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4 WM 2022

IN THE SUPREME COURT OF PENNSYLVANIA

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In re: 2021 Legislative	:	Nos. 4 WM 2022, 11 MM 2022, 14
Reapportionment Commission	:	MM 2022, 7 WM 2022, 16 MM
	:	2022, 11 WM 2022, 17 MM 2022,
	:	18 MM 2022, 12 WM 2022
	:	
	:	

CONSOLIDATED ANSWER OF THE 2021 LEGISLATIVE REAPPORTIONMENT COMMISSION

The 2021 Legislative Reapportionment Commission responds to the nine Petitions for Review challenging the Commission's Final Plan as follows.

1. The Commission incorporates its Consolidated Brief in Opposition to the Petitions for Review, which is being filed concurrently with this Answer.

2. The Commission incorporates the March 4, 2022 Report of Mark A. Nordenberg, Chair of the 2021 Legislative Reapportionment Commission, Regarding the Commission's Final Plan. The Report is attached as Appendix A to the Commission's Brief.

3. The Commission incorporates the supplemental expert reports of Dr. Kosuke Imai (attached as Exhibit 1), Dr. Christopher Warshaw (attached as Exhibit 2), and Dr. Matt Barreto (attached as Exhibit 3.)

4. The Commission further incorporates the expert report of Dr. Jonathan Rodden, which is attached as Exhibit 4.

5. These reports were initially filed by Democratic Leader McClinton and have been reattached here.

The Commission also responds specifically to some of the allegations in the Petitions for Review as follows.

I. Response to Allegations in *Benninghoff v. 2021 Legislative Reapportionment Commission*, 11 MM 2022.

6. Majority Leader Benninghoff repeatedly refers to Chair Nordenberg as a partisan or as a participant in a party-line vote. (*See, e.g.*, Benninghoff Br. 13, 79.)

7. Chair Nordenberg was appointed by a unanimous Supreme Court, presumably because of the non-partisan and neutral approach that has characterized his record of public service.

8. Chair Nordenberg has served on commissions, committees, and task forces at the request of elected leaders of both major parties.

9. In every reapportionment cycle since 1990, including this reapportionment cycle, Chair Nordenberg was encouraged by Republican legislative leaders to consider serving as Chair.

10. Chair Nordenberg has exercised his authority on the Commission as a neutral, independent Chair—sometimes voting with the two Majority Leaders, sometimes voting with the two Democratic Leaders, and sometimes voting with a bipartisan majority.

11. The Commission's Final Plan was passed by a 4-to-1 bipartisan vote, undercutting any claim of partisanship by the Chair.

12. The Petitions for Review challenging the Final Plan further belie any claim of partisanship: the House map is being challenged for

being too favorable to Democrats (*see, e.g.*, Benninghoff Br. 42-54; Roe Br. 11-18, filed in *Roe v. 2021 Legislative Reapportionment Comm'n*, 16 MM 2022)), and the Senate map is being challenged for being too favorable to Republicans (*see* Math/Science Profs.' Br. 20-35, filed in *Donagi v. 2021 Legislative Reapportionment Comm'n*, 17 MM 2022).)

13. Majority Leader Benninghoff has also criticized the Chair and the Commission for not adopting his amendment to the Final Plan.

14. Leader Benninghoff fails to disclose that he only informed Chair Nordenberg and members of the Commission team that he would be offering an amendment the evening of February 3, 2022—in other words, the evening before the vote on the Final Plan was scheduled.

15. Leader Benninghoff further fails to disclose that he did not deliver copies of his alternative Plan to any members of the Commission's team until the morning of February 4, 2022, shortly before he held a press conference and shortly before the Commission's scheduled meeting to vote on its Final Plan.

16. Chair Nordenberg had not seen Leader Benninghoff's alternative Final Plan until a copy was handed to him at the Commission's meeting, which may also have been true of other Commission members.

17. Leader Benninghoff waited until February 4, 2022, to circulate his amendment, even though the date stamp on one of the pages of the amendment's legal description indicates that the amendment was prepared as early as January 26, 2022. (Benninghoff Pet., App'x B at 129a.)

18. Leader Benninghoff never asked to postpone the Commission's meeting so that his amendment could be given due consideration, nor did Leader Benninghoff move to table the Commission's vote so that members of the Commission could appropriately consider his amendment.

19. Leader Benninghoff also did not distribute his amendment to the public so that the public could provide input on the proposal.

20. The Commission never held hearings on the contents of the Benninghoff Amendment because it was not made available until the final vote.

21. The process surrounding the Benninghoff Amendment did not comport with the Commission's commitment to transparency and openness.

II. Response to Allegations in *Koger v. 2021 Legislative Reapportionment Commission*, 7 WM 2022.

22. Mr. Koger alleges that the Commission, and particularly Senator Costa, intentionally removed him from House District 24 in order to benefit one of Senator Costa's employees, who is likely to run for that seat.

23. As has been made clear in Chair Nordenberg's public statements, the caucus leaders were each only involved in drawing the maps for their respective chambers.

24. The two House Leaders focused their energies on drawing the House map, and the two Senate Leaders focused their energies on drawing the Senate map.

25. As such, Senator Costa had no involvement in drawing the House map.

26. Any effect on Mr. Koger was purely incidental.

III. Response to Allegations in *Covert v. 2021 Legislative Reapportionment Commission*, 4 WM 2022, and *Hutz v. 2021 Legislative Reapportionment Commission*, 11 WM 2022.

27. The Covert and Hutz Petitioners take issue with how the House districts in Butler County changed between the Commission's Preliminary and Final Plans.

28. As Chair Nordenberg previously indicated, these changes were the direct result of attempted negotiations with Majority Leader Benninghoff, who had stated that changes to the districts in Butler, Lawrence and Mercer Counties, in order to unpair two Republican incumbents, were one of his highest priorities.

29. The Chair advocated for these changes in order to accommodate that specific request from Majority Leader Benninghoff, in the hope of moving toward a unanimous vote on the Final Plan.

30. The Chair advocated for these changes on the understanding that the Court reviews the Final Plan as a whole and that the issue with the

Butler County districts is the kind of localized dispute that this Court generally refuses to consider.

March 11, 2022

Respectfully submitted,

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CERTIFICATE OF COMPLIANCE

I certify that this filing complies with the provisions of the Case Records Public Access Policy of the Unified Judicial System of Pennsylvania that require filing confidential information and documents differently from non-confidential information and documents.

/s/ Robert L. Byer

EXHIBIT 1

SUPPLEMENTARY EXPERT REPORT

Kosuke Imai, Ph.D.

March 9, 2022

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SUPPLEMENTARY EXPERT REPORT

I. INTRODUCTION AND SCOPE OF WORK

1. My name is Kosuke Imai, Ph.D., and I am a Professor in the Department of Government and the Department of Statistics at Harvard University. I specialize in the development of statistical methods and computational algorithms and their applications to social science research. I am also affiliated with Harvard's Institute for Quantitative Social Science. My qualifications and experiences are described in my initial report (hereafter "initial report") on this matter submitted to the Pennsylvania Legislative Reapportionment Commission, entitled "Written Testimony Regarding the Preliminary State House Plan from the Pennsylvania Legislative Reapportionment Commission" (January 14, 2022).

2. I have been engaged by counsel to statistically analyze relevant data and provide my expert opinions on whether the final State House plan approved by the Pennsylvania Legislative Reapportionment Commission (hereafter "final House plan") is a partisan gerrymander. In addition, I have been asked to comment on Professor Michael Barber's final expert report, entitled "Report on Redistricting Plan for the Pennsylvania House of Representatives of the Pennsylvania Legislative Reapportionment Commission," which presents the results of his race-blind redistricting simulation analysis regarding the final House plan. I have also reviewed the March 4, 2022 Report of Dr. Mark A. Nordenberg who served as the chair of the Pennsylvania Legislative Reapportionment Commission.

3. In my initial report, I conducted three separate simulation analyses to evaluate the possible partisan bias of the preliminary State House plan (hereafter "preliminary House plan"). Specifically, I conducted a *race-blind simulation analysis* that uses no information about race but incorporates other criteria in the Pennsylvania Constitution. I also conducted two simulation analyses that consider race, in addition to constitutional criteria, when generating simulated plans. The first simulation analysis, which is referred to as the *Simulation A analysis*, ensures that, in addition to constitutional criteria, every simulated plan identifies a certain number of majority black and majority Hispanic districts. I also conducted a second simulation analysis, which I refer to as the *Simulation B analysis*. This simulation analysis ensures that every simulated plan includes a

certain number of majority-minority districts (MMDs). These MMDs include coalition districts as well as majority black and majority Hispanic districts. For both *Simulation A and B analyses*, the targets were based on the relevant aspects of the preliminary House plan.

4. In this report, I evaluate the final House plan by conducting the same three simulation analyses as done in my initial report, but with one important improvement over my previous simulations. In particular, I was able to instruct the algorithm to further reduce the number of split municipalities and the total number of municipality splits under the simulated plans so that they are similar to the corresponding numbers under the final House plan. The consideration of municipality splits is important because Article II, § 16 of the Pennsylvania Constitution states that "Unless absolutely necessary no county, city, incorporated town, borough, township or ward shall be divided in forming either a senatorial or representative district." Due to time constraints, I did not make this improvement to the simulation algorithm that I used to evaluate the preliminary House plan. This improvement was partially informed by the Commission's prioritization of splitting larger municipalities as referenced in Dr. Nordenberg's Report.

5. It is also important to note that Professor Barber's simulated plans split many more municipalities than the final House plan. The median number of split municipalities under his simulated plans is 82, which is more than 45% greater than 56 municipalities split under the final House plan. Indeed, as pointed out by Dr. Nordenberg, "*not one* of his 17,537 simulations has as few split municipalities as the Commission's Final Plan. [. . .] This also raises questions about his methodology" (emphasis added).[1] Thus, my improved *race-blind* simulation analysis allows me to investigate whether or not Professor Barber's conclusion holds up once the number of split municipalities is reduced to the range similar to that of the final House plan. Furthermore, I examine the partisan implications of considering race, in addition to constitutional criteria, in the final House plan by comparing the conclusions of my *race-blind* simulation analysis with those of *Simulation A and B analyses* that incorporate the information about race.

6. As done in my initial report, for each of the three simulation analyses, I generated

1. Report of Mark A. Nordenberg, Chair of the 2021 Pennsylvania Legislative Reappointment Commission, Regarding the Commission's Final Plan. footnote 33.

a representative set of 5,000 alternative plans that could be drawn under the corresponding set of redistricting criteria. I then compared the likely number of Democratic districts under the final House plan with that under each set of 5,000 simulated plans. I could generate more simulated plans by running the algorithm longer, but 5,000 simulated plans yield sufficiently precise conclusions for the purpose of my analysis. To make my results comparable with those of Professor Barber's report, I used the same set of all statewide elections between 2012 and 2020 to compute the likely number of Democratic districts under each plan. In addition, I also include the results based on the 2016-2020 statewide elections, which were used by Professor Barber in his previous reports.

II. SUMMARY OF OPINIONS

7. My analysis of the final House plan yields the following findings:

- My *race-blind simulation analysis*, which keeps both the number of municipality splits in the simulated plans comparable to that of the final House plan, shows that the final House plan is not a partisan gerrymander. This important finding contradicts the conclusion of Professor Barber's race-blind simulation analysis, which has many more municipality splits than either the final House plan or my *race-blind* simulated plans. Comparison of this result with the previous finding from my initial report, which analyzed the preliminary House plan, implies that focused compliance with the Pennsylvania Constitution's requirement to minimize municipality splits is critical when assessing the partisan bias of the final House plan.

- My *Simulation A analysis*, which keeps the number of municipality splits in the simulated plans comparable to that of the final House plan, shows that additionally ensuring a certain number of majority black and majority Hispanic districts under each simulated plan leads to the same conclusion as the race-blind simulation analysis: the final House plan is not a partisan gerrymander. This result contradicts the conclusion of Professor Barber's race-blind simulation analysis but is consistent with the previous finding from my initial report.

- My *Simulation B analysis*, which keeps the number of municipality splits in the simulated plans comparable to that of the final House plan, shows that additionally ensuring a certain number of majority-minority districts under each simulated plan leads to the same conclusion as the race-blind simulation analysis: the final House plan is not a partisan gerrymander. This result contradicts the conclusion of Professor Barber's race-blind simulation analysis but is consistent with the previous finding from my initial report.
- All of my three simulation analyses, regardless of whether and how they consider race in addition to constitutional criteria, lead to the same conclusion that the final House plan is not a partisan gerrymander. This implies that the additional consideration of race along with the constitutional criteria in the final House plan does not favor any political party.

In sum, based on my analysis of the final House plan, I reject the conclusion drawn by Professor Barber that the final House plan is a partisan gerrymander.

III. METHODOLOGY

8. I conducted *race-blind* and alternative simulation analyses to evaluate the partisan outcomes expected under the final House plan. The *race-blind* and alternative simulation analyses I conducted only differ in terms of whether race was used as an additional input to the simulation algorithms with the constitutional criteria. The key difference between these simulation analyses and the corresponding simulation analyses described in my initial report is that the current simulation analyses yield simulated plans with the number of municipality splits comparable to that of the final House plan. This is achieved by placing additional constraints that reduce the number of split municipalities as well as the number of municipality splits. Otherwise, the simulation setups used in this report are essentially identical to those used in my initial report. Below, I provide a brief overview of my simulation analysis setups while leaving the details to Appendix A.

A. Race-blind Simulation Setup

9. The first set of 5,000 alternative plans were generated without any consideration of race. I call them *race-blind* simulated plans. My race-blind simulation procedure generated 5,000

alternative plans under the following five reapportionment criteria based on Article II § 16 of the Pennsylvania Constitution:

- there are a total of 203 geographically contiguous districts
- all districts do not exceed an overall population deviation of $\pm$ 5%
- simulated plans are encouraged to be more compact
- simulated plans are encouraged to split fewer number of counties
- simulated plans are encouraged to split fewer number of municipalities
- simulated plans are encouraged to have fewer number of municipality splits

10. In my initial report, I explained that I had been unable to replicate Professor Barber's race-blind simulation analysis because his previous report did not specify the exact algorithm, constraints, and parameter values used in his analysis. Unfortunately, Professor Barber's latest report suffers from the same problem. Although his race-blind simulation analysis is based on the open-source software package `redist` (Kenny et al. 2020), which I developed with my collaborators, Professor Barber does not provide sufficiently detailed information about his algorithmic choices, again making it impossible for me to replicate his analysis.

B. Alternative Simulation Setups Considering Race

11. I also generated two alternative sets of 5,000 simulated plans using the information about race. As explained in my initial report, in addition to the constitutional criteria, I instructed my simulation algorithm to create the specified number of majority-minority districts (hereafter "VRA-related districts"), but otherwise followed the same redistricting criteria as the race-blind simulation procedure used for the first set. Like my race-blind analysis, these alternative simulation analyses do not use partisan information when generating simulated districts.

12. I conducted two alternative simulation analyses that incorporate the consideration of race in addition to constitutional criteria. The *Simulation A analysis* ensures that every simulated plan has a total of 8 majority black districts and 4 majority Hispanic districts. I also conducted the so-called *Simulation B analysis,* which instructs the simulation algorithm to generate a total of 25 majority-minority districts (MMDs) in every simulated plan. These MMDs include 13 coalition

districts as well as the same set of 8 majority black and 4 majority Hispanic districts included in the *Simulation A* analysis. Other than the difference in the use of VRA-related districts, these two alternative sets of 5,000 simulated plans were generated under the same set of redistricting criteria listed above including the constitutional criteria.

C. Partisan Outcome Measure

13. To measure the partisan outcome under a given plan, I exactly follow Professor Barber's approach and compute the likely number of Democratic districts. Although there are other ways to measure partisan outcomes and biases under redistricting plans, this allows me to directly compare the results of my simulation analysis with those presented in Professor Barber's report. Specifically, I first tally a set of vote totals for each party at the precinct level across all statewide elections between 2012 and 2020, which were used by Professor Barber. Then, under a given redistricting plan, I calculate the number of districts out of the 203 total districts where Democrats have more votes than Republicans. This yields the total number of Democratic districts given the plan and election.[2] For the sake of completeness, I also report the results based on all statewide elections between 2014 and 2020, which were used by Professor Barber in his previous reports. The data sources are described in my initial report, whereas the information about the final House plan was obtained from the website of the Pennsylvania Legislative Reapportionment Commission.

IV. EMPIRICAL FINDINGS REGARDING THE FINAL HOUSE PLAN

14. I now present the results of my simulation analysis. I begin by discussing the results of my *race-blind* simulation analysis and then show the findings from my two alternative simulation analyses.

A. Race-blind Simulation Analysis Results

15. Figure 1 presents the likely number of Democratic districts across 5,000 *race-blind* simulated plans (grey histograms), using the 2012–2020 (left plot) and 2014–2020 (right plot)

2. Applying this method to my data, my calculation yields 106 Democratic districts whereas Professor Barber reports 107 districts. The cause of this small discrepancy is unclear, but it does not affect my conclusions.

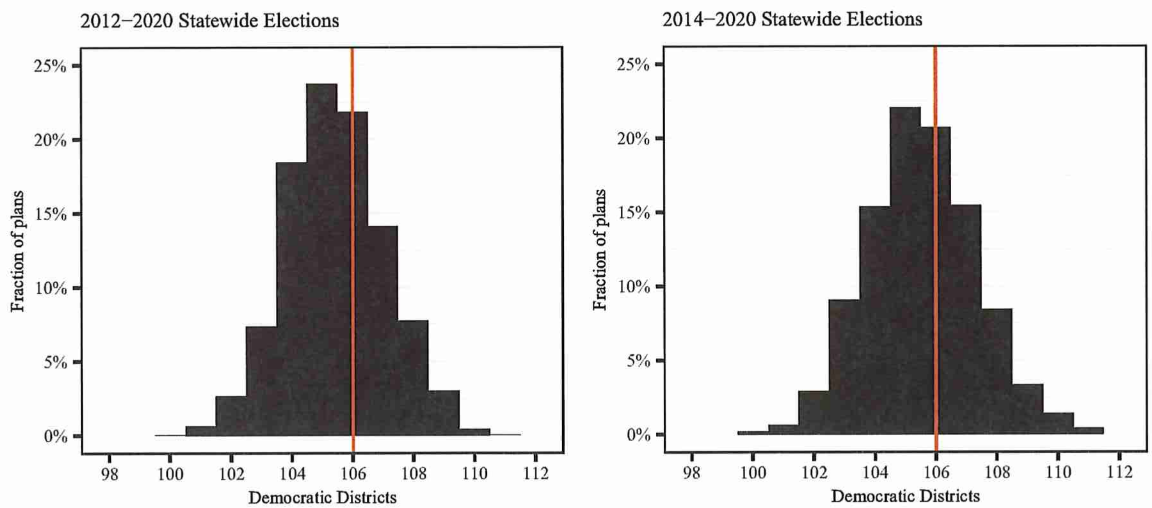

Figure 1: The likely number of Democratic districts across 5,000 *race-blind* simulated plans. Democratic districts are tallied based on an average of statewide elections for the 2012–2020 cycles (left) and the 2014–2020 cycles (right). The red vertical lines represent the results under the final House plan, which fall well within the simulation ranges.

statewide elections. The figure shows that according to the *race-blind* simulation, the most likely number of Democratic districts is 105, regardless of which election set I use. The expected number of Democratic districts under the final House plan (red vertical lines) is 106, which is well within the simulation ranges. In fact, under my *race-blind* simulation, the most likely number of Democratic district is greater by 8 districts than the corresponding number under Professor Barber's simulation analysis. Similarly, under my *race-blind* analysis the expected number of Democratic districts ranges from 100 to 111, whereas this range is [90, 105] under Professor Barber's analysis.

16. The results imply that the final House plan is not a partisan gerrymander even without any consideration of race, sharply contradicting the conclusion of Professor Barber's race-blind simulation analysis.

17. As mentioned earlier, I was unable to replicate Professor Barber's findings in part due to the lack of detailed information about the exact specification of his simulation analysis. This makes it difficult for me to figure out the exact reason why my *race-blind* simulation analysis differs from Professor Barber's race-blind simulation analysis.

