EXPERT REPORT OF JOWEI CHEN, Ph.D.

I am an Associate Professor in the Department of Political Science at the University of Michigan, Ann Arbor. I am also a Faculty Associate at the Center for Political Studies of the Institute for Social Research at the University of Michigan as well as a Research Associate at the Spatial Social Science Laboratory at Stanford University. In 2007, I received a M.S. in Statistics from Stanford University, and in 2009, I received a Ph.D. in political science from Stanford University. I have published academic papers on political geography and districting in top political science journals, including *The American Journal of Political Science* and *The American Political Science Review*, and *Election Law Journal*. My academic areas of expertise include spatial statistics, redistricting, gerrymandering, the Voting Rights Act, legislatures, elections, and political geography. I have unique expertise in the use of computer algorithms and geographic information systems (GIS) to study questions related to political and economic geography and redistricting. I attach my current CV as an exhibit to this report.

I have provided expert reports in the following redistricting court cases: Missouri National Association for the Advancement of Colored People v. Ferguson-Florissant School District and St. Louis County Board of Election Commissioners (E.D. Mo. 2014); Rene Romo et al. v. Ken Detzner et al. (Fla. 2d Judicial Cir. Leon Cnty. 2013); The League of Women Voters of Florida et al. v. Ken Detzner et al. (Fla. 2d Judicial Cir. Leon Cnty. 2012); Raleigh Wake Citizens Association et al. v. Wake County Board of Elections (E.D.N.C. 2015); Corrine Brown et al. v. Ken Detzner et al. (N.D. Fla. 2015); City of Greensboro et al. v. Guilford County Board of Elections, (M.D.N.C. 2015); Common Cause et al. v. Robert A. Rucho et al. (M.D.N.C. 2016). I have testified at trial in the following cases: Raleigh Wake Citizens Association et al. v. Wake County Board of Elections (E.D.N.C. 2015); City of Greensboro et al. v. Guilford County Board of Elections (M.D.N.C. 2015); Common Cause et al. v. Robert A. Rucho et al. (M.D.N.C. 2016). I am being compensated $500 per hour for my work in this case.

Research Question and Summary of Findings

The attorneys for the Petitioners in this case have asked me to analyze Pennsylvania's current congressional districting plan, as created by Act 131 of 2011 (Senate Bill 1249). Specifically, I was asked to analyze:

1) Whether partisan intent was the predominant factor in the drawing of the 2011 enacted Act 131 districting plan;
2) The effect of the enacted plan on the number of congressional Democrats and Republicans elected from Pennsylvania; and
3) The effect of the enacted plan on the ability of the individual Petitioners to elect a Democratic or Republican congressional candidate from their respective districts.

In conducting my academic research on legislative districting, partisan and racial gerrymandering, and electoral bias, I have developed various computer simulation programming techniques that allow me to produce a large number of non-partisan districting plans that adhere to traditional districting criteria using US Census geographies as building blocks. This simulation process is non-partisan in the sense that the computer ignores all partisan and racial considerations when drawing districts. Instead, the computer simulations are programmed to optimize districts with respect to various traditional districting goals, such as equalizing population, maximizing geographic compactness, and preserving county and municipal boundaries. By generating a large number of drawn districting plans that closely follow and optimize on these traditional districting criteria, I am able to assess an enacted plan drawn by a state legislature and determine whether partisan goals motivated the legislature to deviate from these traditional districting criteria.

More specifically, by holding constant the application of non-partisan, traditional districting criteria through the simulations, I am able to determine whether the enacted plan could have been the product of something other than the intentional pursuit of partisan advantage. I determined that it could not.

I use this simulation approach to analyze the Pennsylvania General Assembly's enacted Act 131 congressional districting plan in several ways. First, I conduct 500 independent simulations, instructing the computer to generate valid congressional districting plans that strictly follow non-partisan, traditional districting criteria as applied to Pennsylvania (i.e., equalizing population, maximizing geographic compactness, and preserving county and municipal boundaries). I then measure the extent to which the enacted Act 131 plan deviates from these simulated plans with respect to these traditional districting criteria. The simulation results demonstrate that the enacted Act 131 plan divided far more counties than was reasonably necessary. The enacted plan's districts were also significantly more geographically non-compact

than necessary. By any common measure of compactness, the Act 131 plan was significantly less compact than every single one of the 500 simulated districting plans.

By deviating very significantly from these traditional districting criteria of geographic compactness and preserving county boundaries, the Act 131 plan also managed to create a total of 13 Republican districts out of 18 total districts. By contrast, the simulation results demonstrate that a map-drawing process respecting non-partisan, traditional districting criteria generally creates 7 to 10 Republican districts. None of the 500 simulated districting plans create 13 Republican districts, as exists under the enacted Act 131 plan. Thus, the enacted plan represents an extreme statistical outlier, creating a level of partisan bias never observed in a single one of the 500 computer simulated plans. The enacted plan thus creates several more Republican seats than what is generally achievable under a map-drawing process respecting non-partisan, traditional districting criteria. The simulation results thus warrant the conclusion that partisan considerations predominated over other non-partisan criteria, particularly minimizing county splits and maximizing compactness, in the drawing of the General Assembly's enacted Act 131 plan.

