Gerrymandering and Math

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Lake Forest College

Faculty Discussion Group
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Background

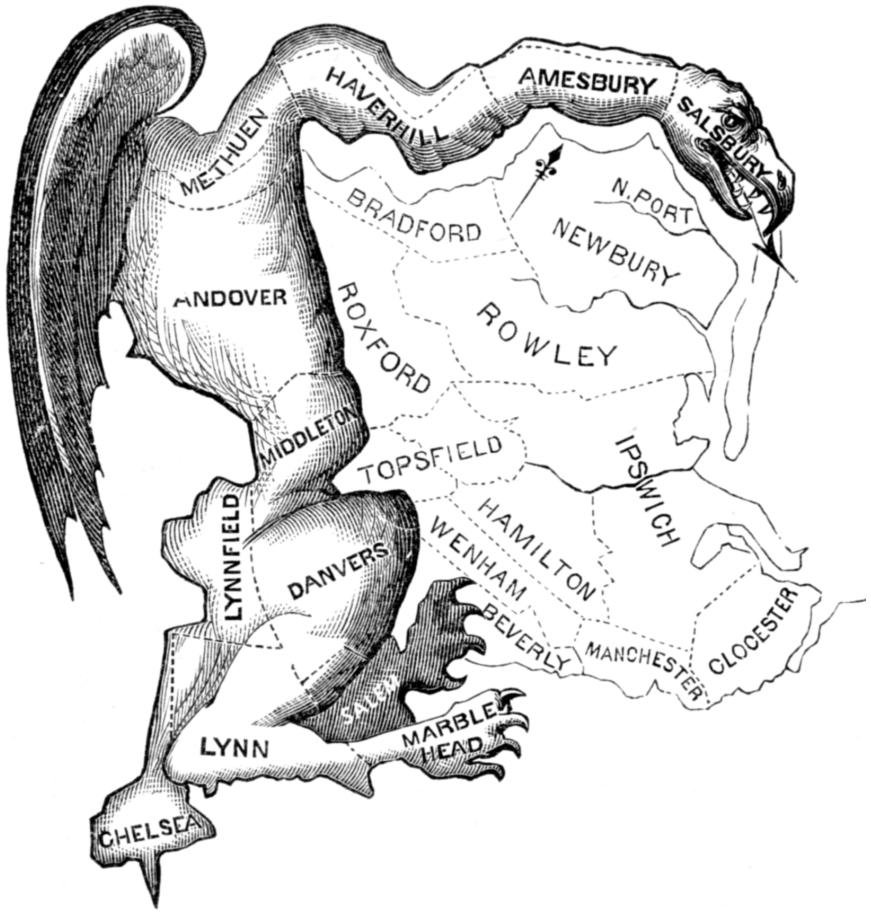
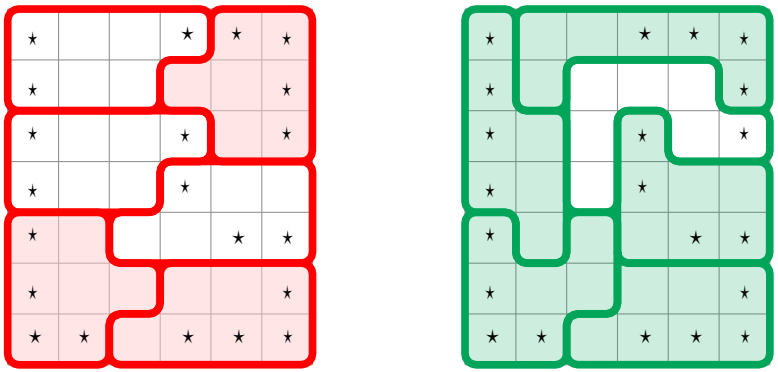


Figure: An 1812 satirical cartoon depicting a “salamander”-looking district created by Massachussettes Governor Gerry.

Packing and Cracking



You can play the Redistricting Game for better examples.

Metric Geometry and Gerrymandering Group

- Ari Nieh is a lecturer of Writing, Rhetoric, and Professional Communication at MIT.
- Mira Bernstein holds a research faculty position in Science, Technology, and Society at Tufts University.
- Moon Duchin is an Associate Professor of mathematics at Tufts University.
- Justin Solomon is an Assistant Professor of Electrical Engineering and Computer Science at the Computer Science and Artificial Intelligence Laboratory at MIT.
- The group created earlier this year has over 3200 people in their mailing list. Has had two workshops and will have 3 more.