	Final House plan	My race-blind simulation median	range	Professor Barber's simulation median	range
Split municipalities	56	51	[39, 66]	82	[61, 105]
Municipality splits	92	100	[84, 116]	119	[98, 140]

Table 1: Number of Split Municipalities and Number of Municipality Splits under the Final House and Simulated Plans. My race-blind simulation splits a fewer number of municipalities and generates a fewer number of municipality splits than Professor Barber's race-blind simulation. The corresponding numbers under the final House plan are well within my simulation ranges. In contrast, none of Professor Barber's simulated plans has as few split municipalities and municipality splits as the final House plan.

18. One key difference, however, is that, as shown in Table 1, Professor Barber's simulated plans split many more municipalities and generate a greater number of municipality splits than my *race-blind* simulated plans. For example, the median number of split municipalities is 60% greater under Professor Barber's simulation than under my *race-blind* simulation. Moreover, none of Professor Barber's simulated plans has as few split municipalities and municipality splits as the final House plan. In contrast, the median number of municipality splits under my *race-blind* simulation is much closer to the corresponding number under the final House plan, which is well within the simulation range (see also the middle and right plots of Figure A.1 in Appendix B). Note that both my *race-blind* simulation and Professor Barber's simulation split about the same number of counties as the final House plan (see the left plot of Figure A.1 in Appendix B). This suggests that the failure to minimize the number of municipality splits under Professor Barber's simulation analysis likely contributed to his conclusion that is opposite of mine.

19. In summary, after I improved the algorithm to reduce the number of municipality splits to the same level as the one in the final House plan, the *race-blind* simulation confirms that the final House plan is not a partisan gerrymander.

B. Simulation A Results

20. Figure 2 presents the results of the *Simulation A* analysis, which incorporates 8 majority black districts and 4 majority Hispanic districts, using the 2012–2020 (left plot) and 2014–2020 (right plot) statewide elections, respectively. Like my *race-blind* simulation analysis, both the number of split municipalities and the total number of municipality splits under the final

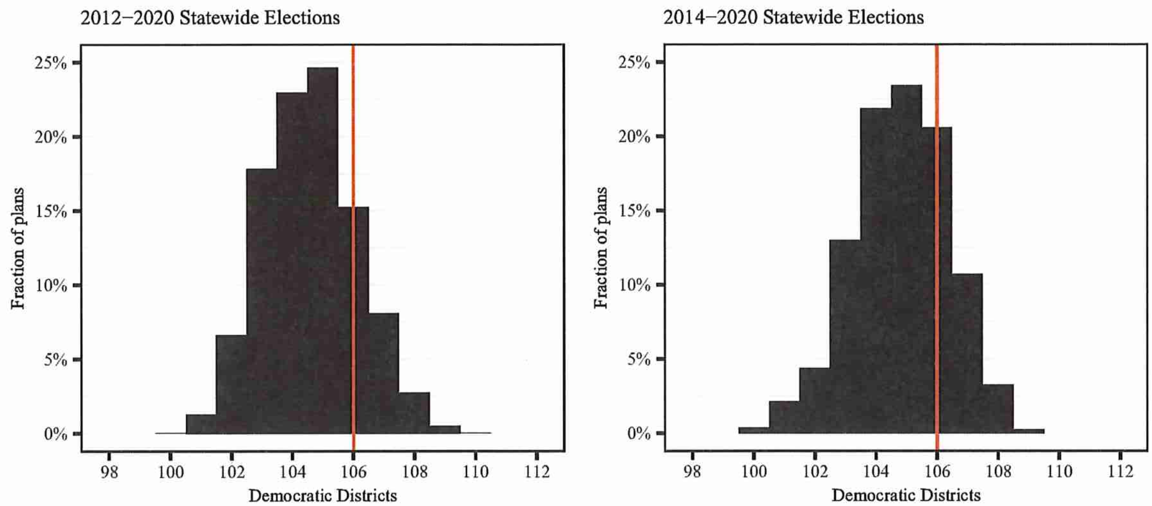

Figure 2: The likely number of Democratic districts across the *Simulation A* plans, each of which has 8 black majority and 4 Hispanic majority districts. Democratic districts are tallied based on an average of statewide elections for the 2012-2020 cycles (left) and the 2014-2020 cycles (right). The red vertical lines represent the results under the final House plan, which fall well within the simulation ranges.

House plan are well within the simulation range for this *Simulation A analysis* (see the middle and right plots of Figure A.2 in Appendix B). Regardless of which election set I use, the most likely number of Democratic districts under the *Simulation A* plans is 105, which is identical to the corresponding number under my *race-blind* simulation analysis. Importantly, this number differs, only by one district, from the expected number of Democratic districts under the final House plan (red vertical line).

21. Thus, the *Simulation A* analysis, which considers race based on the identification of majority black and majority Hispanic districts, in addition to constitutional criteria, yields the same conclusion as my *race-blind* simulation analysis: the final House plan is not a partisan gerrymander. This finding contradicts the results of Professor Barber's race-blind simulation analysis, but is consistent with the result of my previous *Simulation A analysis* shown in my initial report.

C. Simulation B Results

22. Figure 3 presents the results of the *Simulation B* analysis, which incorporates a total of 25 majority-minority districts (MMDs), using the 2012–2020 (left plot) and 2014–2020

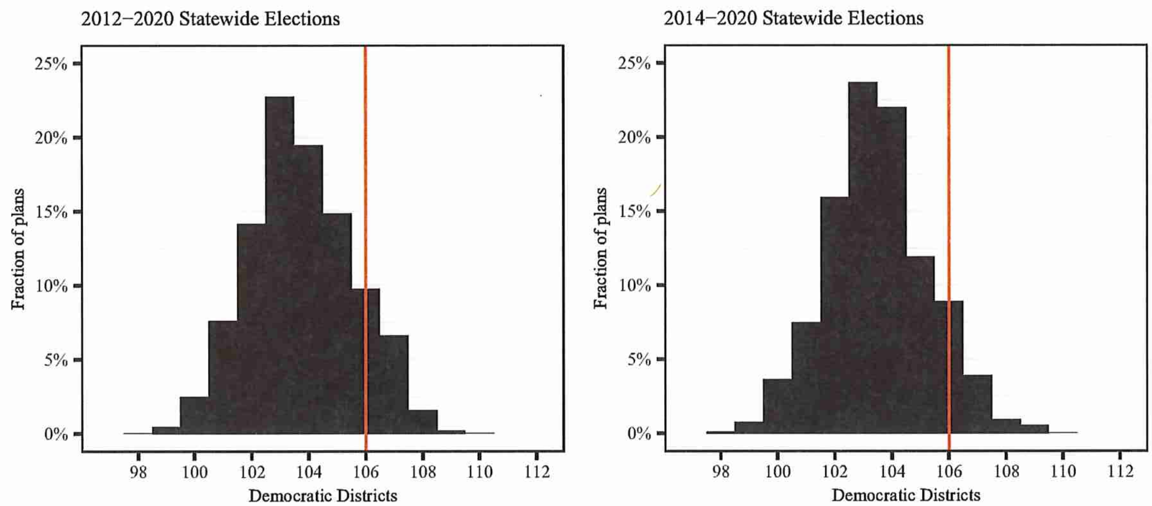

Figure 3: The likely number of Democratic districts across the *Simulation B* plans, each of which has 25 majority-minority districts. Democratic districts are tallied based on an average of statewide elections for the 2012-2020 cycles (left) and the 2014-2020 cycles (right). The red vertical lines represent the results under the final House plan, which fall well within the simulation ranges.

(right plot) statewide elections. Like my *race-blind* simulation analysis, both the number of split municipalities and the total number of municipality splits under the final House plan are well within the simulation range for this *Simulation B analysis* (see the middle and right plots of Figure A.3 in Appendix B). Regardless of which election set I use, the most likely number of Democratic districts under the simulated plans is 103, which is only three districts less than what would be expected under the final House plan. Importantly, the expected number of Democratic districts under the final House plan is well within the simulation range.

23. Therefore, the *Simulation B* analysis confirms the conclusion of my *race-blind* and *Simulation A* analyses that the final House plan is not a partisan gerrymander. This finding again contradicts the results of Professor Barber's race-blind simulation analysis but is consistent with the result of my previous *Simulation B analysis* shown in my initial report.

D. Comparison of the Three Simulation Analyses

24. Finally, I compare the results of the three simulation analyses shown above. The distribution of the expected number of Democratic seats under my *race-blind* simulation analysis

differs relatively little from those under the *Simulation A and B analyses*. In particular, regardless of which election set I use, the most likely number of Democratic districts is identical (i.e., 105 districts) between my *race-blind* simulation analysis and the *Simulation A analysis*. This number differs, only by one district, from the corresponding number under the final House plan. The findings of the *Simulation B analysis* are very similar though resulting simulated plans yield slightly fewer expected number of Democratic districts. Importantly, the expected number of Democratic districts under the final House plan falls well within the simulation range across all three simulation analyses, regardless of election set I use.

25. In sum, all of my simulation analyses, regardless of whether and how they consider race in addition to constitutional criteria, lead to the same conclusion that the final House plan is not a partisan gerrymander. This implies that the additional consideration of race in the final House plan does not favor any political party.

V. APPENDIX

A. Implementation Details

A.1. Race-blind simulation analysis

1. My *race-blind* simulation analysis largely follows that of my initial report and proceeds in two steps: I first divide the state into five clusters (Region A, B, C, D, and E) and a geographically larger remainder. Appendix B.1 of my initial report provides the definitions of these clusters, which are primarily based on counties. I use the merge-split MCMC algorithm in all of my simulations (Autry et al. 2021; Carter et al. 2019). I initialize the merge-split MCMC with the final House plan.[3] I divide the state into clusters to maintain sample diversity, along with continuity of analysis with *Simulation A* and *Simulation B*.

2. Article II § 16 of the Pennsylvania Constitution states districts "shall be composed of compact and contiguous territory as nearly equal in population as practicable." The merge algorithm generates contiguous districts by design. I used a population deviation threshold of

3. The exception is in Region B, where several districts are not contiguous due to discontiguous precincts. In those districts, I manually reassign the discontiguous pieces to their geographically adjacent districts so that the algorithm produces geographically contiguous districts.

	Counties	Municipalities		
	C_{splits}	C_{splits}	$C_{\text{multisplits}}$	$C_{\text{totalsplits}}$
A	1	1	-	-
B	3.5	2	-	-
C	-	1	-	-
D	-	1	1.5	-
E	-	2	1.5	-
Remainder	4	5	0.5	-

Table A.1: The constraints used for my *race-blind* simulations. Spaces with - in them indicate no constraint of that type was used.

$\pm 5\%$. I use a compactness parameter of $\rho = 1$ in all simulations.

3. The same article also states "Unless absolutely necessary no county, city, incorporated town, borough, township or ward shall be divided in forming either a senatorial or representative district." To address this, I use four types of constraints. First, I use the hierarchical split constraint of the merge-split MCMC algorithm applied to municipalities. Second, I use Gibbs constraints of the form $C_{\text{splits}} n_{\text{splits}}$. For this second constraint, C_{splits} is a tuning parameter, and n_{splits} is the number of administrative units that are split. The third constraint takes the form $C_{\text{multisplits}} n_{\text{multisplits}}$, where $C_{\text{multisplits}}$ is a tuning parameter and $n_{\text{multisplits}}$ is the number of administrative units split multiple times. The fourth type of constraint is of the form $C_{\text{totalsplits}} n_{\text{totalsplits}}$, where $C_{\text{totalsplits}}$ is a tuning parameter and $n_{\text{totalsplits}}$ is the total number of splits across all administrative units. I apply the second through fourth constraints to municipalities in each region. For a complete list of tuning parameters, see Table A.1. Values of the parameters were selected based on simulation experiments with the data while maintaining sample diversity. In general, higher values would yield districts with fewer county and municipality splits but diminish the diversity of maps generated.

4. To conduct the simulations in smaller regions A, B, and C, I generate 100 distinct plans by sampling 10,000 total plans, dropping the first 5,000, and then saving every 50th plan thereafter. In the remainder, D, and E, I generate a total of 255,000 maps, dropping the first 5,000, and then saving every 50th plan thereafter. This yields 5,000 plans in the remainder. I then match the plans in each region to the plans in the remainder, with each regional plan corresponding to 50

	Counties	Municipalities		
	C_{splits}	C_{splits}	$C_{\text{multisplits}}$	$C_{\text{totalsplits}}$
A	1	1	-	-
B	3.5	2	1	1
C	-	0.5	0.1	0.5
D	-	1	1.5	-
E	-	2	1.5	-
Remainder	4	5	0.5	-

Table A.2: The constraints used for the *Simulation A* plans. Spaces with - in them indicate no constraint of that type was used.

	Counties	Municipalities		
	C_{splits}	C_{splits}	$C_{\text{multisplits}}$	$C_{\text{totalsplits}}$
A	1	1	-	-
B	3.5	2	1	0.5
C	-	0.5	0.1	0.5
D	-	1	1.5	-
E	-	2	1.5	-
Remainder	4	5	0.5	-

Table A.3: The constraints used for the *Simulation B* plans. Spaces with - in them indicate no constraint of that type was used.

remainder plans.

A.2. Alternative simulation analyses that incorporate the consideration of race

5. Using a similar two-step approach as my *race-blind* simulation, I sample two alternative sets of simulated plans while incorporating race, in addition to constitutional criteria, into simulation algorithms. Following my initial report, I conducted these alternative simulations that consider particular VRA-related districts. Appendix C of my initial report provides the details of these VRA-related districts. As before, I used the merge-split MCMC algorithm in all regions (Autry et al. 2021; Carter et al. 2019). I directed the merge-split algorithm so that it would consider VRA-related districts within each region. I do so by building constraints into the algorithm, to generate maps that include the desired VRA-related districts with higher probabilities.

6. As in the *race-blind* simulations, I use constraints on compactness, along with the four types of constraints on splitting municipalities and counties. I use the same population tolerance of $\pm 5\%$ and a compactness parameter of $\rho = 1$ as before. In some cases, the parameters

for the county and municipality splits changed to accommodate the VRA-related constraints, but the constraints remain the same across *Simulation A and B analyses*. For details on the parameter values, see Table A.2 and A.3.

7. I use the same two types of constraints to target VRA-related districts as the ones used in my initial report (see Appendix B.2 of the initial report for details). I run two versions of the alternative analyses that incorporate race. The *Simulation A analysis* only imposes VRA-related constraints in Regions B and C. The *Simulation B analysis* imposes additional VRA-related constraints in Regions B and C, along with new VRA-related constraints in Region A. When generating plans, I follow the same process as in the *race-blind* simulations: I generate 5,000 plans that are discarded, and then I save every 50th plan thereafter until I have 100 plans that incorporate the VRA-constraints. In each case, if no additional VRA-constraints are imposed, I use the same plans generated under the *race-blind* simulations. In all cases, I use the same 5,000 plans generated for the remainder region.

B. County and Municipality Splits of the Simulated and Final House Plans

8. I now show that my simulation plans have a similar number of county and municipality splits when compared to the final House plan. The middle and right panels of Figures A.1, A.2, and A.3 demonstrate the simulated plans generally split a similar number of municipalities and have a similar number of total municipality splits in comparison to the final House plan. This is indicated by the fact that the number of municipality splits under the final House plan (vertical red lines) falls well within the distribution of the corresponding number under the simulated plans (grey histograms). In addition, the left panels of Figures A.1, A.2, and A.3 show that my simulated plans and the final House plan split a similar number of counties as well.

C. Compactness of the Simulated and Final House Plans

9. I find that my simulated plans are as compact as the final House plan when using the fraction of edges kept measure (DeFord, Duchin, and Solomon 2021; McCartan and Imai 2020). According to the Polsby-Popper measure (Polsby and Popper 1991), however, the final House plan is more compact than my simulated plans. Figure A.4 shows that the final House plan

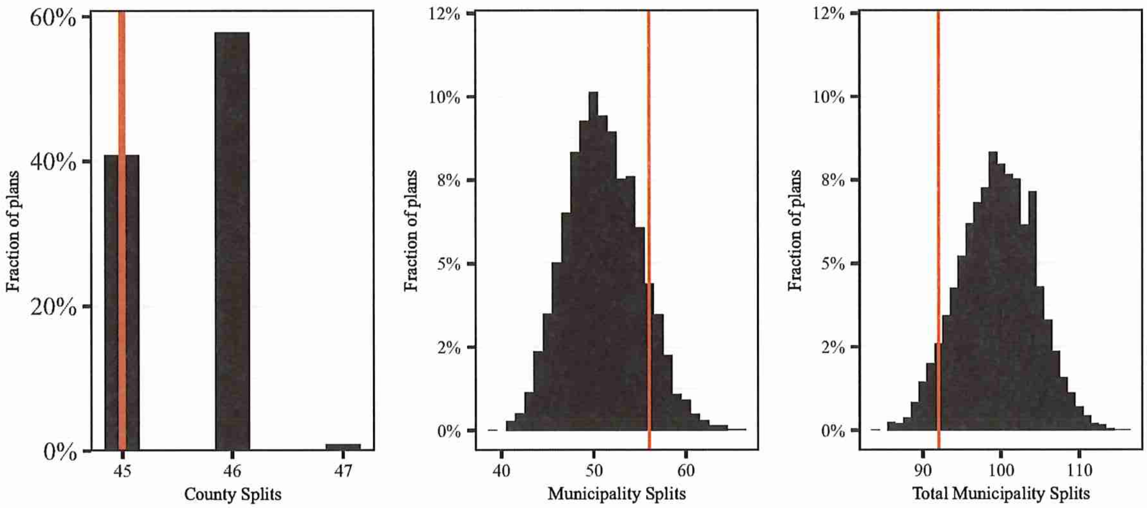

Figure A.1: The number of county and municipality splits in the *race-blind* simulated plans (histogram). An administrative unit is deemed as split if any of its precincts are assigned to different districts. The left plot presents the total number of split counties. The middle plot shows the number of split municipalities while the right plot shows the total number of municipality splits. The red vertical line represents the final House plan, which fall well within the simulation ranges.

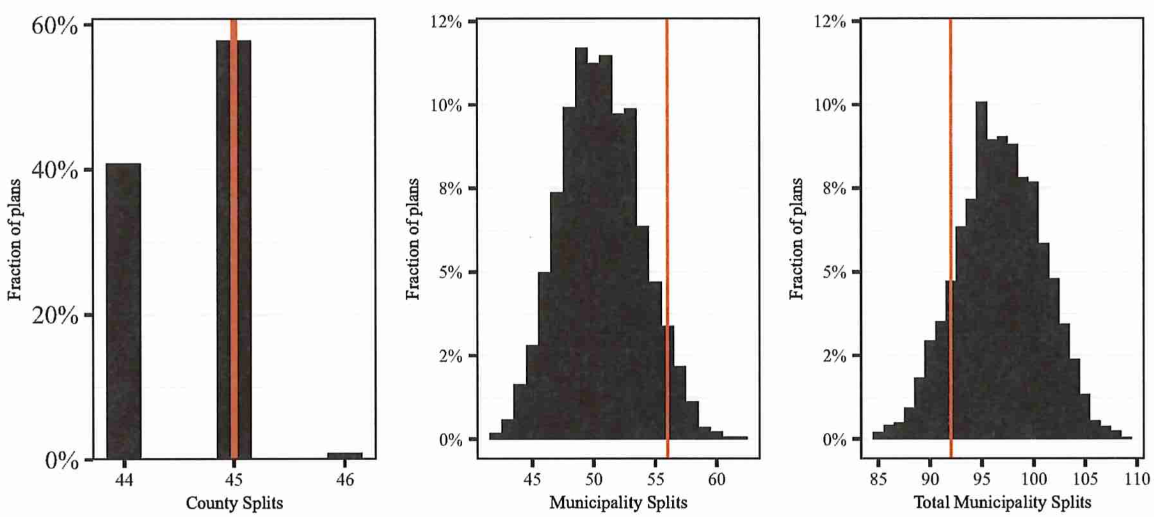

Figure A.2: The number of county and municipality splits in the *Simulation A* plans (histogram). An administrative unit is deemed as split if any of its precincts are assigned to different districts. The left plot presents the total number of split counties. The middle plot shows the number of split municipalities while the right plot shows the total number of municipality splits. The red vertical line represents the final House plan, which fall well within the simulation ranges.

