

BACKGROUND AND QUALIFICATIONS

3. I refer to and incorporate by reference the relevant portions of my first Affidavit, which was filed on February 24, 2022. I attach as Exhibit A to this affidavit a copy of my curriculum vitae.

SCOPE OF ENGAGEMENT AND COMPENSATION

4. I have been retained by Cuti Hecker Wang LLP, counsel for Respondent Senate Majority Leader and President Pro Tempore of the Senate Andrea Stewart-Cousins, and asked to opine on the validity of the analysis used and the conclusions drawn in the two reports submitted by Sean Trende.

5. I am being compensated at a rate of \$400.00 per hour. My compensation does not depend in any way on the outcome of the case or on the opinions or testimony that I provide.

MATERIALS REVIEWED

6. In connection with preparing this testimony and providing the opinions expressed herein, I have reviewed the following materials:

- Report of Sean Trende submitted on behalf of the Petitioners in this case;
- Reply of Sean Trende submitted on behalf of the Petitioners in this case;
- Relevant portions of Article III, Section 4(c) of the New York Constitution setting forth applicable redistricting criteria; and
- McCartan & Imai, *Sequential Monte Carlo for Sampling Balanced and Compact Redistricting Plans*.

SUMMARY OF EXPERT OPINIONS

7. Mr. Trende's stated opinion is that the enacted Congressional and Senate maps were drawn for the purpose of benefiting the Democratic Party. Based on my analysis of Mr.

Trende's report, his reply, and his methodology, I hold the following opinions to a high degree of professional certainty:

- a. As stated in my previous Affidavit, Mr. Trende's own results—based on his choice of electoral index and his sample of districting plans—clearly support the conclusion that the partisan electoral opportunity in the enacted Congressional map is more favorable to Republicans than the party-blind baseline represented by his ensemble. The same is true in the case of the Senate map, but with an even more significant Republican lean. For example, his data shows that the enacted Senate map is predicted to include 49 Democrat-leaning districts, whereas *every single one* of the 5,000 randomly generated maps in his ensemble is predicted to have at least 51 Democrat-leaning districts, and the majority have at least 53 Democrat-leaning districts. It is standard to interpret this data as an indication that the enacted Senate map is significantly *Republican*-favoring relative to maps drawn with the party-blind rules represented by his ensemble. All of this can be visualized in Figures 1 and 2 below.
- b. Although Mr. Trende freely chose in his first report to use a single electoral index created from averaging a set of elections, a large portion of his second report is devoted to critiquing the index that he selected. In an effort to run away from the conclusion that the index he chose to use in his first report compels—that the Congressional and Senate maps favor Republicans, not Democrats—his second report tries to move the goalposts by claiming that there supposedly is parity between the parties when the index he initially used shows that a district leans toward Democrats

- by 53%-47%. His crude attempt to support this more convenient and self-serving hypothesis is fundamentally flawed and entirely unreliable.
- c. Mr. Trende claims that his ensemble of 5,000 Senate maps represent “what maps would tend to look like in New York if they were drawn without respect for politics.” In my opinion, his ensemble of simulated maps can only be said to represent what maps would look like if they were drawn by his algorithm, using parameters that only he knows. I see no evidence that his ensemble of simulated maps are a representative sample according to any reasonable interpretation of the term “representative.” Among other problems, there are very strong indications in Mr. Trende’s report that his ensemble of 5,000 simulated Senate maps consist entirely of small variations on just *two* maps. This alone is sufficient cause to dismiss his ensemble as too fundamentally broken to yield any statistically valid conclusions.

ANALYSIS OF MR. TRENDE’S RESULTS

Analysis of Mr. Trende’s Senate Results

8. As detailed in my first Affidavit and again below, Mr. Trende’s methodology has such substantial flaws as to render his model of little if any statistical value. Notwithstanding those methodological flaws, in this section I will take at face value Mr. Trende’s claim that his ensemble of 5,000 maps represents “what maps would tend to look like in New York if they were drawn without respect for politics.” In this section, I will critique only the conclusions he draws from his ensemble analysis based on this assumption. (To the extent certain statements in this Affidavit are repetitive of statements that I made in my prior Affidavit, that is because the points I made in my prior Affidavit about Mr. Trende’s analysis of the Congressional plan apply similarly to his analysis of the Senate plan.)

