Report on Remedial Districting Plans for North Carolina

Dr. Michael Barber
Brigham Young University
724 Spencer W. Kimball Tower
Provo, UT 84604
barber@byu.edu

Contents

1 Introduction and Qualifications **4**

2 Data and Methods **6**

3 Congressional Plan **7**

3.1 Partisan Lean of Districts 7

3.2 Measures of Partisan Bias 10

3.3 Median-Mean Measure 10

3.4 Efficiency Gap Measure 11

3.5 Close Votes, Close Seats 14

3.6 Partisan Symmetry 19

4 Conclusion for Congressional Plan **24**

5 State House Plan **25**

5.1 Partisan Lean of Districts 25

5.2 Median-Mean Measure 28

5.3 Efficiency Gap Measure 28

5.4 Close Votes, Close Seats 29

5.5 Partisan Symmetry 33

5.6 Considerations of Race 37

6 Conclusion for North Carolina House Plan **37**

7 State Senate Plan **39**

7.1 Partisan Lean of Districts 39

7.2 Median-Mean Measure 42

7.3 Efficiency Gap Measure 42

7.4 Close Votes, Close Seats 43

7.5 Partisan Symmetry 47

7.6 Considerations of Race 51

8 Conclusion for North Carolina Senate Plan **51**

1 Introduction and Qualifications

I have been asked by counsel for the Legislative Defendants to analyze the 2022 Remedial district plans for the North Carolina House, Senate, and Congressional districts recently passed by the North Carolina General Assembly. These were enacted as N.C. session laws 2022-2 (Senate, S744), 2022-3 (Congressional, S745), and 2022-4 (House, H980). I have also been asked to update this report to include the same analysis of the Harper Plaintiffs' recently submitted plans for Congress and the Senate and the NCLCV Plaintiffs' recently submitted plans for Congress, Senate, and House.[1]

I analyze the plans by measuring each plan according to measures of partisan fairness suggested by the North Carolina Supreme Court. These measures are: the median-mean, efficiency gap, close-votes close-seats, and partisan symmetry. I also compute a partisan index based on 12 statewide elections used by one of Plaintiff's experts and present this index and the range of statewide election results for each district in each plan.

The results show that in all three plans (Congress, House, Senate), and across all measures, the Remedial plans exhibit extremely small degrees of bias and are significant improvements over the previous districts on these metrics.

I am an associate professor of political science at Brigham Young University and faculty fellow at the Center for the Study of Elections and Democracy in Provo, Utah. I received my PhD in political science from Princeton University in 2014 with emphases in American politics and quantitative methods/statistical analyses. My dissertation was awarded the 2014 Carl Albert Award for best dissertation in the area of American Politics by the American Political Science Association.

I teach a number of undergraduate courses in American politics and quantitative research methods.[2] These include classes about political representation, Congressional elections, statistical methods, and research design.

[1] My understanding is that the Harper Plaintiffs did not submit a House map.

[2] The political science department at Brigham Young University does not offer any graduate degrees.

I have worked as an expert witness in a number of cases in which I have been asked to analyze and evaluate various political and elections-related data and statistical methods. Cases in which I have testified at trial or by deposition are listed in my CV, which is attached to the end of this report. I have previously provided expert reports in a number of cases related to voting, redistricting, and election-related issues: *Nancy Carola Jacobson, et al., Plaintiffs, vs. Laurel M. Lee, et al., Defendants. Case No. 4:18-cv-00262 MW-CAS (U.S. District Court for the Northern District of Florida); Common Cause, et al., Plaintiffs, vs. Lewis, et al., Defendants. Case No. 18-CVS-14001 (Wake County, North Carolina); Kelvin Jones, et al., Plaintiffs, v. Ron DeSantis, et al., Defendants, Consolidated Case No. 4:19-cv-300 (U.S. District Court for the Northern District of Florida); Community Success Initiative, et al., Plaintiffs, v. Timothy K. Moore, et al., Defendants, Case No. 19-cv-15941 (Wake County, North Carolina); Richard Rose et al., Plaintiffs, v. Brad Raffensperger, Defendant, Civil Action No. 1:20-cv-02921-SDG (U.S. District Court for the Northern District of Georgia); Georgia Coalition for the People's Agenda, Inc., et. al., Plaintiffs, v. Brad Raffensberger, Defendant. Civil Action No. 1:18-cv-04727-ELR (U.S. District Court for the Northern District of Georgia); Alabama, et al., Plaintiffs, v. United States Department of Commerce; Gina Raimondo, et al., Defendants. Case No. CASE NO. 3:21-cv-00211-RAH-ECM-KCN (U.S. District Court for the Middle District of Alabama Eastern Division); League of Women Voters of Ohio, et al., Relators, v. Ohio Redistricting Commission, et al., Respondents. Case No. 2021-1193 (Supreme Court of Ohio); Adams, et al., Relators, v. DeWine, et al., Respondents. Case No. 2021-1428 (Supreme Court of Ohio)*

In my position as a professor of political science, I have conducted research on a variety of election- and voting-related topics in American politics and public opinion. Much of my research uses advanced statistical methods for the analysis of quantitative data. I have worked on a number of research projects that use "big data" that include millions of observations, including a number of state voter files, campaign contribution lists, and data from the US Census. I have also used geographic information systems and other mapping

techniques in my work with political data.

Much of this research has been published in peer-reviewed journals. I have published nearly 20 peer-reviewed articles, including in our discipline's flagship journal, *The American Political Science Review* as well as the inter-disciplinary journal, *Science Advances*. My CV, which details my complete publication record, is attached to this report as Appendix A.

The analysis and opinions I provide in this report are consistent with my education, training in statistical analysis, and knowledge of the relevant academic literature. These skills are well-suited for this type of analysis in political science and quantitative analysis more generally. My conclusions stated herein are based upon my review of the information available to me at this time. I reserve the right to alter, amend, or supplement these conclusions based upon further study or based upon the availability of additional information. I am being compensated for my time in preparing this report at an hourly rate of $400/hour. My compensation is in no way contingent on the conclusions reached as a result of my analysis. The opinions in this report are my own, and do not represent the view of Brigham Young University.

2 Data and Methods

Across all three plans (Congress, House, Senate) I rely upon election data from 12 statewide elections from 2016-2020. Specifically, I use the 2016 Lieutenant Governor and US Presidential races and the 2020 Commissioner of Agriculture, Treasurer, Lieutenant Governor, US Senate, Commissioner of Labor, US President, Attorney General, Auditor, Secretary of State, and Governor races. These are the same 12 elections used by Dr. Mattingly in his original expert report for his county cluster by county cluster analysis.

3 Congressional Plan

3.1 Partisan Lean of Districts

To measure the expected seat share in the remedial Congressional plan, I compute a partisan index of statewide elections for the 12 statewide partisan elections between 2016-2020 noted above. The index is simply the average of the two-party vote share for all 12 elections. In other words, if a district has an index value of 0.51, this would mean that 51% of the votes cast for the two major parties across these 12 elections went to Democratic candidates. Figure 1 shows this value for each of the 14 Congressional seats. Districts are ordered from least Democratic-leaning at the bottom to most Democratic-leaning at the top. Districts with a partisan index less than 0.50 (i.e. Republican-leaning) are shown as squares and districts with a partisan index greater than 0.50 (i.e. Democratic-leaning) are displayed as triangles.

Of the 14 Congressional districts there are 8 districts with an index less than 0.50 (Republican-leaning, shown as squares) and 6 districts with an index greater than 0.50 (Democratic-leaning shown as triangles). A vertical dashed line is placed at 0.50 in the figure for reference. In the now-enjoined 2021 Enacted Congressional plan there were 10 Republican-leaning districts and 4 Democratic leaning districts.

The grey horizontal lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. As can be seen by the width of the grey horizontal bars in each district, there is substantial variation across the 12 elections. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. I call these districts safely partisan since in all 12 of the statewide races the same party won a majority of votes. Districts where the grey horizontal lines cross the 0.50 vertical line indicate districts where both parties have won a majority of the votes in

that district. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

Looking at the range across the index, there are 6 districts colored red (reliably Republican) in the figure, 4 blue districts (reliable Democratic), and 4 green districts (competitive) in the Congressional map. Using an alternative definition of competitiveness based on the closeness of the index to 0.50, there are 6 districts with an index less than 0.48, 4 districts between 0.48 and 0.52 (a commonly used range to define hyper-competitive seats), and 4 districts with an index of greater than 0.52.

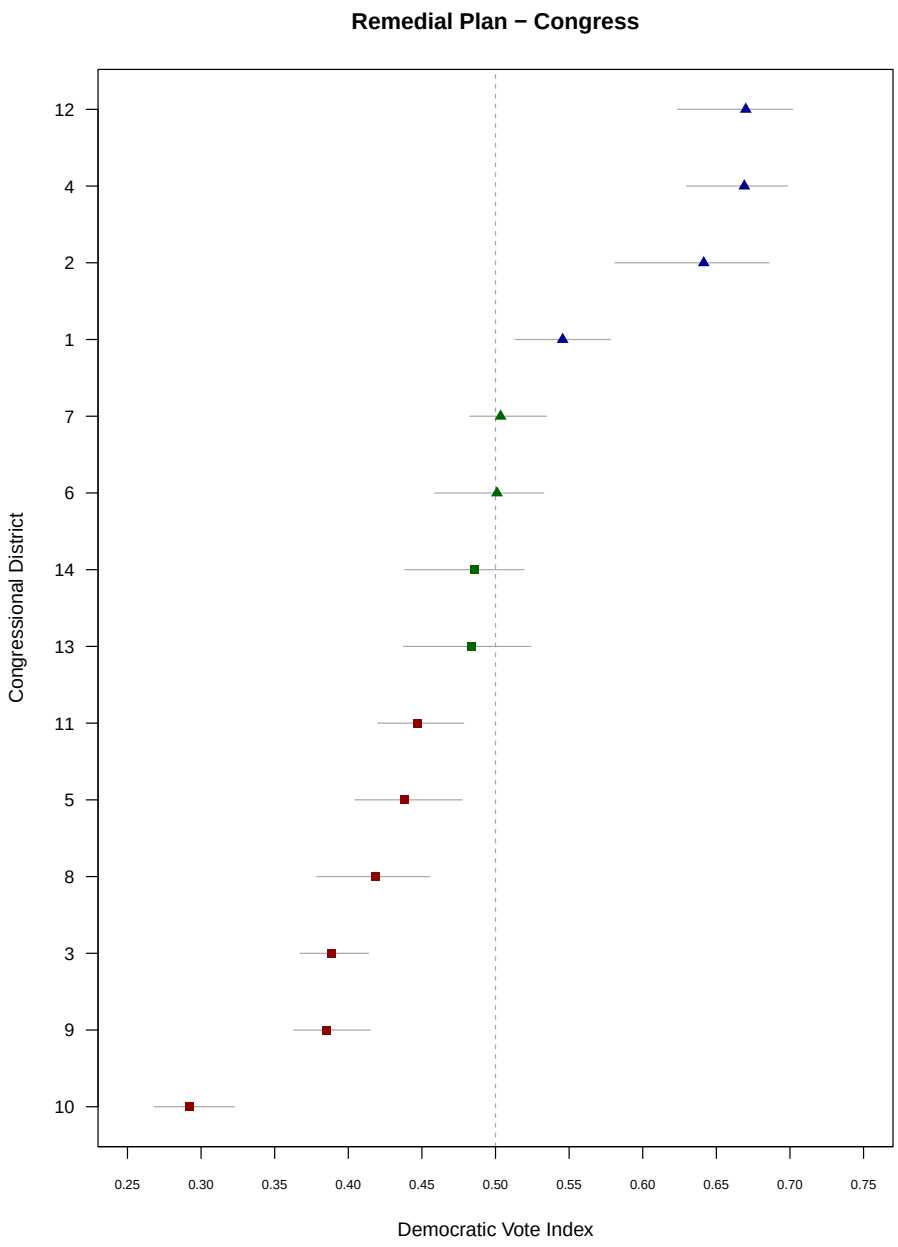


Figure 1: **Partisan Index of Congressional Districts in 2022 Remedial plan:** Partisan Index based on the average of 12 statewide partisan races between 2016-2020. Districts with a partisan index less than .50 (i.e. Republican leaning) are shown as squares and districts with a partisan index greater than .50 (i.e. Democratic leaning) are displayed as triangles. A vertical dashed line is placed at .50 in each panel for reference. The grey lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

3.2 Measures of Partisan Bias

In its ruling, the Court makes reference to four different measures of partisan bias, based on the analysis, reports, and testimony put forward by various experts during the trial. While scholars of these metrics note their limitations and drawbacks, for purposes of this report I assume their usefulness in light of the Court's decision.[3] Thus, I will consider each of these measures of partisan bias for the Congressional plan.

3.3 Median-Mean Measure

Academic literature describes the median-mean measure as being useful to measure the partisan bias of a districting plan.[4] The median-mean measure is calculated by taking the median value of the partisan index across all 14 districts in a plan (the value for which half of the observations are smaller and half the observations are larger) and subtracting from that the mean partisan index (the simple average) of all of the districts from the median. Consider an example in which there are three districts in a plan with partisan indices of 0.91, 0.46, and 0.40. To find the median we look for the district for which there is one district larger and one district smaller (0.46 in this case). To find the mean, we take the average by dividing the sum of the partisan indices by the number of districts. In this case, (0.91+0.46+0.40)/3 = 0.59. The median-mean value would then be 0.46-0.59 = -0.13. As in this example I take the Democratic vote share of the median district minus the mean

[3]Stephanopoulos, Nicholas O., and Eric M. McGhee. "Partisan gerrymandering and the efficiency gap." U. Chi. L. Rev. 82 (2015): 831.
Best, Robin E., Shawn J. Donahue, Jonathan Krasno, Daniel B. Magleby, and Michael D. McDonald. "Considering the prospects for establishing a packing gerrymandering standard." Election Law Journal 17, no. 1 (2018): 1-20.
McGhee, Eric. "Rejoinder to 'Considering the prospects for establishing a packing gerrymandering standard'." Election Law Journal 17, no. 1 (2018): 73-82.

[4]See Best, Robin E., Shawn J. Donahue, Jonathan Krasno, Daniel B. Magleby, and Michael D. McDonald. "Considering the prospects for establishing a packing gerrymandering standard." Election Law Journal 17, no. 1 (2018): 1-20. Warrington, Gregory S. "A comparison of partisan-gerrymandering measures." Election Law Journal: Rules, Politics, and Policy 18, no. 3 (2019): 262-281.
Wang, Samuel S-H. "Three tests for practical evaluation of partisan gerrymandering." Stan. L. Rev. 68 (2016): 1263. McDonald, Michael D., and Robin E. Best. "Unfair partisan gerrymanders in politics and law: A diagnostic applied to six cases." Election Law Journal 14, no. 4 (2015): 312-330.