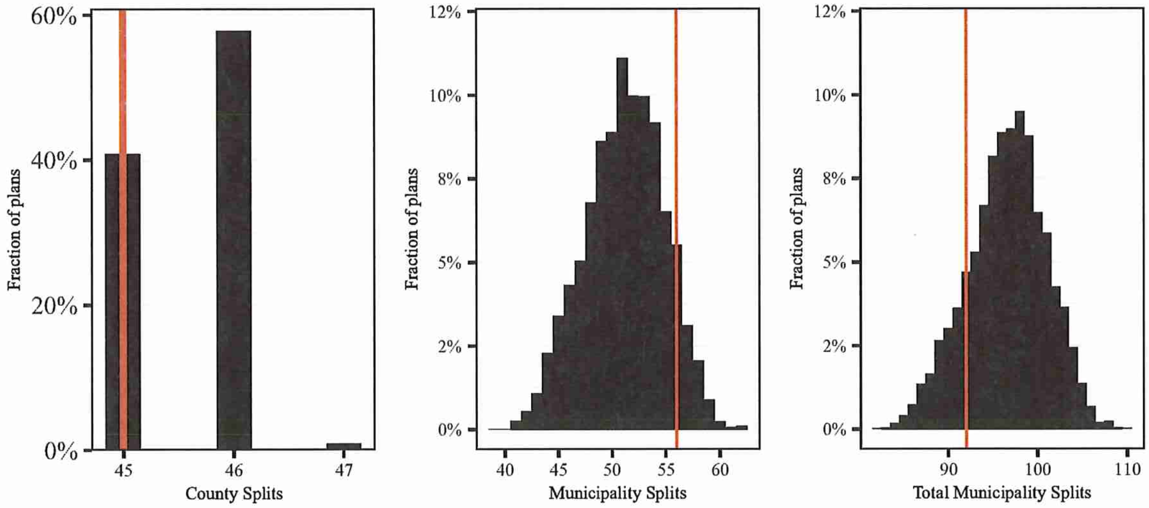

Figure A.3: The number of county and municipality splits in the *Simulation B* plans (histogram). An administrative unit is deemed as split if any of its precincts are assigned to different districts. The left plot presents the total number of split counties. The middle plot shows the number of split municipalities while the right plot shows the total number of municipality splits. The red vertical line represents the final House plan, which fall well within the simulation ranges.

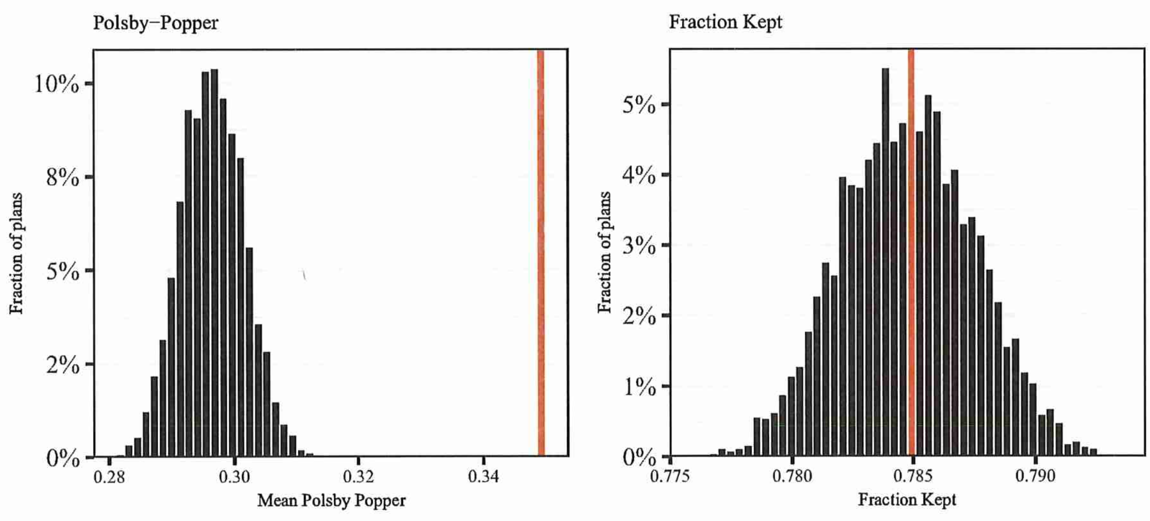

Figure A.4: The compactness of the *race-blind* simulated plans according to two measures – the average Polsby-Popper compactness (left) and fraction of edges kept (right). The red vertical line represents the final House plan.

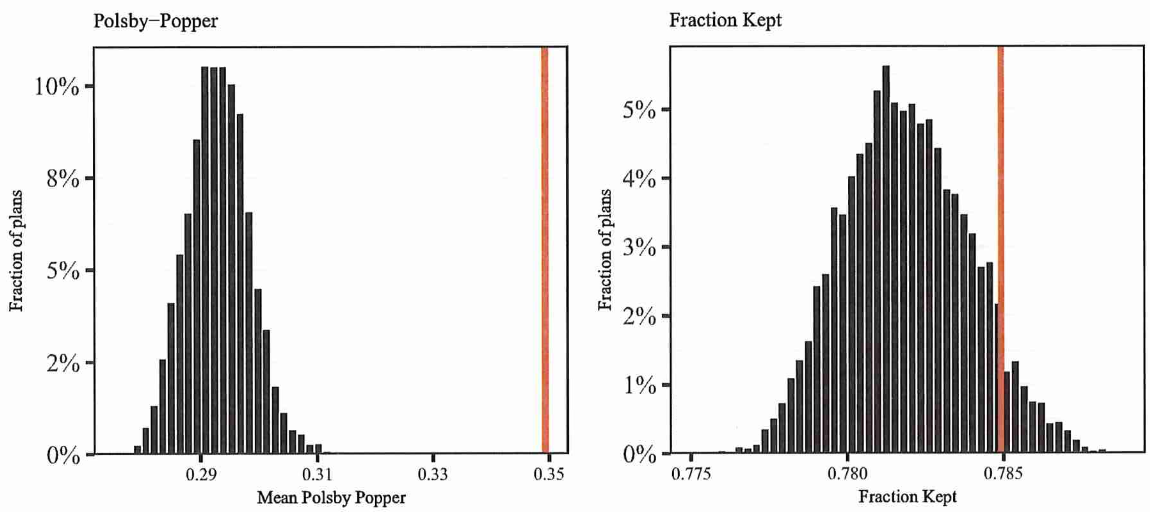

Figure A.5: The compactness of the *Simulation A* plans according to two measures – the average Polsby-Popper compactness (left) and fraction of edges kept (right). The red vertical line represents the final House plan.

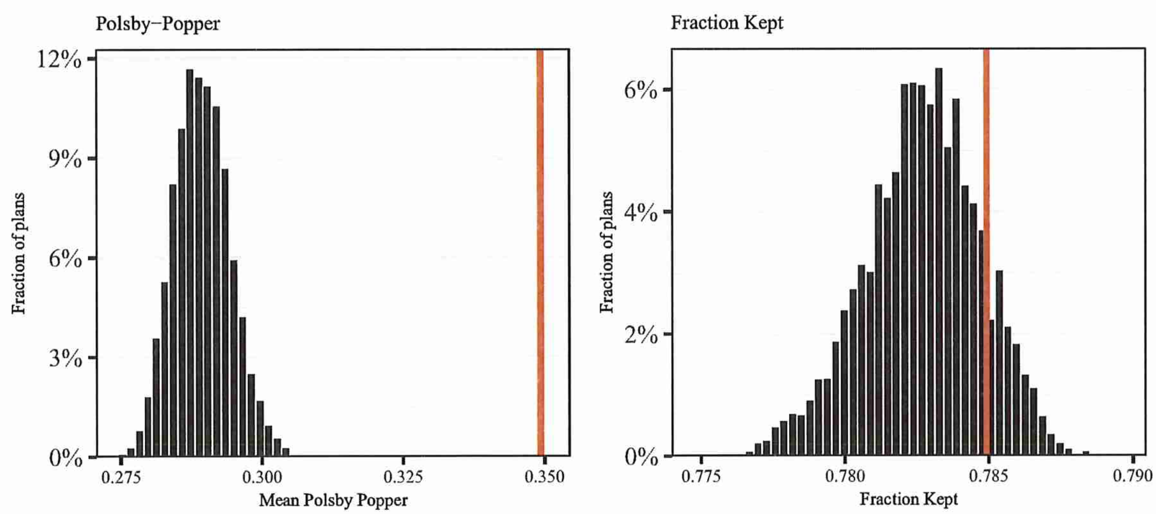

Figure A.6: The compactness of the *Simulation B* plans according to two measures – the average Polsby-Popper compactness (left) and fraction of edges kept (right). The red vertical line represents the final House plan.

is within the range of the *race-blind* simulated plans in terms of edge-removal compactness, and is more compact in terms of the average Polsby–Popper compactness. Figures A.5 and A.6 show similar results when comparing the final House plan to the *Simulation A* and *Simulation B* plans, respectively.

D. References

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EXHIBIT 2

An Evaluation of the Partisan Fairness of the Pennsylvania Legislative Reapportionment Commission's Enacted State House Districting Plan

Christopher Warshaw*

March 9, 2022

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Contents

1 Introduction

My name is Christopher Warshaw. I am an Associate Professor of Political Science at George Washington University. Previously, I was an Associate Professor at the Massachusetts Institute of Technology from July 2016 - July 2017, and an Assistant Professor at MIT from July 2012 - July 2016.

I have been asked by counsel representing the House Democratic Caucus to analyze relevant data and provide my expert opinions to the Legislative Reapportionment Commission (LRC) about its enacted State House districting plan. This report updates the report I submitted to the LRC on January 7th about its preliminary plan in advance of my testimony on January 14th, 2022.

2 Qualifications and Publications

My Ph.D. is in Political Science, from Stanford University, where my graduate training included courses in political science and statistics. I also have a J.D. from Stanford Law School. My academic research focuses on public opinion, representation, elections, and polarization in American Politics. I have written over 20 peer reviewed papers on these topics. Moreover, I have written multiple papers that focus on elections and two articles that focus specifically on partisan gerrymandering. I also have a forthcoming book that includes an extensive analysis on the causes and consequences of partisan gerrymandering in state governments.

My curriculum vitae is attached to this report. All publications that I have authored and published appear in my curriculum vitae. My work is published or forthcoming in peer-reviewed journals such as: the *American Political Science Review*, the *American Journal of Political Science*, the *Journal of Politics*, *Political Analysis*, *Political Science Research and Methods*, the *British Journal of Political Science*, the *Annual Review of Political Science*, *Political Behavior*, *Legislative Studies Quarterly*, *Science Advances*, the *Election Law Journal*, *Nature Energy*, *Public Choice*, and edited volumes from Cambridge University Press and Oxford University Press. My book entitled *Dynamic Democracy in the American States* is forthcoming from the University of Chicago Press. My non-academic writing has been published in the *New York Times* and the *Washington Post.* My work has also been discussed in the *Economist* and many other prominent media outlets.

My opinions in this case are based on the knowledge I have amassed over my education, training and experience, including a detailed review of the relevant academic literature.

They also follow from statistical analysis of the following data:

- GIS Files with the 2014-2020 Pennsylvania State House plan and the enacted 2022-30 plan): I obtained both plans from the Legislative Reapportionment Commission's website.

- Precinct-level data on recent statewide Pennsylvania elections: I use precinct-level data on Pennsylvania's statewide elections between 2016-20 from the Voting and Election Science Team (University of Florida, Wichita State University). I obtained these data from the Harvard Dataverse.[1] I obtained precinct-level data on elections from 2012-14 from the MGGG Redistricting Lab.[2] Finally, I obtained data on state legislative election results from the House Democratic Caucus since they were not available from public sources.

- Estimates of the partisan bias in previous state legislative elections: As part of my peer reviewed academic research, I have estimated the partisan bias of districting plans used in previous state legislative elections around the country from 1972-2020 (Stephanopoulos and Warshaw 2020). This analysis was based on state legislative election results from 1972-2020 collected by Carl Klarner and a large team of collaborators (Klarner et al. 2013). I also utilize data on presidential election returns in state legislative districts. For elections between 1972 and 1991, I used data on county-level presidential election returns from 1972-1988 collected by the Inter-university Consortium for Political and Social Research (ICPSR 2006) and mapped these returns to state legislative districts. For elections between 1992 and 2001, I used data on presidential election returns in the 2000 election collected by McDonald (2014) and Wright et al. (2009). For elections between 2002 and 2011, I used data on the 2004 and 2008 presidential elections collected by Rogers (2017). For elections between 2012 and 2020, I used data on presidential election returns from the DailyKos website and PlanScore.org.

- The Plan Score website: PlanScore is a project of the nonpartisan Campaign Legal Center (CLC) that enables people to score enacted maps for their partisan, demographic, racial, and geometric features. I am on the social science advisory team for PlanScore.

I have previously provided expert reports in seven redistricting-related cases:

1. See `https://dataverse.harvard.edu/dataverse/electionscience`.
2. See `https://github.com/mggg-states/PA-shapefiles`.

- Between 2017 and 2019, I provided reports for *League of Women Voters of Pennsylvania v. Commonwealth of Pennsylvania*, No. 159 MM 2017, *League of Women Voters of Michigan* v. *Johnson*, 17-14148 (E.D. Mich), and *APRI et al.* v. *Smith et al.*, No. 18-cv-357 (S.D. Ohio). My testimony was found to be credible in each of these cases and was extensively cited by the judges in their decisions. In the Pennsylvania Supreme Court's seminal decision that struck down its gerrymandered U.S. House plan, my testimony and analysis was extensively cited by Justice Todd's majority opinion.

- In the current redistricting cycle, I have provided reports in *League of Women Voters* v. *Ohio Redistricting Commission*, No. 2021-1193, *League of Women Voters* vs. *Kent County Apportionment Commission*, *League of Women Voters of Ohio* v. *Ohio Redistricting Commission*, No. 2021-1449, and *League of Women Voters of Michigan* vs *Michigan Independent Citizens Redistricting Commission.*

In addition, I have provided expert testimony and reports in several cases related to the U.S. Census: *State of New York et al.* v. *United States Department of Commerce*, 18-cv-2921 (S.D.N.Y.), *New York* v. *Trump*; *Common Cause* v. *Trump*, 20-cv-2023 (D.D.C.), and *La Union Del Pueblo Entero (LUPE)* v. *Trump*, 19-2710 (D. Md.).

The opinions in this report are my own, and do not represent the views of George Washington University.

3 Summary

As the Pennsylvania Supreme Court wrote in *League of Women Voters of Pennsylvania v. Commonwealth of Pennsylvania*, No. 159 MM 2017, "for our form of government to operate as intended, each and every [] voter must have the same free and equal opportunity to select his or her representatives" (p. 118). Indeed, the relationship between the distribution of partisan support in the electorate and the partisan composition of the government—what Powell (2004) calls "vote–seat representation"—is a critical link in the longer representational chain between citizens' preferences and governments' policies. If the relationship between votes and seats systematically advantages one party over another, then some citizens will enjoy more influence—more "voice"—over elections and political outcomes than others (Caughey, Tausanovitch, and Warshaw 2017).

I use three complementary methodologies to project future election results in order to evaluate the partisan fairness of Pennsylvania's enacted House plan. First, I use a composite of previous statewide election results between 2014-2020 to analyze the enacted

House plan.[3] Second, I analyze the results of the 2020 State House election on the enacted House plan. Third, I complement this approach using the open source PlanScore.org website, which is a project of the Campaign Legal Center.[4] PlanScore uses a statistical model to estimate district-level vote shares for a new map based on the relationship between presidential election results and legislative results between 2014-2020.[5] Based on these three approaches, I characterize the bias in Pennsylvania's plans based on a large set of established metrics of partisan fairness and place the bias in Pennsylvania's plans into historical perspective.[6] I also analyze whether the enacted House plan is responsive to shifts in voters' preferences.

All of these analyses indicate that the enacted House plan is fair with just a small pro-Republican bias. Indeed, one important feature of the enacted House plan is that it enables the party that wins the majority of the votes to nearly always win the majority of the seats. In the actual 2020 State House election, Republicans received 50.5% of the two-party vote and Republicans would win 50.7% of the seats in the enacted House plan.[7] In the 2020 presidential election, Democrat Joe Biden received about 50.6% of the two-party vote and he would have won 103 out of the 203 (50.7%) of the State House districts.[8] Based on the statewide elections in Pennsylvania between 2014-2020, the Democrats' statewide two-party vote share averaged about 54% of the vote and they would win nearly exactly the same proportion of the seats on the enacted House plan (54.5%).[9] Historically, there is a winner's bonus where the party that wins 54% of the votes typically receives about 58% of the seats. So recent statewide elections indicate a modest pro-Republican bias in the enacted House plan using a wide variety of Political Science metrics for partisan fairness.

I also reach the conclusion that the enacted House plan is relatively neutral, with a small pro-Republican bias, using the predictive model on the PlanScore website. PlanScore projects that Republicans would get about 50.3% of the statewide vote, but Republicans are expected to win 53% of the seats in Pennsylvania's enacted House plan (and

3. These include the following elections: 2016 Presidential, 2020 Presidential, 2014 Governor, 2018 Governor, 2016 Attorney General, 2020 Attorney General, 2016 Senate, 2018 Senate, 2016 Treasurer, 2020 Treasurer, 2016 Auditor, and 2020 Auditor election.

4. I am on the social science advisory board of Plan Score, but do not have any role in PlanScore's evaluation of individual maps.

5. See `https://planscore.campaignlegal.org/models/data/2021D/` for more details.

6. These metrics are described in depth on pp. 5-16 of my January 7th report on the LRC's preliminary state house plan.

7. I impute uncontested State House elections using the presidential election results.

8. Following standard convention, throughout my analysis I focus on two-party vote shares.

9. I weight the composite scores to give each election cycle equal weight in the index. The seat-level projections are based on the 12 statewide elections where I have precinct-level data. If instead I simply average across contests, Democrats win 52% of the votes and 52% of the seats on the enacted House plan.

Democrats would win 47% of the seats).[10] Across 1000 simulations, PlanScore indicates that the enacted House plan favors Republican candidates in 95% of scenarios. Based on generally accepted Political Science metrics for partisan fairness, PlanScore indicates that Pennsylvania's enacted House plan is relatively fair with a modest pro-Republican bias.

In addition, the partisan fairness metrics for the LRC's enacted House plan compare very favorably to the congressional plan recently approved by the Pennsylvania Supreme Court.

4 Background on Partisan Fairness

This section provides background about how social scientists conceptualize partisan fairness in a districting plan. Partisan advantage in a districting plan may arise either intentionally, due to a deliberate effort to benefit the line-drawing party and handicap the opposing party via gerrymandering (Kang 2017; Levitt 2017), or unintentionally as a result of factors such as political geography, candidate appeal, and electoral swings (Chen and Rodden 2013; Goedert 2014; Seabrook 2017). Whether districting bias is purposeful or accidental, it means that one party's voters are more "cracked" and "packed" than the other side's supporters. In cracked districts, voters' preferred candidates lose by relatively narrow margins; in packed districts, their candidates of choice win by enormous margins (Stephanopoulos and McGhee 2015). Thanks to disproportionate cracking and packing, the disfavored party is less able than the favored party to convert its statewide support among voters into legislative representation. This gives the favored party the ability to shift policies in its direction (Caughey, Tausanovitch, and Warshaw 2017) and build a durable advantage in downstream elections (Stephanopoulos and Warshaw 2020). It can even lead to undemocratic outcomes where the advantaged party wins the majority of the seats and controls the government while only winning a minority of the votes.

There are a number of approaches that have been proposed to measure partisan advantage in a districting plan. These approaches focus on asymmetries in the efficiency of the vote–seat relationships of the two parties. In recent years, at least 10 different approaches have been proposed (Gelman and King 1994; McGhee 2017; Katz, King, and Rosenblatt 2020). These metrics all stem from the fundamental idea that neither political party should have an unfair advantage in the translation of votes to seats that enables it to lock-in political power. While no measure is perfect, much of the recent literature has focused on a handful of related approaches that I described in my January 7th report

10. This is a probabilistic estimate based on 1000 simulations of possible elections using a model of the elections between 2014-2020.

(partisan symmetry, mean-median difference, the efficiency gap, and the declination).[11] All of these metrics are oriented in my report such that positive values favor Democrats and negative values favor Republicans. A score of zero on each metric indicates that neither party has an advantage in the translation of votes to seats. Thus, scores close to zero indicate that a plan is fair. I utilize these approaches to quantify the partisan fairness of the Commission's enacted House plan.

