EXHIBIT 1
TO COMMON CAUSE OBJECTIONS
(Mattingly Report)

Remedial Report : Congressional and NC Senate Plans

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1 Introduction and summary

We have been asked by the Harper Plaintiffs and the Common Cause Plaintiffs to analyze two redistricting maps for both the North Carolina Congressional districts and the North Carolina Senate districts. Specifically, we will examine the Congressional and Senate maps that were recently passed by the General Assembly in laws 2022-3 (Congressional, S745), 2022-2 (Senate, S744), as well as alternative maps put forward by the Harper plaintiffs. The comments and analysis addressing the Harper Plaintiffs' proposed map were done solely at the request of the Harper Plaintiffs and not by the Common Cause Plaintiffs.

Because of the language in the court ruling, our primary tool of analysis is to examine partisan symmetry, which is the idea that a specific vote share should translate into a specific seat share, independent of which party received that vote.[1] The exact translation of votes to seats need not be known ahead of time; the important aspect of symmetry is that the translation is the same for both parties. As one example, under a map that has partisan symmetry, if the Republicans receive 55% of the vote and 70% of the seats, then when the Democrats receive 55%, they will also receive 70% of the seats. Prioritizing symmetry does not translate into any proportionality standard. However under a symmetric map, the party that wins the majority of the vote should win the majority of the seats (or at least not be in the minority).

The Supreme Court's order also mentioned other metrics that can give some insight into the symmetry properties (as well as other properties) of a map, including the mean-median difference and the efficiency gap. We prefer to report directly on measures of partisan symmetry and focus on those in this report, but we also report mean-median difference and efficiency gaps.

We examine partisan symmetry characteristics of the four maps under 16 historic elections from 2016 and 2020: 2016 Attorney General, 2016 Governor, 2016 Lieutenant Governor, 2016 Presidential, 2016 U.S. Senate, 2020 State Auditor, 2020 Attorney General, 2020 Commissioner of Agriculture, 2020 Commissioner of Insurance, 2020 Commissioner of Labor, 2020 Governor, 2020 Lieutenant Governor, 2020 Presidential, 2020 Secretary of State, 2020 Treasurer, and 2020 U.S. Senate.

We find that the plaintiff maps show significantly greater amounts of symmetry than the recently passed maps put forward by the North Carolina legislature. We also demonstrate that if twenty maps were drawn from our original ensemble, which was constructed without regard to partisan symmetry, it would be extremely likely to find a map with significantly superior partisan symmetry when compared with the legislature's enacted remedial maps. In other words, even drawing maps at random, it is not difficult to draw maps that achieve significantly better partisan symmetry than the legislature's proposed remedial maps.

2 Qualifications

We are Professors of Mathematics at Duke University. Dr. Mattingly is also a Professor of Statistical Science at Duke University. His degrees are from the North Carolina School of Science and Math (High School Diploma), Yale University (B.S.), and Princeton University (Ph.D.). He grew up in Charlotte, North Carolina, and currently lives in Durham, North Carolina. Dr. Herschlag's degrees are from Taylor Allderdice (High School Diploma), University of Chicago (B.S.), and the University of North Carolina at Chapel Hill (Ph.D.). He has lived in North Carolina since 2007.

Both of us lead a group at Duke University that conducts non-partisan research to understand and quantify gerrymandering. This report grows out of aspects of our group's work around the current North Carolina legislative districts which are relevant to the case being filed.

Dr. Mattingly previously submitted an expert report in Common Cause v. Rucho, No. 18-CV-1026 (M.D.N.C.), Diamond v. Torres, No. 17-CV-5054 (E.D. Pa.), Common Cause v. Lewis (N.C. Sup. Ct No. 18-cvs-014001), and Harper v. Lewis

(No. 19-cv-012667) and was an expert witness for the plaintiffs in Common Cause v Rucho and Common Cause v. Lewis. Dr. Herschlag previously submitted an affidavit in North Carolina v. Covington, No. 1:15-cv-00399. We are being paid at a rate of $400/per hour for this work. Much of the work, including the randomly generated maps, derives from an independent research effort, unrelated to this lawsuit, to understand gerrymandering nationally and in North Carolina specifically. Some of the analysis described in this report was previously released publicly as part of a non-partisan effort to inform the discussion around the redistricting process.