Partisan Gerrymandering History

- Supreme Court rules partisan gerrymandering unconstitutional in 1986 (Davis v. Bandemar), but failed to agree on a clear standard for judicial review.
- In Vieth v. Jubiler (2004), the Court had four Justices say that partisan gerrymandering was not-justiciable and a fifth (Kennedy) that concurred but considering that a standard could come up in the future.

Kennedy quotes from his commentary in Vieth:

- “if courts refuse to entertain any claims of partisan gerrymandering, the temptation to use partisan favoritism in districting in an unconstitutional manner will grow.”
- “technology is a threat and a promise”

Partisan Symmetry

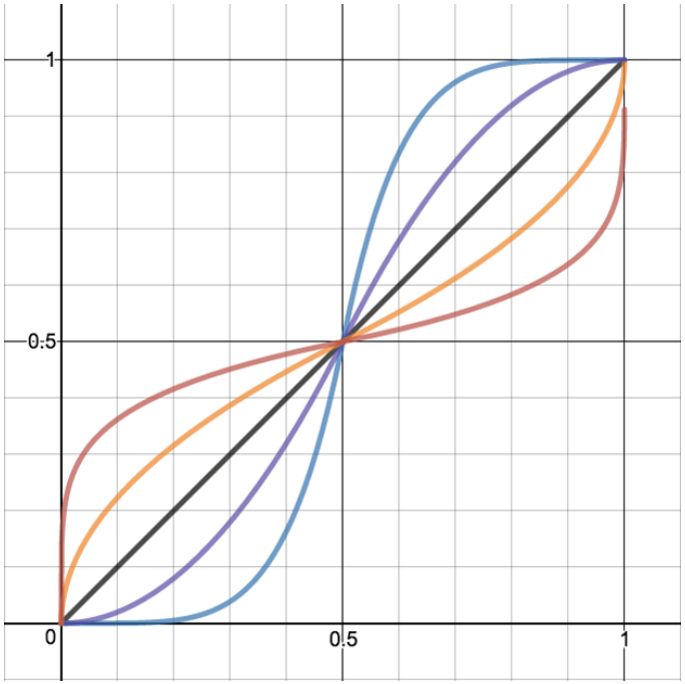
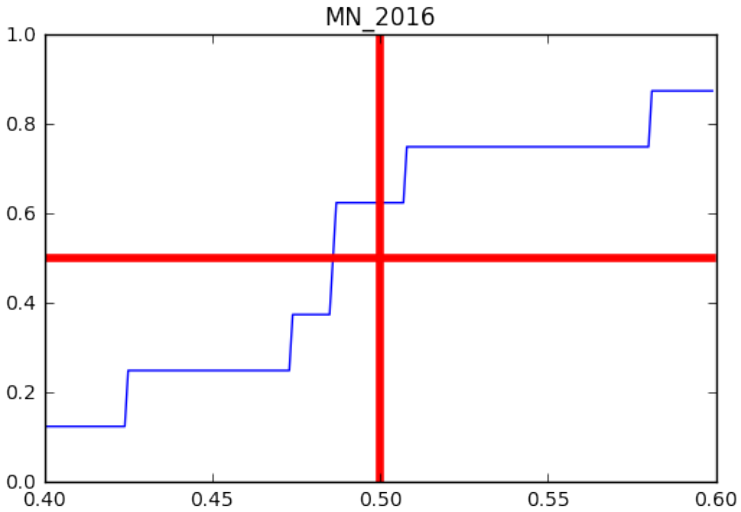
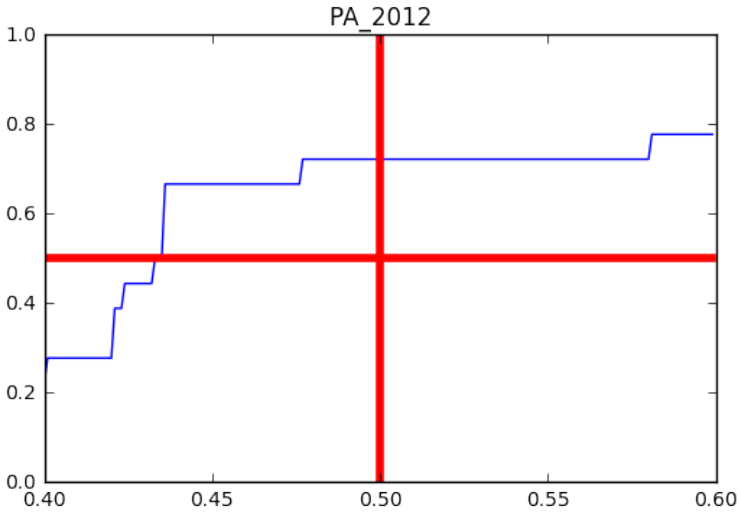