In his expert report that was submitted as an addendum to Leader Benninghofff's complaint, Professor Barber disputes this generally established conception of partisan fairness. He argues that "we do not know if [a redistricting plan] is biased until we compare it to a set of maps that we know were drawn using unbiased inputs" through simulations (54). This is not accurate. I do not know of any peer-reviewed study that has argued simulations should be used as the primary tool to evaluate the fairness or legality of a plan that does not otherwise provide either party an advantage according to generally accepted partisan bias metrics. Notably, Professor Barber's report does not provide any academic citations for his assertion that simulations should be the sole benchmark of bias in a districting plan. In fact, Katz, King, and Rosenblatt (2020, 176) argues that "purely relative measures" from simulations have "little value" for this purpose.[12] According to another recent paper, they are instead best used to "offer a sense of what might have been drawn absent the intent of the redistricting authority" (McGhee 2020, 176).[13] Katz, King, and Rosenblatt (2020, 176) argue they can "convey what is possible, such as plans with de minimis levels of partisan bias while also meeting other criteria."

11. These metrics are described in depth in my January 7, 2022 report on the LRC's preliminary House plan. Note that the exact calculation methods for the efficiency gap and declination differ slightly across sources. To calculate the efficiency gap I use the formula:

$$EG = S_D^{margin} - 2 * V_D^{margin} \tag{1}$$

where S_D^{margin} is the Democratic Party's seat margin (the seat share minus 0.5) and V_D^{margin} is the Democratic Party's vote margin (McGhee 2017, 11-12). This turnout-adjusted version of the efficiency gap takes into account differences in population across districts, and penalizes the party whose districts are under-populated (see pp. 10-11 of my January 7th report). I use the declination formula discussed in Warrington (2018, 42).

12. To illustrate this point, they ask: "Is a plan fair if it is at the 50th percentile of possible plans but, when the parties split the vote equally, [one party] receives 85% of the seats?"

13. In court cases, this simulation approach has been used to evaluate whether an unfair plan (based on the metrics I described above) stems from a state's political geography or the intent of mapmakers to favor one political party.

5 Partisan Fairness of Pennsylvania's enacted State House Map

In this section, I will provide a detailed evaluation of the partisan fairness of Pennsylvania's enacted House plan (see Figure 1 for a map of the enacted House plan). In order to evaluate the enacted House plan, we need to predict future election results on this map. Unfortunately, there is no way to know, with certainty, the results of future elections. Thus, I use three complementary methodologies to predict future State House elections in Pennsylvania and generate the various metrics I discussed earlier.

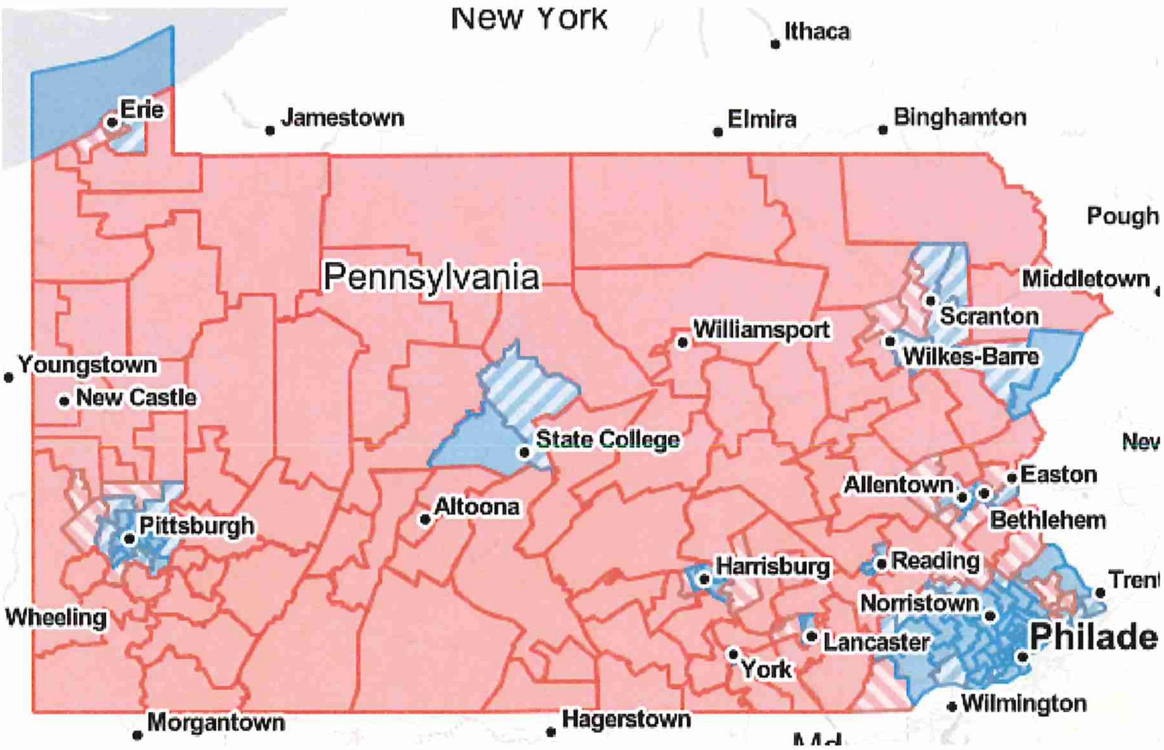


Figure 1: Map of Enacted State House Districts from PlanScore.org

5.1 Composite of previous statewide elections

First, I use a composite of previous statewide election results between 2014-2020 re-aggregated to the enacted House plan.[14] For each year, I estimate each party's vote share, seat share, and the average of the partisan bias metrics across races. I then average

14. These include the following elections: 2016 Presidential, 2020 Presidential, 2014 Governor, 2018 Governor, 2016 Attorney General, 2020 Attorney General, 2016 Senate, 2018 Senate, 2016 Treasurer, 2020 Treasurer, 2016 Auditor, and 2020 Auditor election.

them together to produce a composite result. This approach implicitly assumes that future voting patterns will look like the average of these recent statewide elections.

Metric	Value	2014-2020 Composite > Biased than this % Elections	 > Pro-Rep. than this % Elections
2014-2020 Plan			
Symmetry Bias	-7.7%	77%	85%
Mean-Median	-3.8%	70%	81%
Efficiency Gap	-5.8%	60%	83%
Declination	-.348	66%	82%
Average		68%	83%
Preliminary Plan			
Symmetry Bias	-2.5%	29%	61%
Mean-Median	-1.4%	31%	63%
Efficiency Gap	-2.6%	27%	69%
Declination	-.175	38%	65%
Average		31%	65%
Enacted Plan			
Symmetry Bias	-2.7%	31%	62%
Mean-Median	-1.4%	31%	63%
Efficiency Gap	-2.5%	26%	68%
Declination	-.173	38%	65%
Average		31%	65%

Table 1: Composite bias metrics for enacted House plan based on statewide elections

When I average across these statewide elections from 2014-2020, Democrats win 54% of the votes and 54.5% of the seats on the enacted House plan.[15] Thus, the plan satisfies the principle that the party that wins a significant majority of the statewide vote should also win a majority of the seats. However, Democrats did unusually well in these recent statewide elections. In state legislative elections, the two parties typically get closer to 50% of the statewide vote. Thus, another important benchmark is to examine what happens if each party evenly splits the votes. Basic fairness suggests that when the two parties split the votes they should also split the seats. But the composite election index indicates that when Democrats win 50% of the votes on the enacted House plan, they are likely to only win 47.3% of the seats. This leads to a pro-Republican bias on the symmetry metric of 2.7%.

The enacted House plan also has a small pro-Republican bias on the other metrics I evaluate (see bottom panel of Table 1). For instance, Republicans do about 1.4% better in the median district than in the mean district and Republicans have a 2.5% advantage

15. I weight the composite scores to give each election cycle equal weight in the index. The seat-level projections are based on the 12 statewide elections where I have precinct-level data.

in the Efficiency Gap.[16] Overall, the enacted House plan has a larger pro-Republican bias in the translation of votes to seats than 65% of previous plans over the past 50 years.

5.2 2020 State House election results

Next, I use the 2020 precinct-level State House results on both the 2014-20 map and re-aggregated to the enacted House plan to estimate the various metrics. This approach implicitly assumes that future elections will look like the 2020 election.[17] These endogenous election are likely to be an excellent predictor of future voting patterns in State House elections. But it is important to keep in mind that they could be affected by the individual candidates in each race as well as a host of other factors that wouldn't look exactly the same in future elections.

Metric	Value	More Biased than this % Historical Elections	More Pro-Republican than this % Historical Elections
2014-2020 Plan			
Symmetry Bias	-5.7%	60%	77%
Mean-Median Diff	-4.3%	79%	86%
Efficiency Gap	-4.8%	49%	78%
Declination	-.36	68%	83%
Average		64%	81%
Preliminary Plan			
Symmetry Bias	-0.2%	2%	49%
Mean-Median Diff	-1.9%	40%	68%
Efficiency Gap	0.7%	8%	51%
Declination	-.04	9%	50%
Average		15%	55%
Enacted Plan			
Symmetry Bias	-0.2%	2%	49%
Mean-Median Diff	-1.6%	35%	65%
Efficiency Gap	0.2%	2%	53%
Declination	-.076	17%	54%
Average		14%	55%

Table 2: Partisan bias metrics for State House plan based on 2020 State House election results re-aggregated onto enacted map

The enacted House plan is nearly perfectly unbiased based on the re-aggregated 2020

16. As I noted above in footnote 11, one advantage of the Efficiency Gap is that it accounts for differences in population and turnout across districts (McGhee 2017, 11-12).

17. As is commonly done in the academic literature, I impute uncontested State House elections using the presidential election results. In State House district 7, the Democratic candidate won even though former-President Trump won the majority of the vote. In this district, I adjust the presidential vote so that the Democratic vote share is 51% to ensure that the imputed results yield the correct number of Democratic and Republican seats.

State House results (bottom panel of Table 2). Republicans would win 50.5% of the votes and 50.7% of the seats on the enacted House plan. Moreover, both parties would receive nearly half the seats when the statewide vote is exactly evenly split. Thus, the symmetry bias is only .2%, which is right in the center of the historical distribution of partisan symmetries. The enacted House plan is also nearly perfectly neutral using the other metrics. Only the mean-median difference implies a significant Republican advantage in the translation of votes to seats. When we average across all four metrics, the plan is more extreme than 14% of prior plans, and thus more neutral than 86% of prior plans. When I average across the various metrics, it just has a very small pro-Republican advantage: it is more pro-Republican than 55% of previous plans.

5.3 PlanScore

Third, I evaluate the enacted House plan using a predictive model from the PlanScore.org website.[18] PlanScore uses a statistical model of the relationship between districts' latent partisanship and legislative election outcomes. This enables it to estimate district-level vote shares for a new map and the corresponding partisan gerrymandering metrics.[19] It then calculates various partisan bias metrics. Like the earlier approaches, PlanScore indicates that the enacted House plan is relatively neutral with a small pro-Republican bias (bottom panel of Table 3).

According to PlanScore, the enacted House plan has a small pro-Republican symmetry bias of -2.3%. This means that Republicans would win 52.3% of the seats if the two parties evenly split the votes. The enacted House plan favors Republicans in 95% of the scenarios estimated by PlanScore. The other metrics look similar to the symmetry metric. Across all the metrics, the enacted House plan is more pro-Republican than 64% of prior plans over the past five decades. Figure 2 graphically shows the bias of the enacted House plan compared to previous plans from 1972-2020.[20] Overall, the graphs show that the enacted House plan is close to the center of the distribution of previous plans over the past 50 years with just a small pro-Republican bias.

18. See `https://planscore.campaignlegal.org/plan.html?20220210T141618.834838941Z` for the enacted House plan and `https://planscore.campaignlegal.org/plan.html?20220107T194310.216726037Z` for the 2014-2020 plan.

19. See `https://planscore.campaignlegal.org/models/data/2021D/` for more details.

20. Note that the PlanScore graphs are oriented so that pro-Republican scores have a positive value.

Metric	Value	Favors Rep's in this % of Scenarios	More Biased than this % Historical Plans	More Pro-Republican than this % Historical Plans
2014-2020 Plan				
Symmetry	-4.5%	99%	50%	72%
Mean-Median Diff.	-2.0%	99%	42%	68%
Efficiency Gap	-4.6%	99%	53%	81%
Declination	-.27	99%	57%	76%
Average		99%	51%	74%
Preliminary Plan				
Symmetry	-2.5%	94%	31%	61%
Mean-Median Diff.	-1.2%	94%	27%	61%
Efficiency Gap	-2.5%	95%	32%	70%
Declination	-.15	95%	37%	64%
Average		95%	32%	64%
Enacted Plan				
Symmetry	-2.3%	94%	30%	61%
Mean-Median Diff.	-1.1%	94%	25%	61%
Efficiency Gap	-2.5%	95%	32%	70%
Declination	-.14	95%	35%	63%
Average		95%	31%	64%

Table 3: PlanScore partisan bias metrics for enacted House plan

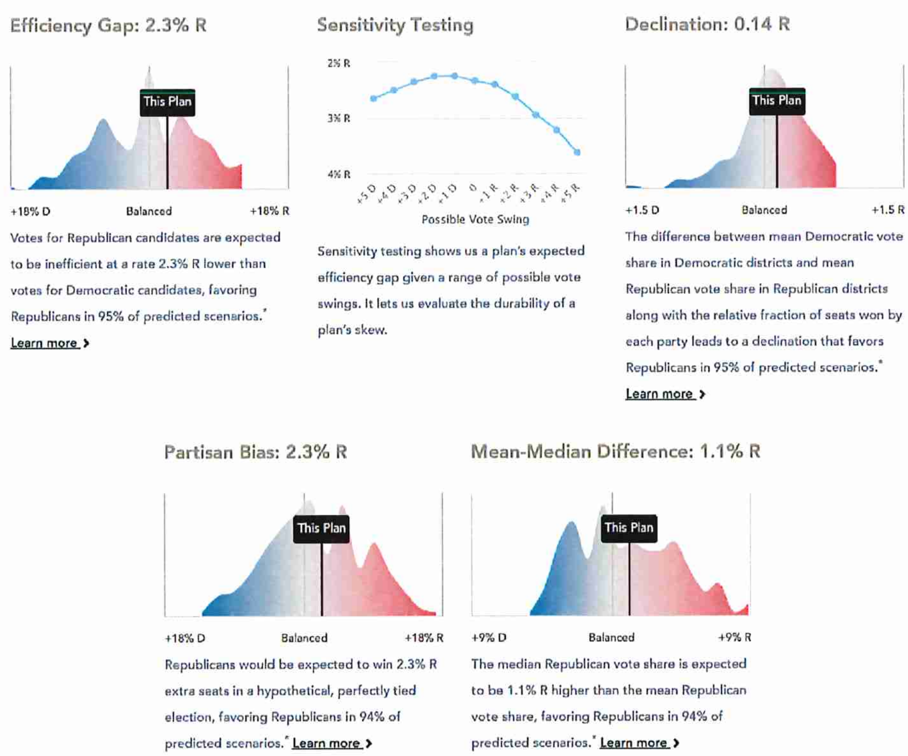
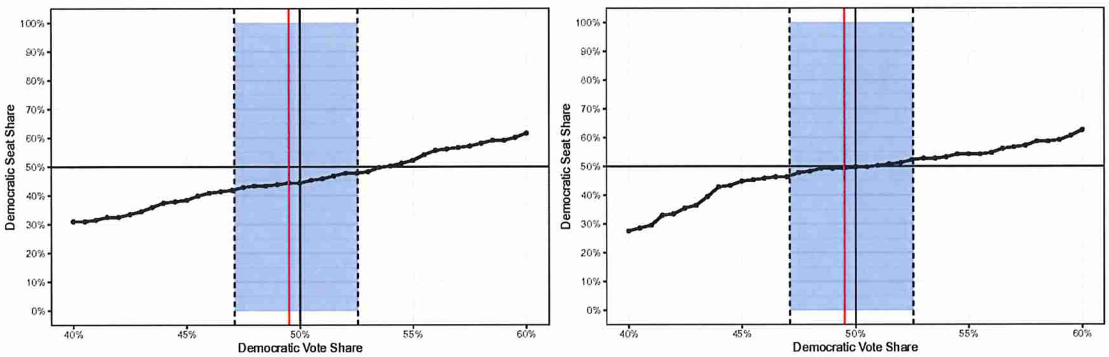


Figure 2: Graphs of PlanScore metrics enacted House plan compared to previous plans from 1972-2020

5.4 Responsiveness of Plan

Another benchmark for a districting plan is the responsiveness of the plan to changes in voters' preferences (Cox and Katz 1999). An unresponsive map ensures that the bias in a districting plan toward the advantaged party is insulated against changes in voters' preferences, and thus is durable across multiple election cycles.



(a) 2014-20 House Map (b) Enacted House Map

Figure 3: Vote-seat curve in Pennsylvania using uniform swings in 2020 election results on the 2014-20 districts and re-aggregated on the enacted House plan. The shaded area shows the range between the minimum and maximum Democratic statewide vote share in State House elections from 2014-2020. The red line shows the actual Democratic statewide vote share in the 2020 State House elections.

Figure 3 compares the responsiveness of the 2014-20 State House plan and the enacted House plan (using re-aggregated votes in the 2020 State House Elections). It shows the vote-seat curve in Pennsylvania using uniform swings in 2020 election results on the 2014-20 districts and re-aggregated on the enacted House plan. The shaded area shows the range between the minimum and maximum Democratic statewide vote share in State House elections from 2014-2020. The red line shows the actual Democratic statewide vote share in the 2020 State House elections.

The graph shows that both the 2014-2020 House plan and the enacted House plan are relatively responsive to shifts in voters' preferences. But the 2014-20 plan had a large pro-Republican bias, which is much smaller in the enacted House plan. Indeed, the Republican Party won a majority of the seats across all of the plausible range of stateside vote shares in the 2014-20 plan, while both parties could get at least half the seats in the enacted House plan.

5.5 Number of Competitive Districts

An important factor that affects the overall responsiveness of a plan is the number of competitive districts in a plan. I use a variety of approaches to estimate the number of competitive districts in both the 2014-20 State House plan and the enacted House plan (see Table 4). Overall, my analysis indicates that the previous plan and the enacted House plan are very similar in terms of the number of competitive seats. Moreover, both plans do about as well as the average percentage of seats that are competitive across other states' elections for their lower chambers in 2020.

Data:	2020 State House Results	Composite (2014-20)	PlanScore			**Mean**
Metric:	45-55	45-55	45-55	20%+ Prob. of Each Party Win.	50%+ Prob. Flip in Dec.	
Plan	(1)	(2)	(3)	(4)	(5)	(6)
Average Nationwide in 2020	13%					
2014-20 House Plan	13%	24%	23%	20%	25%	21%
Enacted House Plan	11%	16%	22%	15%	22%	17%

Table 4: Number of competitive districts using various data sources and metrics.

First, I use the actual 2020 State House results to examine the number of competitive districts. In column 1 of Table 4, I begin by tallying the number of districts where each party's two-party vote share was between 45 and 55%. This approach indicates that 13% of the districts on the 2014-20 plan were competitive and 11% of the districts on the enacted House plan were competitive. It is important to note, however, that a sharp threshold at 55% may not be the best measure of competitiveness.

Next, I use a composite of the 2014-2020 statewide election results to estimate the number of competitive districts. Once again, in column 2 of Table 4, I tally the number of districts where each party's two-party vote share was between 45 and 55%. This approach indicates that 24% of the districts on the 2014-20 plan were competitive and 16% of the districts on the enacted House plan were competitive.

