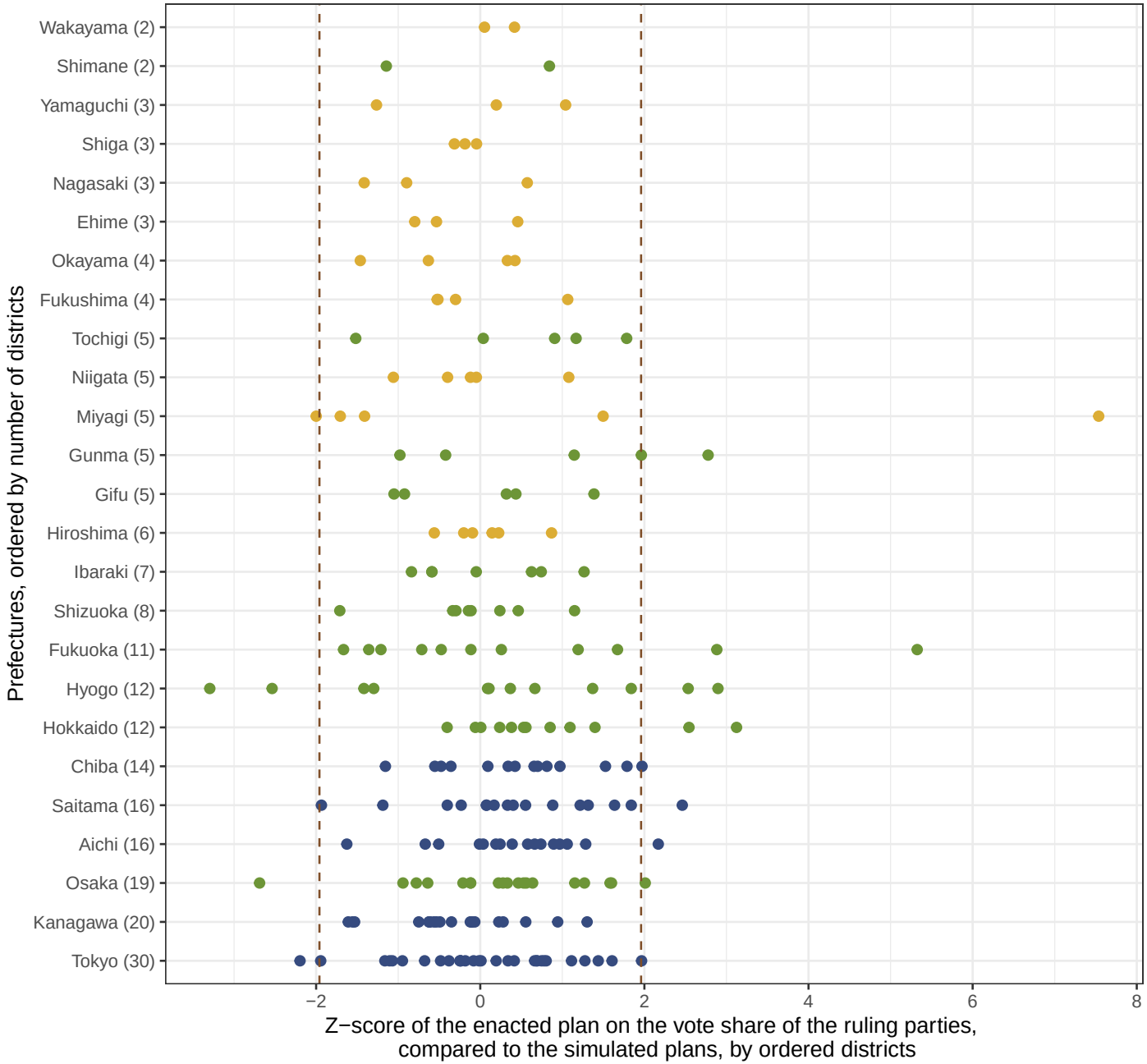
- Non-partisan commission $\rightsquigarrow$ no partisan bias?
- Potential sources of partisan bias
  - members are appointed by the prime minister and approved by the Diet
  - governors are invited to provide their opinions
- 2020 Japanese redistricting
  - redistricting in 25 prefectures out of 47
  - 10 prefectures lost a seat
  - 5 prefectures gained a seat / seats
  - 5 prefectures redrew districts without changing the number of seats