9. The chart on page 21 of Mr. Trende’s original report, titled, “Democratic Vote Share by Simulated Senate District,” indicates that the enacted Senate plan includes 49 Democrat-leaning districts, whereas *every single one* of the 5,000 maps from his ensemble includes at least 51 Democrat-leaning districts. Virtually all of the maps from his ensemble include at least 52 Democrat-leaning districts, and the majority include at least 53 Democrat-leaning districts (and many other maps include 54 or even 55 Democratic-leaning districts). Again, on average, the maps in his ensemble clearly contained more Democrat-leaning districts than does the enacted plan.

10. Mr. Trende’s data, using the index he chose to use in his original report, therefore clearly shows that the enacted Senate plan is a significantly Republican-favoring outlier relative to the maps in his ensemble.

11. Mr. Trende’s use of the “gerrymandering index” to conclude that the Senate plan is “obviously partisan gerrymandered” is simply wrong. As I explained in my prior Affidavit, the gerrymandering index does not provide any information about which party is favored by the enacted map relative to the ensemble, or even whether there is a favored party, nor does the gerrymandering index provide any information about whether the enacted map discourages competitive districts relative to the ensemble. As I explained in my prior Affidavit, partisan lean is only one of many factors that can make the gerrymandering index high, and to the extent that partisan lean contributed to the high gerrymandering index in Mr. Trende’s Senate analysis, it clearly was a Republican-favoring lean that made the gerrymandering index high.

The Standard Interpretation of Trende's Own Results

12. The histograms in Figures 1 and 2 below, made from Mr. Trende's own data,¹ speak for themselves. Mr. Trende has hidden the ball by declining to present this very clear and standard visualization of his own results. In each figure, the vertical line represents the number of districts in which Democrats are a majority in the enacted plans using the index Mr. Trende used in his original report. These histograms shows the number of districts in which Democrats are a majority in all of the maps in Mr. Trende's ensembles using the index used in Mr. Trende's original report. In the case of both the Congressional and Senate plans, the enacted plans have *fewer* districts in which Democrats are a majority than the average maps in Mr. Trende's ensembles. In the case of the Senate plan, the difference is particularly stark.

13. It is standard practice to produce histograms like this in any report relating to redistricting simulations, and the fact that Mr. Trende failed to produce these standard histograms in his original report could reflect his understanding that his data was not consistent with his stated conclusion.

¹ I constructed these histograms from the information on pages 15 and 21 of Mr. Trende's original report by approximating the portion of the dots that are red and blue for each ordered district number. The potential error introduced by this approximation does not affect the key qualitative features of the resulting graphs.

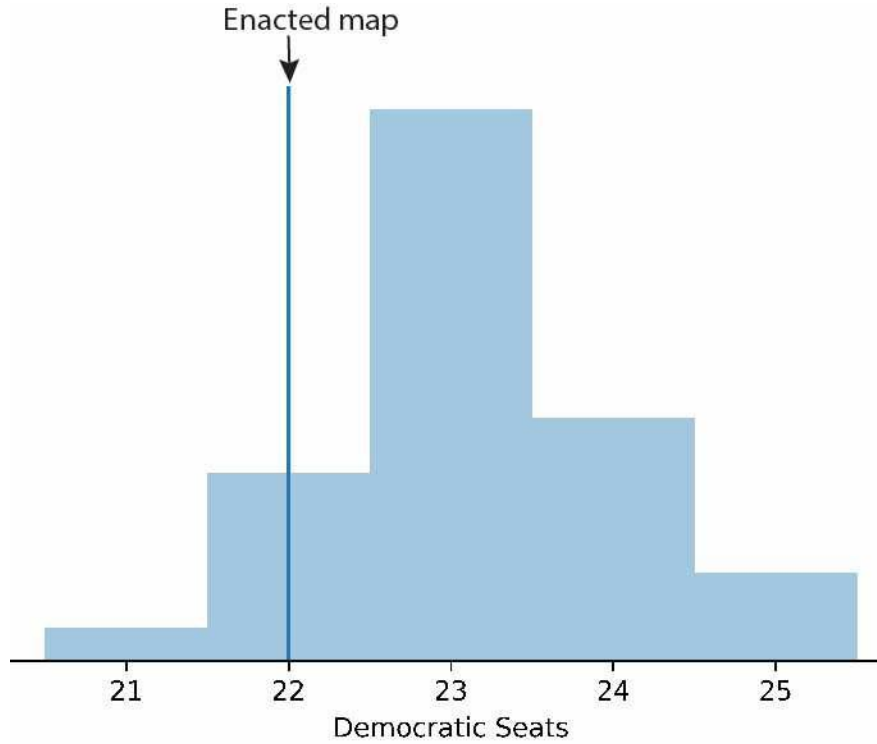


Figure 1: (CONGRESSIONAL) Majority-Democrat seats for the enacted plan and for Mr. Trende's ensemble maps