3 Methods

We evaluate the proposed plans using a partisan symmetry metric described below. We also report the the mean-median difference and the efficiency gap. Each of these metrics was calculated using the results of sixteen recent statewide elections: 2016 Attorney General, 2016 Governor, 2016 Lieutenant Governor, 2016 Presidential, 2016 U.S. Senate, 2020 State Auditor, 2020 Attorney General, 2020 Commissioner of Agriculture, 2020 Commissioner of Insurance, 2020 Commissioner of Labor, 2020 Governor, 2020 Lieutenant Governor, 2020 Presidential, 2020 Secretary of State, 2020 Treasurer, and 2020 U.S. Senate. In many analyses, we also consider the uniform swing of the elections under consideration which allows us to consider a varied range of statewide partisan vote fractions over multiple plausible voting patterns.

In line with the classic definition of partisan symmetry, the North Carolina Supreme Court explained, "voters are entitled to have substantially the same opportunity to electing a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." Harper v. Hall, No. 413PA21, slip op. ¶169 (N.C. Feb. 14, 2022). To implement this directive, we measure the partisan symmetry by calculating the number of seats awarded to the party winning the majority of votes in pairs of elections that have total statewide partisan vote shares which are symmetric about the 50% level. Examples of symmetric pairs are 49% and 51% or 48% and 52%. We then report the absolute difference in the number of seats awarded. If both parties were treated symmetrically, this difference would be zero.

To take an example: we begin with the results of the 2016 Governor election and apply a "uniform swing" to reflect a 48% Democratic statewide vote share for that election. We calculate how many Republican representatives would be elected with this 48% Democratic vote share. We then apply a uniform swing to the election so that it reflects the corresponding, reciprocal Democratic vote share–i.e., 52%. We then compute the number of Democratic representatives that would be elected with that 52% Democratic vote share. We then calculate the absolute difference between the number of Republican representatives elected with 48% Democratic vote share and the number of Democratic representatives elected with a 52% Democratic vote share. Thus, if 8 Republicans were elected with 48% Democratic vote share, and 7 Democrats were elected with 52% vote share, the absolute difference would be 1 seat. (Because the figure is absolute, the value is always positive. It does not reflect which party benefits from the asymmetry; it captures only the degree of asymmetry.) We repeat this process using several sets of vote fractions which are equidistant from the majority line of 50%. Namely, we consider 45% and 55%, 46% and 54%, 47% and 53%, and 49% and 51%.

Reciprocity in a single election does not speak to possible variations in the spatial voting patterns seen across the state in different elections. Therefore, we repeat this procedure across the 16 historic statewide elections listed above, and then calculate an average of the absolute difference between the number of Republican seats elected (under the lower Democratic vote share) and the number of Democratic seats elected (under the higher Democratic vote share). The metric thus captures the average, absolute deviation, across elections and across vote shares, between the number of seats that the two parties are expected to elect at the same given vote share. Lower numbers reflect greater partisan symmetry, and in particular, reflect a more "equal opportunity to electing a supermajority or majority of representatives as the voters of the opposing party would be afforded if they comprised" a given percentage "of the statewide vote share in that same election." Harper slip op. ¶169.

We emphasize that we consider the average deviation across 16 different elections, thereby capturing the degree of partisan symmetry exhibited by the map across a variety of different election climates. This is very different from considering a single electoral vote pattern constructed by averaging elections to create a different, possibly unobserved, vote pattern, and only then assessing the deviation.

In addition to examining the averaged deviation from partisan symmetry, we also examine the mean-median difference and the efficiency gap. The mean-median is defined to be the difference between the average Democratic vote share and the median Democratic vote share.[1] The efficiency gap is defined to be the difference in wasted votes across the two parties

[1] Here we define Democratic/Republican vote share to be the fraction of the vote that went to one party compared with the vote going to both parties, i.e. $D/(R+D)$ where D and R are the Democratic and Republican votes in a district.