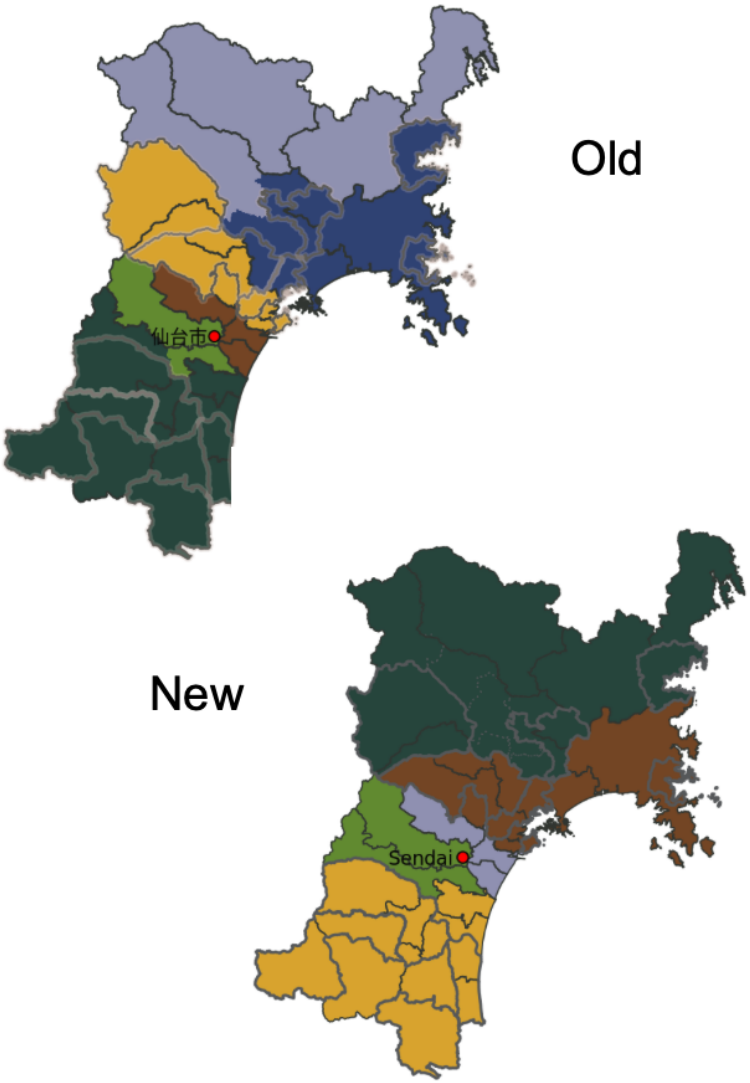
# Little Partisan Bias at the Prefecture Level