Lastly, I use PlanScore to estimate the potential competitiveness of individual districts on the enacted House plan. In column 3 of Table 4, I show the number of districts where PlanScore estimates that each party's two-party vote share is expected to be between 45 and 55%. This approach indicates that 23% of the districts on the 2014-20 plan were competitive and 22% of the districts on the enacted House plan were competitive

It is also possible to use PlanScore to evaluate whether a district is likely to switch parties at least once per decade (Henderson, Hamel, and Goldzimer 2018). PlanScore conducts 1,000 simulations of possible electoral scenarios based on the results of the 2014-2020 congressional and state legislative elections in every state. Using these simulations, PlanScore provides an estimate of the probability that each party will win each seat as well as whether they are likely to have at least a 50% chance of winning each seat once over the course of the decade. In column 4 of Table 4, I estimate the number of districts where each party has at least a 20% chance of winning according to PlanScore. This approach indicates that 20% of the districts on the 2014-20 plan were competitive and 15% of the districts on the enacted House plan were competitive. In column 5 of Table 4, I conduct a similar analysis where I tally the number of districts that each party would have at least a 50% chance of winning at least once over the course of the decade. This approach indicates that 25% of the districts on the 2014-20 plan were competitive and 22% of the districts on the enacted House plan were competitive

Finally, column 6 of Table 4 averages across all of these approaches. It indicates that 21% of the districts on the 2014-20 plan were competitive and 17% of the districts on the enacted House plan were competitive. Thus, the previous plan and the enacted House plan are fairly similar in terms of the number of competitive seats. The enacted House plan also has roughly the same percentage of seats that are competitive as other states' elections for their lower chambers in 2020.

6 Comparison of enacted House plan with Congressional plan and Benninghoff plan

In this section, I compare the enacted House plan to both the congressional plan recently approved by the Pennsylvania Supreme Court and Leader Benninghoff's proposed alternative plan. Overall, I find that the enacted House plan has very similar partisan bias metrics as the congressional plan recently approved by the Pennsylvania Supreme Court. Both plans look relatively fair with a small pro-Republican bias. In contrast, Leader Benninghoff's plan has a much more substantial degree of pro-Republican bias than either the enacted House plan or the enacted congressional plan.

Table 5 shows the detailed comparisons. The lefthand side of the panel shows partisan fairness metrics based on the composite of statewide elections from 2014-2020, while the righthand side shows the partisan fairness metrics from PlanScore.org. The top panel of Table 5 shows an evaluation of the partisan fairness of the recently enacted congressional plan. Each of the individual metrics using both the composite elections and PlanScore are close to zero with a small pro-Republican bias. When I compare the results of my analysis of the final congressional plan to other congressional elections around the country over the past 50 years, Pennsylvania's congressional plan is more pro-Republican than about

	Composite of Statewide Elections			PlanScore		
Metric	Value	More Biased than this % of Elections	More Pro-Rep. than this % of Elections	Value	More Biased than this % of Elections	More Pro-Rep. than this % of Elections
2022 Congressional Plan						
Symmetry Bias	-5.3%	42%	71%	-1.3%	12%	61%
Mean-Median Diff	-1.3%	18%	60%	-0.4%	7%	58%
Efficiency Gap	-0.9%	8%	58%	-1.8%	20%	66%
Declination	-.056	16%	52%	-.05	23%	59%
Average		21%	61%		16%	61%
Enacted LRC State House Plan						
Symmetry Bias	-2.7%	31%	62%	-2.3%	30%	61%
Mean-Median Diff	-1.4%	31%	63%	-1.1%	25%	61%
Efficiency Gap	-2.5%	26%	68%	-2.5%	32%	70%
Declination	-.173	38%	65%	-.14	35%	63%
Average		31%	65%		31%	64%
Benninghoff State House Plan						
Symmetry Bias	-5.7%	60%	77%	-3.7%	40%	65%
Mean-Median Diff	-4.3%	79%	86%	-1.6%	33%	63%
Efficiency Gap	-4.8%	49%	78%	-3.7%	42%	77%
Declination	-.36	68%	83%	-.22	49%	70%
Average		64%	81%		46%	69%

Table 5: Partisan bias metrics for Enacted House Plan and Recent Congressional Plans

61% of previous congressional plans.

The middle panel reiterates the metrics for the enacted House plan that I presented in the previous sections of this report. Each of the individual metrics using both the composite elections and PlanScore are close to zero with a small pro-Republican bias. This indicates that the enacted House Plan is relatively fair with a small degree of pro-Republican bias. When I compare the results of my analysis of the enacted House plan to other state house elections around the country over the past 50 years, my analysis indicates that it is more pro-Republican than about 64-65% of previous plans around the country. Thus, the partisan fairness of the enacted House plan looks very similar to the enacted congressional plan recently implemented by the Pennsylvania Supreme Court.

The bottom panel evaluates Leader Benninghoff's proposed state house plan. The partisan fairness metrics for this plan look totally unlike the congressional plan recently approved by the Pennsylvania Supreme Court. Leader Benninghoff's plan has a larger pro-Republican bias on each of the partisan fairness metrics. For instance, Republicans are likely to win about 54-56% of the seats on this plan in a tied statewide election. Overall, the plan is more pro-Republican than 69-81% of previous plans around the country. Leader Benninghoff's proposed has a much larger pro-Republican bias than either the final congressional plan or the enacted House plan.

7 Professor Barber's report

Professor Barber's expert report that was submitted as an addendum to Leader Benninghoff's complaint assesses a number of aspects of the enacted House plan. One of the things it assesses is the partisan fairness of the plan. Professor Barber concludes that the enacted House plan is a partisan gerrymander. Professor Barber's analysis does not actually indicate, however, that the enacted House plan is a partisan gerrymander.

Most importantly, he reaches almost identical conclusions as my analysis as-to the modest pro-Republican bias of the enacted House plan based on the efficiency gap and the mean-median difference. He claims that he uses a composite of the 2012-2020 statewide elections to predict two-party vote shares in each districts. Based on this composite index, Professor Barber finds that the enacted House plan has a pro-Republican mean-median difference of 1.5% (p. 56) and a pro-Republican Efficiency Gap of 2.7% (p. 59). Based on a composite of statewide elections from 2014-2020, I find a pro-Republican mean-median difference of 1.4% (p. 56) and a pro-Republican Efficiency Gap of 2.5%. So there is no disagreement that the proposed plan is relatively neutral on generally accepted partisan fairness metrics with a small pro-Republican advantage. Thus, both Professor Barber and my analysis indicate that the plan treats both parties' voters relatively symmetrically. As a result, neither party's voters are diluted and neither party's voters have more voice over political outcomes in Pennsylvania. For all these reasons, the enacted House plan is not a partisan gerrymander.

8 Conclusion

This report has evaluated the partisan fairness of the Legislative Reapportionment Commission's enacted Pennsylvania State House plan. Overall, there is no evidence that this plan is a partisan gerrymander. In my opinion, it is a generally fair plan.

- Based on three methods of projecting future elections and four different, generally accepted partisan bias metrics, I find that the enacted House plan is fair, with just a small pro-Republican bias. On this plan, the party that wins the majority of the votes is likely to usually win the majority of the seats. Neither party's voters are diluted on this plan and voters from both parties have a roughly equal opportunity to translate their votes into representation. Thus, the plan satisfies a key premise of democratic theory.

- The enacted House plan is much more fair than the 2014-2020 State House plan, which had a large and durable pro-Republican bias.

- On some metrics, the enacted House plan is actually slightly more fair than the Preliminary Plan.[21]
- The plan is likely to be responsive to shifts in voters' preferences.
- The partisan fairness of the plan compares favorably to the congressional plan recently approved by the Pennsylvania Supreme Court.

21. See the initial report I submitted to the LRC on January 7th, my testimony on January 14th, and the analysis in Tables 1-3 above.

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EXHIBIT 3

To: Chairman Mark Nordenberg, Pennsylvania Legislative Reapportionment Commission
From: Dr. Matt A. Barreto, Faculty Director, UCLA Voting Rights Project
Re: Final Assessment of Voting Rights Act compliance in Pennsylvania Redistricting
March 10, 2022

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1. My name is Matt A. Barreto, and I am currently Professor of Political Science and Chicana/o Studies at the University of California, Los Angeles. I was appointed Full Professor with tenure at UCLA in 2015. Prior to that I was a tenured professor of Political Science at the University of Washington from 2005 to 2014. At UCLA, I am the faculty director of the Voting Rights Project in the Luskin School of Public Affairs and I teach a year-long course on the Voting Rights Act (VRA), focusing specifically on social science statistical analysis, demographics and voting patterns that are relevant in VRA expert reports. I have written expert reports and been qualified as an expert witness more than three dozen times in Federal and State voting rights and civil rights cases. I have been invited to give Congressional testimony about voting rights and co-authored a report on racially polarized voting that Congress relied on in their reauthorization of the VRA in 2006. I have published peer-reviewed, social science articles specifically about minority voting patterns, racially polarized voting, and have co-authored a software package specifically for use in understanding racial voting patterns in VRA cases. I have been retained as an expert consultant by counties and states across the country in 2021 to advise them on racial voting patterns as they relate to VRA compliance during redistricting. I have worked extensively with both plaintiffs' groups and on behalf of defendants in VRA lawsuits, always to provide independent analysis. As an expert witness in VRA lawsuits, my testimony has been relied on by courts to find in favor of both plaintiffs and defendants.

2. I have closely analyzed and reviewed the Legislative Reapportionment Commission's ("LRC") approved Preliminary and Final House Plans. In addition, I have carefully reviewed testimony and reports submitted by other experts, including Dr. Michael Barber and Dr. Jonathan Katz. I have also reviewed filed Petitions for Review including House Republican Majority Leader Benninghoff's Petition for Review, and the March 4 Report of LRC Chairman Mark A. Nordenberg. After careful review of the approved Preliminary and Final House Plans and all accompanying documentation and reports, I can state with confidence that the approved Final Plan fully complies with the Voting Rights Act ("VRA") and does not dilute minority voting strength or deprive minorities of equal voting opportunities.

3. First, it is important to clarify for the record that the "final" report submitted by Dr. Jonathan Katz on February 4, 2022 is substantively identical to his "preliminary" report submitted on January 14, 2022. Indeed, there is only one change: he added two sentences on page 1 stating he had reviewed the 2022 Final House Plan and he did not feel compelled to change his original analysis. However, his *original* report undertook no analysis related specifically

to either the LRC's Preliminary or Final House Plan, and his February 4 report is simply an exact copy of his original January 14 report. To be clear, as Chairman Nordenberg stated in his March 4, 2022 Report, Dr. Katz never offered any data or analysis to support his assertions. On January 18, 2022, I offered an extensive rebuttal to Dr. Katz[1] which is unrefuted. Dr. Katz attempted to draw inferences about Hispanic voting patterns in Pennsylvania, not based on Pennsylvania data, but rather based on Hispanic voter registration data in Bakersfield, California, which a federal court dismissed as not-relevant and short-sighted in that case. Rather than obtain Pennsylvania data and perform an analysis to present to the LRC, Dr. Katz re-referenced years-old and debunked data from California in an attempt to cast doubt on a well-established methodology of ecological inference to measure racially polarized voting. Indeed, ecological inference is regularly accepted by state and federal courts as a political science methodology to study racially polarized voting. Dr. Katz introduces no evidence whatsoever that racially polarized voting does not exist in Pennsylvania. In fact, racially polarized voting does exist across the Commonwealth of Pennsylvania, and there is no evidence to the contrary.

4. Second, Dr. Barber's simulation analysis is fatally flawed because he admits that he purposely did not consider compliance with the VRA. While Leader Benninghoff quotes Dr. Barber at length, reliance on Dr. Barber's simulations and findings cannot be taken seriously if the Commonwealth of Pennsylvania wishes to comply with the VRA. Dr. Barber admitted under questioning that his simulations did not consider compliance with the Federal Voting Rights Act, which every state redistricting body must do.

5. When Leader Benninghoff, again relying on Dr. Barber, states that the final plan dilutes minority votes, he is misguided in the concepts of packing and cracking, concepts with which experts of voting rights are quite familiar. A district does not have to be packed to 70% or more minority population in order to constitute a VRA-compliant district. Indeed, federal courts have regularly held that such high concentrations constitute packing, which prevents minority groups from having influence in a second, nearby district. In contrast, cracking occurs when the minority population is spread too thin and made too small to be able to have influence in electing representatives of the minority population's choice. Leader Benninghoff fails to understand, or ignores, this distinction. Further, neither Dr. Barber nor Leader Benninghoff offer any **performance analysis** of the adopted Final LRC House Plan in support of their insinuation that certain districts will not perform for minority candidates of choice. In contrast, I have carefully examined these districts (in both the LRC's Preliminary and Final House Plans) and determined with a reasonable degree of professional certainty that minority voters will be able to elect their representatives of choice. There is no evidence

[1] https://www.redistricting.state.pa.us/resources/Press/2022-01-18%20Barreto%20reply.pdf

of minority vote dilution even presented by Leader Benninghoff, he simply makes a claim with no social science data or analysis to support the claim.

6. Third, Leader Benninghoff offers no data, evidence or analysis in his Petition for Review to challenge any of the data, evidence and analysis I thoroughly lay out in my various reports and presentations. In Paragraph 75 of the Petition, he claims that I conceded that my analysis failed to show racially polarized voting. This is a categorically false assertion and one which I refuted before the LRC. My analysis presents a series of charts and ecological inference tables which analyze both white vs. non-white voters, and also specifically Black, Latino and Asian American voters. In Paragraph 11 of my January 7, 2022 report, I summarize my analysis: "In regions in Pennsylvania that have sizable populations of both White and minority voters, data across more than a dozen elections points to a clear pattern of racially polarized voting. **Black, Latino and Asian American** voters demonstrate unified and cohesive voting, siding for the same candidates with 75% to 90% support." I further explain that outside of Pittsburgh and Philadelphia, "White voters demonstrate considerable block voting against minority candidates of choice, often voting in the exact opposite pattern of **Blacks, Latinos, and Asian Americans**." In the remainder of my January 7 report, in paragraphs 12 – 19, I make specific reference to Black, Latino and Asian American voting patterns, not lumping all minorities together as Leader Benninghoff inaccurately claims. For illustrative purposes only, I presented scatterplots of precinct data sorted along the x-axis of percent White in the voting precinct. However, these accompanying charts are merely additional datapoints to demonstrate clear racially polarized voting. Contrary to Leader Benninghoff's claim, I did run, analyze and report, voting patterns for Black, Latino, Asian and White voters in Pennsylvania. Leader Benninghoff is plainly wrong in claiming that I denied the existence of racially polarized voting. My analysis—which I hereby reaffirm—supports the opposite conclusion: there is racially polarized voting across Pennsylvania.

7. Additionally, during my January 14, 2022 presentation to the LRC, at which Leader Benninghoff questioned me, I presented a data table (see Slide 16[2]) with separate racially polarized voting estimates of White, Black and Latino voting patterns, as well as for minority voters overall. Thus, Leader Benninghoff's claim that my racially polarized voting analysis lumped together minorities and otherwise failed to show white-bloc oppositional voting is belied by the LRC's record. Finally, in my January 18, 2022 reply to Dr. Katz, I once again drew separate attention to Latino voting patterns on their own, an area that Dr, Katz baselessly called into question. This is found on Table 1 at the bottom of page 1 of my January 18 reply[3].

8. Finally, Leader Benninghoff also claims in his Petition for Review (Paragraph 75) that I failed to account for primary elections. However, there is no authority or court precedent

[2] https://www.redistricting.state.pa.us/resources/Press/2022-01-14%20Barreto%20Presentation.pdf
[3] https://www.redistricting.state.pa.us/resources/Press/2022-01-18%20Barreto%20reply.pdf

requiring that a racially polarized voting analysis examine primary elections. Indeed, expert researchers determine which types of elections are under scrutiny and relevant. In the case of the Commonwealth of Pennsylvania House Plan, it is November general elections which most clearly differentiate White and non-white voting preferences. Thus, for this particular inquiry, general elections are most relevant to understanding racially polarized voting. I note, however, that neither Leader Benninghoff nor Dr. Katz provided any racially polarized voting analysis involving any Pennsylvania election data, primary or general.

9. With respect to the brief filed by Leader Benninghoff on March 7, 2022, he is wrong in claiming that I have not proven racially polarized voting and the *Gingles* standards. Indeed, my analysis which is effectively unrebutted, has clearly demonstrated that across Pennsylvania voting patterns clearly meet the political science and legal definitions of racially polarized voting. Given that there is clear evidence that Whites bloc-vote against minority preferred candidates, state legislative districts won by Republican candidates represent instances in which the preferences of White voters were cohesive in blocking Black and Latino preferred candidates (Democrats). I made these points clear in my report submitted to the LRC on January 7[4], writing in Paragraph 11 "In contrast, White voters tend to block vote against minority candidates of choice" and "in most instances outside of these two large cities, White voters demonstrate considerable block voting against minority candidates of choice, often voting in the exact opposite pattern of Blacks, Latinos, and Asian Americans." In Paragraph 13, I make specific reference to the *Gingles* test writing "This provides evidence of the second component of racially polarized voting under the *Gingles* test of White block voting against minority candidates of choice." In total, Republicans won 13 state House seats in 2020 by a margin of less than 10 points in which whites bloc-voted against Black and Hispanic voter preferences. There are 25 state House districts which are between 15% to 33% non-white in which non-whites heavily vote for Democratic candidates of choice, but Whites bloc-vote against these candidates to override minority preferences and elect Republicans.

10. Further, Benninghoff's analysis is misguided in that he cites the *Gingles* standards as they exist in a Section 2 VRA lawsuit in which a plaintiff brings a challenge to an already enacted districting plan. To the contrary, redistricting bodies, like the LRC, have discretion in complying with constitutional criteria and the VRA to stave off minority vote dilution. Specifically Benninghoff writes that "under the third precondition, <u>a plaintiff</u> must prove that a white voting bloc consistently defeats the candidates of choice of the minority community." As noted in my Paragraph 9 just above, White voters are indeed bloc-voting against minority preferences. It is Leader Benninghoff who has supplied the LRC with no evidence to the contrary. If Whites were voting in coalition to support minority preferences, the State legislature would be overwhelmingly Democrat. But this is not the case because Whites are

[4] https://www.redistricting.state.pa.us/resources/Press/2022-01-14%20Barreto%20Testimony.pdf

voting very heavily in favor of Republican candidates, who win election against the voting preferences of Black, Hispanic and Asian voters. While there is *some* limited evidence of white cross-over voting within the cities of Pittsburgh and Philadelphia, in 65 counties across the entire state, Whites are voting in strong majority against minority candidates of choice.

11. Throughout the March 7 brief filed by Leader Benninghoff he cites supposed evidence of cracking of the Hispanic and Black population; however each of the districts he cites support minority candidates of choice. Leader Benninghoff points to population data, not electoral performance data, to suggest that districts 126, 127, and 129 are weakened and dilute Hispanic votes. This is false. Given the strong Hispanic population growth in this region, my analysis confirms that the final plan does not impair or prevent minorities from electing candidates of their choice. Likewise, Leader Benninghoff states, again with no evidence, that Black votes are being diluted in districts 103 and 104, but again my analysis confirms that Black voters in both districts will have a fair opportunity to elect candidates of their choice. Finally, I have carefully reviewed Leader Benninghoff's claim that district 22 in the Final House Plan will fail to perform for minority candidates of choice. Based on my review of electoral performance data and the fact that this district, in the Final House Plan, has a 67% minority voting age population, it is my expert opinion that district 22 will very likely perform to elect minority candidates of choice. There is no empirical evidence to support Leader Benninghoff's claim regarding district 22.

12. With respect to the petition submitted by Mr. Gabriel Ingram et al. related to district 159, the claim in Paragraphs 43-44 that district 159 is not likely to remain a strong minority performing district is wrong. The Final Plan adult population of district 159 is 56% minority and 44% white. Further, Black voters remain the single largest segment of the electorate and performance analysis demonstrates district 159 will remain a strong minority performing district, as drawn in the Final Plan, President Biden carried with 70% of the vote in the precincts that make up district 159.

13. With respect to the allegations submitted by Mr. Koger related to district 24, there is no evidence that minority voting power is diluted or impaired. The overwhelming evidence shows that Democratic candidates, not Republicans, are the preference of Black voters in this district. Thus there is no evidence of vote dilution or disenfranchisement and no reason to believe that district 24 will impair minority voters' ability to elect the candidates of their choice.

14. Below I have analyzed the list of districts in the Final House Plan, questioned in the petitions for review. I have listed the Minority Voting Age Population (MVAP) and expected Electoral Performance confirming that, according to my analysis, these districts are likely to perform to elect minority candidates of choice.