divided by the total vote for the two parties. Wasted votes are found by summing overall votes in losing districts and all votes in winning districts that are more than half the total votes; for example, if D and R are the Democratic and Republican votes in a district, and $D < R$ then the Democrats would have wasted D votes and the Republicans would have wasted $R - (D + R)/2$ votes. When computing the efficiency gap we uniformly swing each election to range from 45% to 55% of the vote in increments of 1%, which provides greater diversity to the elections considered. [2]

4 Congressional Districts

Using the set of statewide elections listed in Section 3, the partisan symmetry of the Harper Plaintiffs' proposed congressional map – as measured using the metric described below, which reflects the average deviation in seats won between the parties given a particular vote share – is 0.36875 seats. In practical terms, this means that for any given statewide election, the number of Democratic and Republican seats elected at a given party vote fraction will more often than not be the same number; and the expected difference averaged across a range of sixteen statewide elections is only 0.36875 seats. Only 96 of the 80,000 sampled congressional plans both accounted for incumbency and had a partisan symmetry score of less than 0.40 seats.

The legislature's 2022 remedial congressional plan has an average partisan symmetry deviation of 1.575 seats – meaning the average seat deviation between the parties given the same vote share is 4 times as high as it is in Harper plaintiffs proposed plan. This reflects that, under the enacted plan, Republicans win 8 or 9 seats when they get 51% of the vote, while Democrats win 7 or 8 seats when they get 51% of the vote. If the map makers would have examined just 20 random plans from our ensemble, they would have found a plan with higher partisan symmetry than the S745 plan with a 99.998% chance. Furthermore, there would be a 98.56% chance that at least one of those plans would have a seat deviation of less than 1. The 2022 enacted remedial Congressional plan has a mean-median gap of 1.01%. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is 7.312%.

As to other partisan fairness metrics identified in the Supreme Courts order and opinion: The average mean-median difference for the Harper Plaintiffs' proposed map is 0.4504%. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is 2.7180%.