Having found that partisan considerations predominated over the General Assembly's drawing of its enacted plan, I then consider two possible alternative explanations for the extreme partisan bias in the enacted plan. First, I evaluate whether an attempt to protect incumbent members of Pennsylvania's Congressional delegation might explain the enacted plan's partisan bias in the enacted plan. Second, I also analyze whether possible racial goals in the General Assembly's drawing of the Act 131 plan might have explained the statistically extreme partisan composition of the districting plan.

Protection of Incumbents: I found that the enacted Act 131 plan protects 17 of the 19 incumbent members of Pennsylvania's Congressional delegation as of the November 2012 election by avoiding the pairing of two or more incumbents into the same district. Only Jason Altmire and Mark Critz, the incumbents from the 4th District and the 12th District of the previous decade's Congressional plan, were paired together in a single district by the Act 131 plan. Although the protection of incumbents is not a traditional districting principle, I nevertheless analyzed whether the General Assembly's efforts to protect 17 of 19 incumbents might somehow alter the partisan composition of valid districting plans and explain the enacted plan's 13-5 Republican advantage.

I therefore conducted a second set of 500 simulations in which I instructed the computer to produce valid districting plans that intentionally avoid pairing 17 incumbents while otherwise adhering strictly to traditional districting criteria (equalizing population, maximizing geographic compactness, and preserving county and municipal boundaries). This second set of simulation results demonstrates that an effort to avoid pairing 17 congressional incumbents does not explain the extreme 13-5 Republican bias of the enacted plan. Among the 500 simulated plans that avoid pairing 17 of Pennsylvania's Congressional House incumbents, not a single simulated plans creates 13 Republican-leaning districts; instead, most of these simulated plans contain either 9 or 10 Republican districts. These simulation results clearly reject any notion that an effort to avoid pairing incumbents can explain the extreme partisan bias observed in the General Assembly's enacted plan.

Racial Composition: The 2nd Congressional District (Philadelphia) of the Act 131 plan has an African-American voting-age population (VAP) of 56.8%, and it is the only district that contains an African-American majority.[1] I thus analyzed whether a hypothetical districting goal of creating a district with at least a 56.8% African-American VAP might have caused the extreme 13-5 Republican advantage in the enacted plan. Among both sets of 500 simulated districting plans, I thus analyzed the subset of these simulated plans that achieved at least the same level of African-American VAP in a Philadelphia-area district. Among this subset of plans that create a 56.8% African-American VAP district, not a single simulated plan creates remotely close to 13 Republican districts; instead, most of these simulated plans contain either 8 or 9 Republican districts. Therefore, these simulation results exclude the notion that an intentional effort to create a certain level of African-American population in one district might explain the extreme partisan bias observed in the General Assembly's enacted plan.

This report proceeds as follows. First, I explain the logic of using computer-generated districting simulations to evaluate the partisan bias of a districting plan. I then present two different sets of computer simulations of valid districting plans, as described above. Next, I explain how the results of these districting simulations demonstrate that partisan concerns predominated significantly over other factors in the drawing of the General Assembly's enacted map.

[1] Appendix A and B provide calculations, based on US Census data, regarding the racial and ethnic composition of each congressional district under the current decade's enacted plan (Act 131 of 2011) and the previous decade's enacted plan (Act 34 of 2002).

The Logic of Redistricting Simulations

Once a districting plan has been drawn, academics and judges face a challenge in assessing the intent of the map-drawers, especially regarding partisan motivations. The central problem is that the mere presence of partisan bias may tell us very little about the intentions of those drawing the districts. Whenever political representation is based on winner-take-all districts, asymmetries between votes and seats can emerge merely because one party's supporters are more clustered in space than those of the other party. When this happens, the party with a more concentrated support base achieves a smaller seat share because it racks up large numbers of "surplus" votes in the districts it wins, while falling just short of the winning threshold in many of the districts it loses. This phenomenon, which I have described in my academic work,[2] can happen quite naturally in cities due to such factors as racial segregation, housing and labor markets, transportation infrastructure, and residential sorting by income and lifestyle.

Tallying votes in statewide races such as those for U.S. President, U.S. Senator, or Governor over the previous ten years shows that Pennsylvania's statewide electorate contains slightly more Democratic than Republican voters. Yet Republicans currently hold a very significant 13-5 advantage over Democrats in control over Pennsylvania's U.S. congressional seats.