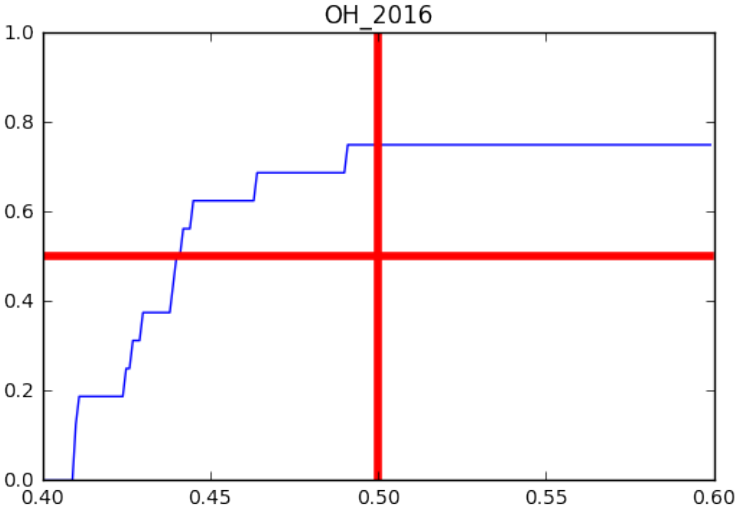
Figure: The x-axis represents proportion of the vote a party gets. The y-axis is the proportion of seats it gets. (Image by Mira Bernstein.)

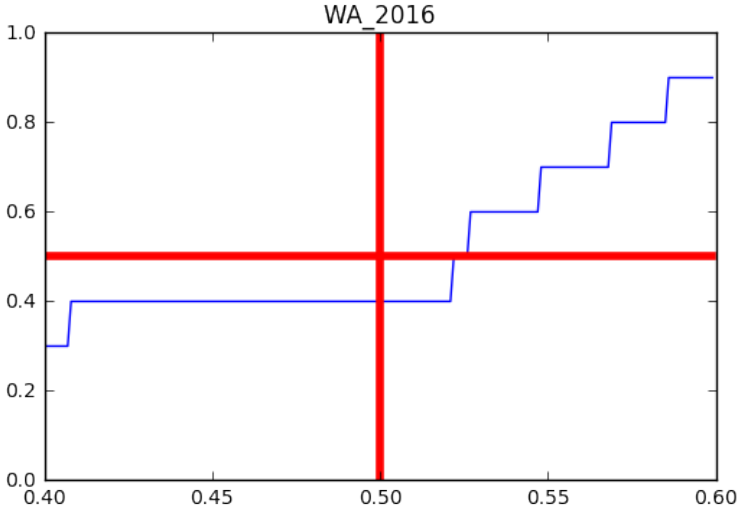
Idea: If one party gets S seats with x per cent of the vote, then if the other party gets x per cent of the vote, they should also get S seats.

Partisan Symmetry 2









Efficiency Gap

- Created around 2015. It is a measure created by Eric McGhee (political scientist at a think tank).
- First published by McGhee with with Nicholas Stephanopoulos (U. Chicago law professor) in *Partisan Gerrymandering and the Efficiency Gap* , 82 U. Chi. L. Rev. 831, 836-838 (2015).
- The measure tries to estimate how much packing and cracking there is by considering “wasted votes”.
- The Washington Post has a great article showing it in action.