Democratic vote share for all 14 districts in the Remedial plan. Negative numbers indicate a districting plan that favors Republicans and positive numbers indicate a slant in favor of Democrats.

Using the 12 statewide elections described above, the proposed remedial Congressional map has a median-mean value of -0.61%. This value is within the ±1% standard outlined by the Court's ruling.[5] Using the same data and method, the now-enjoined 2021 Enacted Congressional plan had a median-mean measure of -5.97%.

Using the 12 statewide elections described above, the proposed Congressional map proposed by the Harper Plaintiffs has a median-mean value of 0.04%. This value is within the ±1% standard outlined by the Court's ruling. Using the same data and method, the NCLCV Plaintiffs' Congressional plan has a median-mean measure of 1.65%. This is outside the bounds of the 1% standard outlined by the Court's ruling.[6]

3.4 Efficiency Gap Measure

The efficiency gap is another redistricting metric discussed by academics and is similar to the median-mean measure in that it looks for the degree to which a political party's votes statewide are translated into seats in each district.[7] A description of this measure provided by the Brennen Center for Justice summarizes it: "[T]he efficiency gap counts the number of votes each party wastes in an election to determine whether either party enjoyed a systematic advantage in turning votes into seats. Any vote cast for a losing candidate is considered

[5] I have seen the recently submitted report by the Harper Plaintiffs in which Dr. Mattingly uses 16 statewide elections instead of the 12 he presented in his original report to the trial court. Using these 16 elections the remedial Congressional plan has a median-mean value of -0.86%, which is also within the threshold outlined by the Court.

[6] Using the 16 elections in the Harper Plaintiffs' most recent report, the Harper Congressional proposal has a median-mean value of 0.0% and the NCLCV Congressional proposal has a median-mean value of 1.62%, which is outside the bounds of the threshold stated by the Court. In my review of Dr. Duchin's report I do not see anywhere that she produces the median-mean score using the same 12 or 16 elections that I do here. Thus, it is impossible to make an apples-to-apples comparison between her calculations and mine.

[7] McGhee, Eric. "Measuring efficiency in redistricting." Election Law Journal: Rules, Politics, and Policy 16, no. 4 (2017): 417-442. Veomett, Ellen. "Efficiency gap, voter turnout, and the efficiency principle." Election Law Journal: Rules, Politics, and Policy 17, no. 4 (2018): 249-263. Plener Cover, Benjamin. "Quantifying partisan gerrymandering: An evaluation of the efficiency gap proposal." Stan. L. Rev. 70 (2018): 1131.

wasted, as are all the votes cast for a winning candidate in excess of the number needed to win."[8] In other words, under the efficiency gap the ideal strategy for a political party to maximize the impact of their voters is to distribute them as evenly as possible across districts so as to win by a narrow margin in the districts they win and lose by very large margins in the districts where they lose. Put another way, under the theory of minimizing wasted votes, "win by a little, lose by a lot" is the ideal strategy for a party to maximize their impact of their voters.[9]

The Brennen Center provides a simple example of how the efficiency gap is calculated:

> To understand how the efficiency gap works, consider a hypothetical state with 500 residents that is divided into five legislative districts, each with 100 voters. In the most recent election cycle, Democrats won Districts 1 and 2 by wide margins, while Republicans won Districts 3, 4, and 5 in closer races. Overall, Democratic candidates received 55 percent of the statewide vote but won just 40 percent of the legislative seats, while Republican candidates received 45 percent and won 60 percent of the seats. The table below shows the election results for each district.[10]

District	D votes	R Votes	Result
1	75	25	D wins
2	60	40	D wins
3	43	57	R wins
4	48	52	R wins
5	49	51	R wins
Total:	275	225	

Once we have the election results, the first step is to consider the number of "wasted votes" in each district. Because the Republican candidate in this example lost in District 1, all 25 of the votes cast for that candidates are wasted. The Democratic candidate in District 1 won, but by 24 more votes than would be necessary (since all that is needed is 51 votes

[8] https://www.brennancenter.org/sites/default/files/legal-work/How_the_Efficiency_Gap_Standard_Works.pdf

[9] Of course, parties have other priorities and winning by a single vote might not be their ideal scenario in reality.

[10] https://www.brennancenter.org/sites/default/files/legal-work/How_the_Efficiency_Gap_Standard_Works.pdf

to win). Thus, there are 24 wasted Democratic votes in this district. Taking the difference indicates that there was a net of 1 Republican wasted vote in this district.

The efficiency gap is then calculated as Efficiency Gap = (Total Democratic Wasted Votes - Total Republican Wasted Votes) / Total Votes.[11] In this example and in analyzing the remedial Congressional plan, I use the Democratic seat and vote margins which means that negative efficiency gap numbers indicate a districting plan that favors Republican voters and positive numbers indicate a plan that favors Democratic voters.

Using the 12 statewide elections described above, the proposed remedial Congressional map has an efficiency gap value of -5.29%. This value is within the ±7% standard outlined by the Court's ruling.[12] Using the same data and method, the now enjoined Enacted Congressional plan had an efficiency gap measure of -19.51%.

Using the 12 statewide elections described above, the proposed Congressional map from the Harper Plaintiffs has an efficiency gap value of 1.03%. This value is within the ±7% standard outlined by the Court's ruling. Using the same data and method, the NCLCV Plaintiffs' Congressional plan has an efficiency gap measure of 7.92%. This is outside the ±7% standard outlined by the Court's ruling.[13]

[11]See McGhee, Eric. "Measuring efficiency in redistricting." Election Law Journal: Rules, Politics, and Policy 16, no. 4 (2017): 417-442.

[12]Using the 16 elections in the Harper Plaintiff's most recent report, the remedial Congressional plan has an efficiency gap value of -5.1%, which is also within the threshold outlined by the Court. Having a very brief amount of time to review her report, Dr. Duchin appears to attempt to calculate the efficiency gap using the same 12 elections that I use and Dr. Mattingly uses. She incorrectly implies that I selectively choose the 12 elections from Dr. Mattingly's analysis. A review of Dr. Mattingly's original report shows that throughout the *vast majority* of his report in which he performs his cluster by cluster analysis includes exactly the same 12 elections I use. Any issues with the selection of elections are thus equally applied to the results of Dr. Mattingly's analysis, which the court relied upon heavily. In this updated report I also replicate the results using the 16 (not 15, as Dr. Duchin incorrectly states) elections Dr. Mattingly uses in another portion of his report. In one case Dr. Duchin calculates the efficiency gap using the total votes cast for all 12 elections. In a separate column of the table (see page 13 of her report) she calculates the efficiency gap separately for each election and then takes the average across those individual elections. Dr. Duchin appears to prefer the latter method. Dr. Duchin implies that the efficiency gap loses its meaning when elections are put together into an index. However, we must remember that in *all of these cases we are proxying congressional elections using different elections.* The values we calculate, whether a particular statewide race, or an index of statewide races, are all abstractions from the actual elections at question - congressional elections.

[13]Using the 16 elections in the Harper Plaintiffs' most recent report, the Harper Congressional proposal has an efficiency gap value of 1.22% and the NCLCV Congressional proposal has an efficiency gap value of 0.83%.

3.5 Close Votes, Close Seats

The court makes reference to "Dr. Duchin's close-votes-close-seats" analysis and quotes the trial court's determination that a map should not "prevent Democrats from gaining a tie or a majority in the House" (paragraph 199). This measure of partisan fairness is less defined than the median-mean and efficiency gap, and I am not aware of any published work by Dr. Duchin or others that explicitly lays out the mathematical definition or technical components of this test. However, Dr. Duchin describes the general idea in her initial expert report submitted in this case where she states, "The numerical notions of partisan fairness all tend to agree on one central point: an electoral climate with a roughly 50-50 split in partisan preference should produce a roughly 50-50 representational split. I will call this the Close-Votes-Close-Seats principle" (pg. 4, Duchin Report). She goes on to state, "[Close-Votes-Close-Seats] is closely related to the principle of Majority Rule: a party or group with more than half of the votes should be able to secure more than half of the seats. In fact, Close-Votes-Close-Seats is essentially a corollary (or byproduct) of Majority Rule. It is not practicable to design a map that always attains these properties, but by contrast a map that consistently thwarts them should be closely scrutinized and usually rejected." (pg. 4, Duchin Report).

In another redistricting case in Pennsylvania, Dr. Duchin further describes how she would measure and display this concept. She states, "To illustrate Close-Votes-Close-Seats, Majority Rule, and other norms of partisan fairness, it is helpful to examine a plot that shows vote shares on one axis and seat outcomes on the other. A plan can be overlaid with a vote pattern to see how the seat share relates to the vote share for that election. Repeating this across a range of different kinds of elections provides a robust view of the performance of the plan. Majority Rule, then, translates to the idea that the Southeast and Northwest quadrants should be avoided" (pg. 14).[14]

[14] https://www.pacourts.us/Storage/media/pdfs/20220216/190511-feb.14,2022-exceptionswithbriefinsupportincorporated(govwolf).pdf, retrieved Feb 16, 2022.

With this in mind, Figure 2 produces the type of chart that Dr. Duchin describes. The left figure shows the results for the 2021 Enacted Congressional plan and the right panel shows the results for the 2022 Remedial Congressional plan. The horizontal axis of each chart measures the statewide vote share earned by the Democratic candidates for each of the 12 statewide elections discussed above. The vertical axis of each figure measure the proportion of districts where the Democratic candidate won a majority of the votes in that same election. In other words, this chart is measuring the degree to which statewide votes are translated to seats. Per Dr. Duchin's test, the "northwest" and "southeast" quadrants of this figure, colored in red, indicate outcomes that are anti-majoritarian, or places where a party wins a majority of the votes statewide but those votes are not translated into a majority of the seats.

In each figure there are 12 dots, one for each of the 12 statewide elections. We see that in the enjoined 2021 Enacted Congressional plan there are 4 points in the lower right panel representing anti-majoritarian outcomes. Furthermore, as one moves along the horizontal axis, the dots tend not to move upwards along the vertical axis, indicating a map that is not especially responsive to changes in voters' preferences.

The 2022 Remedial map is very different. Only 1 of the 12 points (Attorney General 2020) reside in the lower right quadrant where the Democratic candidate for office won a majority of the votes but those votes would not have translated into a majority of the seats. Notably, in this one election the Democratic candidate won with 50.13% of the vote.[15]

All of the remaining 11 elections produce majoritarian outcomes where a majority of votes statewide translate into a majority of the seats for Congress. These are the dots in the lower left (southwest) and upper right (northeast) quadrants of the figure.[16]

[15]The closeness of this race is reflected in the individual district calculations as well. The Republican candidate of Attorney General won District 13 and District 14 by less than one half of one percent of the two-party vote share. A shift of roughly 1,300 votes and 2,600 votes respectively would have thus flipped this election from an 8-R/6-D map to a 6-R/8-D map, which would also have made this election a "majoritarian" outcome in Figure 2.

[16]In my brief review of Dr. Duchin's report, differences in our close-votes-close seats analysis appear to be due to the selection of different elections to analyze.

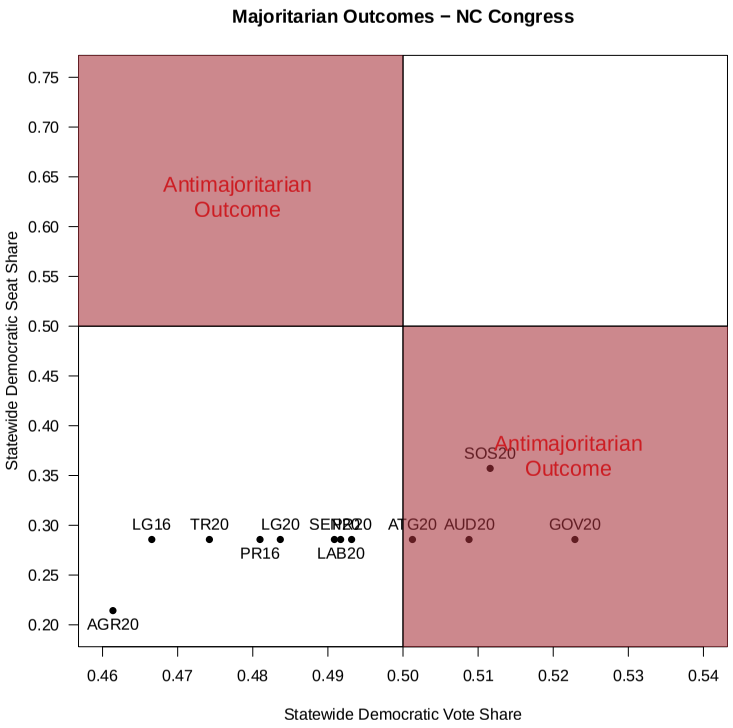
It is not expected that all of the points will fall outside of the red quadrants. As Dr. Duchin states, "It is not practicable to design a map that always attains these properties" (pg. 4, Duchin Report), however, the Remedial Congressional plan performs very well in that 11 of the 12 elections result in majoritarian outcomes.

Furthermore, the points in the 2022 Remedial Congressional plan exhibit a general upward slope, meaning that as a party wins more votes statewide their share of the seats based on those votes tends to likewise increase. This indicates a map that is more responsive to changes in voters' preferences.

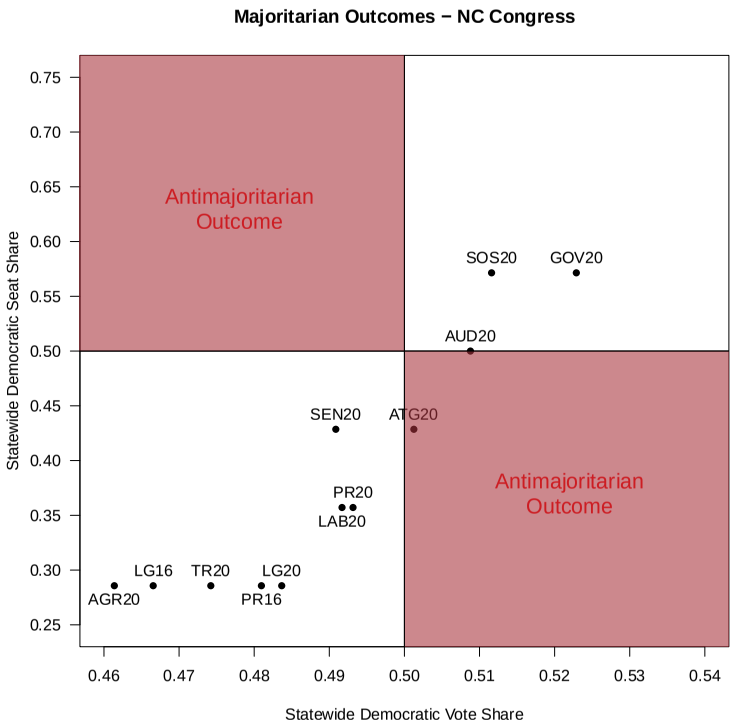
Figure 3 shows the same analysis for the Harper Plaintiffs' (left panel) and NCLCV Plaintiffs' (right panel) proposed Congressional maps. The Harper Congressional map contains no anti-majoritarian outcomes while the NCLCV Congressional plan contains two anti-majoritarian outcomes, both benefiting the Democratic Party (President 2020 and Labor Commissioner 2020, top left quadrant).