The crucial question is whether the distribution of partisan outcomes created by the General Assembly's enacted districting plan could have plausibly emerged from a non-partisan districting process and thus could be explained by non-partisan factors, such as any clustering of Democratic voters in large cities. To assess this question, it is necessary to compare the General Assembly's enacted districting plan against a standard that is based on a non-partisan districting process and follows traditional redistricting criteria.

The computer simulations I conducted for this report have been created expressly for the purpose of developing such a standard. Conducting computer simulations of the districting process is the most statistically accurate strategy for generating a baseline against which to compare an enacted districting plan, such as the Act 131 plan. The computer simulation process

[2] Jowei Chen and Jonathan Rodden, 2013. "Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures" *Quarterly Journal of Political Science*, 8(3): 239-269; Jowei Chen and David Cottrell, 2016. "Evaluating Partisan Gains from Congressional Gerrymandering: Using Computer Simulations to Estimate the Effect of Gerrymandering in the U.S. House." *Electoral Studies*, Vol. 44, No. 4: 329-430.

leaves aside any data about partisanship or demographic characteristics other than population counts, and the computer algorithm generates complete and legally compliant districting plans based purely on traditional districting criteria. The districting simulation process uses precisely the same Census geographies and population data that the General Assembly used in creating congressional districts. In this way, the districting plans that emerge from this computer simulation analysis are based on, and thus account for, the very same population patterns and political boundaries across Pennsylvania that the General Assembly faced when drawing its Act 131 enacted plan. If the population patterns of Pennsylvania voters naturally favor one party over the other, the simulated plans would capture that inherent bias.

The computer algorithm described above allows for the generation of hundreds of simulated plans. Each plan combines Pennsylvania's census blocks together in a different way, but always in compliance with the non-partisan traditional districting criteria that the computer has been programmed to follow. The simulations thus produce a large distribution of non-partisan districting plans that comport with traditional districting criteria.

To measure partisan performance under each of these computer-simulated plans, I used actual election results from the past ten years. I obtained publicly-available election results at the voting precinct level for statewide elections held in Pennsylvania during the past ten years. I then overlaid these precinct-level results onto the simulated districts, and I calculated the number of districts that would have been won by Democrats and Republicans under each districting plan in order to measure the partisan performance of the districting plan. In other words, I look at the precincts that would comprise a particular district in a given simulation, and calculate whether that simulated district would be won by Democrats or Republicans based on actual election results from those precincts. I calculated this result for each of the 18 districts under a given simulation to measure the total seats Democrats or Republicans would win under that particular simulated districting map.

I also performed the same calculations for the enacted Act 131 plan drawn by the General Assembly. As a statistical matter, if the Act 131 plan had been drawn without partisanship as its predominant consideration, the enacted plan's partisan breakdown of seats will fall somewhere roughly within the normal range of the distribution of simulated, non-partisan plans. If the plan produced by the legislature is far in the tail of the distribution, or lies outside the distribution altogether—meaning that it favors one party more than the vast majority or all of the simulated

plans—then such a finding is a strong indication that the enacted plan was drawn with an overriding partisan intent to favor that political party, rather than to follow non-partisan, traditional districting criteria.

By randomly drawing districting plans with a process designed to optimize on traditional districting criteria, the computer simulation process thus gives us a precise indication of the range of districting plans that plausibly and likely emerge when map-drawers are not motivated primarily by partisan goals. By comparing the enacted plans against the range of simulated plans with respect to partisan measurements, I am able to determine the extent to which a map-drawer's deviations from traditional districting criteria, such as geographic compactness and county splits, was motivated by partisan goals.

These computer simulation methods are widely used by academic scholars to analyze districting maps. For over a decade, political scientists have used such computer-simulated districting techniques to make inferences about the racial and partisan intent of legislative map-drawers.[3] In recent years, a number of courts have also relied upon computer simulations to assess partisan bias in enacted districting plans.[4]

Traditional Districting Principles in Pennsylvania Congressional Districting

In programming the computer simulation algorithm to produce valid congressional plans for Pennsylvania, I drew upon my expertise as a political scientist who has studied and published on state legislative and congressional redistricting across the 50 US states. In general, the primary traditional districting criteria in the drawing of congressional districting maps are population equality, geographic compactness and contiguity, and the preservation of county and municipal boundaries. I have been informed by Petitioners' counsel that the Pennsylvania Supreme Court has recognized these same traditional districting principles in the context of congressional districting, and that these principles are also embodied in Article II, Section 16 of the Pennsylvania Constitution, which enumerates criteria to be followed in state legislative districting plans. This listing of districting criteria in the Pennsylvania Constitution aligns

[3] E.g., Carmen Cirincione, Thomas A. Darling, Timothy G. O'Rourke. "Assessing South Carolina's 1990s Congressional Districting," Political Geography 19 (2000) 189–211; Jowei Chen, "The Impact of Political Geography on Wisconsin Redistricting: An Analysis of Wisconsin's Act 43 Assembly Districting Plan." Election Law Journal

[4] *See Raleigh Wake Citizens Association v. Wake County Board of Elections*, 827 F.3d 333, 344-45 (4th Cir. 2016); *City of Greensboro v. Guilford County Board of Elections*, No. 1:15-CV-599, 2017 WL 1229736 (M.D.N.C. Apr 3, 2017).

perfectly with and confirms my expert understanding of traditional districting criteria as commonly practiced in congressional districting across the US states.