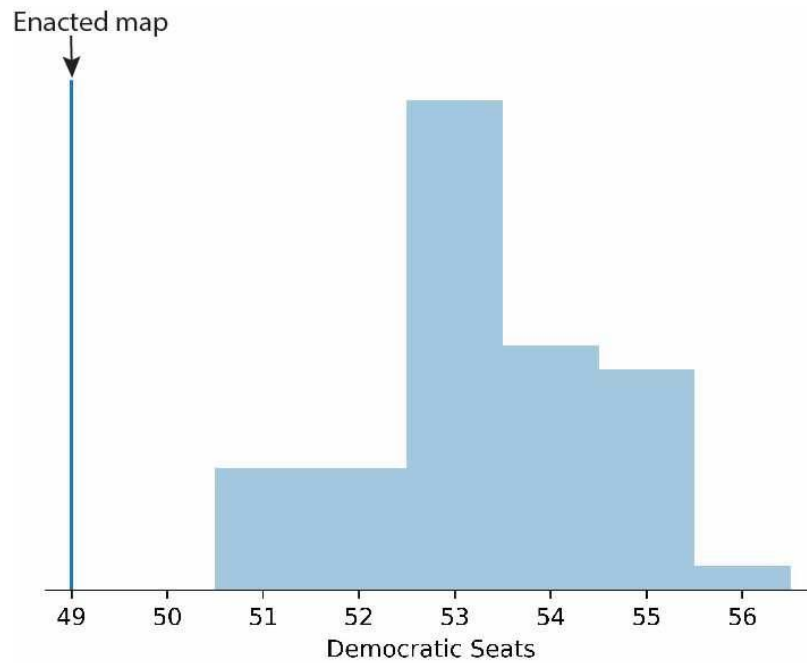


Figure 2: (SENATE) Majority-Democrat Seats for the enacted map and for Mr. Trende's ensemble maps

Mr. Trende's Ad Hoc Partisan Analysis

14. Mr. Trende freely chose to use a single electoral index created from averaging a set of state-wide elections. Mr. Trende justified this decision in his original report (footnote 2 on

page 12), by saying that “The simulation approach tends not to be as sensitive to the choice of elections as other metrics, unless political coalitions in a state vary radically from election-to-election. Regardless, to remove my discretion, I have simply used the calculation of partisanship contained in the dataset that I downloaded from the ALARM project” Yet now Mr. Trende is exercising arbitrary discretion in moving the goalposts by changing his choice of elections.

15. A large portion of Mr. Trende’s second report is devoted to critiquing the election index that he freely chose to use and justified using in his first report. To do this, he attempts to move the goalposts from the most obvious assumption—that 50% of the vote in recent prior elections corresponds to parity between the parties—to an entirely ad hoc and counter-intuitive assumption that there supposedly is parity between the parties when a district is 53% Democrat-leaning.

16. If Mr. Trende believes that the partisan data he selected for his model does not correctly predict Congressional/Senate elections, then he should have selected partisan data that does. Moreover, there is a good reason that his convoluted two-stage approach has never been done before: any statistical significance that can be attributed to a two-stage experiment is decreased significantly when the bar of the second stage is set only after seeing how the first stage turns out. That is like shooting an arrow and then drawing a target around the spot where it lands. It invites precisely the subjectivity and discretion that Trende purported to avoid by choosing a set of statewide elections in the first instance.

17. Even setting that issue aside, Mr. Trende’s method for determining that Republicans did better in recent Congressional elections than in statewide elections by about 3% of the vote share, and that it therefore supposedly makes sense to move the goalposts by 3% to compensate for this, is fundamentally flawed.