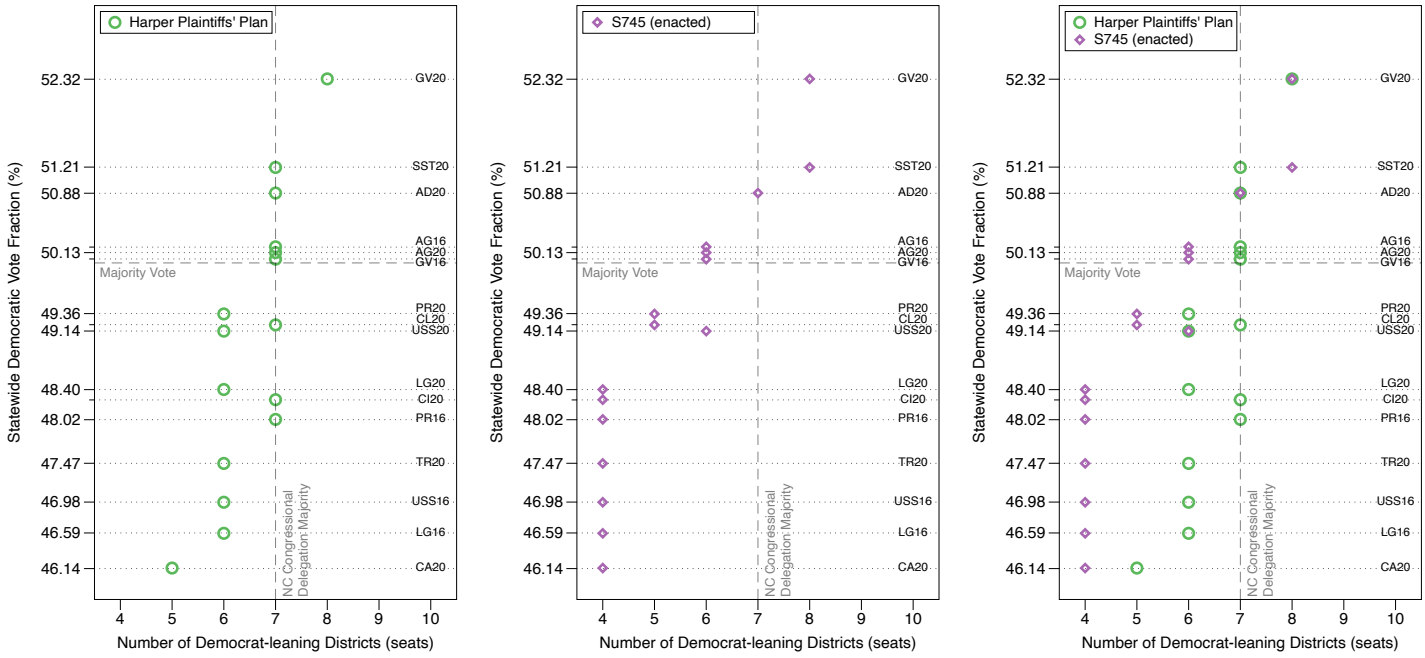

Figure 1: We show the number of seats (horizontal axis) compared with the statewide vote (vertical axis) in our 16 historic elections under the Harper Plaintiffs' map (left), and the enacted map (S745; middle). We also directly compare the two maps (right)

[2] When performing a uniform swing analysis, it is more efficient to estimate the efficiency gap using the Democratic/Republican vote fractions as opposed to the vote. Under equal votes in each district, the use of the fractions gives the exact same result, however, it will provide a slight difference if this is not true. When employing uniform swings, we use the vote fractions. In our experience, this sightly different formulation creates little difference in the values because the populations are balanced across districts.

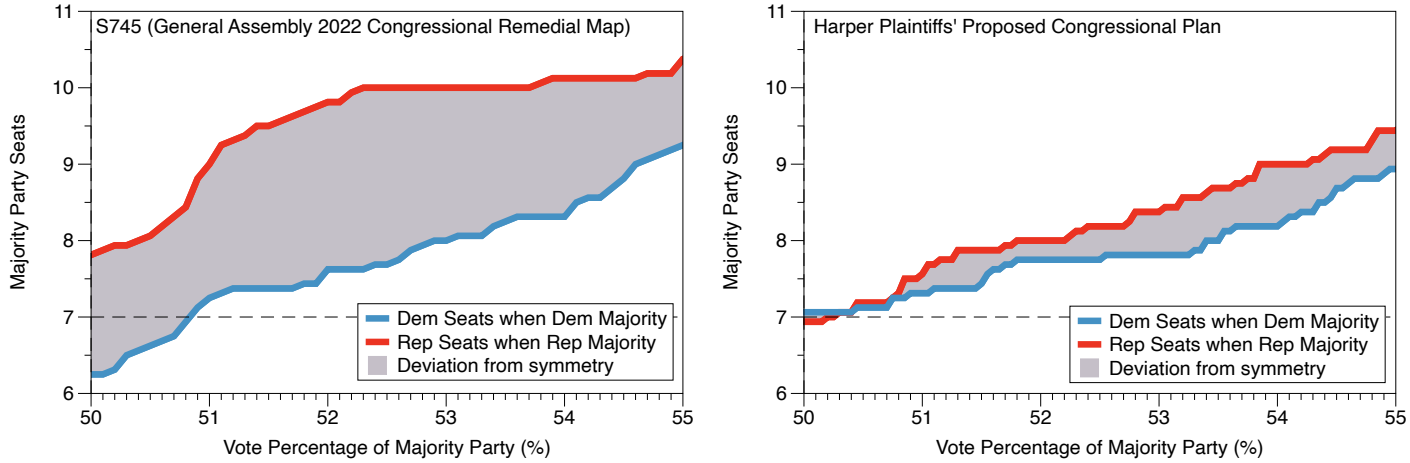

Figure 2: We show the statewide vote percentage won by the party in the majority of the vote (horizontal axis) compared with the statewide seats won by the majority party (vertical axis) in our 16 historic elections under the enacted map (S745; left), and the Harper Plaintiffs' plan (right). In a perfectly symmetric map, the blue line would always coincide with the red line.

To better illuminate the extent to which the two maps treat the parties symmetrically, we plot in Figure 1 what would be results of congressional elections run with historical elections mentioned in Section 3. We begin by noticing that the Harper Plaintiffs' proposed map always gives at at least half of the seats to the party which wins the majority of the votes. In contrast, the Legislature's S745 map only gives the Democrats at least half the seat in three of the six elections where they win the majority while always giving the Republicans at least half the seats in the elections where they win the majority of the votes. One can also understand the degree to which the maps produce seat counts which are symmetric. In a symmetric map, the behavior in the bottom half of these plots should "mirror" the behavior in the top half.