Below, I describe these traditional districting criteria in detail and explain how each criterion is implemented by the computer algorithm in producing simulated plans for Pennsylvania's congressional districts:

1) *Population Equality:* Pennsylvania's 2010 Census population was 12,702,379, so districts in the 18-district congressional plan have an ideal population of 705,687.7. Specifically, then, the computer simulation algorithm is designed to populate each districting plan such that precisely five districts have a population of 705,687, while the remaining thirteen districts have a population of exactly 705,688.

2) *Contiguity*: The computer simulations require districts to be geographically contiguous, with point contiguity prohibited, as is common in many states.

3) *Avoiding County Splits:* A traditional districting principle in the drawing of congressional plans is the avoidance of county splits, except only when necessary to equalize district populations. In fact, Article II, Section 16 of the Pennsylvania Constitution specifically mandates this districting principle in the drawing of state legislative plans: "Unless absolutely necessary no county…shall be divided in forming either a senatorial or representative district."

The computer simulation algorithm thus attempts to avoid splitting any of Pennsylvania's 67 counties, except when doing so is necessary to avoid creating an unequally populated district. In practice, the non-partisan simulation process is able to always create valid districting plans by splitting only 11 to 16 counties, in contrast to the 28 counties split by the enacted Act 131 plan.

4) ***Avoiding Municipality Splits***: A traditional districting principle in the drawing of congressional plans is the avoidance of splitting municipality boundaries, except when inevitable or necessary to avoid violating one of the aforementioned criteria. The avoiding of municipality is splits is also explicitly mandated for state house and senate districts by the Article II, Section 16 of the Pennsylvania Constitution, which mandates that no "city, incorporated town, borough, township or ward" may be split into multiple districts, except when "absolutely necessary." Pennsylvania is divided into 2,562 cities, towns, boroughs, and townships, which I refer to as "municipalities" throughout this report. The computer simulation algorithm attempts to keep these municipalities intact and not split them into multiple districts, except when doing so is necessary for creating equally-populated and contiguous districts or to avoid additional county

splits. The enacted Act 131 plan splits 68 municipalities in Pennsylvania. As described later in this report, all 1,000 of the computer simulated maps produced in this report split fewer municipalities than the Act 131 plan.