Efficiency Gap Math

- Let W_i^{Dem} and W_i^{Rep} be the votes wasted in district i for Democrats and Republicans, respectively.
- Let T_i^{Dem} and T_i^{Rep} be the number of voters in district i that voted Democrat and Republican, respectively.
- S^{Dem} is the number of seats Democrats win. S^{Rep} is the number of seats Republicans win.
- Then

$$EG = \sum_{i=1}^{S} \frac{W_i^{Dem} - W_i^{Rep}}{T} = \frac{W^{Dem} - W^{Rep}}{T},$$

  where W^{Dem}, W^{Rep} are the total number of wasted voted for each party, and T is the total number of voters.
- The suggestion from the authors of the Efficiency Gap is to use 8% as a threshold (with some caveats).

Efficiency Gap Surprise

- Let σ be the proportion of seats of the Democrats minus the proportion of the Republicans.
- Let τ be the proportion of votes of the Democrats minus the proportion of votes of Republicans.

$$EG = \tau - \frac{1}{2}\sigma.$$

Example: Suppose Democrats got 55% of the vote and 65% of the seats. Then

$$EG = (.55 - .45) - \frac{1}{2}(.65 - .35) = .1 - \frac{1}{2}(.3) = -.05.$$

Therefore, the efficiency gap is -5%.

Efficiency Gap Issues

- If the efficiency gap measures packing and cracking, why can we calculate it without knowing the results of each district?
- **Penalizes Proportionality**. Note how it suggests a hyperproportional outcome instead of the intuitively fair proportional system.
- The Efficiency Gap penalizes making competitive districts (since they create many "wasted votes"). Therefore, there's an incentive to not make competitive districts, which creates a disincentive to vote in certain districts.
- A district has perfect efficiency gap if it has a 75%-25% margin.
- If a party gets more than 79% of the vote, then no outcome is considered fair under the Efficiency Gap.
- Very problematic when there's a small number of districts.

Monte Carlo Simulation

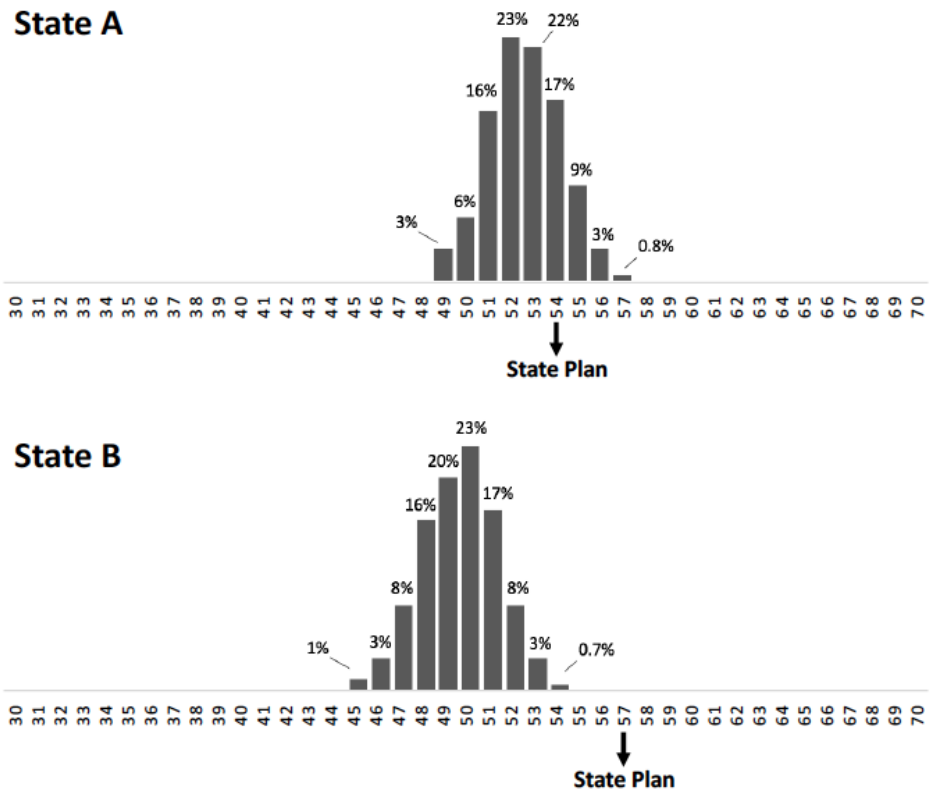
IDEA: Create a computer simulation that makes lots of maps that satisfy certain criteria that are necessary for it to be a districting map. For example, the map should

- Break into districts with equal population.
- Have every district be contiguous (connected) and have a compact shape.
- Satisfy the Voting Rights Act.
- Take into account geographic area.