Figure 2: **Close-Votes-Close-Seats Analysis**

(a) 2021 Enacted Plan



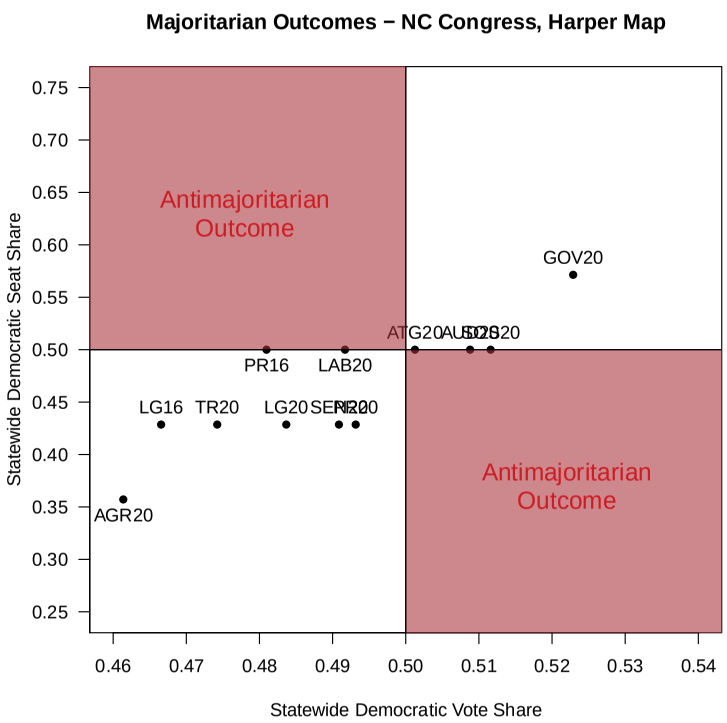
(b) 2022 Remedial Plan



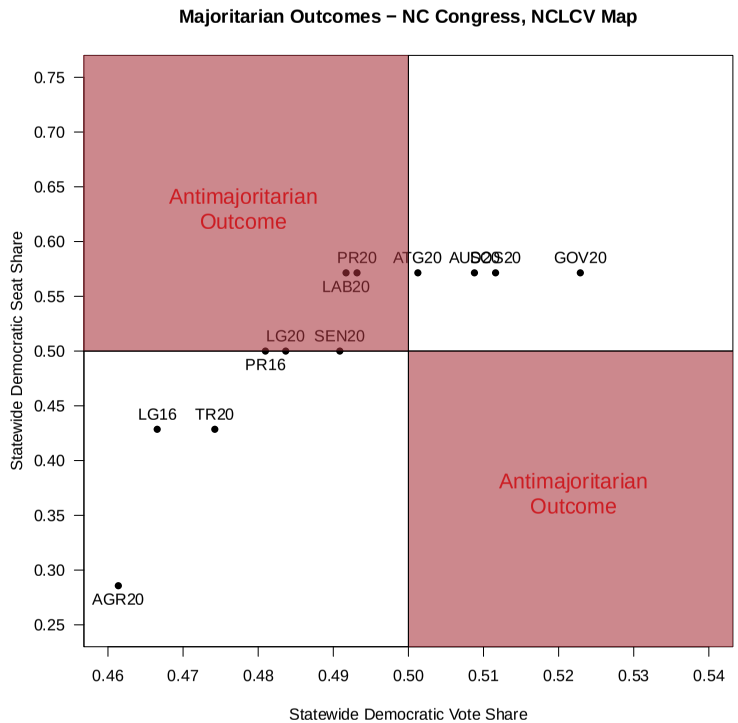
Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

Figure 3: **Close-Votes-Close-Seats Analysis, Plaintiff Proposals**

(a) Harper Plaintiffs Plan



(b) NCLCV Plaintiffs Plan



Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts. The left panel shows this for the Harper Plaintiffs proposed Congressional map. The right panel shows this for the NCLCV Plaintiffs' proposed Congressional map.

3.6 Partisan Symmetry

According to academic literature, the idea behind the concept of partisan symmetry is to attempt to measure whether a redistricting plan treats both parties equally. In his expert report in this case, Dr. Chen discusses this concept, stating: "Another common measure of partisan bias is based on the concept of partisan symmetry and asks the following question: Under a given districting plan and given a particular election-based measure of district partisanship, what share of seats would each party win in a hypothetical tied election (i.e., 50% vote share for each of two parties)" (pg. 46). This statement illustrates one of the key ideas of the concept of partisan symmetry - how seats are distributed across the two political parties in a hypothetical election in which both political parties receive 50% of the votes.

The concept, however, can be extended beyond an analysis of a 50/50 tie. More broadly, the concept of partisan symmetry implies that a particular vote share for Party A that yields a particular seat share for Party A should, in turn, produce roughly the same result for Party B.[17] In other words, if Republicans win 53% of the statewide vote and obtain 60% of the seats in a chamber, then partisan symmetry would suggest that if Democrats were to win 53% of the statewide vote, they should also win 60% of the seats.[18]

A common way academic studies measure partisan symmetry is by producing a seats-votes curve generated by a uniform partisan swing.[19] The basic idea is to look at the vote share in each district and increase/decrease the vote share in each district by a uniform amount across a range of outcomes. As you do this, we note the change in the number of districts won/lost by a party. What this produces is a figure where the horizontal axis shows the statewide vote share across a range of value and the vertical axis shows the proportion of districts carried by a party for each of the vote shares. Each point then shows the

[17] Nagle, John F., and Alec Ramsay. "On measuring two-party partisan bias in unbalanced states." Election Law Journal: Rules, Politics, and Policy 20, no. 1 (2021): 116-138.

[18] It is often the case that the party that wins a majority of the votes wins more than their proportion of votes in seats. This is referred to as the "winners bonus."

[19] See https://www.amacad.org/news/redistricting-and-representation for an example and explanation by Dr. Duchin.

translation of statewide votes (horizontal axis) to the statewide proportion of seats (vertical axis). Connecting these points creates what is called a seats-votes curve.

Under the partisan symmetry measure, a symmetric plan should exhibit two properties. First, the seats-votes curve should cross, or be very close to, the point (0.5, 0.5), which would indicate a plan where 50% of the votes statewide yields 50% of the seats statewide. Of course, not all plans will perfectly cross this point, but the further a seats-votes curve is from the 50/50 point, the less symmetric the plan is. Furthermore, the seats-votes curve should increase and decrease at roughly the same rate on either side of the 0.50 value. In other words, as Democrats gain more votes statewide, the translation of those votes to seats should be similar to when Republicans gain an equally large share of the votes.

Figure 4 shows the seats-votes curve from a uniform partisan swing for the Congressional maps. The left panel shows this for the 2021 Enacted Congressional map and the right panel shows this for the 2022 Remedial Congressional map. It is immediately apparent that the 2021 Enacted Congressional map is less symmetric than the 2022 Remedial Congressional map.

Each figure notes two important statistics. The first, seat bias at 50% vote, indicates the distance between 50% of the seats and the predicted seat share when the both parties obtain 50% of the votes. In the 2021 Enacted plan this value is 21.4%, or three seats in the 14 district plan. In other words, in the enjoined 2021 Enacted Congressional plan when Democrats win 50% of the vote we would have predicted that they would win 28.6% of the seats (4/14). The 2022 Remedial Congressional plan is much improved by this measure. Now when Democrats win 50% of the vote it is predicted that they will win 42.8% of the seats (6/14).

The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the enjoined 2021 Enacted Congressional plan this is 5.9%. In other words, we would expect Democrats to have to win 55.9% of the statewide vote before

they would receive 50% of the 14 seats in the congressional delegation. This statistic is also much improved in the 2022 Remedial Congressional plan. Here the vote bias for 50% of seats is 0.6%, meaning that we would expect Democrats to win 7 out of the 14 seats for Congress when they obtain 50.6% of the statewide vote.

The final thing to note in the partisan symmetry analysis is the overall trajectory of the seats-votes curves in each plot. The 2022 Remedial Congressional plan moves in a much smoother and symmetric manner from the bottom left to top right quadrants of the figure. This is not the case in the 2021 Enacted Congressional plan. Here the line is much less symmetric in these two quadrants. In the bottom left quadrant the line is relatively flat while in the top right quadrant the line is relatively steep. This would indicate asymmetry in a plan whereas the line in the 2022 Remedial plan is much more symmetric.

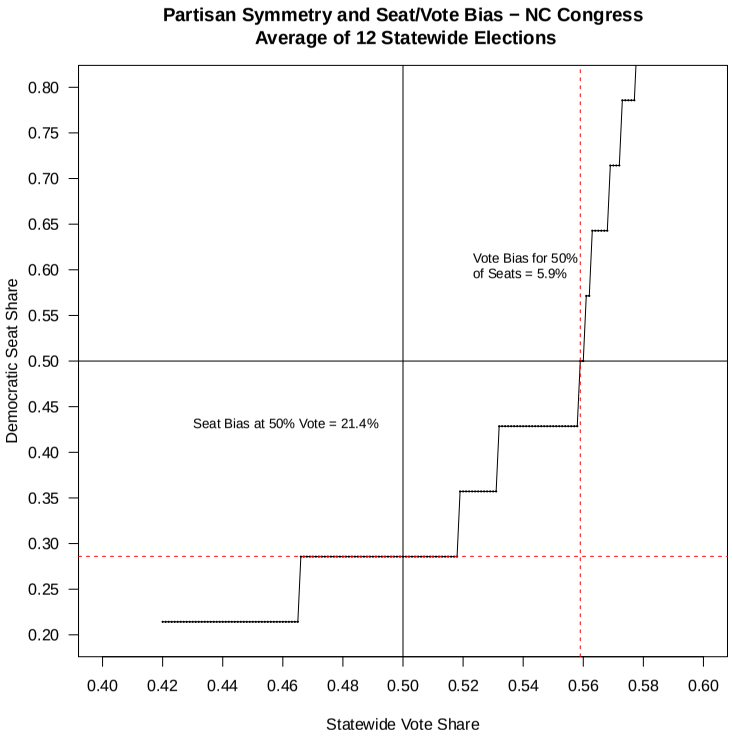
Figure 5 shows the seats-votes curve from a uniform partisan swing for the Congressional maps proposed by the Harper and NCLCV Plaintiffs. The left panel shows this for the Harper Plaintiffs' proposed Congressional map and the right panel shows this for the NCLCV Plaintiffs' Congressional map.

In the Harper Congressional proposal has a seat bias of 0%. The NCLCV Congressional proposal has a seat bias of -7.1%, or one seat in the 14 district plan. In other words, in the NCLCV Congressional proposal, when Democrats win 50% of the vote we would predict that they would win 57.1% of the seats (8/14).

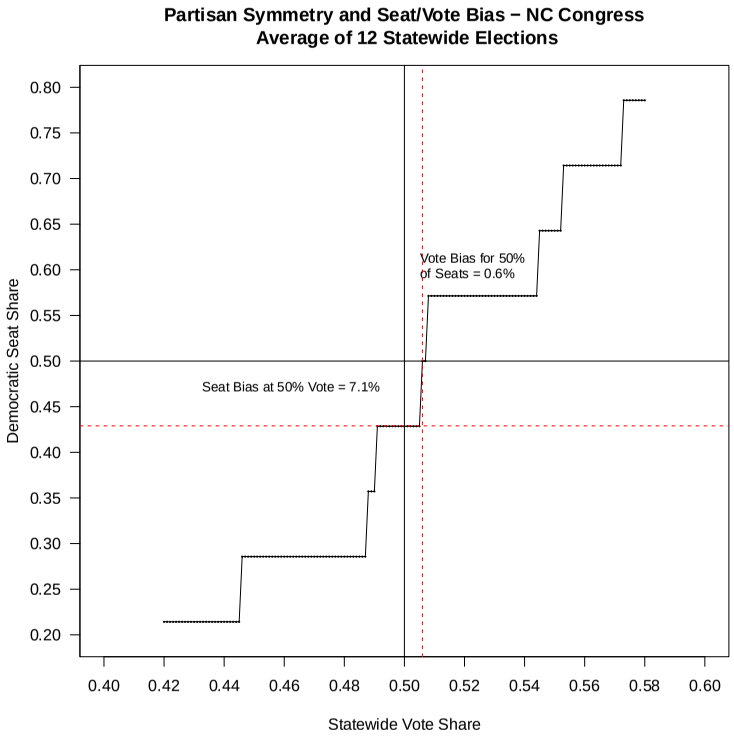
The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the Harper Plaintiffs' proposed Congressional plan this is -1.2%. In other words, we would expect Democrats to have to win 48.8% of the statewide vote in order to receive 50% of the 14 seats in the congressional delegation. In the NCLCV Congressional proposal the vote bias for 50% of seats is -2.4%, meaning that we would expect Democrats to win 7 out of the 14 seats for Congress when they obtain 47.6% of the statewide vote.