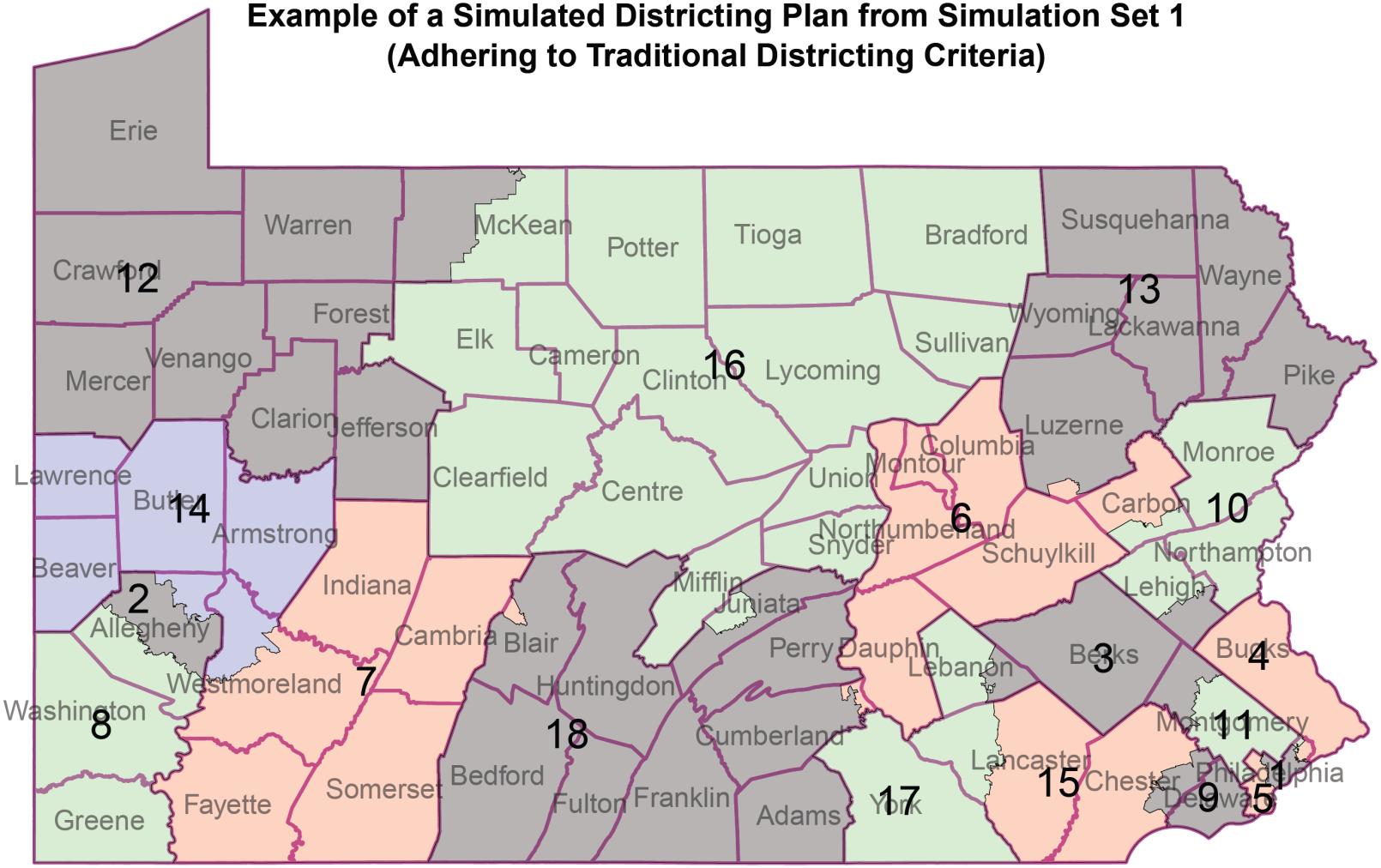
5) ***Geographic Compactness***: The drawing of geographically compact districts is a traditional criterion in congressional districting. The computer simulation algorithm thus prioritizes the drawing of geographically compact districts whenever doing so does not violate any of the aforementioned criteria. After completing the computer simulations, I then compare the compactness of the simulated plans and the enacted plans using two different, widely used measures of compactness:

First, I calculate the average "Reock score" of the districts within each plan. The Reock score for each individual district is calculated as the ratio of the district's area to the area of the smallest bounding circle that can be drawn to completely contain the district. The General Assembly's enacted Act 131 districting plan has an average Reock score of 0.2776 across its 18 districts. As described later, the computer simulation process is able to always generate plans that are significantly more compact than the enacted Act 131 plan, as measured by average Reock score.

Second, I calculate the average "Popper-Polsby score" of each plan's districts. The Popper-Polsby score for each individual district is calculated as the ratio of the district's area to the area of a hypothetical circle whose circumference is identical to the length of the district's perimeter. The General Assembly's Act 131 districting plan has an average Popper-Polsby score of 0.1637 across its 18 districts. As described later, the computer simulation process is able to always generate plans that are significantly more compact than the enacted Act 131 plan, as measured by average Popper-Polsby score.

Figure 1 illustrates an example of one of the simulated districting plans produced by this computer algorithm. The simulated map in Figure 1A was produced within the second set of simulations, in which the computer intentionally avoided pairing 17 incumbents while otherwise strictly following non-partisan traditional districting criteria. Thus, it was able to split fewer counties and produce significantly more geographically compact districts than the enacted Act 131 plan.