18. Mr. Trende first relies on the table on page 10 of his reply, which shows the results of Congressional elections in the old districts in New York from 2016, 2018, and 2020, to claim that “Republicans almost always win in districts up to roughly a 53% threshold in our [historical partisan voting] index, and are competitive/capable of winning in districts up to roughly a 55.5% threshold.” His point seems to be that if you look at the 53% partisan index level in his table, the cells above are mostly red, while the cells below are mostly blue. But the more precise observation is that all but six of the cells above the 53% index level are red, while all but three of the cells below that level are blue. If you instead look at the 52% index level, a closer balance is achieved: all but five of the cells above that level are red, while all but five of the cells below are blue. This undermines his claim that a 53%-47% Republican-leaning district is parity.

19. Indeed, if you ignore District 24 (in which John Katko, a popular Republican Congressman who consistently won a Democrat-leaning district, has now announced his retirement, which makes this district a poor predictor of future Congressional elections), then the level on Mr. Trende’s chart at which there are equal numbers of blue districts above and red districts below is approximately the 51.5% index. My point here is not that a bump of less than 3% would be more statistically justifiable than a 3% bump. It is simply that Mr. Trende’s reliance on the table on page 10 of his reply is not precise, reliable, or statistically valid.

20. Second, Mr. Trende states that he arrived at his proposed 3% bump by performing a simple linear regression comparing the statewide partisan voting history of each old Congressional district to the results in the Congressional elections. But this simple regression is likewise unreliable for several reasons.

21. Mr. Trende acknowledges in footnote 3 of his reply report that the partisan index he used in his original report “use[s] statewide races because it helps to control for things like candidate quality, fundraising, and incumbency in a uniform way across the State.” There is good reason that responsible practitioners rely on statewide rather than districted election data when using past results to forecast future results. The major reason that districted election results sometimes differ from statewide results is the presence of specific incumbents who are popular, controversial, etc. But changing district lines changes incumbent effects – after all, once you change the old district lines to form new districts, the effects of incumbency change by definition – which is why it is commonly understood by people who specialize in this area that one should not assume there will be no change in the incumbency advantage or disadvantage of present representatives when a totally new set of lines is enacted. Yet Mr. Trende’s regression does not control for incumbency in any way.

22. In addition, Mr. Trende’s simple linear regression is sensitive to data values that are too far away from 50% to matter. For example, in a district with a partisan index of 85%, it would make no difference to the election outcome whether the Democrat Congressional vote share is 75% or 95%, yet this difference would change his calculation.

23. It bears noting that Mr. Trende’s table 2 reports a p-value and a confidence interval, which shows that a 0% bump would lie with his reported 95%-confidence interval. In other words, Mr. Trende’s math shows that a 0% bump is reasonable. I tried other possible regression models, which similarly concluded that a 0% bump is reasonable.

24. In sum, Trende’s regression results are effectively nothing but a measurement of incumbency effects from the previous decade, which are irrelevant to analysis of a totally new set of lines for the new decade.

25. Finally, it is notable that Mr. Trende’s statement that 55.6% is “the point at which Republicans have no chance at winning whatsoever” appears to be entirely based on the fact that in District 24, with an index of 55.66%, John Katko won all three of the elections in Mr. Trende’s chart. In other words, he does not appear to have derived that number – which he asserts as the outer bound for a potentially competitive district – from his regression or from anything except for the past Congressional election results in one Democrat-leaning district on the old map in which the popular Republican incumbent has announced his retirement.

26. I especially do not see any justification for applying the 3% bump to Mr. Trende’s analysis of Senate maps. His proposed 3% bump was derived purely from Congressional data, and Mr. Trende does not give any indication as to why he believes that data would be predictive of Senate elections, or why the Senate bump, if there should be one at all, should be exactly the same as the Congressional bump.

ANALYSIS OF MR. TRENDE’S METHODOLOGY

Mr. Trende’s Senate Ensemble is Fatally Flawed

27. In my prior Affidavit, I described numerous flaws in Mr. Trende’s methodology with respect to his analysis of the Congressional plan, which demonstrated that his ensemble was not a representative sample of lawful maps that could be drawn without partisan considerations. Mr. Trende’s analysis of the Senate plan was also deficient in all of those ways, including lack of reproducibility, failure to define the target distribution, and failure to consider constitutionally required redistricting criteria.

28. In addition, as described below, there are strong indications that there was a fatal redundancy in Mr. Trende’s Senate ensemble – the 5,000 maps in the ensemble seem to in fact all be modest variations on just two maps.