# Some but Relatively Little Partisan Bias at the District Level



# Miyagi Prefecture

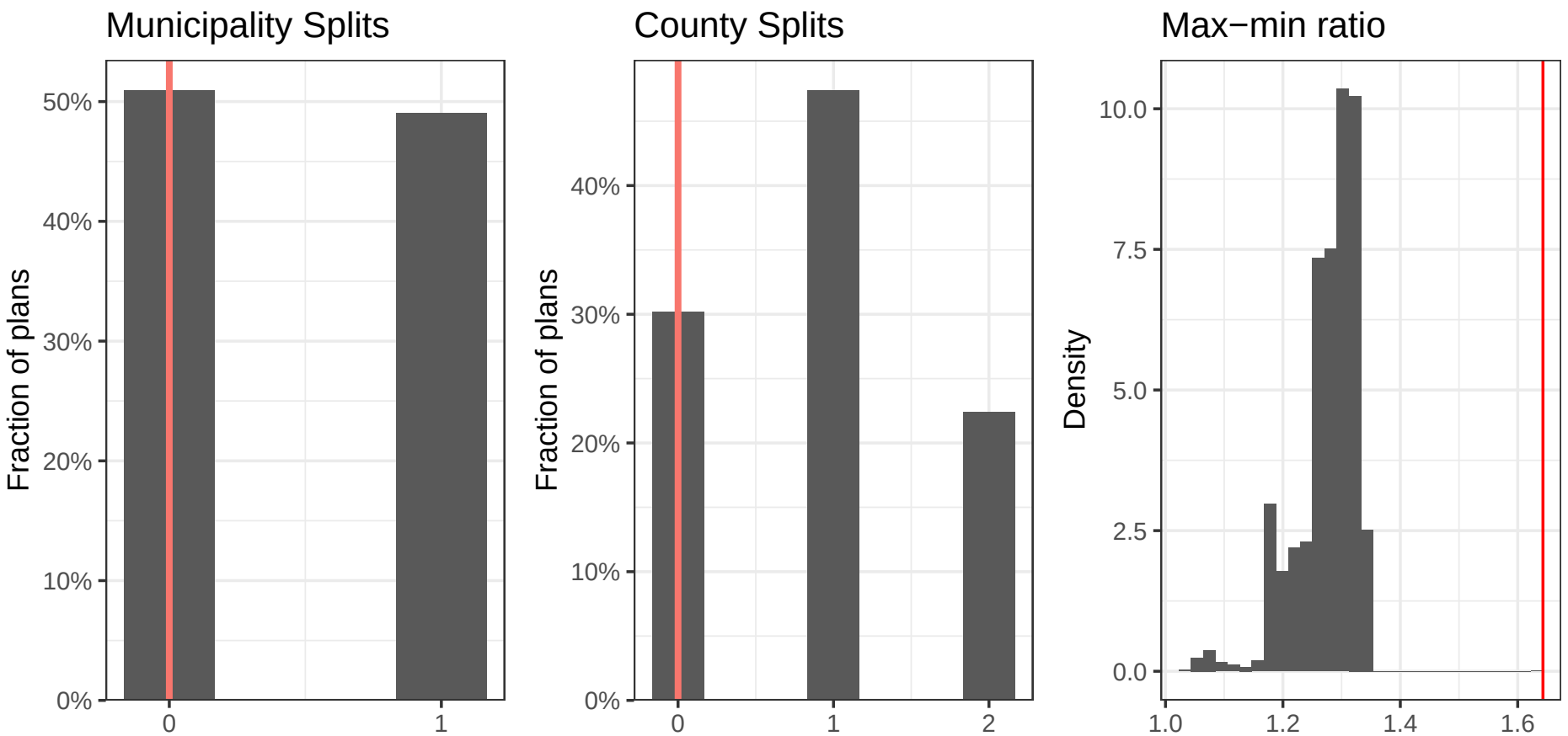



- # of seats: 6 → 5
- # of municipality splits: 2 → 0
- # of county splits: 2 → 0
- Population deviation: 1.94 → 1.64