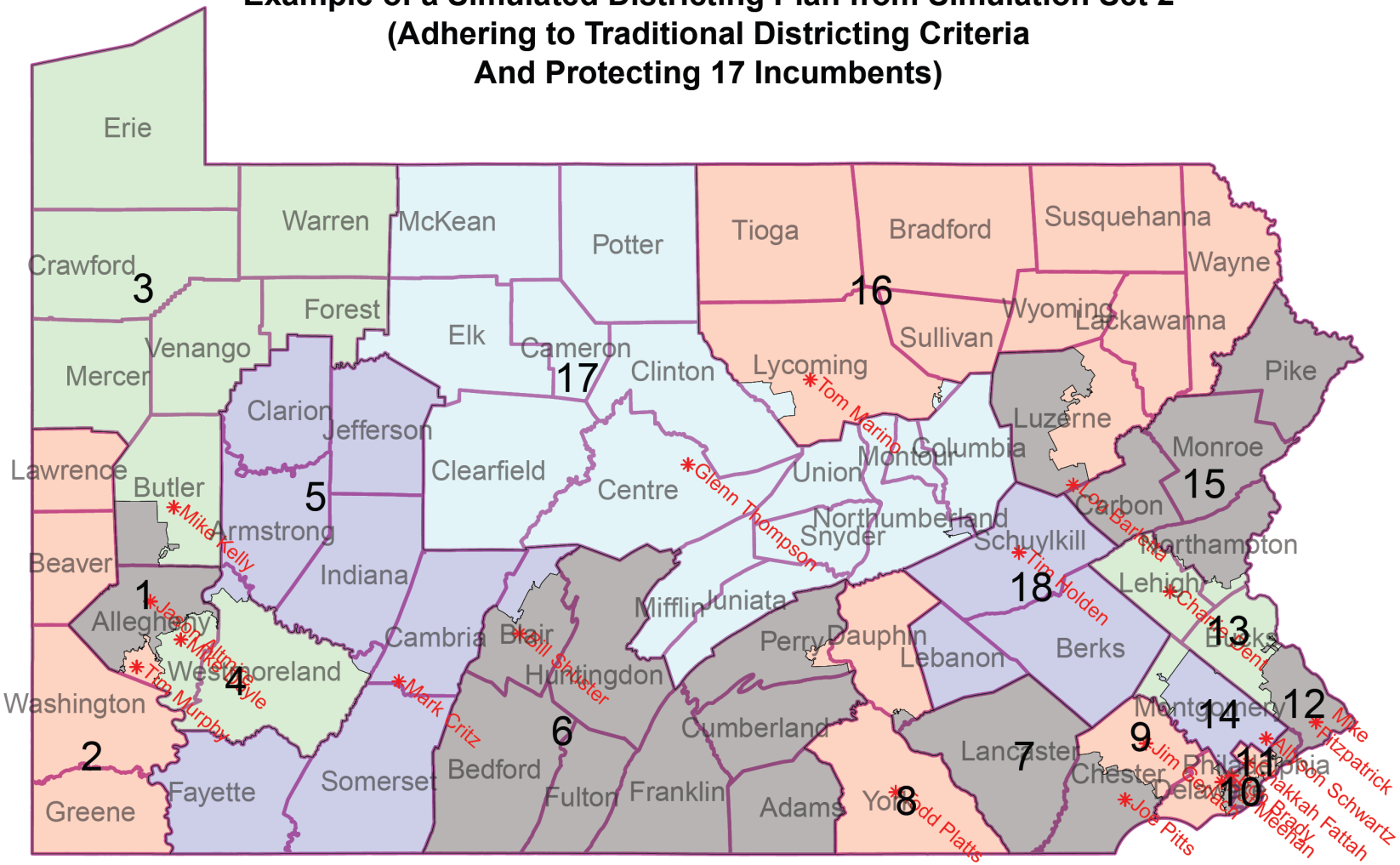
Figure 1:



	Simulated Map:	Enacted Map:
Expected Republican Seats:	9	13
Counties Split:	14	28
Average Reock Compactness Score:	0.442	0.278
Average Popper-Polsby Compactness Score:	0.310	0.164

Figure 1A:

Example of a Simulated Districting Plan from Simulation Set 2
(Adhering to Traditional Districting Criteria
And Protecting 17 Incumbents)



	Simulated Map:	Enacted Map:
Expected Republican Seats:	9	13
Counties Split:	15	28
Average Reock Compactness Score:	0.396	0.278
Average Popper-Polsby Compactness Score:	0.273	0.164
Incumbents Paired:	Jim Gerlach & Pat Meehan	Jason Altmire & Mark Critz

Measuring the Partisanship of Districting Plans

I use actual election results from recent, statewide election races in Pennsylvania to assess the partisan performance of the simulated and enacted districting plans in this report. Overlaying these past election results onto a districting plan enables me to calculate the number of Republican and Democratic-leaning districts within each simulated plan and within the enacted Act 131 plan. These calculations thus allow me to directly compare the partisanship of the enacted plan and the simulated plans. These partisan comparisons allow me to determine whether or not the partisan distribution of seats in the enacted plan could reasonably have arisen from a districting process respecting the non-partisan traditional districting criteria.

Past voting history in federal and statewide elections is a strong predictor of future voting history. Mapmakers thus can and do use past voting history to identify the class of voters, at a precinct-by-precinct level, who are likely to vote for Democratic (or Republican) candidates for Congress. Indeed, that is the entire reason why mapmakers are able to gerrymander maps so effectively to produce political outcomes. To analyze the strength of federal and statewide elections as a predictor of future voting in Pennsylvania, I examined the correlation between different past Pennsylvania federal and statewide elections. I found that the correlation between different elections in Pennsylvania is extremely strong.