29. As with his Congressional model, Mr. Trende provides almost no information about his methodology for his Senate simulations, which makes it impossible to precisely reproduce his results or definitively diagnose his errors. Relatedly, Mr. Trende does not define his *target distribution*, so it is impossible for me to diagnose how far he is from hitting his target of creating a representative sample.

30. As with his Congressional model, Mr. Trende's Senate model incorporates only a subset of the criteria that the New York Constitution states shall be used in redistricting. Among other factors, Mr. Trende's model does not take into account the following considerations:

- whether the districts would result in the denial or abridgement of racial or language minority voting rights
- whether the districts are drawn so that racial or minority language groups do not have less opportunity to participate in the political process than other members of the electorate and to elect representatives of their choice
- maintenance of cores of existing districts
- maintenance of cities
- maintenance of towns
- maintenance of communities of interest

31. Because Mr. Trende's Senate model does not include those considerations, the model is incapable of creating a representative sample of legally compliant maps that would be drawn without partisan considerations.

32. An even more fatal problem is the evidence of massive redundancy in Mr. Trende's ensemble, especially in his Senate ensemble, which I believe arose because Mr. Trende

used an ensemble size that was too small.² There is no basis to believe that an ensemble of 5,000 or even 10,000 simulated maps was large enough to support reliable conclusions. The McCartan-Imai algorithm is very new, and not much is known yet about the ensemble size that is sufficient when using this algorithm, which depends on many factors. The empirical validation study in the McCartan-Imai paper at issue, which has not yet been peer reviewed, used an ensemble of 10,000 simulated maps to analyze a hypothetical jurisdiction with 50 precincts to be partitioned into 3 districts. Mr. Trende used an ensemble size of just 5,000 simulated maps for New York, which has over 15,000 precincts that must be partitioned into 63 Senate districts (or 26 Congressional districts). For this particular algorithm, there are technical reasons why a state with larger numbers of precincts should be expected to require a much larger ensemble. Mr. Trende's casual assumption that it was sufficient to use the same sample size that McCartan and Imai used to simulate a hypothetical jurisdiction that is far less complex than New York is baseless and reason enough to conclude that his simulations prove nothing, especially given that the McCartan-Imai algorithm is still in the peer review process and is known to require larger sample sizes for larger numbers of precincts.

33. I believe that the algorithm that Mr. Trende used behaved as if the Senate maps were constructed something like this: imagine that two people, Amy and Bob, each separately construct a partial Senate plan by drawing the first 50 of the 63 districts. Imagine that the algorithm used by Mr. Trende then were to randomly find 2,500 different ways to complete Amy's partial map and 2,500 different ways to complete Bob's partial map, and then produce the

² The term "redundancy" applies when the maps that comprise an ensemble of 5,000 simulated maps are not actually 5,000 distinct simulated maps, but instead include a significant number of maps that are highly similar to each other. An ensemble with a high level of redundancy cannot be said to provide a representative sample of its target distribution.

resulting ensemble of 5,000 maps, effectively locking in only two versions of how the first 50 districts were drawn. There are under-the-hood reasons³ to worry that the algorithm used by Mr. Trende might behave in this way when used in the manner that Mr. Trende seems to have used it.

34. As discussed further below, the reasons to be concerned about this significant issue are not just theoretical. There also are strong indications that the algorithm Mr. Trende used did in fact behave in this way, and that Mr. Trende's Senate ensemble is therefore fundamentally and fatally flawed.

35. One glaring indicator that Mr. Trende's Senate ensemble likely is actually infected with this fatal redundancy problem is the graph at the top of page 22 of Mr. Trende's original report. In the chart, the Polsby-Popper scores of the Senate maps are clustered in two distinct areas with virtually no results in between those two clusters. This shows that the ensemble of simulated Senate maps is fundamentally split into two clusters of maps, with each cluster having very similar properties to all of the maps within the cluster, but with the two clusters having strongly different properties to each other. There is nothing about New York's geography (or any state's geography) that could account for the bizarrely stark bimodal nature of this compactness histogram. By far the most plausible explanation for this stark compactness bimodality is that it indicates that the ensemble-generating algorithm did not work correctly because 5,000 simulated maps was an insufficiently small sample size for this particular