Figure 4: **Partisan Symmetry Analysis**

(a) 2021 Enacted Plan



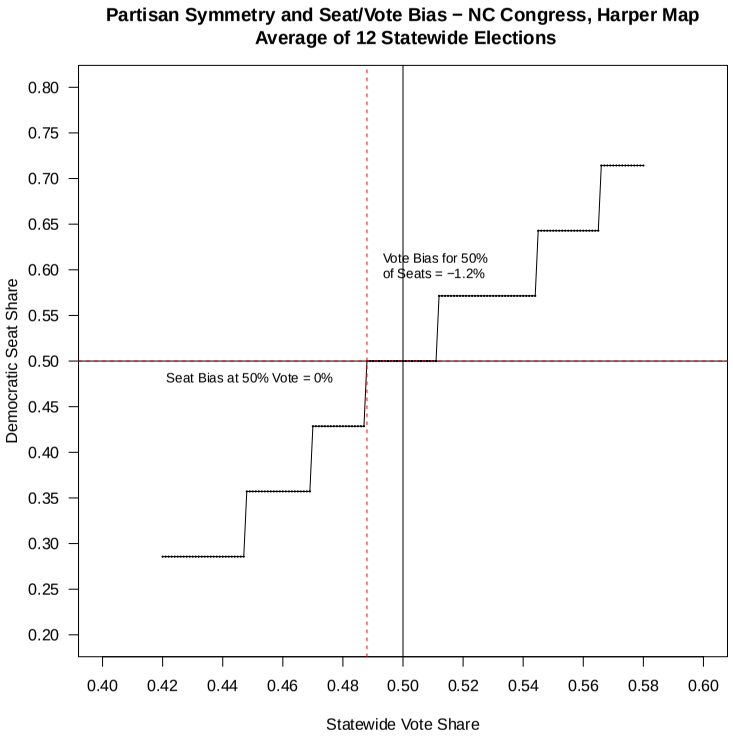
(b) 2022 Remedial Plan



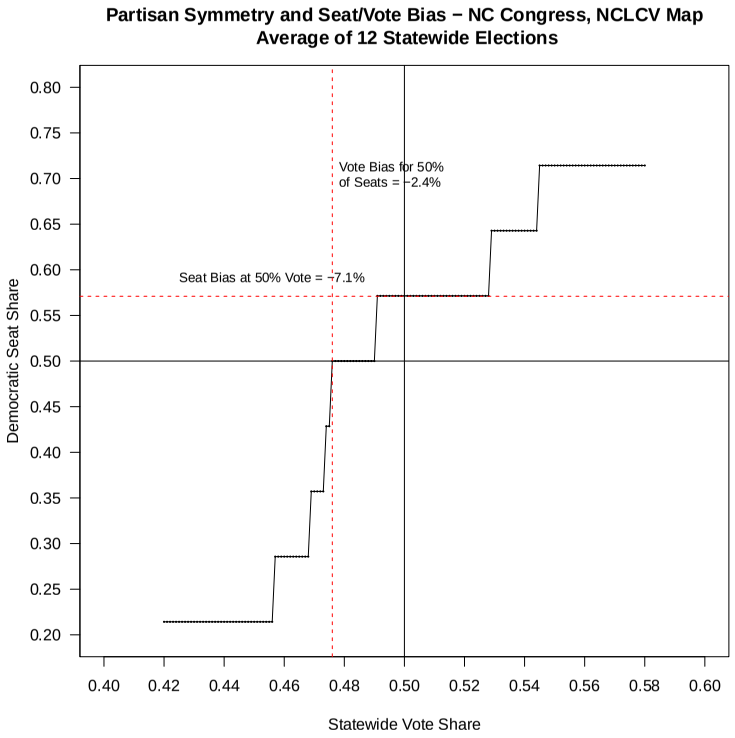
Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

Figure 5: **Partisan Symmetry Analysis, Plaintiff Proposals**

(a) Harper Plaintiffs Plan



(b) NCLCV Plaintiffs Plan



Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares. The left panel shows this for the Harper Plaintiff's proposed map. The right panel shows this for the NCLCV Plaintiff's proposed map.

4 Conclusion for Congressional Plan

Overall, the 2022 Remedial plan for North Carolina's congressional districts is an improvement over the 2021 Enacted Congressional plan on the four measures outlined by the Court. The Remedial plan is within the Court's thresholds on the median-mean (-0.61%) and efficiency gap (-5.29%) measures.

The Harper Plaintiffs' Congressional plan is likewise within the Court's thresholds on median-mean (0.04) and efficiency gap (1.03), while the NCLCV Plaintiffs' Congressional plan is outside the bounds set by the Court on these measures (median-mean=1.65, efficiency gap=7.92).

The Remedial Congressional plan produces majoritarian outcomes in 11 of the 12 elections considered in the close-votes-close-seats analysis and the plan is much more responsive and symmetric in the seats-votes curves that measure partisan symmetry. The Harper plan produces majoritarian outcomes in 12 of the 12 elections considered in the close-votes-close-seats analysis. The NCLCV plan produces majoritarian outcomes in 10 of the 12 elections considered in the close-votes-close-seats analysis.

5 State House Plan

5.1 Partisan Lean of Districts

Figure 6 shows the partisan lean for each of the 120 seats in the 2022 Remedial House plan for the North Carolina House of Representatives. Districts are ordered from least Democratic-leaning at the bottom to most Democratic-leaning at the top. Districts with a partisan index less than 0.50 (i.e. Republican-leaning) are shown as squares and districts with a partisan index greater than 0.50 (i.e. Democratic-leaning) are displayed as triangles.

Of the 120 districts in the 2022 Remedial House plan, there are 63 districts with an index less than 0.50 (Republican-leaning, shown as squares) and 57 districts with an index greater than 0.50 (Democratic-leaning shown as triangles). A vertical dashed line is placed at 0.50 in the figure for reference. In the now-enjoined 2021 Enacted House plan there were 70 Republican-leaning districts and 50 Democratic leaning districts.

The grey horizontal lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. As can be seen by the width of the grey horizontal bars in each district, there is substantial variation across the 12 elections. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. I call these districts safely partisan since in all 12 of the statewide races the same party won a majority of votes. Districts where the grey horizontal lines cross the 0.50 vertical line indicate districts where both parties have won a majority of the votes in that district. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

Looking at the range across the index, there are 55 districts colored red (reliably Republican) in the figure, 42 blue districts (reliable Democratic), and 23 green districts

(competitive) in the House map. Using an alternative definition of competitiveness based on the closeness of the index to 0.50, there are 59 districts with an index less than 0.48, 12 districts between 0.48 and 0.52 (a commonly used range to define hyper-competitive seats), and 49 districts with an index of greater than 0.52.

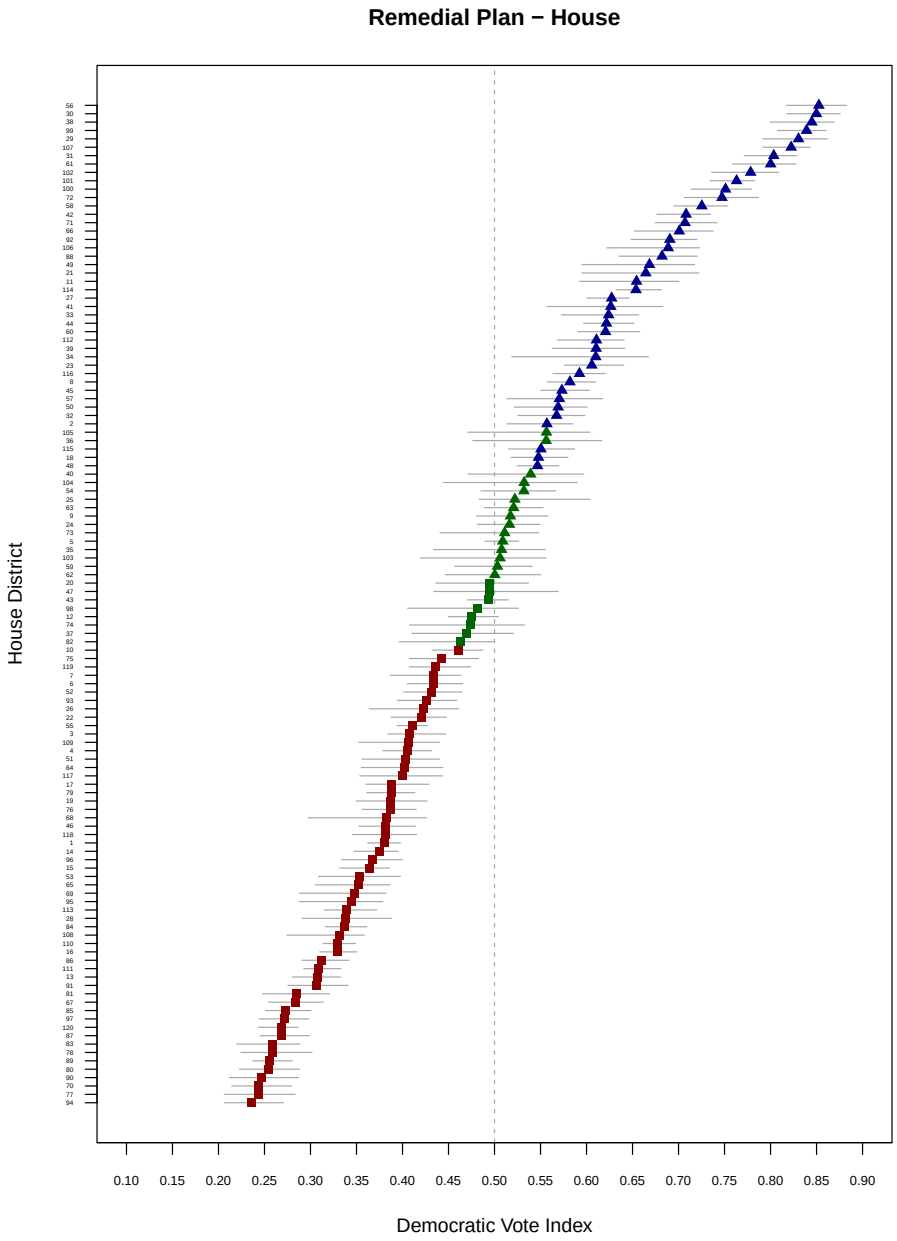


Figure 6: **Partisan Index of House Districts in 2022 Remedial plan:** Partisan Index based on the average of 12 statewide partisan races between 2016-2020. Districts with a partisan index less than .50 (i.e. Republican leaning) are shown as squares and districts with a partisan index greater than .50 (i.e. Democratic leaning) are displayed as triangles. A vertical dashed line is placed at .50 in each panel for reference. The grey lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

5.2 Median-Mean Measure

Using the 12 statewide elections described above, the proposed 2022 Remedial House map has a median-mean value of -0.70%. This value is within the ±1% standard outlined by the Court's ruling. Using the same data and method, the 2021 Enacted House plan had a median-mean measure of -3.36%.[20]

Using the 12 statewide elections described above, the NCLCV Plaintiffs' proposed House map has a median-mean value of -1.22%. This value is outside the ±1% standard outlined by the Court's ruling. The Harper Plaintiffs did not submit a proposed House map.[21]

5.3 Efficiency Gap Measure

Using the 12 statewide elections described above, the proposed 2022 Remedial House map has an efficiency gap value of -0.84%. This value is within the ±7% standard outlined by the Court's ruling. Using the same data and method, the 2021 Enacted House plan had an efficiency gap measure of -7.16%.[22]

Using the 12 statewide elections described above, the NCLCV Plaintiffs' proposed House map has an efficiency gap value of -1.43%. This value is within the ±7% standard outlined by the Court's ruling. The Harper Plaintiffs did not submit a proposed House map.[23]

[20] Using the 16 elections in the Harper Plaintiff's most recent report, the remedial House plan has an median-mean value of -0.92%, which is also within the threshold outlined by the Court.

[21] Using the 16 elections in the Harper Plaintiffs' most recent report, the NCLCV House proposal has a median-mean value of -1.21%, which is outside of the threshold set by the Court.

[22] Using the 16 elections in the Harper Plaintiff's most recent report, the remedial House plan has an efficiency gap value of -2.9%, which is also within the threshold outlined by the Court.

[23] Using the 16 elections in the Harper Plaintiffs' most recent report, the NCLCV House proposal has an efficiency gap value of -2.16%.

5.4 Close Votes, Close Seats

Figure 7 shows the close-votes-close-seats analysis for both the enjoined 2021 Enacted House plan and the 2022 Remedial House plan. The left figure shows the results for the 2021 Enacted House plan and the right panel shows the results for the 2022 proposed Remedial House plan. The horizontal axis of each chart measures the statewide vote share earned by the Democratic candidates for each of the 12 statewide elections discussed above. The vertical axis of each chart measures the proportion of districts where the Democratic candidate won a majority of the votes in that same election. in other words, this chart is measuring the degree to which statewide votes are translated to seats. The "northwest" and "southeast" quadrants, colored in red, indicate outcomes that are anti-majoritarian, or places where a party wins a majority of the votes statewide but those votes are not translated into a majority of the seats.

In each figure there are 12 dots, one for each of the 12 statewide elections. We see that in the 2021 Enacted House plan there are 4 points in the lower right panel representing anti-majoritarian outcomes. The 2022 Remedial House map is very different. Only 1 of the 12 points (Attorney General 2020) resides in the lower right quadrant where the Democratic candidate for office won a majority of the votes but those votes would not have translated into a majority of the seats. Notably, in this election the Democratic candidate won with only 50.13% of the vote.

All of the remaining 11 elections produce majoritarian outcomes where a majority of votes statewide translate into a majority of the seats in the House. These are the dots in the lower left (southwest) and upper right (northeast) quadrants of the figure.

It is not expected that all of the points will fall outside of the red quadrants. As Dr. Duchin states, "It is not practicable to design a map that always attains these properties" (pg. 4, Duchin Report), however, the 2022 Remedial House plan performs very well in that 11 of the 12 elections result in majoritarian outcomes.

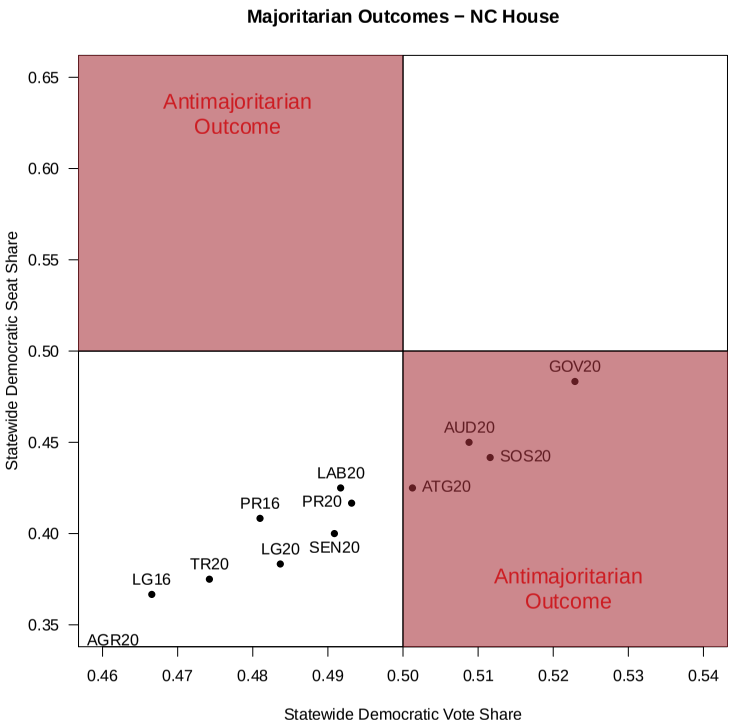
Furthermore, the points in the 2022 Remedial plan exhibit a general upward slope,

meaning that as a party wins more votes statewide their share of the seats based on those votes tends to likewise increase. This indicates a map that is more responsive to changes in voters' preferences.