In general, the most reliable method of comparing the partisanship of different legislative districts within a state is to consider whether the districts—and more specifically, the precincts that comprise each district—have tended to favor Republican or Democratic candidates in recent, competitive *statewide* elections, such as the Presidential, Gubernatorial, and US Senate elections. Recent statewide elections provide the most reliable bases for comparisons of different precincts' partisan tendencies because in any statewide election, because the anomalous candidate-specific effects that shape the election outcome are equally present in all precincts across the state. Statewide elections are thus a better basis for comparison than the results of legislative elections (such as U.S. House elections) because the particular outcome of any legislative election may deviate from the long-term partisan voting trends of that precinct, due to factors idiosyncratic to the legislative district as currently constructed. Such factors can include the presence or absence of a quality challenger, anomalous difference between the candidates in campaign efforts or

campaign finances, incumbency advantage, candidate scandals, and coattail effects.[5] Because these idiosyncratic factors would change if the legislative district were drawn differently, it is particularly unsuitable to use election results from legislative district when comparing the partisanship of an existing district to a simulated district that would have different boundaries.

Indeed, based on my experience studying redistricting practices in multiple states, it is common for legislative map-drawers to assess the partisanship of a districting plan using the election results of past statewide races, rather than legislative district races. For example, map-drawers did this in North Carolina and Wisconsin. Map-drawers recognize that legislative district election results are highly sensitive to the district-specific factors listed above, while the results of statewide races are directly comparable across different districts within the state.

Moreover, statewide elections are also a more reliable indicator of a district's partisanship than partisan voter registration counts. Voter registration by party is a uniquely unreliable method of comparing districts' partisan tendencies because many voters who consistently support candidates from one party nevertheless do not officially register with either major party, while others vote for candidates of one party while registering with a different party.[6] This is especially true among Republicans in Pennsylvania, where the statewide Republican share of registered voters has been significantly lower than the share of voters who have actually voted for Republican candidates in recent legislative and statewide elections. As a result, based on my expertise and my experience studying redistricting practices in multiple states, legislative map-drawers generally do not rely heavily on voter registration data in assessing the partisan performance of districts.

In analyzing the partisanship of districts in both the enacted Act 131 plan and the 1,000 simulated plans, I therefore use the results of all six statewide elections held in Pennsylvania from 2008 to 2010. These include the Presidential, Attorney General, Auditor General, and State Treasurer elections in 2008 and the US Senator and Gubernatorial elections in 2010. I use the results of these elections because: 1) These were the most recent elections held just before the 2011 redistricting process; 2) All eight of these elections were reasonably closely contested; and

[5] E.g., Alan Abramowitz, Brad Alexander, and Matthew Gunning. "Incumbency, Redistricting, and the Decline of Competition in U.S. House Elections." *The Journal of Politics.* Vol. 68, No. 1 (February 2006): 75-88.

[6] Kenneth J. Meier, "Party Identification and Vote Choice: The Causal Relationship" Vol. 28, No. 3 (Sep., 1975): 496-505.

3) The precinct-level vote counts from these elections were available to the state legislature during its drawing of the 2011 Congressional districting plan.[7]

To measure the partisanship of each district in the enacted plan and each computer simulated plan, I first obtained files reporting precinct-level election results for all statewide elections since 2008 from the Pennsylvania Department of State's Bureau of Elections. I then merged these election results files with shapefile maps of Pennsylvania's voting precincts and Census blocks. I then overlaid these precinct-level and block-level election vote counts onto the district boundaries in each plan, thereby allowing me to calculate the vote totals across these statewide elections within every district in the enacted plan and each of my computer-simulated plans. These calculations allow me to determine whether each district in each simulated plan (and the enacted plan) favors Republican or Democratic candidates.

I find that, using the results of these eight statewide elections, total Republican voters outnumbered total Democratic voters in 13 of 18 districts in the enacted Act 131 plan. These 13 Republican districts correspond with the same 13 districts that have consistently elected a Republican Congressional Representative during the 2012, 2014, and 2016 general elections. I apply the same formula for evaluating all of the simulated plans, thus allowing for a direct comparison of the partisanship of the enacted and the simulated districting plans.

Simulation Set 1:
Following Traditional Districting Criteria with No Incumbent Protection

I conducted a first set of 500 computer simulations in which plans were drawn to optimize on the five non-partisan, traditional districting criteria described previously: population equality, contiguity, avoiding county splits, avoiding municipal splits, and geographic compactness. Table 1 details how the simulated plans in this first simulation set and my second simulation set perform with respect to these various districting criteria. (Simulation Set 2 is discussed in further detail below).