To better examine this, we calculate the seats won by the party with the majority of the vote under the sixteen specified elections when they are shifted, using the uniform swing hypothesis, to have a statewide Democratic share ranging from 45% to 55%. We then average these 16 seat counts over each of the statewide vote fractions. We plot this average in Figure 2 as a function of the statewide majority vote fraction. When the Democrats are in the Majority (Democratic vote shares of 50%-55%) we use a blue curve and plot the Democratic seat share. When the Republicans are in the Majority (Democratic vote shares of 45%-50%), we use a red curve and plot the Republican seat share. If the map is symmetric, the seats elected in response to Democratic majority votes will be the same as the seats elected in response to Republican majority votes, and the two curves will lie on top of each other. The gray shaded region emphasizes the deviation from ideal partisan symmetry.

Looking at Figure 2, we see that there is a significant deviation from symmetry in the legislature's proposed 2022 remedial Congressional plan while the Harper Plaintiffs' proposed plan shows a high degree of symmetry, particularly between 49% and 51%. Both maps favor the Republicans with respect to their deviation from partisan symmetry, as shown by the fact that the red curve is above the blue curve.

Democratic Elections						Republican Elections					
		S745 (Cong.)		Plaintiffs' Cong.				S745 (Cong.)		Plaintiffs' Cong.	
Election	Democratic Vote (%)	Dem. Seats	Dem. Split or Won Majority	Dem. Seats	Dem. Split or Won Majority	Election	Republican Vote (%)	Rep. Seats	Rep. Split or Won Majority	Rep. Seats	Rep. Split or Won Majority
GV16	50.05	6	**No**	7	Yes	PR20	50.64	9	Yes	8	Yes
AG20	50.13	6	**No**	7	Yes	CL20	50.78	9	Yes	7	Yes
AG16	50.20	6	**No**	7	Yes	USS 20	50.86	8	Yes	8	Yes
AD20	50.88	7	Yes	7	Yes	LG20	51.60	10	Yes	8	Yes
SST20	51.21	8	Yes	7	Yes	CI20	51.73	10	Yes	7	Yes
GV20	52.32	8	Yes	8	Yes	PR16	51.98	10	Yes	7	Yes
						TR20	52.53	10	Yes	8	Yes
						USS 16	53.02	10	Yes	8	Yes
						LG16	53.41	10	Yes	8	Yes
						CA20	53.85	10	Yes	9	Yes

Table 1: We summarize Figure 2 on the congressional two maps with the above table. Pay particular attention to the number of times which map fails to give a party the majority of seats when they win the majority of the votes. Notice that this only occurs for the Democrats.