Dist	Prior % MVAP	Final Plan % MVAP	Expected performance for Minority preferred candidate
22	71.1	67.3	66.3
24	59.5	52.2	89.4
49	9.5	53.3	66.8
96	54.0	26.6	60.3
103	66.4	38.0	62.4
104	26.2	57.5	65.8
126	48.8	42.8	54.5
127	75.6	64.1	64.8
129	17.5	47.3	58.4
132	53.4	31.2	57.1
134	15.3	51.3	59.8
159	64.9	56.0	69.9

15. In summary, after a thorough and careful review of the approved Final House Plan, it remains my opinion that the Final Plan fully complies with the VRA and does not impair any minority group's ability to elect representatives of their choice.

Matt A. Barreto

Matt A. Barreto, Ph.D.
March 10, 2022
Los Angeles, California

EXHIBIT 4

<u>EXPERT REPORT OF JONATHAN RODDEN, Ph.D.</u>

On behalf of the Pennsylvania House Democratic Caucus
March 10, 2022

I. INTRODUCTION

I have been asked to evaluate the report of Dr. Michael Barber that was included as Appendix A in the Petition for Review in *Benninghoff v. 2021 Legislative Reapportionment Commission*, filed on February 17, 2022. Much of Dr. Barber's testimony purports to be based on interpretations of my research on the political geography of Pennsylvania. I have been asked to evaluate Dr. Barber's interpretations, and, more broadly, his claim that the Pennsylvania Legislative Reapportionment Commission's final State House plan (hereinafter "Final House Plan") is "a significant deviation from a fair outcome," as well as certain of his specific claims about the sources of those purported deviations.

Dr. Barber contends that because Democrats in Pennsylvania are highly concentrated in cities and Republicans are more efficiently dispersed in exurban and rural areas, a "fair" or "unbiased" map must provide the Republican Party with a much higher seat share than its vote share—even in the event of a tied election. Furthermore, he avers that a "fair" or "unbiased" map is one whose overall partisanship resembles the modal outcome in a large ensemble of computer-generated redistricting plans.

"Bias" is a term that has a very specific meaning in the academic literature on redistricting. It refers to a situation in which a party can expect more than half the seats when it obtains half of the votes. Likewise, scholars typically refer to "partisan fairness" as a situation where a party with 50 percent of the votes can anticipate 50 percent of the seats. Dr. Barber appears to be using a very different concept, in which he considers a map to be "unbiased" or "fair" if it resembles the modal partisan outcome in a large ensemble of computer-generated maps.

This is not a notion of bias or fairness that appears anywhere in the academic literature. Using the standard definition, the Final House Plan is, in fact, biased in favor of the *Republican* Party, not the Democratic Party—a fact that is indeed likely driven by the relative urban concentration of Democrats that Dr. Barber describes.

Dr. Barber's key claim appears to be that the Final House Plan contains slightly more Democratic-leaning districts than the modal computer-generated plan in a handful of medium-sized Pennsylvania cities, and as a result, we can conclude that the Final House Plan subverted traditional redistricting principles in order to reverse any underlying geographic advantage for Republicans and instead favor Democrats. However, he provides no credible evidence to support his claim. In fact, his report contains considerable evidence to the contrary. Above all, the Final House Plan is more respectful of traditional redistricting principles than his computer-generated plans. Specifically, it is more compact and splits fewer counties and municipalities.

Lacking any systematic statewide evidence that the Final House Plan subverts traditional redistricting principles in order to help Democrats, Dr. Barber turns to a series of case studies of several medium-sized cities. However, these case studies also fail to generate any evidence that the traditional redistricting criteria outlined in the Pennsylvania Constitution have been subverted in favor of partisan goals.

II. QUALIFICATIONS AND EXPERIENCE

I am currently a tenured Professor of Political Science at Stanford University and the founder and director of the Stanford Spatial Social Science Lab—a center for research and teaching with a focus on the analysis of geo-spatial data in the social sciences. I am engaged in a variety of research projects involving large, fine-grained geo-spatial data sets including ballots and election results at the level of polling places, individual records of registered voters, census data, and survey responses. I am also a senior fellow at the Stanford Institute for Economic Policy Research and the Hoover Institution. Prior to my employment at Stanford, I was the Ford Professor of Political Science at the Massachusetts Institute of Technology. I received my Ph.D. from Yale University and my B.A. from the University of Michigan, Ann Arbor, both in political science. A copy of my current C.V. is included as Exhibit A.

In my current academic work, I conduct research on the relationship between the patterns of political representation, geographic location of demographic and partisan groups, and the drawing of electoral districts. I have published papers using statistical methods to assess political geography, balloting, and representation in a variety of academic journals, including *Statistics and Public Policy, Political Analysis, Proceedings of the National Academy of Science*, *American Economic Review Papers and Proceedings*, the *Journal of Economic Perspectives*, the *Virginia Law Review*, the *American Journal of Political Science*, the *British Journal of Political Science*, the *Annual Review of Political Science*, and the *Journal of Politics.* One of these papers was selected by the American Political Science Association as the winner of the Michael Wallerstein Award for the best paper on political economy published in the last year, and another received an award from the American Political Science Association section on social networks. In 2021, I received a John Simon Guggenheim Memorial Foundation Fellowship, and received the Martha Derthick Award of the American Political Science Association for "the best book published at least ten years ago that has made a lasting contribution to the study of federalism and intergovernmental relations."

I have recently written a series of papers, along with my co-authors, using automated redistricting algorithms in the context of redistricting. This work has been published in the *Quarterly Journal of Political Science*, *Election Law Journal*, and *Political Analysis*, and it has been featured in more popular publications like *The Wall Street Journal*, *The New York Times*, and *Boston Review.* I recently published a book, published by *Basic Books* in June of 2019, on the relationship between political districts, the residential geography of social groups, and their political representation in the United States and other countries that use winner-take-all electoral districts. The book was reviewed in *The New York Times*, *The New York Review of Books*, *Wall Street Journal*, *The Economist*, and *The Atlantic*, among others. This book, which was discussed in Dr. Barber's report, pays special attention to Pennsylvania.

I have expertise in the use of large data sets and geographic information systems (GIS), and conduct research and teaching in the area of applied statistics related to elections. My Ph.D. students frequently take academic and private sector jobs as statisticians and data scientists. I frequently work with geo-coded voter files and other large administrative data sets, including in recent papers published in the *Annals of Internal Medicine* and *The New England Journal of Medicine.* I have developed a national data set of geo-coded precinct-level election results that has been used extensively in policy-oriented research related to redistricting and representation.

I have been accepted and testified as an expert witness in a number of election law and redistricting cases: *Romo v. Detzner,* No. 2012-CA-000412 (Fla. Cir. Ct. 2012); *Mo. State Conference of the NAACP* v. *Ferguson-Florissant Sch. Dist.,* No. 4:2014-CV-02077 (E.D. Mo. 2014); *Lee v. Va. State Bd. of Elections,* No. 3:15-CV-00357 (E.D. Va. 2015); *Democratic Nat'l Committee et al. v. Hobbs et al.*, No. 16-1065-PHX-DLR (D. Ariz. 2016); *Bethune-Hill v. Virginia State Board of Elections*, No. 3:14-cv-00852-REP-AWA-BMK (E.D. Va. 2014); and *Jacobson et al. v. Lee*, No. 4:18-cv-00262 (N.D. Fla. 2018). In January 2022, the Supreme Court of Ohio credited my expert analysis in *Bennett v. Ohio Redistricting Commission*, No. 2012-1198 (Ohio 2022), and *Adams v. DeWine*, No. 2012-1428 (Ohio 2022), two redistricting cases challenging state legislative and congressional maps. I also worked with a coalition of academics to file Amicus Briefs in the Supreme Court of the United States in *Gill v. Whitford*, No. 16-1161, and *Rucho v. Common Cause*, No. 18-422. Much of the testimony in these cases had to do with geography, electoral districts, voting, ballots, and election administration. I recently worked as a consultant for the Maryland Redistricting Commission, and I drew a Pennsylvania Congressional redistricting plan, known as the "Carter Plan," that was chosen by the Pennsylvania Supreme Court for implementation. *Carter v. Chapman*, No. 7 MM 2022, 2022 WL 549106 (Pa. Feb. 23, 2022).

III. DATA SOURCES

In order to assess statewide partisanship, I have collected statewide election results for selected elections from 2012 to 2020 from the Pennsylvania Department of State.[1] The specific elections and results are detailed in Table 1 below. I also accessed precinct-level election results from the Pennsylvania Department of State for statewide elections from 2016 to 2020 that were matched to 2020 Pennsylvania vote tabulation districts by a team at Harvard University called the Algorithm-Assisted Redistricting Methodology Project.[2] I also used block-level 2020 population estimates produced by the United States Census Department for the purposes of legislative redistricting. I consulted geographic boundary files for the Final House Plan from its web page: redistricting.state.pa.us/maps. I also received shapefiles of the boundaries of the Benninghoff Amendment. I also consulted shapefiles of the boundaries of vote tabulation districts, census places, counties, and county subdivisions from the U.S. Census Department. From the National Historical GIS (nhgis.org), I also consulted data from the 2020 decennial census on race and ethnicity at the level of census block groups, as well as shapefiles for census block groups. In preparing this report, I used Maptitude, ArcGIS, R, and Stata software packages.

IV. ELECTORAL BIAS AND ELECTORAL FAIRNESS

On several occasions in his report, Dr. Barber makes the curious and confusing claim that the Final House Plan is "biased" or "unfair." Without explaining his logic or relating it to the very large body of academic literatures on votes, seats, and redistricting algorithms, he makes a rather unusual claim that maps generated by a computer algorithm are, by definition, "unbiased." On page 4, for instance, he writes "…in comparing the Commission's map to the simulated districts, we are comping [sic] a map to a set [sic] alternative maps that we know to be unbiased. If the Commission's map produces a similar outcome as the alternative set of maps, we may reasonably conclude that the Commission's plan is also unbiased. Alternatively, if the Commission's proposed

[1] https://www.electionreturns.pa.gov/ReportCenter/Reports

[2] https://alarm-redist.github.io/posts/2021-08-10-census-2020/

plan significantly diverges from the set of simulated maps, it may be the case that the proposed plan is biased in favor of one party." He goes on to generate a set of maps using a computer algorithm, and since he estimates that there are 107 Democratic-leaning districts in the Final House Plan, and the most common estimate among his ensemble of computer-generated plans is 97 such districts, he concludes that the Final House Plan is "biased," or as he puts it on page 10, a "significant deviation from a fair outcome."

These claims are confusing because in the academic literature on votes and seats in legislative elections, bias has a very specific definition that has nothing to do with computer simulations. In a two-party democracy, if a party receives 50 percent of the votes, but 50 percent plus x of the seats, the quantity x is known as electoral bias. For instance, a party with 50 percent of the votes that receives 53 percent of the seats enjoys a bias of 3 percent in its favor.

It is useful to apply this concept to the Final House Plan before commenting further on Dr. Barber's analysis. Dr. Barber characterizes the partisanship of each district in the Final House Plan, as well as in his computer-generated plans, by using statewide partisan elections from 2012 to 2020. I do not have access to his data, and thus cannot assess his estimates of the partisanship of each district. From the Secretary of State, however, I can ascertain that using the elections specified by Dr. Barber, the average Democratic vote share from 2012 to 2020 was 52.85 percent (see Table 1). Dr. Barber claims that 107 districts are Democratic leaning in the Final House Plan, which would be 52.7 percent of the seats. A common feature of votes and seats is the so-called "winner's bonus," whereby, in a two-party system, the party with greater than 50 percent of the vote receives more than a proportional share of seats. A party with 53 percent of the vote, for instance, can often expect more than 55 percent of the seats, even in a plan that is not drawn to produce partisan advantage for either party. However, according to Dr. Barber's analysis, the Democrats could expect a seat share slightly *below* their vote share under the Final House Plan, even though with almost 53 percent of the votes during the period he analyzed, one would expect them to benefit from the winner's bonus.

This is already a clear sign that the Final House Plan is not, in any sense, biased against the Republican Party. In order to calculate electoral bias, as defined above, election scholars typically consider a hypothetical election in which the overall votes are tied, which is achieved by applying a "uniform swing" across all districts, and then calculating the number of seats that would be won by each party in such a scenario. I do not have access to Dr. Barber's district-level estimates, and thus cannot use them to measure electoral bias. However, I do have access to precinct-level results of statewide elections from 2016 to 2020, which I can sum up within the boundaries of the Commission's districts and then generate an average district-level Democratic vote share for each district. When I do this, I find that there are not 107 Democratic-leaning districts in the Final House Plan, but 104, or 51.2 percent of the 203 districts—well below the Democrats' overall vote share, which exceeded 52 percent during this period.

Next, to calculate electoral bias, I apply a uniform swing toward the Republican Party in each district in order to examine a hypothetical tied statewide election. I do this separately for each statewide election and take an average over all elections. Using this approach, I ascertain that the Republican Party can expect an average electoral bias in its favor of around 1.5 percent under the Final House Plan.

Table 1: Pennsylvania Statewide Election Results, 2012-2020

	Democratic votes	Republican votes	Democratic vote share
2012 President	2,990,274	2,680,434	52.73%
2012 Senate	3,021,364	2,509,132	54.63%
2012 Attorney General	3,125,557	2,313,506	57.46%
2012 Auditor General	2,729,565	2,548,767	51.71%
2012 Treasurer	2,872,344	2,405,654	54.42%
2014 Governor	1,920,355	1,575,511	54.93%
2016 Presidential	2,926,441	2,970,733	49.62%
2016 U.S. Senate	2,865,012	2,951,702	49.25%
2016 Attorney General	3,057,010	2,891,325	51.39%
2016 Auditor General	2,958,818	2,667,318	52.59%
2016 Treasurer	2,991,404	2,610,811	53.40%
2018 U.S. Senate	2,792,437	2,134,848	56.67%
2018 Governor	2,895,652	2,039,882	58.67%
2020 Presidential	3,458,229	3,377,674	50.59%
2020 Attorney General	3,461,472	3,153,831	52.33%
2020 Auditor General	3,129,131	3,338,009	48.39%
2020 Treasurer	3,239,331	3,291,877	49.60%
2012-2020 Average			52.85%
2016-2020 Average			52.05%
2018-2020 Average			52.71%

Note: Democratic vote share is the Democratic share of the votes for the two major parties (Democrats and Republicans). The denominator does not include minor parties and write-in candidates.

Clearly, the Final House Plan is biased in favor of the Republicans, not the Democrats. In fact, Dr. Barber's analysis confirms this. On page 56, he indicates that according to another metric of partisan fairness—the mean-median difference—the Final House Plan favors the Republican Party as well. And on page 59, he indicates that the Final House Plan favors the Republican Party according to yet another metric: the efficiency gap.

Dr. Barber is arguing for a completely different view of partisan fairness than any I have encountered in the academic literature. His claim is that a "fair" or "unbiased" plan is one that resembles the most frequent outcome that emerges from a large ensemble of computer-generated plans. Using his 2012-2020 partisan metric, he assessed the partisanship of the amended plan introduced by Leader Benninghoff, (hereinafter "Benninghoff Plan") and determined that it has the same number of Democratic-leaning seats as the most common outcome in his computer-generated plans, thus making it a "fair" plan. As I described above for the Final House Plan, I have aggregated the precinct-level votes within the boundaries of the Benninghoff Plan and calculated the average Democratic vote share in each district for statewide elections from 2016 to 2020.

According to this metric, the Benninghoff Plan has 94 Democratic-leaning seats. With 52.05 percent of the statewide vote (see Table 1), the Democratic Party can thus expect 46.3 percent of the seats under this plan. This is a most unusual definition of partisan fairness. Applying the uniform swing to each statewide election, I calculate an average bias of 5.11 percent, meaning that in the event of a tied election, given the distribution of votes across districts in the Benninghoff Plan, the Republican Party could expect 55.11 percent of the seats.

V. THE ROLE OF ELECTORAL GEOGRAPHY

It is not clear why Dr. Barber views such clearly counter-majoritarian outcomes as normatively desirable or somehow required by the Pennsylvania Constitution or the majority opinion in *League of Women Voters*. His claim seems to be that since Democratic voting is highly correlated with population density, any reasonable application of traditional redistricting principles and other legal requirements would necessarily lead to a redistricting plan in which Democrats are inefficiently concentrated in extremely Democratic urban districts, while Republicans are more efficiently distributed in Republican-leaning suburbs and rural areas.

In making these claims, Dr. Barber draws heavily on my work, often in a misleading way. I have recently published a book about the spatial distribution of voters in the United States and other countries around the world, using the history of Pennsylvania as a running example.[3] In the book, I explore the history of labor unions and the geography of manufacturing, and then the more recent rise of racial, moral, and social issues in shaping political conflicts between the parties. I document how these forces have led to a growing correlation between population density and voting behavior over the last 75 years. Specifically, the urban core of most American cities, even including smaller Pennsylvania cities like Reading and Lancaster, have voted overwhelmingly for the Democratic Party, and the Republican vote share increases as one moves through the inner-ring suburbs, into the outer-ring suburbs and exurbs, and finally into the rural periphery.

I also demonstrate that the nature of this gradient varies a great deal from one city to another, and changes substantially over time. In particular, in the final chapter of the book, I explore a very recent transformation, where minorities have moved in large numbers away from the urban core of cities and into surrounding suburban areas. Moreover, as the Democratic Party has gained strength among college-educated professionals and the Republican Party has oriented itself increasingly toward whites without college degrees, growing suburban and even exurban communities in cities with many jobs in knowledge-based industries have realigned to the Democratic Party, with important implications for political geography.

In the book, I demonstrate that historical patterns of political geography are consequential for representation. I ask: what happens if we ignore race and the Voting Rights Act, county boundaries, communities of interest, and specific redistricting rules in states, and draw a series of

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[3] Jonathan Rodden, *Why Cities Lose: The Deep Roots of the Urban-Rural Political Divide*. New York: Basic Books.

compact, contiguous districts using a simple computer algorithm? I discover that in decades past, such districts would often have been biased (as defined above) against the Democratic Party because their voters have been inefficiently concentrated in the precincts of urban core areas. That is, Democrats "wasted" too many votes in the districts they were able to win, while Republicans typically won by smaller majorities in the exurban districts that they were able to win.

The point of this exercise was to illuminate the importance of political geography—clarifying the implications of "pure" geographic partisan patterns by stripping away all the things that inform the redistricting process in the real world, like neighborhoods, communities, racial and ethnic groups, incumbents, and political parties. The point was not that the modal simulated map from an ensemble of naïve simulations is normatively desirable or reflective of a fair or even legal redistricting process. On the contrary, these simulations often produced unfair maps, and ones that would not pass legal muster in many states.

In the book, I suggested that there may be some settings where residential patterns of partisanship, combined with the location of state boundaries or bodies of water relative to cities and the spatial scale of the relevant districts, are so disadvantageous for the Democrats that in order to achieve zero pro-Republican bias, it might be necessary to draw districts that are relatively non-compact. For example, when small Democratic cities are arranged quite far from one another along the rail lines or canals of the 19th century period of industrial city formation, it may be the case that the only way to produce a single Democratic-leaning Congressional district is to draw a non-compact district that follows the historic rail line.

However, the book goes to great lengths to demonstrate that this is not universal, but rather, highly contingent on the specific state, region, and spatial scale (e.g., state legislature versus Congress). Dr. Barber seems to have drawn the mistaken conclusion from my research that due to a universal and inescapable pattern of political geography, it is not possible, in Pennsylvania or evidently anywhere else in the United States, to reduce pro-Republican bias without drawing districts that "amble about the state and divide municipalities so as to create districts that had less overwhelming Democratic support" (page 17). In the next sentence, he bases this claim directly on a lengthy quotation from my book. It is useful to review this quotation in context. I reproduce it here.

"The details of political geography are crucial. In a context like western Pennsylvania at the scale of congressional districts, where Democrats are highly concentrated in a big city, to achieve a seat share that is anywhere near its vote share, the Democrats would need a redistricting process that intentionally carved up large cities like pizza slices or spokes of a wheel, so as to combine some very Democratic urban neighborhoods with some Republican exurbs in an effort to spread Democrats more efficiently across districts."

Tellingly, Dr. Barber's use of this quotation omits the first sentence and most of the second sentence, beginning with "The Democrats," making it appear that those words are the beginning of the sentence. As the first sentence of the full quotation shows, the purpose of this paragraph was to point out not a universal rule, but precisely the opposite. I went on in the following paragraph to point out that "there are also settings, like eastern Pennsylvania at the scale of congressional districts, where the size and distribution of Democratic cities is such that a nonpartisan redistricting process would serve them (the Democrats) reasonably well. Without partisan manipulation, Democratic suburbs and cities in eastern Pennsylvania would string together to form Democratic districts. In that setting, the only way to produce substantial Republican advantage is through artful gerrymandering" (p. 156).