³ At each of the algorithm's 63 stages (one for each Senate district), it samples from a pool of only 5,000 partially-constructed weighted maps whose weights vary by multiplicative factors that could be orders of magnitude larger than 5,000 (depending on how the parameters are set). This could lead to extreme redundancy in the next-stage sample. In fact, it could lead to a situation where exactly two such partially-constructed maps (Amy's and Bob's in my illustration) are extremely upweighted relative to the other plans. In this case, there is a strong basis to be concerned that almost half of the next-stage maps might come from just two extremely upweighted partially constructed maps from the previous stage.

application and that the 5,000 maps in Mr. Trende's Senate ensemble are just modest variations of two maps (or because there was a different fatal flaw in Mr. Trende's model that cannot be identified from the limited information that he provides).

36. Mr. Trende's simulations clearly are deeply flawed and fail to produce a representative sample.

Mr. Trende's Congressional Ensemble Still Is Not a Representative Sample

37. In his second report, Mr. Trende supplemented the methodology for his initial Congressional ensemble with modifications that he says were intended to model additional constitutional requirements, and he says that he has now run 10,000 simulations instead of 5,000. Even with those modifications, there remain substantial methodological flaws that make clear that Mr. Trende's Congressional ensemble is not a representative sample of legally complaint maps that could be drawn without partisan considerations.

38. As is widely acknowledged, many kinds of algorithms can have hidden bias. Even a "random" and well-intentioned process may fail to draw a sample that is fairly distributed. A responsible modeler would confirm that maps are being drawn just in proportion to their properties, and can explain why certain kinds of maps occur more often than others. As a purely hypothetical example, imagine that the algorithm constructs maps that mostly keep eastern Long Island together, or that mostly split it horizontally, or that mostly split it vertically. In a well-designed model, this would be explained by explicit properties of the maps, such as their compactness. A responsible modeler would have been transparent from the start about the balance of maps that the algorithm will select, so its effect on Long Island could have been predicted in advance and can be subject to criticism or defense.

39. I can assert with confidence that Mr. Trende’s ensembles are not representative samples of the legally valid maps under any reasonable interpretation of the term “representative.” He is using an algorithm capable of sampling from a specified balance of maps, but he has not controlled the settings in a manner that can possibly achieve this. Mr. Trende claims that his ensemble of 5,000 maps (and now 10,000 maps) represent “what maps would tend to look like in New York if they were drawn without respect for politics.” I see no reason to believe that Mr. Trende’s Congressional ensemble is a representative sample of maps drawn without partisan considerations. Rather, his maps can only be said to represent what maps would look like if they were drawn by his algorithm, using parameters that only he knows.

40. One case in point is the balance of county-splits in his ensembles. The maps in his Congressional ensemble have only between 12 and 16 county-splits each, which indicates to me that his algorithm functioned more like a minimizer than a sampler, producing the kinds of maps that humans would draw if they tried their hardest for a very long time to split as few counties as possible, at the expense of all other considerations. This is one of many indications that Mr. Trende has not achieved the goal of drawing maps that accurately represent the universe of possibilities for good faith human line-drawers.

41. Mr. Trende’s model still does not take into account the maintenance of communities of interest, which the New York Constitution requires to be considered in redistricting. I am sympathetic to his point that communities of interest are “a notoriously difficult concept to nail down” and are “difficult to encode.” There is no easy or canonical way to program an algorithm to respect communities of interest in a state like New York where there is no agreed-upon specification of exactly which communities should be maintained.

42. It is nevertheless insufficient for Mr. Trende to effectively say, “I did my best.” Even if it’s true that there’s no obvious way he could have done better at incorporating communities of interest into his model, the conclusions that he can draw from its model are weakened by this missing constitutional requirement. Trende’s main punchline is that the enacted map is an outlier relative to the maps in his ensemble. But an outlier only shows that a map was likely drawn with some priorities that were not included in the model (like maintenance of communities of interest, among other possibilities). In ensemble analysis, when an enacted map is different from the random outputs, that only tells you that something else was in play, not that something impermissible was in play.

43. And, as discussed below, there is cause for concern that Mr. Trende’s Congressional ensemble might also be infected with the same potentially fatal redundancy as the Senate ensemble.