After creating all of these maps, analyze the seat distribution won by a party if the election had gone the exact same way, but trying on the random maps. Check on what percentile the actual election landed on.

Simulation Example

Illustrative Example (this is due to Eric Lander):



Researchers creating random maps to evaluate

- Wendy Cho of the University of Illinois (Departments of Political Science, Statistics Professor)
- Jonathan Mattingly of Duke University; (Mathematics Professor)
- Jowei Chen of the University of Michigan, (Political Science Associate Professor)
- Jonathan Rodden of Stanford University, (Political Science Professor)
- David Cottrell of Dartmouth College; and (Social Science Lecturer)
- Michael McDonald of Binghamton University. (Political Science Professor)

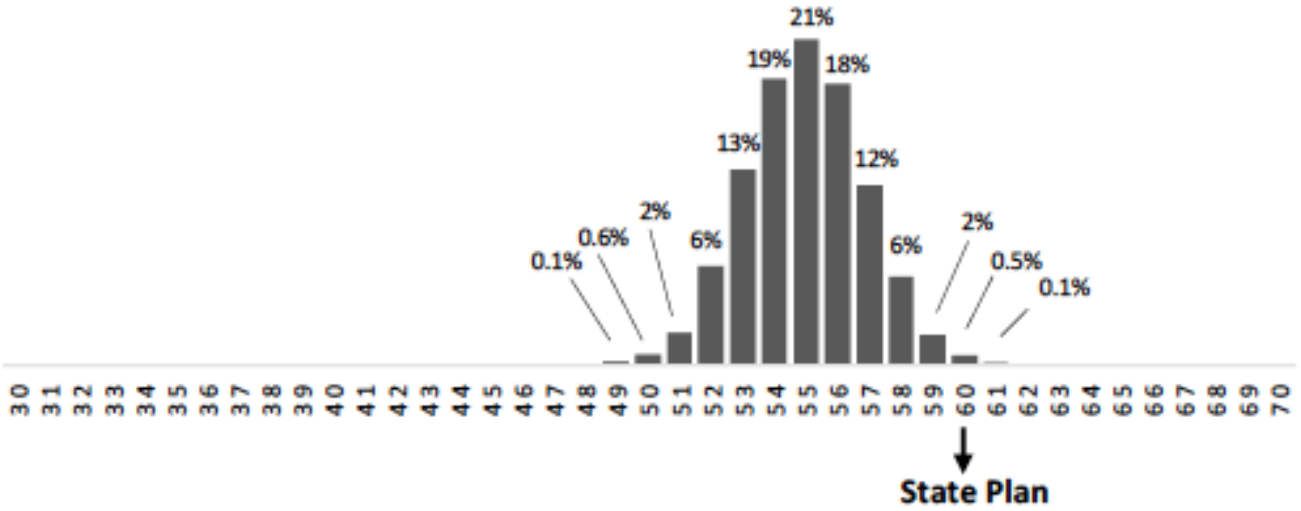
Gill v. Whitford

Argued before the Supreme Court on October 3, 2017.
Some comments on the arguments:

- Several Justices are worried about standing. Can Whitford be gerrymandered if he lives in one district? In cases for racial gerrymandering, a plaintiff only has standing on their own district. The plaintiff argued that diluting votes is different.
- Roberts is worried about whether ruling the map as gerrymandered will bring many more cases which he (seems to) consider too political. The reason for this worry is that gerrymandering cases cannot be denied by the Supreme Court. The plaintiff argued denying gerrymandering in such evident cases makes the Court more partisan.
- The state says the efficiency gap gives too many false positives. The plaintiff argues that it's only one piece of much evidence pointing in the same direction.

Strong evidence for gerrymandering in Wisconsin

The work of several Duke researchers (led by Mattingly) created the following histogram out of nearly 20,000 maps:



The map drawn by Wisconsin is an extreme outlier. In the 99.4 percentile.
In an amicus brief to the Court, Eric Lander suggested the Court use “extreme outlier” as a standard.

Thank You!

Any Questions?