Throughout the book, I emphasize important heterogeneity in the role of political geography across states, regions, and spatial scales. Nowhere does the book claim that it is universally impossible, or even difficult, to draw fair redistricting plans that respect traditional redistricting principles.

Moreover, it is not the case that one must intentionally focus on partisanship to arrive at a fair redistricting plan. Partisan fairness often goes hand in hand with the preservation of communities of interest. For instance, as described above, minority voters have been moving from the urban core to suburbs in many cities. Consider, for instance, a redistricting plan that included minority voters in the urban core with those in the suburbs using relatively compact districts that hold jurisdictions and neighborhoods together. Such a district might produce a Democratic district that would not have emerged in an alternative arrangement where the inner-ring suburban minority neighborhoods had been hived off from the city and surrounded in a mostly rural district.

Or consider a swath of suburbia composed of four small municipalities with a relatively large minority population. One arrangement might keep that swath together in a single state legislative district. Another arrangement might divide the minority group in half, combining two of the municipalities with neighboring white municipalities, and doing the same with the other two. These arrangements might be equally respectful of municipal boundaries and equally compact, but with different implications for both communities of interest and ultimately the partisanship of the districts.

Or instead of race or ethnicity, consider the metropolitan geography of education and employment. One suburban districting scheme might keep clusters of young knowledge-economy workers together in a single district, while another, with a similar level of compactness and municipal splits, might spread them among two relatively rural districts. Again, choices made by district-drawers with knowledge of local communities might create districts that are less biased against Democrats than a naïve computer algorithm that lacks such information.

VI. BARBER FAILS TO PROVIDE EVIDENCE THAT THE FINAL HOUSE PLAN UNDERMINES TRADITIONAL REDISTRICTING PRINCIPLES

In sum, it is simply not the case that because of its current political geography, it is necessary to "amble around the state" (p. 17, Barber Report) and "pinwheel" and "pie-up" municipalities (p. 18) in order to minimize pro-Republican bias. And as clarified above, the Commission did not, in fact, minimize pro-Republican bias; its plan is still notably biased in favor of the Republican Party. But the main question is empirical rather than theoretical: Does Dr. Barber provide any evidence of pinwheels, pie-slices, or non-compact, ambling districts that contradict traditional redistricting principals to favor Democrats?

In fact, all of Dr. Barber's evidence points very strongly in the opposite direction. Dr. Barber explained that he used an algorithm that attempted to generate plans that were as compact as possible while also minimizing splits of counties and municipalities. Dr. Barber's algorithm, however, failed to reduce the number of county and municipal splits to match the Final House Plan. In Table 1 of his report, Dr. Barber reveals that the median simulation split 46 counties, but the Final House Plan actually performed *better,* splitting 45 counties. Moreover, Table 1 reveals that the number of municipalities split, as well as the total number of municipal splits, was substantially lower than the entire range of his simulations. That is to say, the Final House Plan split fewer municipalities than even the very best of his 50,000 simulations, leading Dr. Barber to comment that "the proposal appears to perform well at having few municipal splits." Indeed, the Final House Plan is also more compact than all of Dr. Barber's 50,000 plans.

The central claim of Dr. Barber's report is that in order to produce more Democratic seats than the modal computer-generated plan, relative to the "unbiased" simulations, the Commission sacrificed compactness and the unity of municipalities. Yet, this simply cannot be, since the Final House Plan is more compact, and splits fewer municipalities, than *any* of the simulated plans.

Dr. Barber moves beyond the quantitative statewide analysis, focusing instead on a series of case studies. First, he makes an interesting observation: the number of Democratic-leaning seats in Philadelphia and Allegheny Counties is exactly the same as the modal outcome in the simulations, which, in his framework, indicates that districts in those counties were not drawn for partisan gain. His assertions about ambling, pinwheeling, and pie-ups are limited to the Lehigh Valley, the Scranton-Wilkes-Barre corridor, Lancaster, Reading, Harrisburg, and State College (see Table 2 of his report).

Specifically, his claim is that some Democratic cities contained a split that was not strictly necessary given the city's population. However, this simple observation means very little when divorced from the myriad other considerations facing district-drawers, including those specified in the Pennsylvania Constitution. In some instances, the split of a larger city allowed for fewer splits of surrounding municipalities. In others, such splits facilitated fewer transgressions of county boundaries. In other cases, by splitting a city, the Commission prevented the emergence of non-contiguities in the districts that are present in the structure of the boundaries of cities and vote tabulation districts that have very odd boundaries as a result of the haphazard process of historical annexations. Relatedly, in several cases these splits facilitated a more compact set of districts in the area. And finally, in some cases, these splits facilitated the preservation of communities of interest that spill over from larger cities to their neighboring municipalities.

Scranton and Wilkes-Barre

First, consider the counties of Lackawanna and Luzerne—home to Scranton and Wilkes-Barre. Scranton is larger than the size of a district, and it must be split once, and indeed, this is the case in the Final House Plan. Wilkes-Barre is smaller than the size of a House legislative district and need not be split. Indeed, it is not split in the Final House Plan. It is very difficult to understand what aspects of the Final House Plan in the Scranton-Wilkes-Barre corridor are deemed to be violations of traditional redistricting principles that may have been carried out to favor a political party.

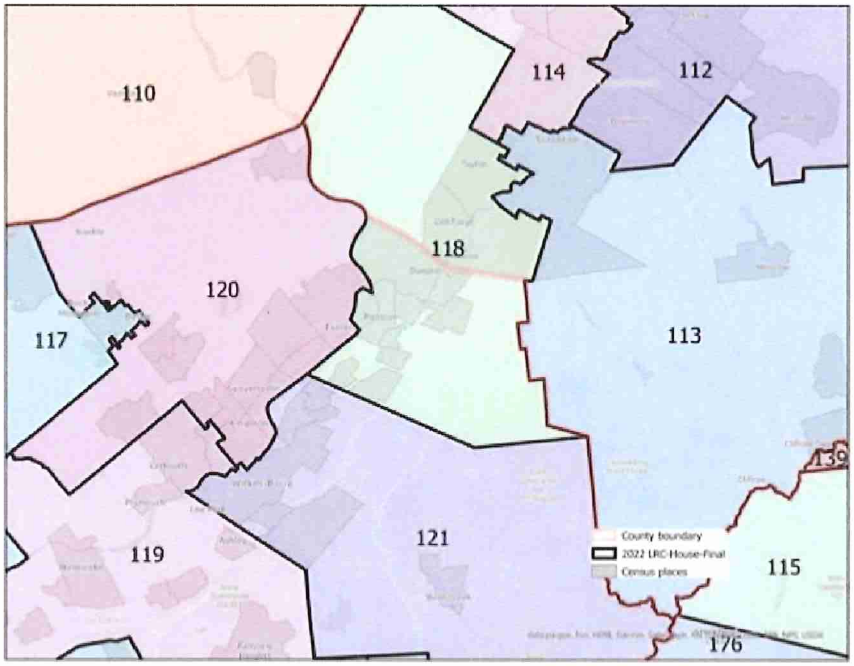
Dr. Barber does not provide any of his computer-generated plans to use as a comparison map that he deems to be non-partisan, but he does endorse the Benninghoff Plan. Figure 1 provides images of both the Commission's map and the Benninghoff Plan. At first glance, the two maps look rather similar. However, upon closer inspection, we can see that the Final House Plan only splits Scranton once, placing part of the city in District 113 and part in District 114. The Benninghoff Plan, in contrast, splits Scranton between four districts: 113, 114, 112, and 118. Moreover, in the Final House Plan, Scranton is the only split in either Lackawanna or Luzerne Counties, whereas in addition to its multiple splits of Scranton, the Benninghoff Plan also splits Moosic Township in Lackawanna and West Pittston in Luzerne. Nor is the Benninghoff Plan more compact than the Final House Plan.[4]

In sum, in the Scranton-Wilkes-Barre corridor, which according to Table 2 in Dr. Barber's report, produces two more Democratic-leaning seats than the modal computer-generated plan, it is very difficult to see evidence of meandering, non-compact districts, pie-slices, or pinwheels. If anything, the Final House Plan conforms more clearly with traditional redistricting principles than does the alternative offered by Representative Benninghoff.

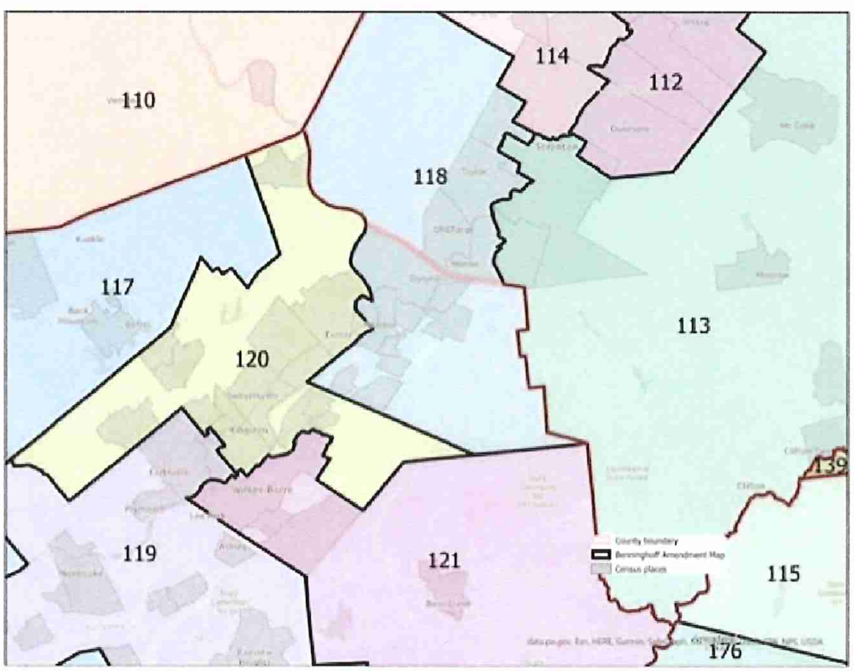
[4] The average Reock score for the districts of the Commission's plan in Lackawanna County is .42, whereas the average for the Benninghoff Plan is .39, indicating that the Commission's Plan is more compact. Using the Polsby-Popper score, however, the pattern is reversed, indicating that we cannot draw clear conclusions that one plan is more compact than the other. In Luzerne, the Commission's Plan is slightly more compact on average according to the Reock score (.41 versus .39), but the two plans are quite similar according to the Polsby-Popper score.

Figure 1: Scranton and Wilkes-Barre

Final House Plan



Benninghoff Plan



Lancaster

Next, let us consider Lancaster City and its surrounding communities. Again, Dr. Barber includes maps of districts that do not raise any red flags regarding traditional redistricting principles upon initial visual inspection. His only claim appears to be that since the city of Lancaster has a population just below the ideal population size of a Pennsylvania House district, it should be included in a single district. However, again, since he does not provide any other arrangements or discuss possible trade-offs associated with a single-district approach, it is difficult to know what to make of this critique. Figure 2 provides images of the Lancaster-area districts in the Commission's map and again, the Benninghoff Plan.

Let us begin with the Final House Plan. Note that there are two non-contiguous fragments of District 41 that appear as islands in District 96. This is because of the arrangement of townships and cities where, due to haphazard patterns of city annexation and incorporation over time, some vote tabulation districts—the basic building block of legislative districts in Pennsylvania—are themselves non-contiguous or separated from the rest of the municipal entity to which they belong. These non-contiguities are clearly undesirable, given possible confusion among residents of the isolated islands and possible mistakes in election administration. But these non-contiguities may under some conditions be unavoidable when drawing districts in Pennsylvania if attempting to keep vote tabulation districts whole.

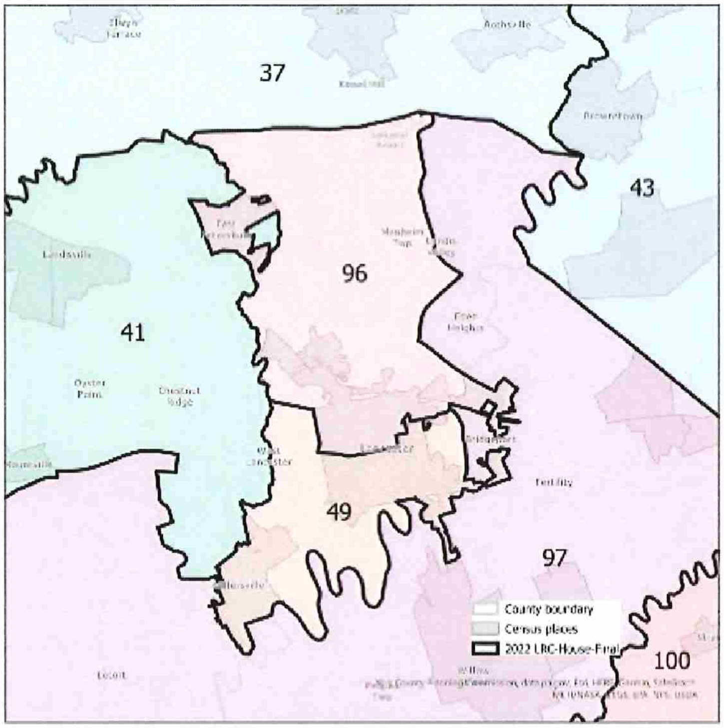
By looking at the Benninghoff Plan, we can appreciate why it may be undesirable to create a single Lancaster district whose shape is dictated by the city boundaries. Not only does this produce a non-compact district with several appendages, claws, and arms, but it also creates a very large number of non-contiguities, especially amongst the Northern appendages of the city. To see this more clearly, Figure 3 zooms in on this area, demonstrating that by keeping Lancaster whole, Leader Benninghoff was forced to produce a very large number of "stranded" neighborhoods that are disconnected from the rest of the district. In my experience working on redistricting in the United States, I do not recall seeing that a district like this has been implemented.

A simple way to minimize the number of non-contiguities is to give up on the project of keeping Lancaster whole, instead combining sections of the city with surrounding townships whose vote tabulation districts are partially embedded in the city. This is the approach taken in the Final House Plan. Not only does this dramatically reduce the number of non-contiguities, but it also allows Lancaster Township to stay whole, rather than splitting it, as the Benninghoff Plan does. Another obvious advantage to the Commission's approach is compactness. The Polsby-Popper score of the Benninghoff Lancaster district (number 96) is only .05, whereas the average for the two Lancaster districts in the Final House Plan (96 and 49) is .17.

Again, as with Scranton and Wilkes-Barre, it is very difficult to see how the Lancaster area in the Final House Plan can be understood to be violative of traditional redistricting principles for partisan gain.

Figure 2: Lancaster

Final House Plan



Benninghoff Plan

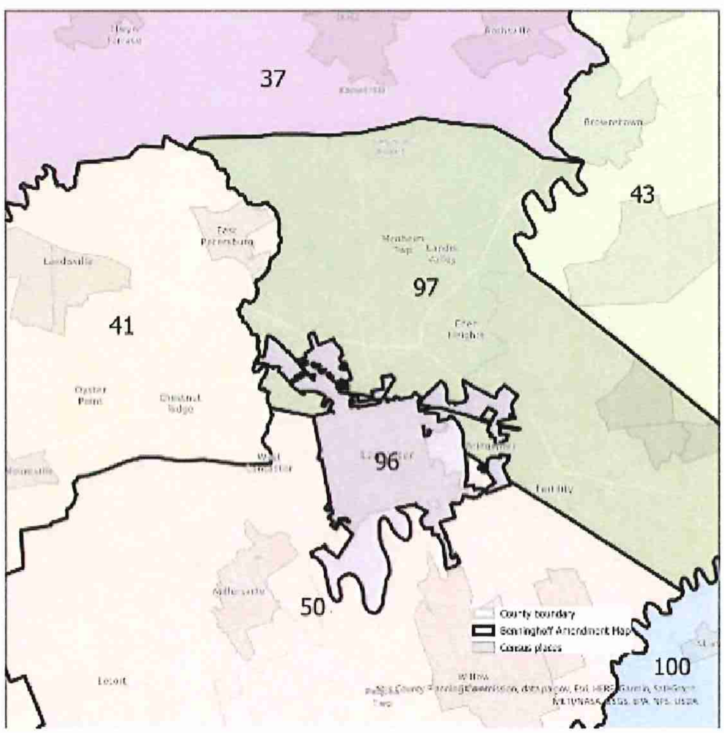
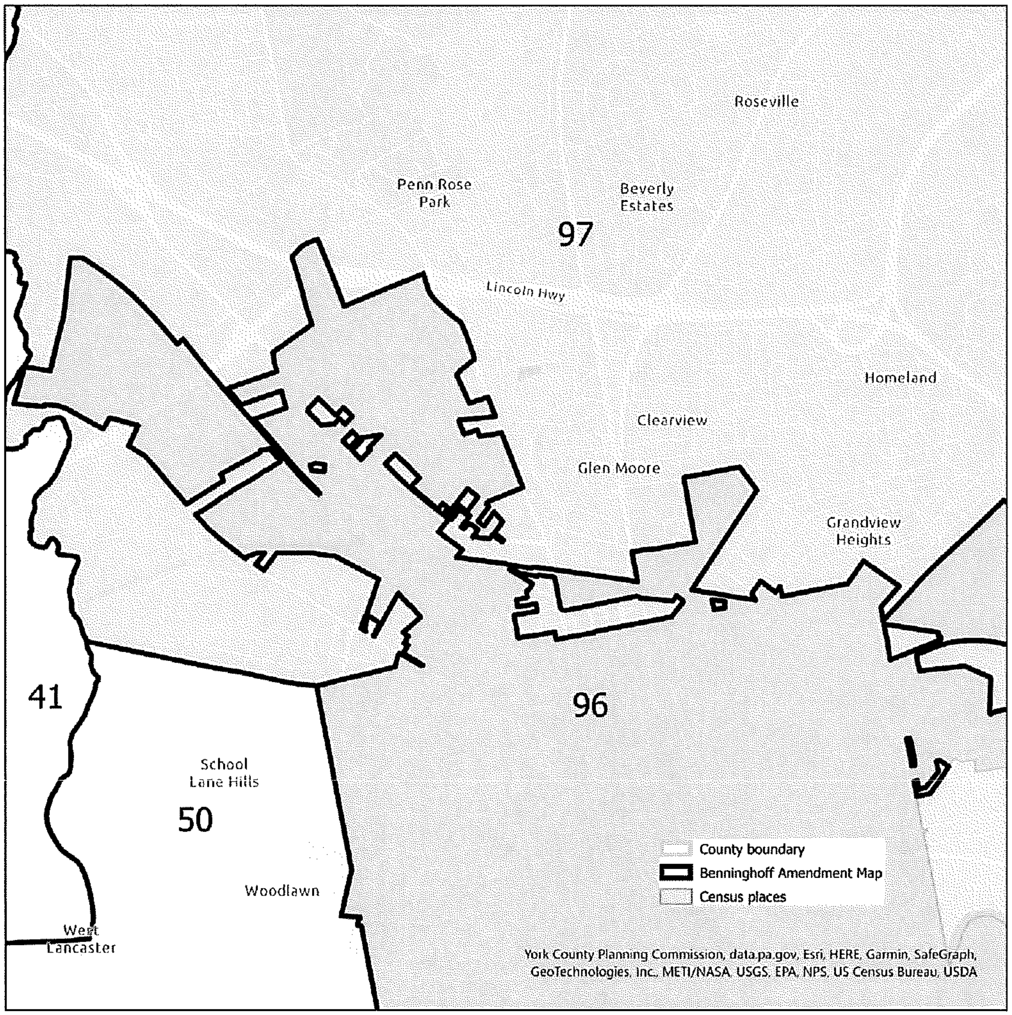


Figure 3: Northern Lancaster City, Benninghoff Plan

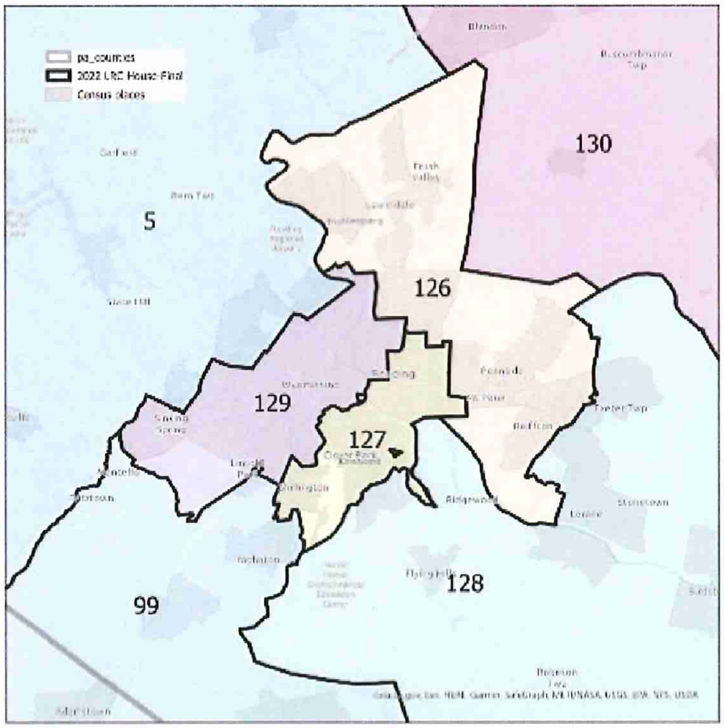


Reading

Dr. Barber also points to the city of Reading, referring to the districts as having a "pinwheel" shape that combines urban neighborhoods with distant suburbs. The Final House Plan's Reading districts, along with those in the Benninghoff Plan, are displayed in Figure 4. Comparing the two maps, it is not clear why Dr. Barber considers the Final House Plan to have a pinwheel shape. The Commission's approach to Berks County led to a more compact arrangement to the Southwest, and one that required fewer splits of the Berks County boundary (2) than the Benninghoff Plan (3).