Replicated Evidence of Fatal Redundancy in Mr. Trende’s Ensembles

44. As discussed above, there are significant reasons to believe that Mr. Trende’s ensembles have massive redundancy in the maps that comprise them. Since I was not granted access to Mr. Trende’s outputs, I ran a replication study to determine how susceptible his method is to the problem of massive ensemble redundancy. I created a replication of Mr. Trende’s ensembles of 5,000 maps using the same McCartan-Imai algorithm that he used. Since Mr. Trende only reported a few of the parameters he used, I could not perfectly match all of his choices, but I re-ran the replication several times in order to try multiple possibilities for the compactness parameter, which is the one that most affects a sample’s redundancy.

Compactness⁴ can be set to any number between 0 and 1. My experiments showed that ensembles created by replicating Trende’s method using *any* compactness setting can contain massive levels of redundancy that in some cases render the ensembles statistically useless.

45. I first tried compactness settings that were less than 1 (including 0, 0.25, 0.75), and these settings resulted in ensembles with such massive levels of redundancy that the algorithm’s own built-in validation system threw up warnings that the ensembles were broken and useless. The algorithm progresses through one stage for each district, so it takes 63 stages to create a Senate ensemble. Along the way, the algorithm can be asked to report the *effective sample size* of each stage. The *actual sample size* of each stage is 5,000 (the ensemble size), but because of imperfections inherent in this sampling method, the *effective sample size* will be less than 5,000. Numbers very close to 5,000 indicate that only a negligible amount of redundancy crept in during that stage. In my replication, the effective sample sizes at all stages were shockingly low; in fact, they were in the double and single digits. The values from the first 12 stages (with compactness=0.5) are reported in Table 1. The results were just as problematic with compactness set to 0 or 0.25 or 0.75.

	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th	11 th	12 th
Senate ensemble	20	14	12	6	21	14	24	33	45	30	7	6
Congressional ensemble	7	3	7	6	1	2	5	3	3	2	2	6

Table 1: Effective samples sizes (rounded) for the first 12 stages in constructing the ensemble (compactness=.5)

⁴ I find the name “compactness” here misleading, since it incorrectly suggests that higher values are always better. In fact, a compactness score of 0 is the only way to realize the *redist* algorithm’s often-mentioned promise of being able to sample from the uniform or any target distribution. Mathematically, the choice *compactness* = 0 corresponds to the uniform distribution. The choice *compactness* = 1 corresponds to the mathematically complicated “spanning tree distribution” when the county-preservation switch is turned off, and it corresponds to even more complicated “hierarchical spanning tree distribution” when this switch is turned on.

46. To illustrate the implication of the single-digit effective samples sizes reported in Table 1, note that the previously mentioned Amy-Bob scenario describes essentially what one would expect if the effective sample size were to equal 2 in stage 50. As another illustration, Table 1 reports an effective sample size of only 6 in the 12th stage of generating the Congressional ensemble. This means the algorithm acted roughly as if only six different people were asked to draw the first 12 districts, and all of the final maps were guaranteed to have their first 12 districts drawn in one of these six ways. Moreover, this redundancy is compounded in the other stages. The small effective sample sizes in the stages prior to the 12th means that it is as if these six people were severely constrained in how they could draw the first 11 of their 12 districts. The small effective sample sizes in all of the stages after the 12th means that the redundancy is further compounded as the remaining districts are constructed.

47. I next tried setting the compactness equal to 1. This setting avoided the algorithm's built-in warning lights, but I nevertheless found a massive amount of redundancy when I carefully studied the ensemble. More precisely, I measured the extent to which the 5,000 maps in this ensemble differed from each other. Imagine taking a pair of scissors to each of the 5,000 maps in this ensemble, cutting apart its 63 districts, and throwing all of the districts from all of the maps together into a pile. This pile would contain $5000 \times 63 = 315,000$ districts. If the ensemble maps were all completely different from each other, then one would expect the 315,000 districts in this pile to mostly all be different from each other. Instead, the 315,000 districts in this pile ended up all being copies of just 12,319 distinct districts. Moreover, the repetition level was quite extreme. For example, there were 31 districts that each occurred exactly 3,219 times. In other words, *more than half of the maps had almost half of their districts exactly identical*. Furthermore, if you were to randomly grab one of the 315,000 districts from

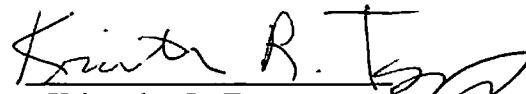
this pile, you would expect there to be 1,360 copies of that district in the pile on average. This is a head-turning level of redundancy, even though the ensemble was built with the compactness=1, which is the setting that best avoids redundancy.