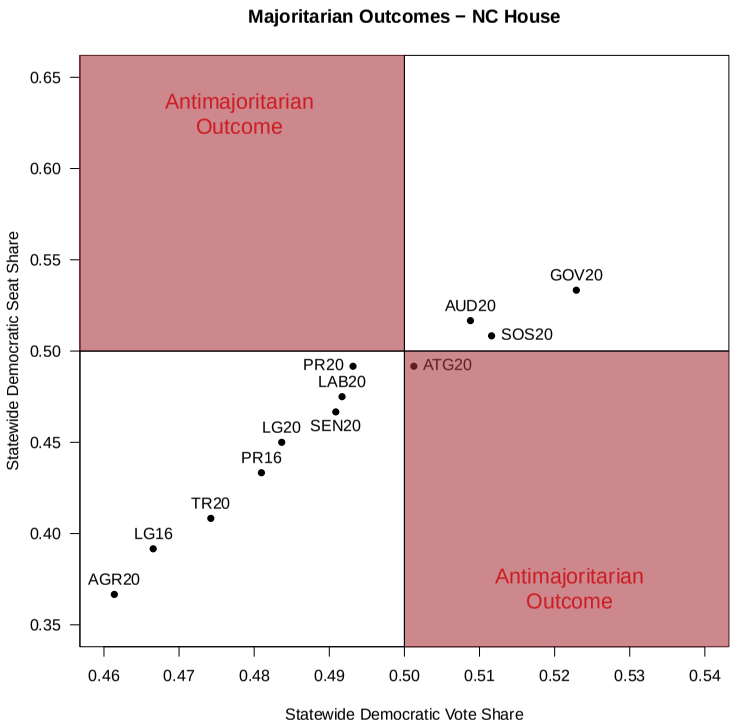
Figure 8 shows the same analysis for the NCLCV Plaintiffs' proposed House map. The Harper Plaintiffs did not submit a proposed House map. 1 of the 12 points (Attorney General 2020) resides in the lower right quadrant where the Democratic candidate for office won a majority of the votes but those votes would not have translated into a majority of the seats. Notably, in this election the Democratic candidate won with only 50.13% of the vote. This is the same election that produces an anti-majoritarian outcome in the 2022 Remedial Plan, shown in Figure 7.

Figure 7: **Close-Votes-Close-Seats Analysis**

(a) 2021 Enacted Plan

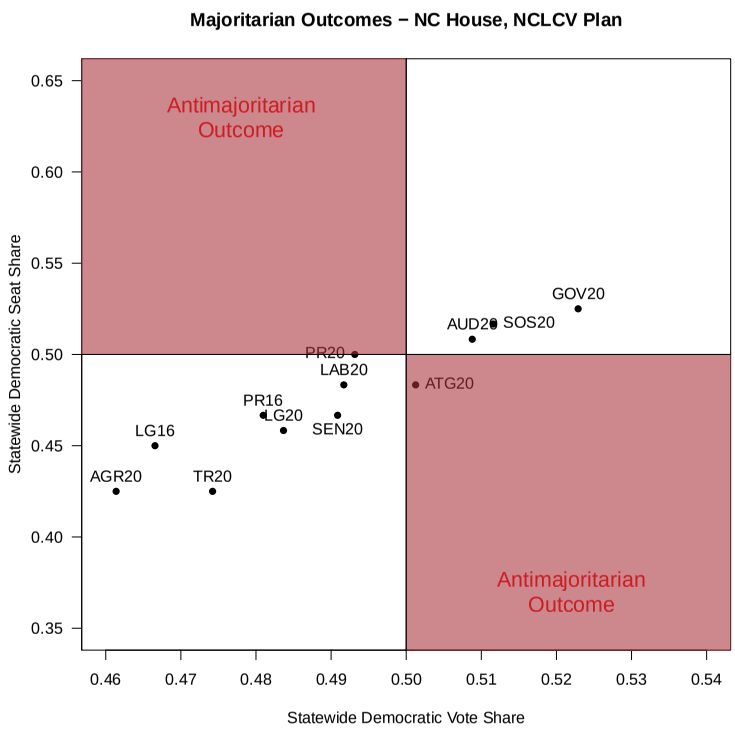


(b) 2022 Remedial plan



Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

Figure 8: **Close-Votes-Close-Seats Analysis, NCLCV Plaintiff Proposal**



Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts.

5.5 Partisan Symmetry

Figure 9 shows the seats-votes curve from a uniform partisan swing for the state House maps. The left panel shows this for the 2021 Enacted House map and the right panel shows this for the 2022 Remedial House map. It is immediately apparent that the 2021 Enacted House map is less symmetric than the 2022 Remedial House map.

Each figure notes two important statistics. The first, seat bias at 50% vote, indicates the distance between 50% of the seats and the predicted seat share when the both parties obtain 50% of the votes. In the 2021 Enacted plan this value is 7.5%. In other words, in the 2021 Enacted House plan when Democrats win 50% of the vote we would predict that they would win 42.5% of the seats. The 2022 Remedial House plan is much improved on the partisan symmetry metric. Now when Democrats win 50% of the vote it is predicted that they will win 50% of the seats.

The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the 2021 Enacted House plan this is 3.1%. In other words, we would expect Democrats to have to win 53.1% of the statewide vote before they would receive 50% of the seats in the state House. This statistic is also much improved in the 2022 Remedial House plan. Here the vote bias for 50% of seats is -0.2%, meaning that we would expect Democrats to win 60 out of the 120 seats in the chamber when they obtain 49.8% of the statewide vote.

The final thing to note is the overall trajectory of the seats-votes curves in each plot. The 2022 Remedial House plan moves in a much smoother and symmetric manner from the bottom left to top right quadrants of the figure. This is not the case in the 2021 Enacted House plan, where the line is much less symmetric in these two quadrants. The 2022 Remedial House plan also passes exactly through the 50/50 point at the middle of the graph.

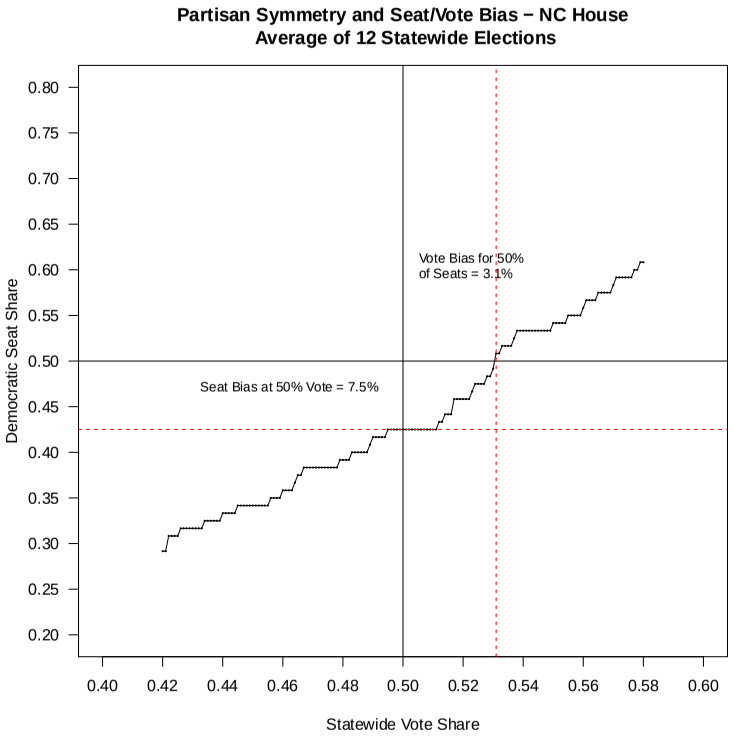
Figure 10 shows the seats-votes curve from a uniform partisan swing for the state

House maps proposed by the NCLCV Plaintiffs. In this proposal the seat bias at 50% vote value is 0.8%. In other words, in the NCLCV proposed House plan when Democrats win 50% of the vote we would predict that they would win 49.2% of the seats.

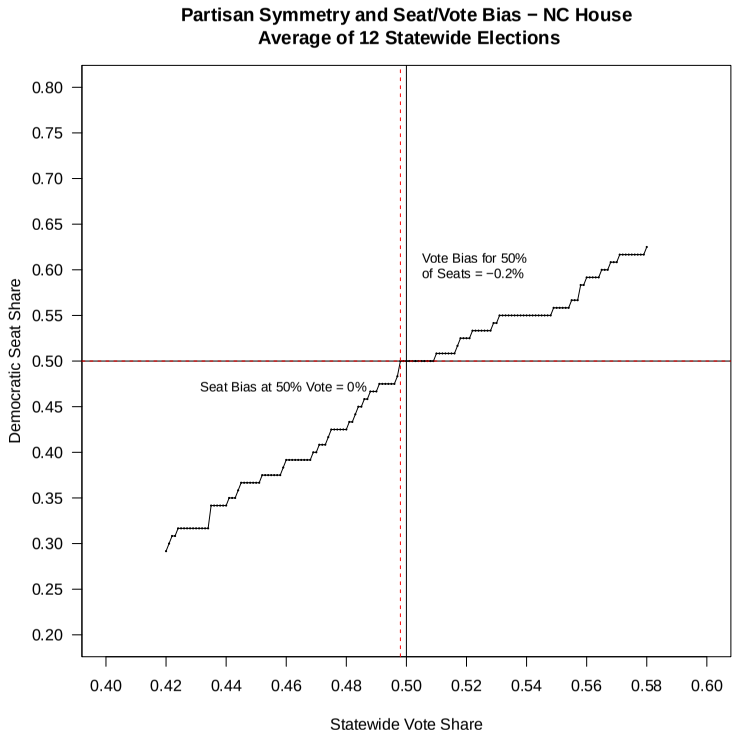
The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the NCLCV proposed House plan this is 0.5%. In other words, we would expect Democrats to have to win 50.5% of the statewide vote before they would receive 50% of the seats in the state House.

Figure 9: **Partisan Symmetry Analysis**

(a) 2021 Enacted Plan

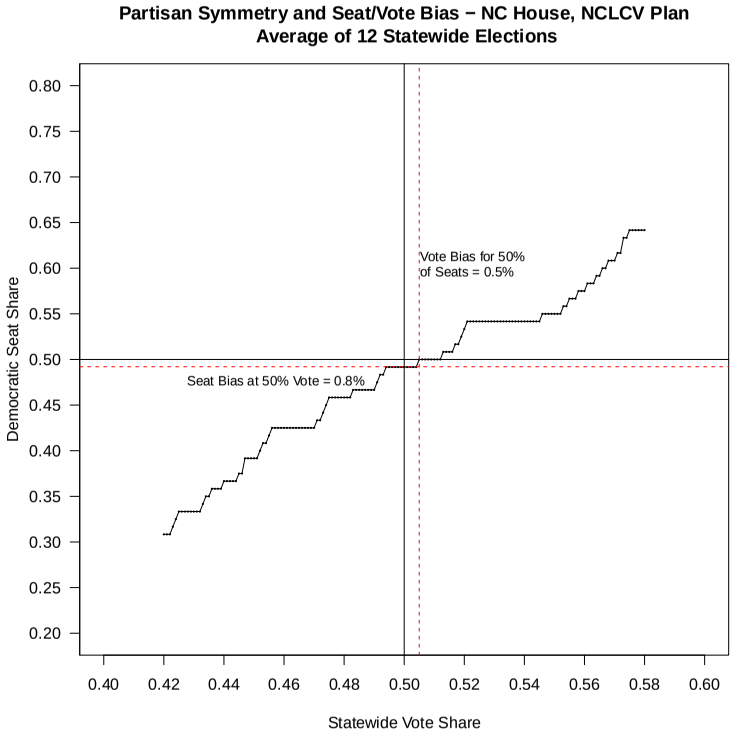


(b) 2022 Remedial plan



Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

Figure 10: **Partisan Symmetry Analysis, NCLCV Plaintiffs Proposal**



Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares.

5.6 Considerations of Race

During the trail court hearing various plaintiffs discussed the racial composition of House districts, the presence or absence of racially polarized voting, and the thresholds necessary for Black voters to elect the candidates of their choice. Table 1 below shows the Black voting age population percent for districts with Black incumbents for the districts used in the 2018 election cycle, the 2020 election cycle, the enjoined 2021 Enacted House districts, and the 2022 Remedial plan.

6 Conclusion for North Carolina House Plan

Overall, the 2022 Remedial plan for North Carolina's state House districts is an improvement over the 2021 Enacted House plan on the four measures outlined by the Court. The Remedial House plan is within the Court's thresholds on the median-mean (-0.70%) and efficiency gap (-0.84%) measures.

The NCLCV Plaintiiffs' proposed plan is outside the Court's thresholds on the median-mean (-1.22%) and is within the Court's thresholds on the efficiency gap measure (-1.43%). The Harper Plaintiffs did not submit a proposed House map.

The Remedial House plan produces majoritarian outcomes in 11 of the 12 elections considered in the close-votes-close-seats analysis and the plan is responsive and symmetric using the seats-votes curve to measure partisan symmetry. The NCLCV Plaintiffs' proposed plan also produces majoritarian outcomes in 11 of the 12 elections considered.

Table 1: BVAP for House Districts with Black Incumbents

Incumbent	2018 District	2018 District %BVAP	Incumbent	2020 District	2020 District %BVAP	SL-2021-175 District	SL-2021-175 %BVAP	2022 Remedial District	2022 Remedial District %BVAP
Hunter	5	44.32%	Hunter	5	42.23%	5	38.59%	5	38.59%
Smith, K.	8	44.85%	Smith, K.	8	43.74%	8	45.45%	8	38.13%
Smith, R.	21	39.00%	Smith, R.	21	38.68%	10	34.27%	10	34.37%
Willingham	23	51.83%	Willingham	23	51.53%	23	53.41%	23	53.41%
Cooper-Suggs	24	38.11%	Cooper-Suggs	24	39.14%	24	37.52%	24	38.50%
Gailliard	25	40.73%	Gailliard	25	43.63%	25	41.00%	25	39.97%
Alston	29	37.49%	Alston	29	38.43%	29	39.58%	29	31.03%
Hawkins	31	49.56%	Hawkins	31	41.29%	31	39.72%	31	45.63%
Garrison	32	49.12%	Garrison	32	49.17%	32	43.24%	32	43.36%
Gill	33	44.18%	Gill	33	41.48%	33	30.91%	33	34.01%
Batch	37	14.34%							
Hulley	38	48.30%	Jones, A.	38	41.46%	38	45.44%	38	43.91%
			Roberson	39	37.83%	39	33.04%	39	33.65%
Lucas	42	42.23%	Lucas	42	40.97%	42	40.97%	42	41.97%
Floyd	43	49.96%							
Pierce	48	36.13%	Pierce	48	37.09%	48	37.09%	48	37.09%
Reives	54	15.74%	Reives	54	13.56%	54	11.60%	54	11.60%
Quick	58	42.66%	Quick	58	44.95%	58	44.65%	58	48.38%
Brockman	60	40.06%	Brockman	60	35.86%	60	36.15%	60	34.68%
Terry	71	36.56%	Terry	71	42.04%	71	41.19%	71	34.81%
Montgomery	72	47.51%	Baker, A.	72	35.76%	72	34.96%	72	40.46%
Beasley	92	30.16%	Brown	92	42.04%	92	40.82%	92	34.38%
Majeed	99	49.54%	Majeed	99	37.71%	99	48.91%	99	48.75%
Logan	101	50.82%	Logan	101	49.89%	101	48.79%	101	53.42%
Lofton	104	6.22%	Lofton	104	12.76%	104	9.10%	104	9.76%
Cunningham	106	38.00%	Cunningham	106	48.48%	106	45.47%	106	37.58%
Alexander	107	49.39%	Alexander	107	55.65%	107	49.16%	107	59.22%

Note: BVAP percents are "% any part Black."