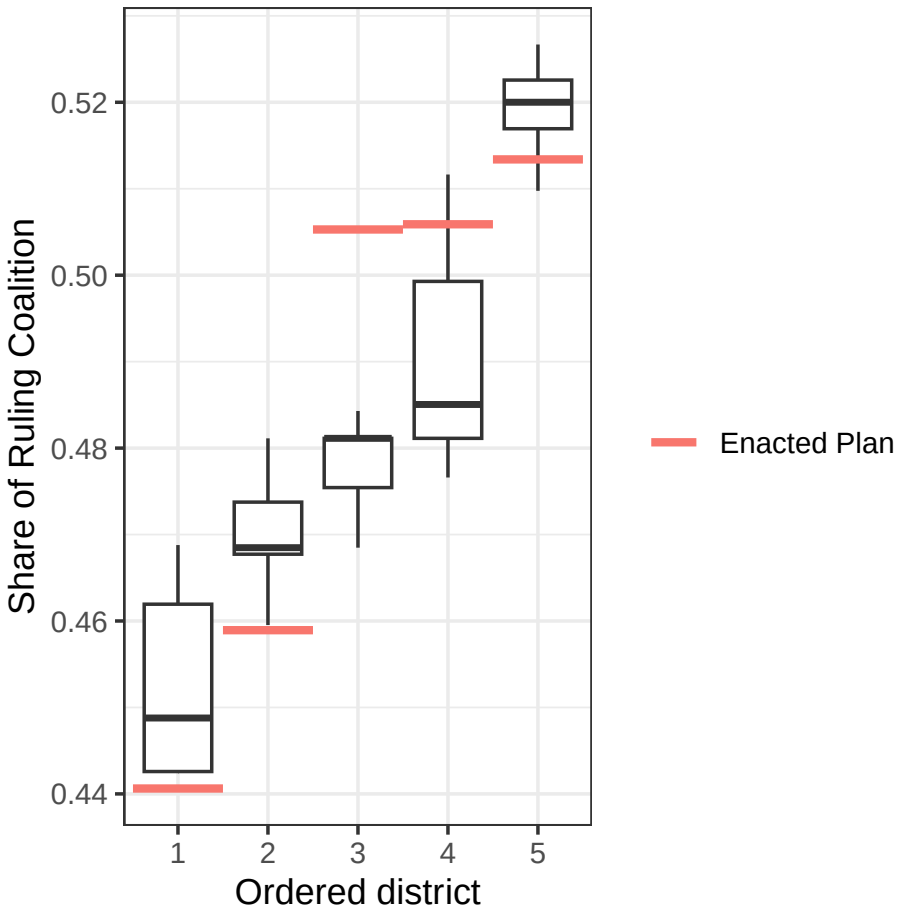
- Lower House Electoral results
  - 2017: 5 LDP, 1 independent
  - 2021: 4 LDP, 2 opposition

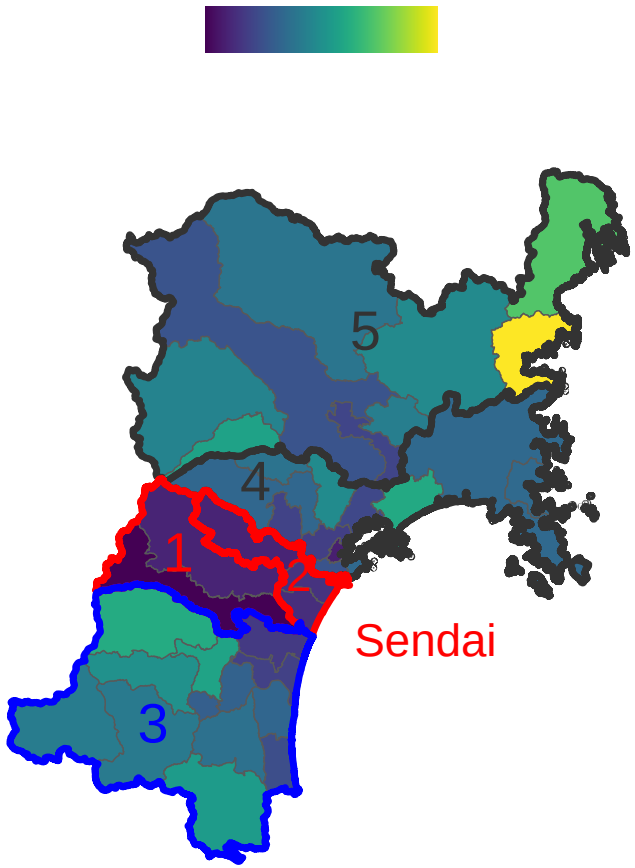
- 5,000 simulated plans

# Simulated Plans Have More Desirable Properties



# Partisan Bias



# Concluding Remarks

- Redistricting matters
  - fair representation and policy outcomes
  - competitiveness of districts and responsiveness
  - political polarization
  - state and local offices, education districts, non-US contexts
- How should we stop gerrymandering?
  - independent commission (e.g., Michigan)
  - use of algorithms to detect gerrymandering
- Role of experts
  - legislative process
  - court testimony
  - work with non-partisan groups and commissions
- Open problems
  - large-scale redistricting problems (e.g., state legislatures)
  - algorithm-generated redistricting plan proposals
  - communities of interest, impact of redistricting rules