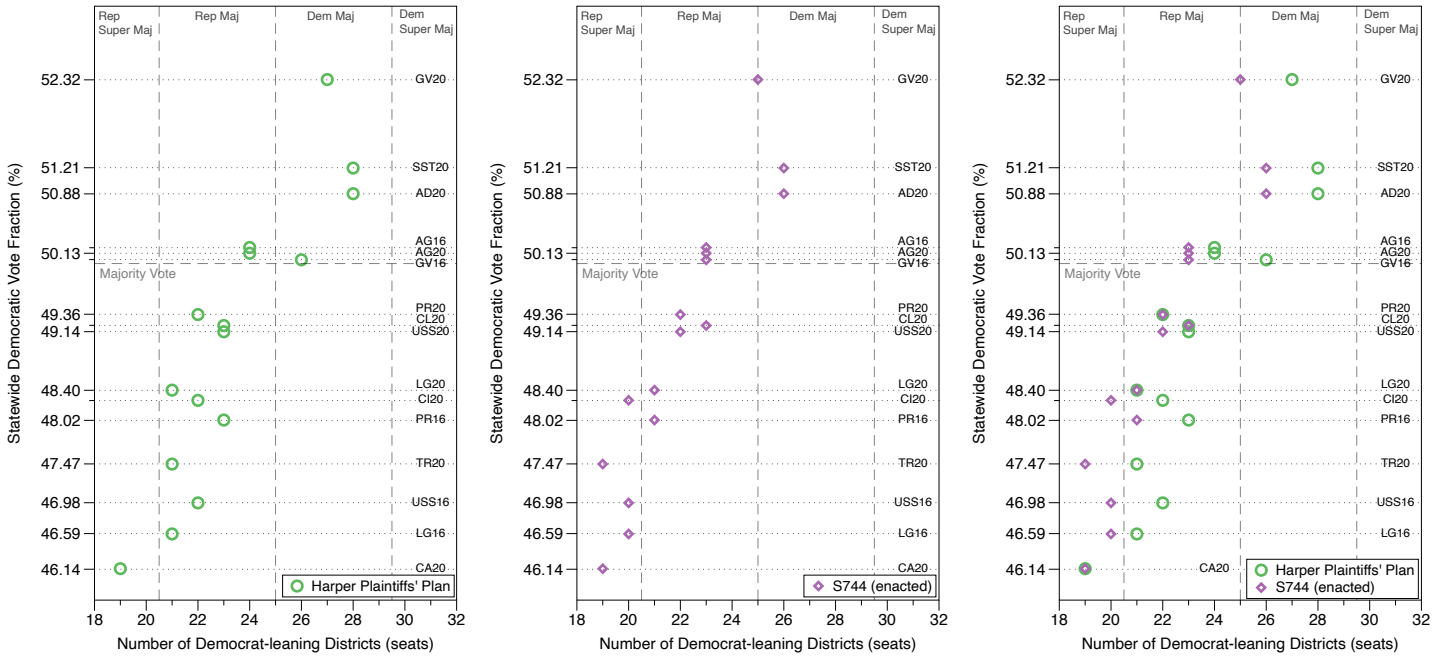

Figure 3: We show the number of seats (horizontal axis) compared with the statewide vote (vertical axis) in our 16 historic elections under the Harper Plaintiffs' map (left), and the NC Legislature's enacted map (S744; middle). We also directly compare the two maps (right).

5 Senate Districts

Using the set of statewide elections listed in Section 3, the partisan symmetry of the Harper Plaintiffs' proposed senate map – as measured using the metric described above for the congressional plans, which reflects the average deviation in seats won between the parties given a particular vote share – is 1.04375 seats.[3]

The legislature's 2022 enacted remedial senate plan has an average partisan symmetry deviation of 4.0125 seats – meaning the average seat deviation between the parties given the same vote share is again 4 times as high as it is in Harper plaintiffs proposed plan. This reflects that, under the enacted plan, Republicans win 29 or 30 seats when they get 52% of the vote, while Democrats win 25 or 26 seats when they get 52% of the vote. This is enough to potentially grant the Republicans a supermajority, whereas the Democrats either split the chamber or gain the smallest possible majority. If the map makers would have examined just 1 random plan from our ensemble, they would have found a plan with higher partisan symmetry than the S744 plan with a 99.6% chance. Furthermore, there would be a 92.5% chance that at least one of those plans would have a symmetry deviation of less than 3 seats. If they had considered 20 plans, they would have been essentially guaranteed to find one with a symmetry deviation of less than 3 seats. The 2022 enacted remedial Senate plan has a mean-median gap of 1.304%. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is 4.072%.

As to other partisan fairness metrics identified in the Supreme Courts order and opinion: The average mean-median difference for the Harper Plaintiffs' proposed senate map is 0.228%. The average efficiency gap calculated by conducting uniform swings on these election results, ranging from 45% to 55% Democratic vote share, is 1.955%.

In Figure 3, we plot what would be results of North Carolina Senate elections run with historical elections mentioned in Section 3. We begin by noticing that both the Harper Plaintiffs' proposed NC Senate map and the Legislature's S744 map always give at least half of the seats to the Republican Party when they win the majority. The Harper Plaintiffs' proposed NC Senate map gives the majority of the seats to the Democrats in four out of six elections where they win the majority of the votes while the Legislature's S744 map does so in three out of six elections. More telling, the Legislature's S744 map gives the Republicans the supermajority of seats or close to it, when they receive between 51% and 52% of the votes while the Democrats barely get or share the majority when they receive between 51% and 52% of the votes.