7 State Senate Plan

7.1 Partisan Lean of Districts

Figure 11 shows the partisan lean based on the index of statewide elections for each of the 50 seats in the 2022 Remedial plan for the North Carolina Senate. Districts are ordered from least Democratic-leaning at the bottom to most Democratic-leaning at the top. Districts with a partisan index less than 0.50 (i.e. Republican-leaning) are shown as squares and districts with a partisan index greater than 0.50 (i.e. Democratic-leaning) are displayed as triangles.

Of the 50 districts there are 28 districts with an index less than 0.50 (Republican-leaning, shown as squares) and 22 districts with an index greater than 0.50 (Democratic-leaning shown as triangles). A vertical dashed line is placed at 0.50 in the figure for reference. In the now-enjoined 2021 Enacted plan there were 30 Republican-leaning districts and 20 Democratic leaning districts.

The grey horizontal lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. As can be seen by the width of the grey horizontal bars in each district, there is substantial variation across the 12 elections. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. I call these districts safely partisan since in all 12 of the statewide races the same party won a majority of votes. Districts where the grey horizontal lines cross the 0.50 vertical line indicate districts where both parties have won a majority of the votes in that district. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

Looking at the range across the index, there are 24 districts colored red (reliably Republican) in the figure, 18 blue districts (reliable Democratic), and 8 green districts (com-

petitive) in the Remedial Senate map. Using an alternative definition of competitiveness based on the closeness of the index to 0.50, there are 25 districts with an index less than 0.48, 6 districts between 0.48 and 0.52 (a commonly used range to define hyper-competitive seats), and 19 districts with an index of greater than 0.52.

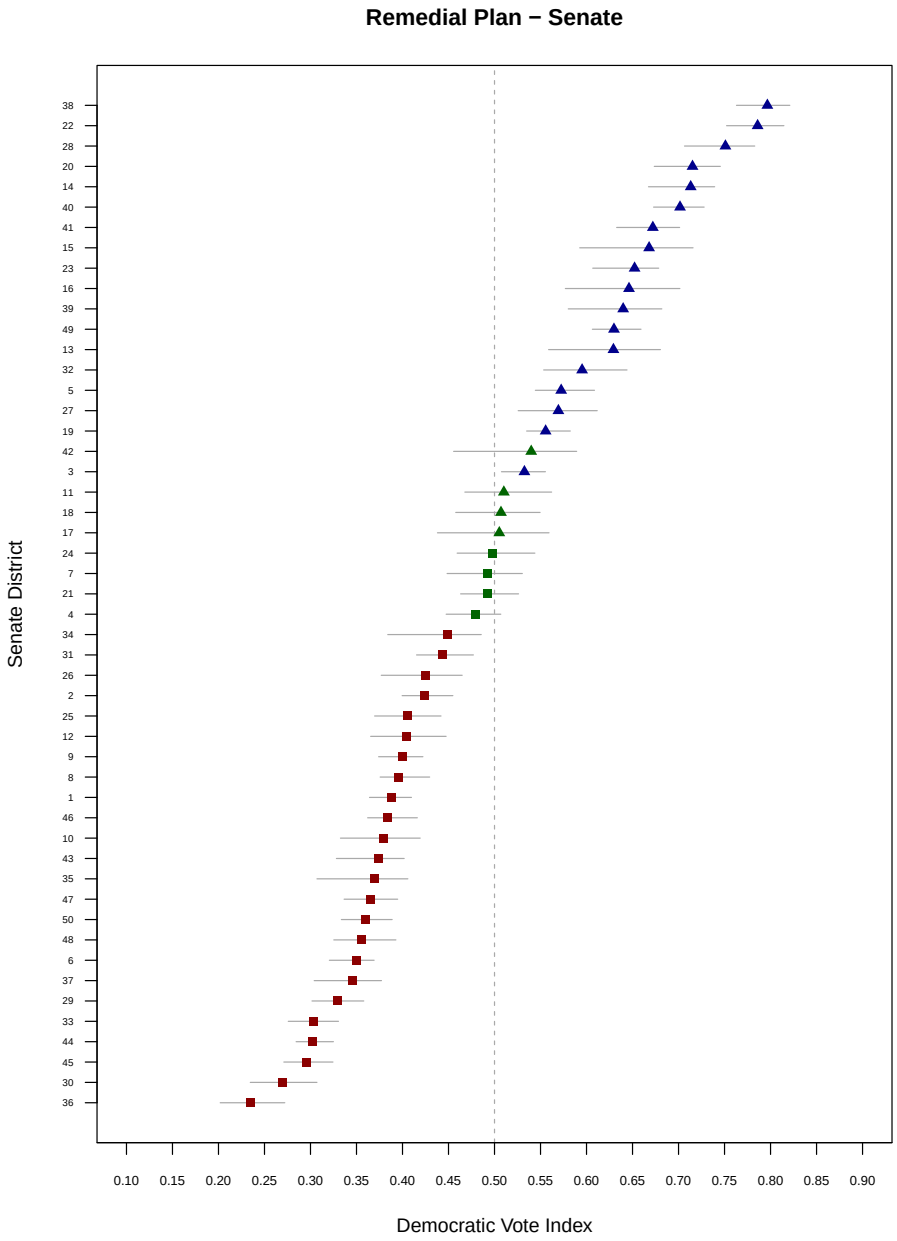


Figure 11: **Partisan Index of Senate Districts in 2022 Remedial plan:** Partisan Index based on the average of 12 statewide partisan races between 2016-2020. Districts with a partisan index less than .50 (i.e. Republican leaning) are shown as squares and districts with a partisan index greater than .50 (i.e. Democratic leaning) are displayed as triangles. A vertical dashed line is placed at .50 in each panel for reference. The grey lines around each point show the range of election outcomes for all of the 12 statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored red while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all 12 races are colored blue. Districts where both parties have won a majority of the two-party vote share in these 12 races are colored green.

7.2 Median-Mean Measure

Using the 12 statewide elections described above, the proposed 2022 Remedial Senate map has a median-mean value of -0.65%. This value is within the ±1% standard outlined by the Court's ruling. Using the same data and method, the now-enjoined 2021 Enacted Senate plan had a median-mean measure of -3.49%.[24]

Using the 12 statewide elections described above, the Harper Plaintiffs' Senate map has a median-mean value of 0.17%. This value is within the ±1% standard outlined by the Court's ruling. Using the same data and method, the NCLCV Plaintiffs' Senate plan has a median-mean measure of 0.34%. This is also within the ±1% threshold outlined by the Court.[25]

7.3 Efficiency Gap Measure

Using the 12 statewide elections described above, the proposed 2022 Remedial Senate plan has an efficiency gap value of -3.97%. This value is within the ±7% standard outlined by the Court's ruling. Using the same data and method, the now enjoined 2021 Enacted Senate plan had an efficiency gap value of -8.04%.[26]

Using the 12 statewide elections described above, the Harper Plaintiffs' proposed Senate map has an efficiency gap value of -3.64%. This value is within the ±7% standard outlined by the Court's ruling. Using the same data and method, the NCLCV Plaintiffs' proposed Senate plan has an efficiency gap value of 0.03%, which is also within the thresholds set by the Court.[27]

[24] Using the 16 elections in the Harper Plaintiff's most recent report, the remedial Senate plan has a median-mean value of -0.61%, which is also within the threshold outlined by the Court.

[25] Using the 16 elections in the Harper Plaintiffs' most recent report, the Harper Senate proposal has a median-mean value of 0.11% and the NCLCV Senate proposal has a median-mean value of 0.45%.

[26] Using the 16 elections in the Harper Plaintiff's most recent report, the remedial Senate plan has an efficiency gap value of -4.28%, which is also within the threshold outlined by the Court.

[27] Using the 16 elections in the Harper Plaintiffs' most recent report, the Harper Senate proposal has an efficiency gap value of -1.95% and the NCLCV Senate proposal has an efficiency gap value of -0.45%.

7.4 Close Votes, Close Seats

Figure 12 shows the close-votes-close-seats analysis for the Senate plan. The left figure shows the results for the 2021 Enacted Senate plan and the right panel shows the results for the 2022 proposed Remedial Senate plan. The horizontal axis of each chart measures the statewide vote share earned by the Democratic candidates for each of the 12 statewide elections discussed above. The vertical axis of each chart measures the proportion of districts where the Democratic candidate won a majority of the votes in that same election. In other words, this chart is measuring the degree to which statewide votes are translated to seats. The "northwest" and "southeast" quadrants, colored in red, indicate outcomes that are anti-majoritarian, or places where a party wins a majority of the votes statewide but those votes are not translated into a majority of the seats.

In each figure there are 12 dots, one for each of the 12 statewide elections. We see that in the 2021 Enacted Senate plan there are 4 points in the lower right panel representing anti-majoritarian outcomes. The 2022 Remedial Senate map is very different. Only 1 of the 12 points (Attorney General 2020) reside in the lower right quadrant where the Democratic candidate for office one a majority of the votes but those votes would not have translated into a majority of the seats. Notably, in this election the Democratic candidate won with only 50.13% of the vote.

All of the remaining 11 elections produce majoritarian outcomes where a majority of votes statewide translate into a majority of the seats for the state Senate (the Governor 2020 race produces a 25/25 tie). These are the dots in the lower left (southwest) and upper right (northeast) quadrants of the figure.

It is not expected that all of the points will fall outside of the red quadrants. As Dr. Duchin states, "It is not practicable to design a map that always attains these properties" (pg. 4, Duchin Report), however, the 2022 Remedial plan performs very well in that 11 of the 12 elections result in majoritarian outcomes.

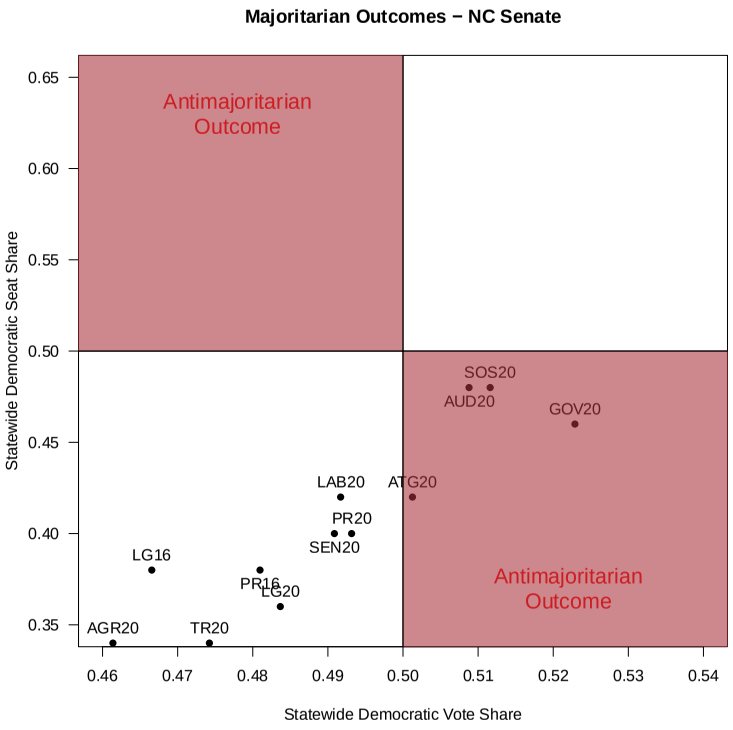
Furthermore, the points in the 2022 Remedial plan exhibit a general upward slope,

meaning that as a party wins more votes statewide their share of the seats based on those votes tends to likewise increase. This indicates a map that is more responsive to changes in voters' preferences.

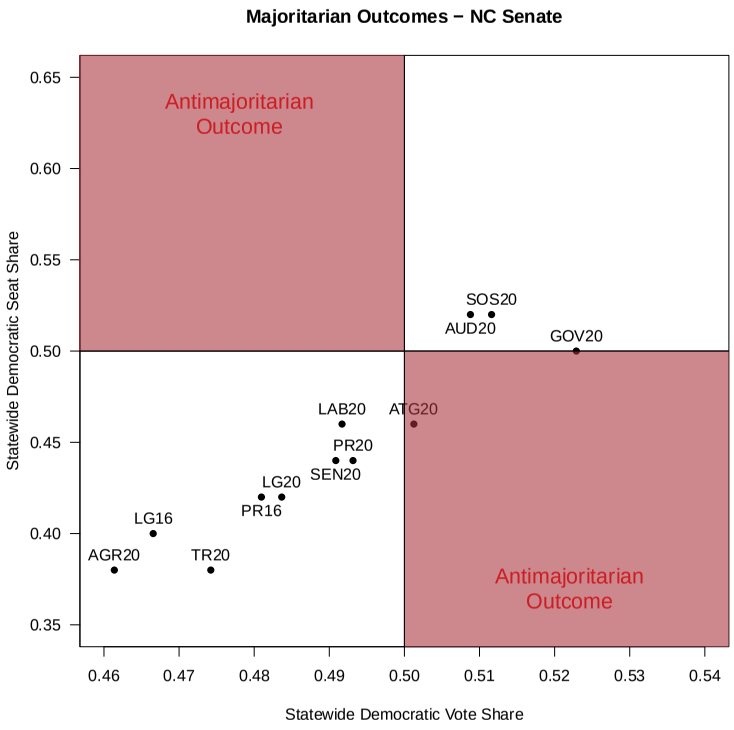
Figure 13 shows the same analysis for the Harper Plaintiffs' (left panel) and NCLCV Plaintiffs' (right panel) proposed Senate maps. The Harper Senate map contains 1 anti-majoritarian outcome (Attorney General 2020 election) while the NCLCV Senate plan contains no anti-majoritarian outcomes.