Figure 4: Reading

Final House Plan



Benninghoff Plan

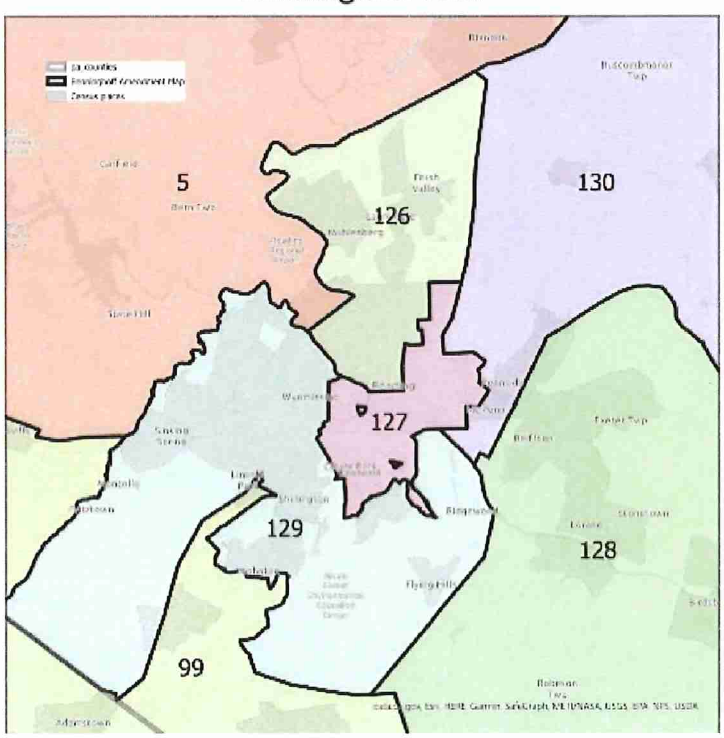
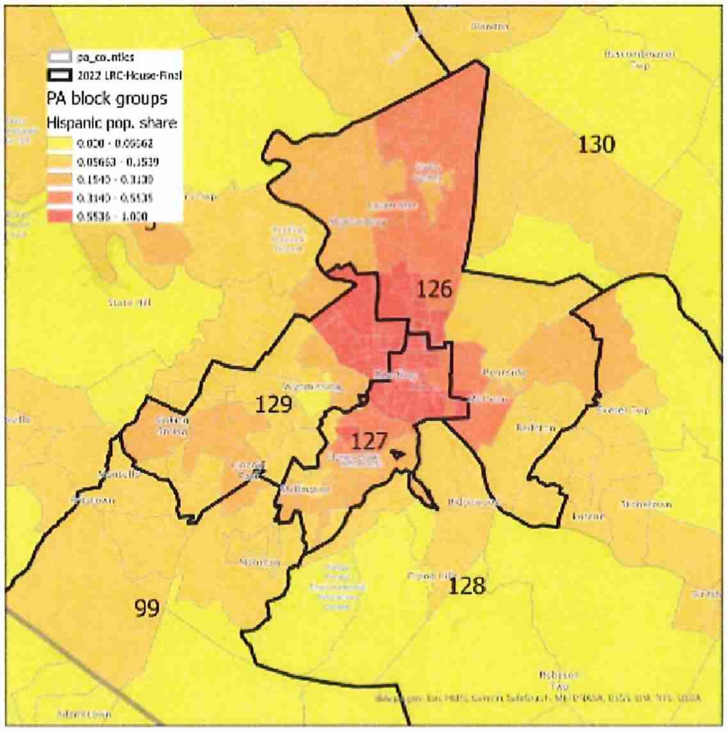
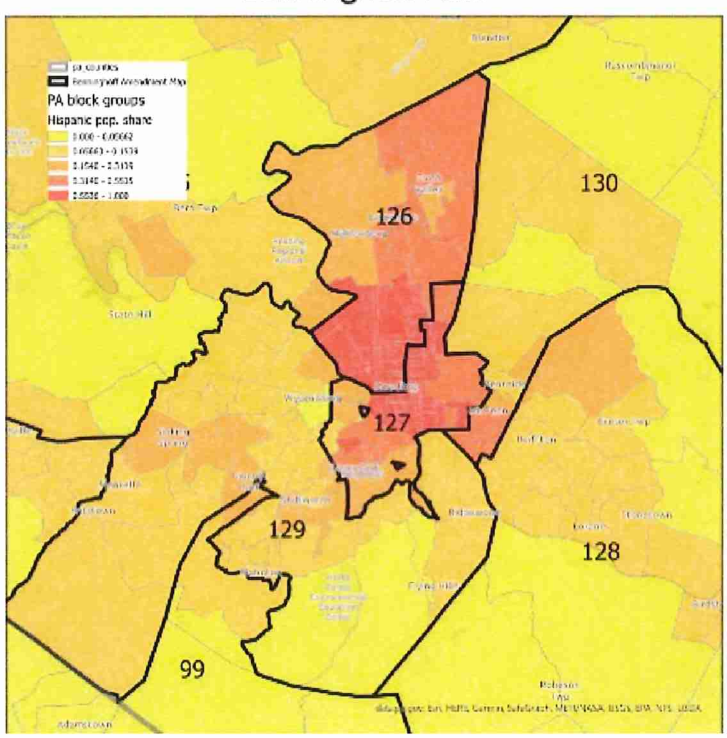


Figure 5: Hispanic Population Share, Reading

Final House Plan



Benninghoff Plan



Another feature of the Final House Plan can be appreciated with Figure 5, which adds a display of Hispanics as a share of the total population in each census block group. It demonstrates that there is a significant Hispanic population not only in Reading proper, but also in a series of suburban communities on both the East and West sides of the city. The Benninghoff Plan splits the suburban Hispanic community on the East side into four different districts: 126, 127, 128, and 130. District 130 reaches from the rural periphery all the way to the Reading border, extracting Mount Penn and its surroundings, and splitting the communities of Pennside and Stony Creek Mills along the way. In contrast, the Final House Plan keeps all of these suburban communities in the same district: 126.

Lehigh Valley

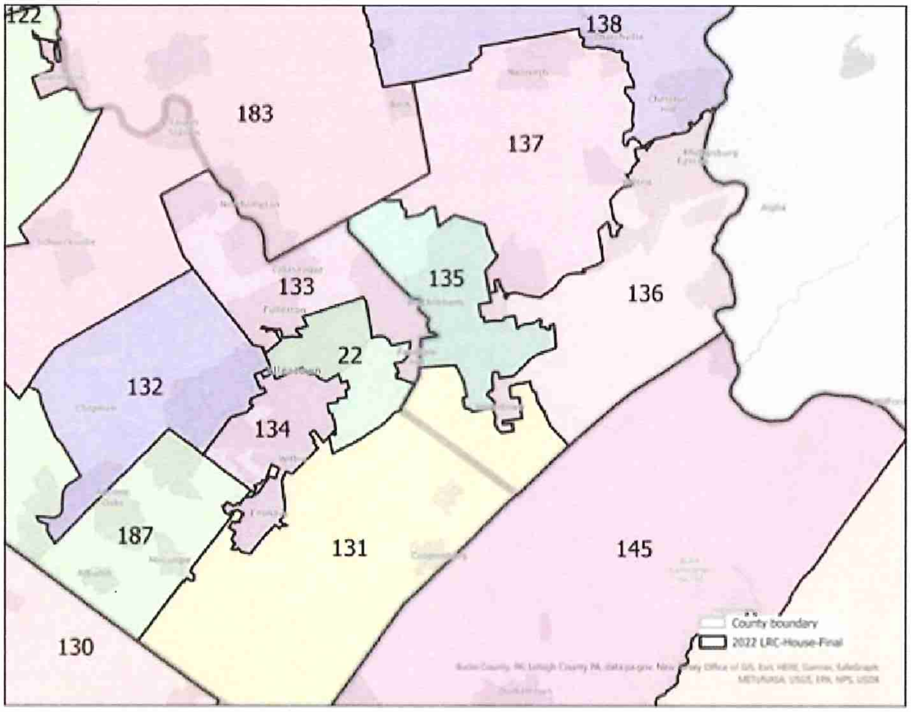
Next, let us consider the Lehigh Valley. Dr. Barber has no complaints about the boundaries of Easton or Bethlehem. However, Dr. Barber makes a claim about Allentown that is very similar to his claim about Lancaster. Since the population of Allentown is very slightly less than twice the target population for a district, he concludes that it must be divided into two districts. But as in Lancaster, this introduces a difficult trade-off related to compactness that can be appreciated by examining Figure 6. When trying to fit Allentown into only two districts, a district-drawer is placed into a straitjacket by its municipal boundaries. In the Benninghoff Plan, for instance, Districts 132 and 134 are forced into a very non-compact arrangement, whereas the Final House Plan, by splitting Allentown, was able to pursue a more compact arrangement, avoiding a highly non-compact district like Benninghoff's 134, which reaches all the way across the county via a narrow corridor that circumvents Allentown. This is a classic example of a basic trade-off in redistricting necessitating a municipal split.

Harrisburg

Harrisburg provides another example of this same trade-off. Harrisburg's population is somewhat lower than the target population of a district, so it is possible to keep it whole and combine it with other smaller communities in the vicinity. However, due to the narrow, non-compact arrangement of the city along the banks of the Susquehanna, and because of the structure of the borders of Dauphin County, this choice has knock-on effects when one is also trying to minimize county splits and avoid splitting other communities. This can be visualized in the second panel of Figure 7 below. In addition to the Harrisburg district, other surrounding districts, especially 104 and 125, are forced into a less compact arrangement in the Benninghoff Plan than in the Final House Plan, which splits Harrisburg in exchange for a more compact arrangement. The average Reock score for Dauphin County districts in the Final House Plan is .44, whereas it is .37 in the Benninghoff Plan. The average Polsby-Popper Score for Dauphin County is .32 in the Final House Plan, and .30 in the Benninghoff plan.

Figure 6: Lehigh Valley

Final House Plan



Benninghoff Plan

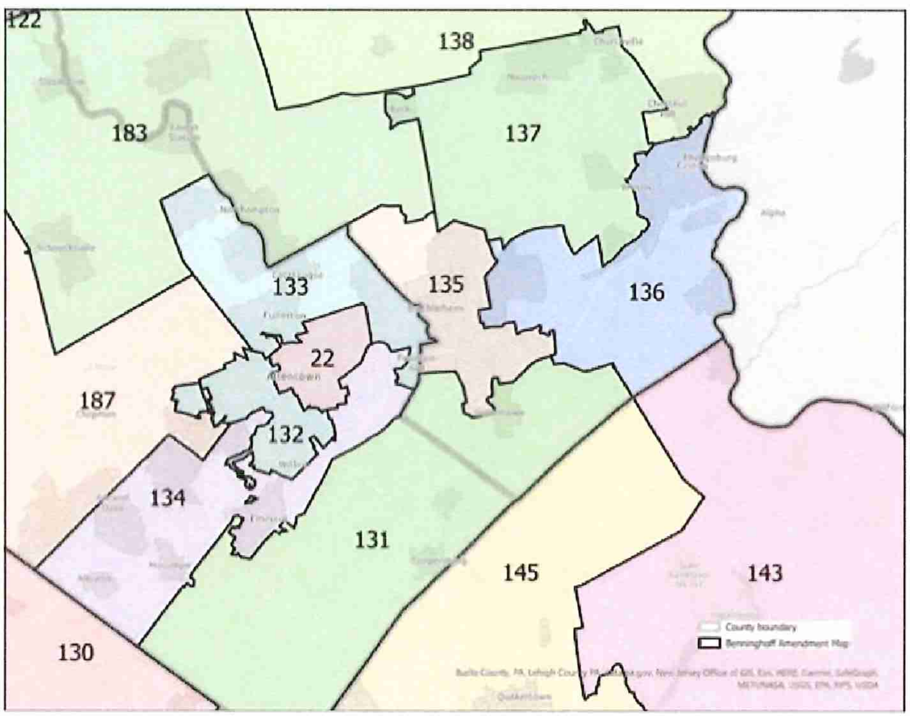
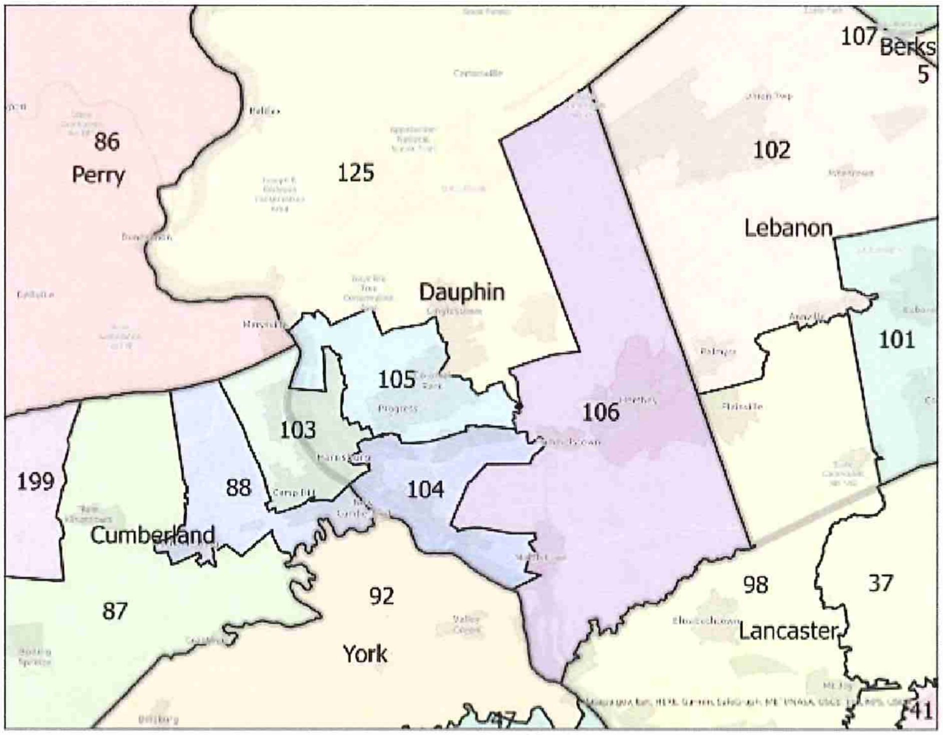
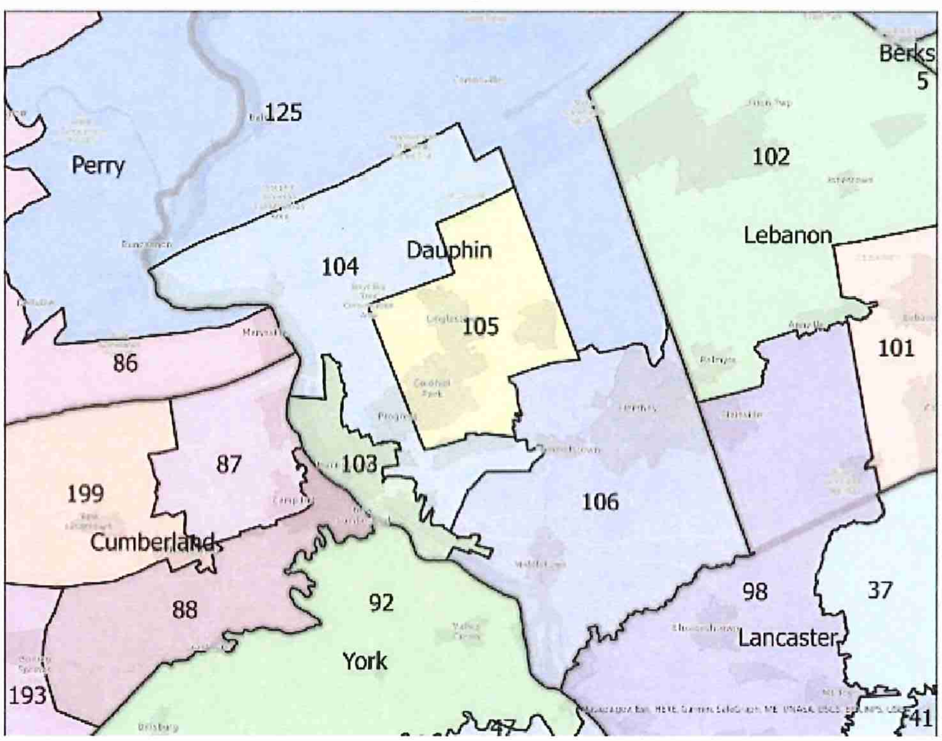


Figure 7: Metro Harrisburg

Final House Plan



Benninghoff Plan



Summary of Case Studies

Due to time constraints, I have not been able to provide an exhaustive assessment of the metropolitan districts in the Final House Plan or the Benninghoff Plan. Rather, based on an illustrative exploration of several of Dr. Barber's case studies, I have evaluated his claim that by simply visualizing maps of selected metro-area districts and considering the number of splits relative to city population counts, one can infer that traditional redistricting principles were subverted for partisan gain.

Dr. Barber's main observation is that in the Final House Plan, population counts indicate that districts could have been drawn in a handful of cities with one split fewer. However, the case studies discussed above reveal that divorced from other considerations like compactness, communities of interest, county boundaries, and splits of other surrounding municipalities, this observation tells us very little about whether, from the perspective of the Pennsylvania Constitution or traditional redistricting principles more broadly, these splits were necessary. In the illustrative cases reviewed above, removing the extra split would have involved a variety of countervailing compromises of other constitutional redistricting criteria.

VII. CONCLUSION

Dr. Barber's report does not provide any evidence that the Commission's redistricting plan is biased in favor of the Democratic Party. In fact, likely because of aspects of Pennsylvania's political geography, it is somewhat biased in favor of the Republican Party. Dr. Barber's central claim appears to be that traditional redistricting criteria must have been subverted when drawing the Final House Plan because it is *insufficiently biased* in favor of Republicans relative to the modal plan in an ensemble of computer-generated plans. This claim is difficult to understand, since the Final House Plan outperformed the entire ensemble of simulations on measures of county splits, municipal splits, and compactness.

Furthermore, Dr. Barber's report points out a handful of specific instances where the Commission carried out a single additional city split beyond what was technically necessary. However, upon closer inspection, these choices reflected basic trade-offs that are well known in the redistricting community, above all between limiting municipal splits to situations of absolute necessity and 1) compactness; 2) contiguity; 3) county splits; and 4) the preservation of communities of interest.

I reserve the right to supplement or amend this Report to best inform the Court of my opinions and conclusions.

Jonathan Rodden, Ph.D.
March 10, 2022