48. Even if Mr. Trende used the compactness setting of 1 (which is the setting that best avoids redundancy), his Senate ensemble would be expected to have about the same level of redundancy as my replication that used this same compactness setting, which is enough to render it statistically meaningless.⁵ This would mean that, from his ensemble of 5,000 maps, it is possible to separate out a subcollection of 3,219 of them that all have in common how their first 31 districts were drawn. This locked-in decision about how the first 31 districts were drawn (in over half of the maps of his ensemble) might by pure chance be extremely Democrat-favoring or extremely Republican-favoring. It might by pure chance favor competitiveness or favor anticompetitiveness. These wildly variable chance effects in what should have been just a single version of how the first 31 districts are drawn would get amplified by the redundancy and would therefore have a greatly outsized effect on all of the partisan statistics he computed using the ensemble. In other words, if Mr. Trende's ensemble has anywhere near the redundancy that my replication has, then all of the partisan conclusions he drew could be caused by a single wildly variable chance effect. Again, as I describe above, there are clear indications in Mr. Trende's results, such as the bimodal nature of his Senate Polsby-Popper chart on page 22 of his first report, that strongly suggest this is the case.

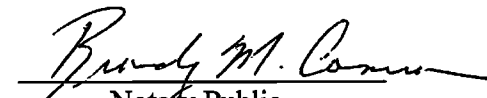
⁵ Mr. Trende's Congressional ensemble may well have a similarly high level of redundancy even if it used a compactness setting of 1. I have not yet been able to conduct a replication of Mr. Trende's Congressional ensemble with a compactness setting of 1, or to examine the level of redundancy in the resulting districts, simply due to the litigation schedule not providing sufficient time to do so.

49. In conclusion, my replication experiment demonstrated that Mr. Trende's Senate ensemble is very likely to be infected with a level of redundancy that renders them statistically useless, and that his Congressional ensemble may well suffer from the same deficiency. To repeat, even with the compactness dialed to the setting that best avoids redundancy in my replication, more than half of the maps had almost half of their districts in common. No valid conclusions can be drawn from a broken ensemble. For a state as large as New York, using the settings that Mr. Trende seems to have used, I feel strongly that 5,000 or even 10,000 is not necessarily enough to yield an ensemble in which one can have any confidence, at least not without performing careful validations to make sure that there is enough diversity in the ensemble. Mr. Trende has not described performing any such validations for his ensembles, and I can state with certainty that they are not representative samples of maps that could be drawn without partisan considerations.

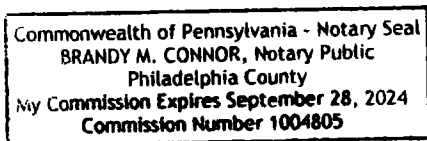
Dated: March 10, 2022


Kristopher R. Tapp

Sworn and Subscribed before me this 10th
day of March, 2022


Notary Public

My Commission Expires: *September 28, 2024*



CERTIFICATE OF CONFORMITY PURSUANT TO N.Y. C.P.L.R. § 2309(c)

I, Randy C. Greene, do hereby certify and attest that I am an attorney duly admitted to practice law in the Commonwealth of Pennsylvania

I make this certification for the purposes of compliance with New York State Civil Practice Law & Rules Section 2309(c) with regard to the foregoing Affidavit of Kristopher R. Tapp, to be filed in Supreme Court in Steuben County, State of New York.

Said Affidavit, acknowledged and sworn by Mr. Tapp before a Notary Public in and for the Commonwealth of Pennsylvania, and said Affidavit being therein sworn in the Commonwealth of Pennsylvania, is and appears to be, based upon my review of said document and notarization thereof, in conformity with the laws of the Commonwealth of Pennsylvania for the making of an affidavit and the notarization thereof.

Sworn and Subscribed before me this 10th day of March, 2022

Brandy M. Connor
Notary Public

My Commission Expires: *September 28, 2024*

Commonwealth of Pennsylvania - Notary Seal
BRANDY M. CONNOR, Notary Public
Philadelphia County
My Commission Expires September 28, 2024
Commission Number 1004805