Figure 12: **Close-Votes-Close-Seats Analysis**

(a) 2021 Enacted Plan



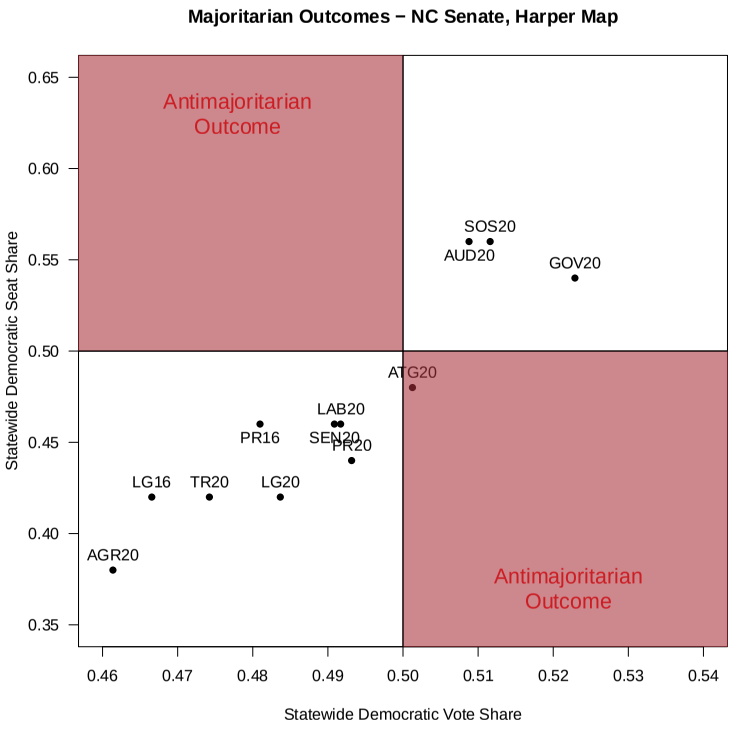
(b) 2022 Remedial plan



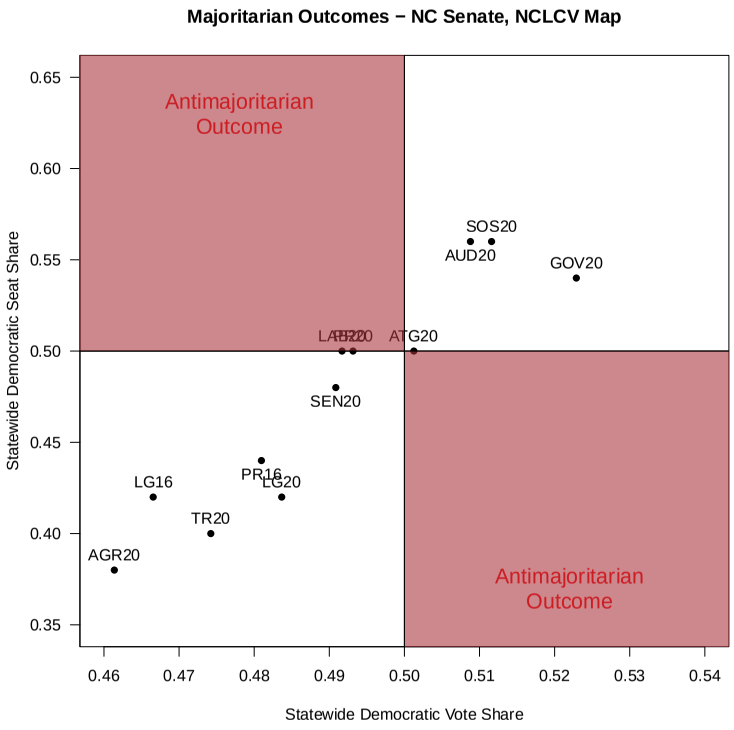
Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

Figure 13: **Close-Votes-Close-Seats Analysis**

(a) Harper Plaintiffs Plan



(b) NCLCV Plaintiffs Plan



Note: Each dot in the figure is a statewide election. The horizontal axis shows the Democratic vote share in each election. The vertical axis shows the proportion of districts that would be won when statewide votes are disaggregated across districts. The left panel shows this for the Harper Plaintiffs' proposed map. The right panel shows this for the NCLCV Plaintiffs' proposed map.

7.5 Partisan Symmetry

Figure 14 shows the seats-votes curve from a uniform partisan swing for the state Senate maps. The left panel shows this for the 2021 Enacted Senate map and the right panel shows this for the 2022 Remedial Senate map. It is immediately apparent that the 2021 Enacted Senate map is less symmetric than the 2022 Remedial Senate map.

Each figure notes two important statistics. The first, seat bias at 50% vote, indicates the distance between 50% of the seats and the predicted seat share when the both parties obtain 50% of the votes. In the 2021 Enacted Senate plan this value is 6%. In other words, in the 2021 Enacted Senate plan when Democrats win 50% of the vote we would predict that they would win 44% of the seats. The 2022 Remedial Senate plan is much improved on this measure. Now when Democrats win 50% of the vote it is predicted that they will win 50% of the seats.

The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the 2021 Enacted Senate plan this is 2.9%. In other words, we would expect Democrats to have to win 52.9% of the statewide vote before they would receive 50% of the seats in the state Senate. This statistic is also much improved in the 2022 Remedial Senate plan. Here the vote bias for 50% of seats is exactly 0%, meaning that we would expect Democrats to win 25 out of the 50 seats in the chamber when they obtain 50% of the statewide vote.

The final thing to note is the overall trajectory of the seats-votes curves in each plot. The 2022 Remedial Senate plan moves in a much smoother and symmetric manner from the bottom left to top right quadrants of the figure. This is not the case in the 2021 Enacted Senate plan. Here the line is much less symmetric in these two quadrants. In the bottom left quadrant the line is relatively flat while in the top right quadrant the line is relatively steep. This would indicate asymmetry in a plan whereas the line in the 2022 Remedial Senate plan is much more symmetric and passes exactly through the 50/50 point at the middle of the

graph.

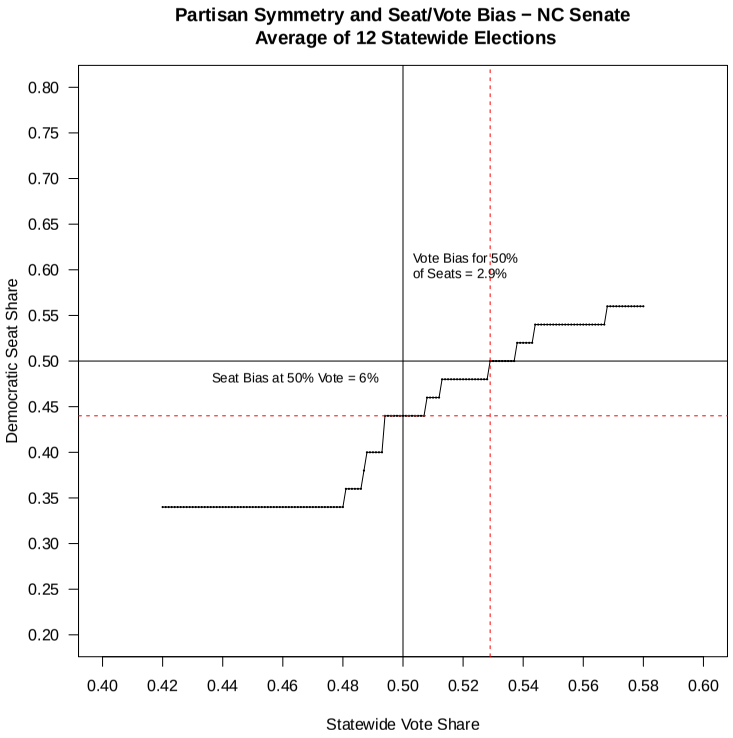
Figure 15 shows the seats-votes curve from a uniform partisan swing for the Senate maps proposed by the Harper and NCLCV Plaintiffs. The left panel shows this for the Harper Plaintiffs' proposed Senate map and the right panel shows this for the NCLCV Plaintiffs' Senate map.

In the Harper Senate proposal has a seat bias of -2%. The NCLCV Senate proposal has a seat bias of -2%. In other words, in both the Harper and the NCLCV Senate proposals, when Democrats win 50% of the vote we would predict that they would win 52% of the seats (26/50).

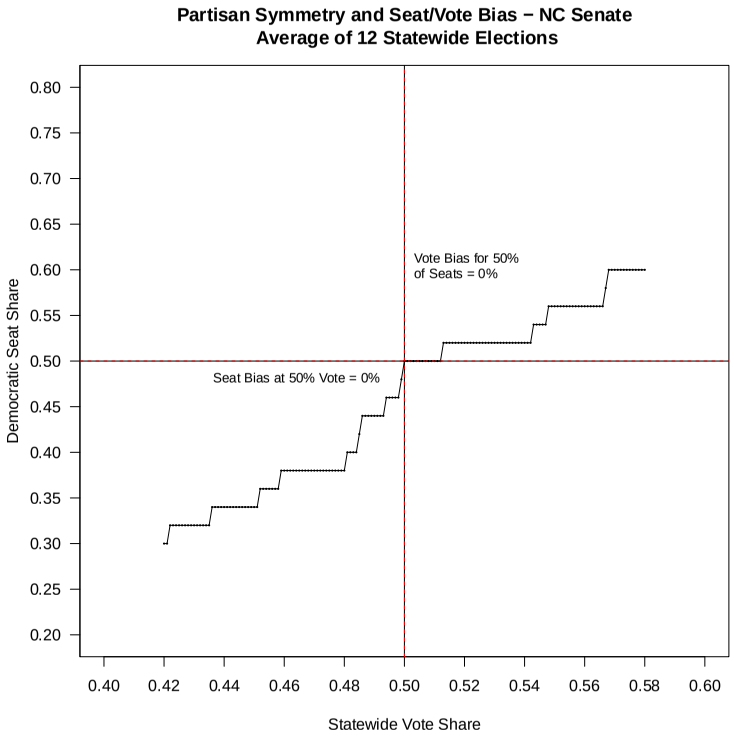
The next statistic to note is the "vote bias for 50% of seats", which measures the proportion of the statewide vote that we would expect a party to need to win in order to obtain 50% of the seats. In the Harper Plaintiffs' proposed Senate plan this is -0.3%. In other words, we would expect Democrats to have to win 49.7% of the statewide vote in order to receive 50% of the 50 seats in the state Senate. In the NCLCV Senate proposal the vote bias for 50% of seats is -0.6%, meaning that we would expect Democrats to win 49.4% of the statewide vote in order to net 50% of the seats in the chamber.

Figure 14: **Partisan Symmetry Analysis**

(a) 2021 Enacted Plan



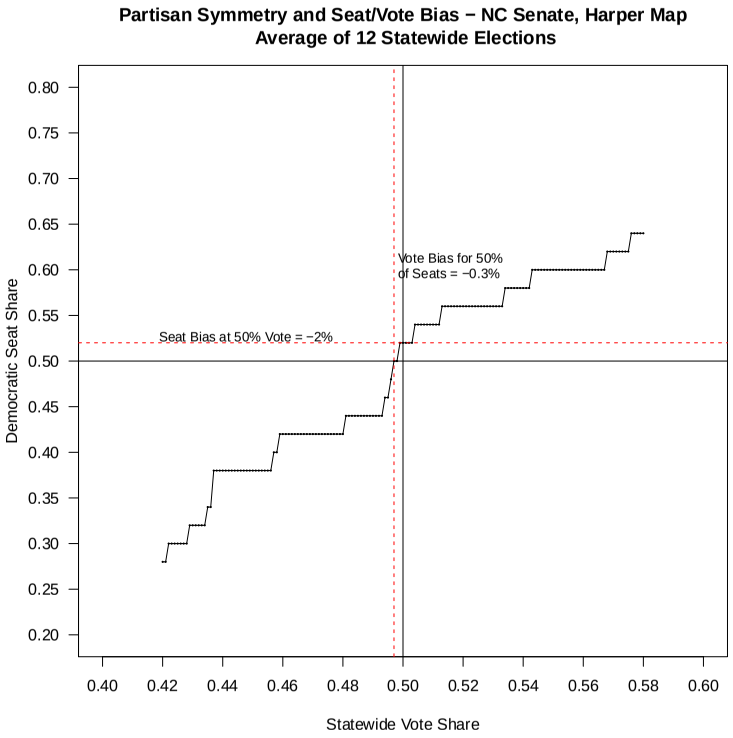
(b) 2022 Remedial plan



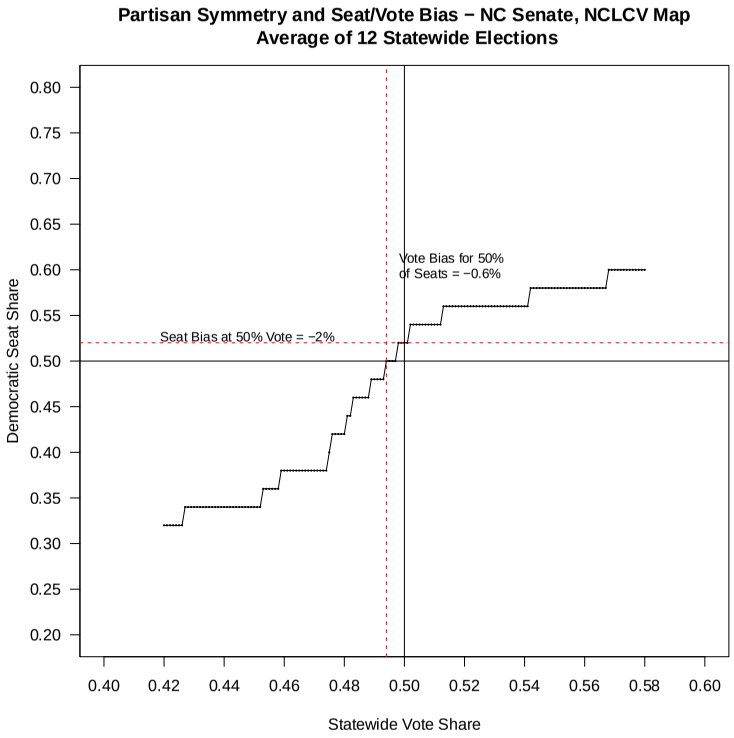
Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares. The left panel shows this for the 2021 Enacted map. The right panel shows this for the 2022 Remedial map.

Figure 15: **Partisan Symmetry Analysis, Plaintiff Proposals**

(a) Harper Plaintiffs Plan



(b) NCLCV Plaintiffs Plan



Note: The horizontal axis measures the statewide vote share from a uniform swing. The vertical axis shows the expected Democratic share of seats. The seats-votes curve shows the relationship between statewide vote shares and expected statewide seat shares. The left panel shows this for the Harper Plaintiff's proposed map. The right panel shows this for the NCLCV Plaintiff's proposed map.

7.6 Considerations of Race

During the trail court hearing various plaintiffs discussed the racial composition of Senate districts, the presence or absence of racially polarized voting, and the thresholds necessary for Black voters to elect the candidates of their choice. Table 2 shows the Black voting age population percent for districts with Black incumbents for the districts used in the 2018 election cycle, the 2020 election cycle, the 2021 now-enjoined Enacted Senate districts, and the 2022 Remedial Senate plan.