To better understand the extent to which the two plans respond symmetrically to swings in the Democratic or Republican

[3]We remark that the coarse averaging of the measure we use is a rough approximation for the area of the gray regions shown in Figure 4 In this case, the 45%,55% vote pairing is over-weighted and drives the average up (there are only 4 other number we are averaging with). If we would have instead averaged the seat deviation across all vote fractions between 50%-55%, the deviation would have been closer to 0.5.

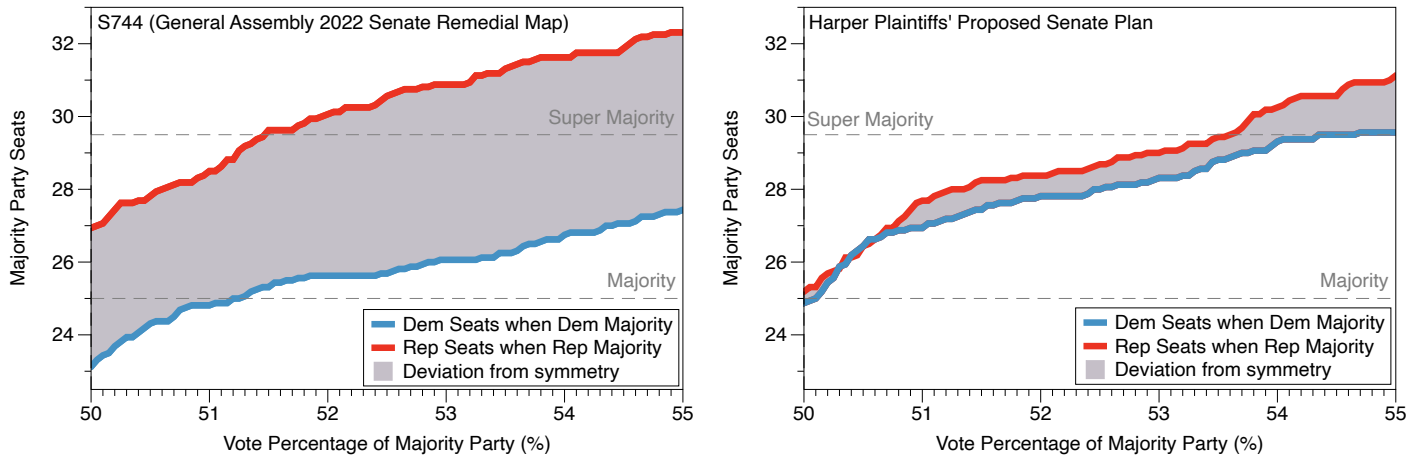

Figure 4: We show the statewide vote percentage won by the party with the majority of the vote (horizontal axis) compared with the statewide won seats by the majority party (vertical axis) in our 16 historic elections under the enacted map (S744; left), and the Harper Plaintiffs' plan (right). In a perfectly symmetric map, the blue line would always coincide with the red line

direction, we calculate the seats won by the party with the majority of the vote under the sixteen specified elections when they are shifted, using the uniform swing hypothesis, to have statewide Democratic share ranging from 45% to 55%. We then average these 16 seat counts over each of the statewide vote fractions. We plot this average in Figure 4 as a function of the statewide majority vote fraction. When the Democrats are in the Majority (Democratic vote shares of 50%-55%) we use a blue curve. When the Republicans are in the Majority (Democratic vote shares of 45%-50%), we use a red curve and plot the Republican seat share. If the response to Democratic majority votes is the same as Republican majority votes the two curves will be on top of each other. The gray shaded region emphasizes the deviation from ideal partisan symmetry.

It is clear from Figure 4 that the Legislature's S744 map is significantly less symmetric than the Harper Plaintiffs' plan. It is particularly striking that Harper Plaintiffs' plan shows almost perfect symmetry for deviations immediately around 50%. Beyond that range the Harper Plaintiffs' plan actually treats Republicans more favorably than Democrats.

References

[1] Bernard Grofman and Gary King. The future of partisan symmetry as a judicial test for partisan gerrymandering after *LULAC v. Perry*. *Election Law Journal*, 6(1):457–472, 2007.

We 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 our knowledge.

Greg Herschlag 2/21/2022

Jonathan Mattingly, 2/21/2022