8 Conclusion for North Carolina Senate Plan

Overall, the 2022 Remedial plan for North Carolina's Senate districts is an improvement over the 2021 Enacted plan on the four measures outlined by the Court. The 2022 Remedial plan is within the Court's thresholds on the median-mean (-0.65%) and efficiency gap (-3.97%) measures.

The Harper Plaintiffs' proposed Senate plan is within the Court's thresholds on the median-mean (0.17%) and is within the Court's thresholds on the efficiency gap measure (-3.64%).

The NCLCV Plaintiffs' proposed plan is within the Court's thresholds on the median-mean (0.34%) and is within the Court's thresholds on the efficiency gap measure (0.03%).

The Remedial Senate plan produces majoritarian outcomes in 11 of the 12 elections considered in the close-votes-close-seats analysis and the plan is responsive and symmetric using the seats-votes curve to measure partisan symmetry.

The Harper Plaintiffs' proposed Senate plan produces majoritarian outcomes in 11 of the 12 elections considered, and the NCLCV Plaintiffs' proposed plan produces majoritarian outcomes in 12 of the 12 elections considered.

Table 2: BVAP for Senate Districts with Black Incumbents

Incumbent	2018 District	2018 District %BVAP	Incumbent	2020 District	2020 District %BVAP	SL-2021-173 District	SL-2021-173 District %BVAP	2022 Remedial District	2022 Remedial District %BVAP
Smith, E.	3	44.36%	Bazemore	3	43.04%	1	29.49%	3	42.33%
Fitch	4	47.46%	Fitch	4	47.44%	4	35.02%	4	35.02%
Davis	5	32.94%	Davis	5	35.89%	5	40.35%	5	40.35%
Blue	14	38.85%	Blue	14	33.45%	14	43.25%	14	42.99%
			Batch	17	9.49%	17	10.86%	17	11.47%
Murdock	20	40.35%	Murdock	20	36.79%	20	27.34%	20	27.34%
Clark	21	42.15%	Clark	21	44.13%	24	29.63%	24	29.63%
						19	48.07%	19	39.24%
Foushee	23	12.81%	Foushee	23	11.74%	23	16.73%	23	16.73%
Robinson	28	43.64%	Robinson	28	45.64%	28	51.45%*	28	45.64%
Lewis	32	39.18%	Lowe	32	25.00%	32	35.30%	32	25.19%
			Salvador	39	22.64%	39	40.75%	39	23.13%
Wadell	40	38.88%	Waddell	40	40.59%	40	49.54%	40	38.67%

Note: BVAP percents are "% any part Black." *This district's composition was the result of an amendment offered by that district's incumbent, Democratic Senator Robinson, who stated she thought the district, as amended, was fair and complied with the VRA. The trail court wrote of this: "109. Ultimately, two amendments were accepted in the Senate Committee: (1) An amendment offered by Senator Clark changing the Guilford/Rockingham County grouping (SD26, SD27, and SD28). Senator Hise testified that this amendment was presented at the behest of Senator Robinson, a Democratic member from Guilford, who, under the version presented by the chairs, was double-bunked with Senator Garrett. Trial Tr. 01/05/2022. During debate, Senator Robinson attested in Committee that she understood the amendment complied with the VRA and considered it a fair draw."

I declare under penalty of perjury under the laws of the state of North Carolina that the foregoing is true and correct to the best of my knowledge.

Michael Barber

21 February 2022

Appendix A: Curriculum Vitae

Michael Jay Barber

Contact Information

Brigham Young University
Department of Political Science
724 KMBL
Provo, UT 84602

barber@byu.edu
http://michaeljaybarber.com
Ph: (801) 422-7492

Academic Appointments

Brigham Young University, Provo, UT

August 2020 - present Associate Professor, Department of Political Science
2014 - July 2020 Assistant Professor, Department of Political Science
2014 - present Faculty Scholar, Center for the Study of Elections and Democracy

Education

Princeton University Department of Politics, Princeton, NJ

Ph.D., Politics, July 2014

- Advisors: Brandice Canes-Wrone, Nolan McCarty, and Kosuke Imai
- Dissertation: "Buying Representation: the Incentives, Ideology, and Influence of Campaign Contributions on American Politics"
- 2015 Carl Albert Award for Best Dissertation, Legislative Studies Section, American Political Science Association (APSA)

M.A., Politics, December 2011

Brigham Young University, Provo, UT

B.A., International Relations - Political Economy Focus, April, 2008

- *Cum Laude*

Research Interests

American politics, congressional polarization, political ideology, campaign finance, survey research

Publications

19. **"Ideological Disagreement and Pre-emption in Municipal Policymaking"**
with Adam Dynes
Forthcoming at *American Journal of Political Science*
18. **"Comparing Campaign Finance and Vote Based Measures of Ideology"**
Forthcoming at *Journal of Politics*
17. **"The Participatory and Partisan Impacts of Mandatory Vote-by-Mail"**, with John Holbein
Science Advances, 2020. Vol. 6, no. 35, DOI: 10.1126/sciadv.abc7685
16. **"Issue Politicization and Interest Group Campaign Contribution Strategies"**, with Mandi Eatough
Journal of Politics, 2020. Vol. 82: No. 3, pp. 1008-1025

15. **"Campaign Contributions and Donors' Policy Agreement with Presidential Candidates"**, with Brandice Canes-Wrone and Sharece Thrower
Presidential Studies Quarterly, 2019, 49 (4) 770–797

14. **"Conservatism in the Era of Trump"**, with Jeremy Pope
Perspectives on Politics, 2019, 17 (3) 719–736

13. **"Legislative Constraints on Executive Unilateralism in Separation of Powers Systems"**, with Alex Bolton and Sharece Thrower
Legislative Studies Quarterly, 2019, 44 (3) 515–548
Awarded the Jewell-Loewenberg Award for best article in the area of subnational politics published in *Legislative Studies Quarterly* in 2019

12. **"Electoral Competitiveness and Legislative Productivity"**, with Soren Schmidt
American Politics Research, 2019, 47 (4) 683–708

11. **"Does Party Trump Ideology? Disentangling Party and Ideology in America"**, with Jeremy Pope
American Political Science Review, 2019, 113 (1) 38–54

10. **"The Evolution of National Constitutions"**, with Scott Abramson
Quarterly Journal of Political Science, 2019, 14 (1) 89–114

9. **"Who is Ideological? Measuring Ideological Responses to Policy Questions in the American Public"**, with Jeremy Pope
The Forum: A Journal of Applied Research in Contemporary Politics, 2018, 16 (1) 97–122

8. **"Status Quo Bias in Ballot Wording"**, with David Gordon, Ryan Hill, and Joe Price
The Journal of Experimental Political Science, 2017, 4 (2) 151–160.

7. **"Ideologically Sophisticated Donors: Which Candidates Do Individual Contributors Finance?"**, with Brandice Canes-Wrone and Sharece Thrower
American Journal of Political Science, 2017, 61 (2) 271–288.

6. **"Gender Inequalities in Campaign Finance: A Regression Discontinuity Design"**, with Daniel Butler and Jessica Preece
Quarterly Journal of Political Science, 2016, Vol. 11, No. 2: 219–248.

5. **"Representing the Preferences of Donors, Partisans, and Voters in the U.S. Senate"**
Public Opinion Quarterly, 2016, 80: 225–249.

4. **"Donation Motivations: Testing Theories of Access and Ideology"**
Political Research Quarterly, 2016, 69 (1) 148–160.

3. **"Ideological Donors, Contribution Limits, and the Polarization of State Legislatures"**
Journal of Politics, 2016, 78 (1) 296–310.

2. **"Online Polls and Registration Based Sampling: A New Method for Pre-Election Polling"** with Quin Monson, Kelly Patterson and Chris Mann.
Political Analysis 2014, 22 (3) 321–335.

1. **"Causes and Consequences of Political Polarization"** In *Negotiating Agreement in Politics*. Jane Mansbridge and Cathie Jo Martin, eds., Washington, DC: American Political Science Association: 19–53. with Nolan McCarty. 2013.

   - Reprinted in *Solutions to Political Polarization in America*, Cambridge University Press. Nate Persily, eds. 2015
   - Reprinted in *Political Negotiation: A Handbook*, Brookings Institution Press. Jane Mansbridge and Cathie Jo Martin, eds. 2015

Available Working Papers

"Misclassification and Bias in Predictions of Individual Ethnicity from Administrative Records" (Revise and Resubmit at *American Political Science Review*)

"Taking Cues When You Don't Care: Issue Importance and Partisan Cue Taking"
with Jeremy Pope (Revise and Resubmit)

"A Revolution of Rights in American Founding Documents"
with Scott Abramson and Jeremy Pope (Conditionally Accepted)

"410 Million Voting Records Show the Distribution of Turnout in America Today"
with John Holbein (Revise and Resubmit)

"Partisanship and Trolleyology"
with Ryan Davis (Under Review)

"Who's the Partisan: Are Issues or Groups More Important to Partisanship?"
with Jeremy Pope (Revise and Resubmit)

"Race and Realignment in American Politics"
with Jeremy Pope (Revise and Resubmit)

"The Policy Preferences of Donors and Voters"

"Estimating Neighborhood Effects on Turnout from Geocoded Voter Registration Records."
with Kosuke Imai

"Super PAC Contributions in Congressional Elections"

Works in Progress

"Collaborative Study of Democracy and Politics"
with Brandice Canes-Wrone, Gregory Huber, and Joshua Clinton

"Preferences for Representational Styles in the American Public"
with Ryan Davis and Adam Dynes

"Representation and Issue Congruence in Congress"
with Taylor Petersen

"Education, Income, and the Vote for Trump"
with Edie Ellison

Invited Presentations

"Are Mormons Breaking Up with Republicanism? The Unique Political Behavior of Mormons in the 2016 Presidential Election"

- Ivy League LDS Student Association Conference - Princeton University, November 2018, Princeton, NJ

"Issue Politicization and Access-Oriented Giving: A Theory of PAC Contribution Behavior"

- Vanderbilt University, May 2017, Nashville, TN

"Lost in Issue Space? Measuring Levels of Ideology in the American Public"

- Yale University, April 2016, New Haven, CT

"The Incentives, Ideology, and Influence of Campaign Donors in American Politics"

- University of Oklahoma, April 2016, Norman, OK

"Lost in Issue Space? Measuring Levels of Ideology in the American Public"

- University of Wisconsin - Madison, February 2016, Madison, WI

"Polarization and Campaign Contributors: Motivations, Ideology, and Policy"

- Hewlett Foundation Conference on Lobbying and Campaign Finance, October 2014, Palo Alto, CA

"Ideological Donors, Contribution Limits, and the Polarization of State Legislatures"

- Bipartisan Policy Center Meeting on Party Polarization and Campaign Finance, September 2014, Washington, DC

"Representing the Preferences of Donors, Partisans, and Voters in the U.S. Senate"

- Yale Center for the Study of American Politics Conference, May 2014, New Haven, CT

Conference Presentations

Washington D.C. Political Economy Conference (PECO):

- 2017 discussant

American Political Science Association (APSA) Annual Meeting:

- 2014 participant and discussant, 2015 participant, 2016 participant, 2017 participant, 2018 participant

Midwest Political Science Association (MPSA) Annual Meeting:

- 2015 participant and discussant, 2016 participant and discussant, 2018 participant

Southern Political Science Association (SPSA) Annual Meeting:

- 2015 participant and discussant, 2016 participant and discussant, 2017 participant

Teaching Experience

Poli 315: Congress and the Legislative Process

- Fall 2014, Winter 2015, Fall 2015, Winter 2016, Summer 2017

Poli 328: Quantitative Analysis

- Winter 2017, Fall 2017, Fall 2019, Winter 2020, Fall 2020, Winter 2021

Poli 410: Undergraduate Research Seminar in American Politics

- Fall 2014, Winter 2015, Fall 2015, Winter 2016, Summer 2017

Awards and Grants

2019 BYU Mentored Environment Grant (MEG), American Ideology Project, $30,000

2017 BYU Political Science Teacher of the Year Award

2017 BYU Mentored Environment Grant (MEG), Funding American Democracy Project, $20,000

2016 BYU Political Science Department, Political Ideology and President Trump (with Jeremy Pope), $7,500

2016 BYU Office of Research and Creative Activities (ORCA) Student Mentored Grant x 3

- Hayden Galloway, Jennica Peterson, Rebecca Shuel

2015 BYU Office of Research and Creative Activities (ORCA) Student Mentored Grant x 3

- Michael-Sean Covey, Hayden Galloway, Sean Stephenson

2015 BYU Student Experiential Learning Grant, American Founding Comparative Constitutions Project (with Jeremy Pope), $9,000

2015 BYU Social Science College Research Grant, $5,000

2014 BYU Political Science Department, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $3,000

2014 BYU Social Science College Award, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $3,000

2014 BYU Center for the Study of Elections and Democracy, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $2,000

2012 Princeton Center for the Study of Democratic Politics Dissertation Improvement Grant, $5,000

2011 Princeton Mamdouha S. Bobst Center for Peace and Justice Dissertation Research Grant, $5,000

2011 Princeton Political Economy Research Grant, $1,500

Other Scholarly Activities

Expert Witness in Nancy Carola Jacobson, et al., Plaintiffs, vs. Laurel M. Lee, et al., Defendants. Case No. 4:18-cv-00262 MW-CAS (U.S. District Court for the Northern District of Florida)

Expert Witness in Common Cause, et al., Plaintiffs, vs. LEWIS, et al., Defendants. Case No. 18-CVS-14001 (Wake County, North Carolina)

Expert Witness in Kelvin Jones, et al., Plaintiffs, v. Ron DeSantis, et al., Defendants, Consolidated Case No. 4:19-cv-300 (U.S. District Court for the Northern District of Florida)

Expert Witness in Community Success Initiative, et al., Plaintiffs, v. Timothy K. Moore, et al., Defendants, Case No. 19-cv-15941 (Wake County, North Carolina)

Expert Witness in Richard Rose et al., Plaintiffs, v. Brad Raffensperger, Defendant, Civil Action No. 1:20-cv-02921-SDG (U.S. District Court for the Northern District of Georgia)

Georgia Coalition for the People's Agenda, Inc., et. al., Plaintiffs, v. Brad Raffensberger, Defendant. Civil Action No. 1:18-cv-04727-ELR (U.S. District Court for the Northern District of Georgia)

Expert Witness in Alabama, et al., Plaintiffs, v. United States Department of Commerce; Gina Raimondo, et al., Defendants. Case No. CASE No. 3:21-cv-00211-RAH-ECM-KCN (U.S. District Court for the Middle District of Alabama Eastern Division)

Expert Witness in League of Women Voters of Ohio, et al., Relators, v. Ohio Redistricting Commission, et al., Respondents. Case No. 2021-1193 (Supreme Court of Ohio)

Additional Training

EITM 2012 at Princeton University - Participant and Graduate Student Coordinator

Computer Skills

Statistical Programs: R, Stata, SPSS, parallel computing

Updated December 22, 2021