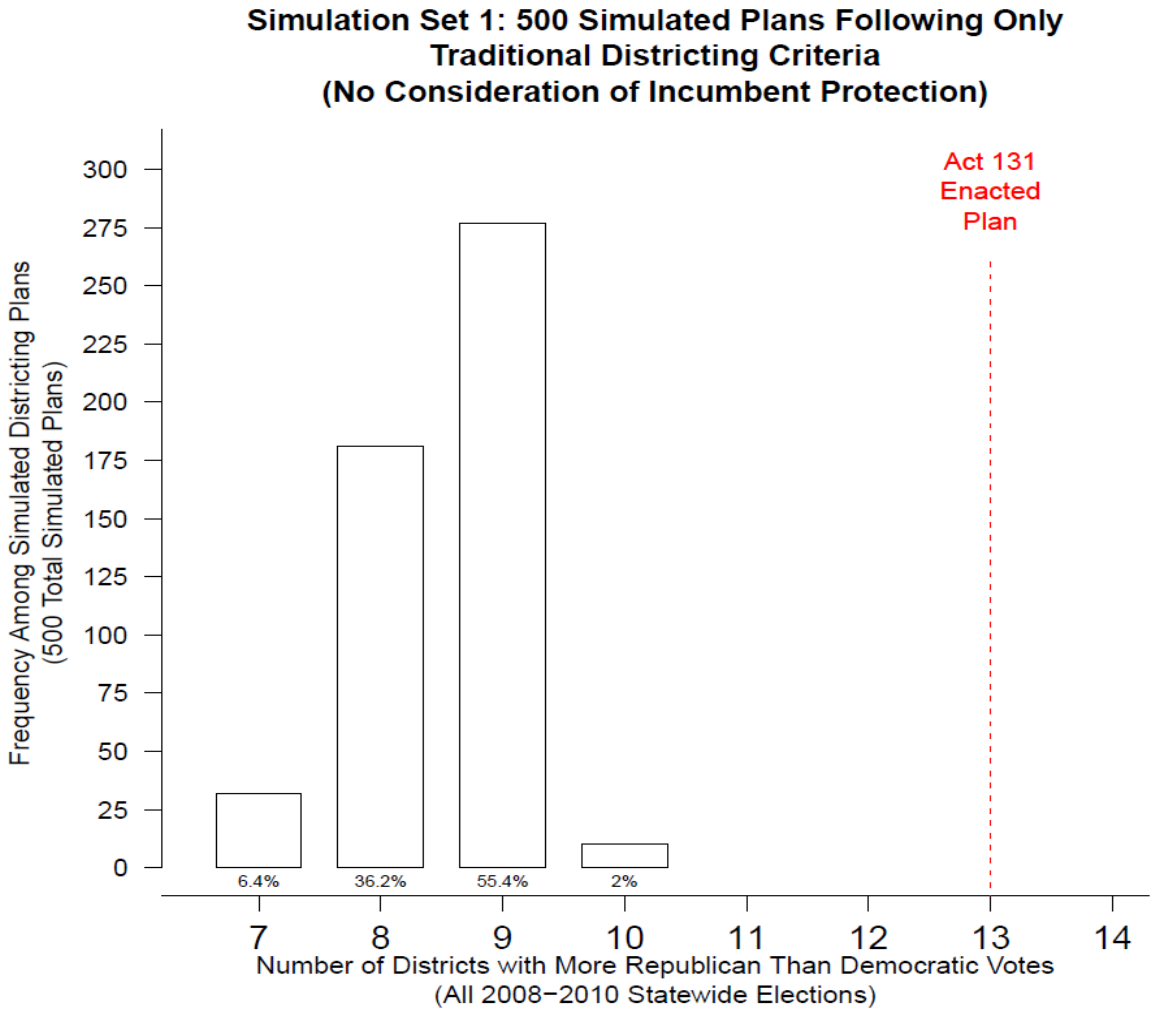
[7] As a robustness measure, in Appendix C, I analyze the simulated maps using data from statewide elections from 2012 to 2016. My results using 2012-2016 elections data are consistent with the results using 2008-2010 data.

Table 1: Summary of Two Sets of Simulated Districting Plans and Enacted Act 131 Plan

	Act 131 Plan (Senate Bill 1249):	**Simulation Set 1:**	**Simulation Set 2:**
Description:	General Assembly's Enacted Plan	Simulated maps only follow traditional districting criteria	Simulated maps protect 17 incumbents and otherwise follow traditional districting criteria
Total Number of Simulated Plans:		500 simulated maps	500 simulated maps
Number of Split Counties:	28	11 to 16	12 to 19
Number of Split Municipalities:	68	40 to 58	50 to 66
Incumbents Protected:	17	3 to 13	17
Average Reock Score (Compactness):	0.278	0.358 to 0.470	0.328 to 0.426
Average Popper-Polsby Score (Compactness):	0.164	0.286 to 0.342	0.192 to 0.291
Republican Districts (using 2008-2010 statewide elections):	13	7 (32 simulations) 8 (181 simulations) 9 (277 simulations) 10 (10 simulations)	7 (2 simulation) 8 (46 simulations) 9 (153 simulations) 10 (206 simulations) 11 (88 simulations) 12 (5 simulations)

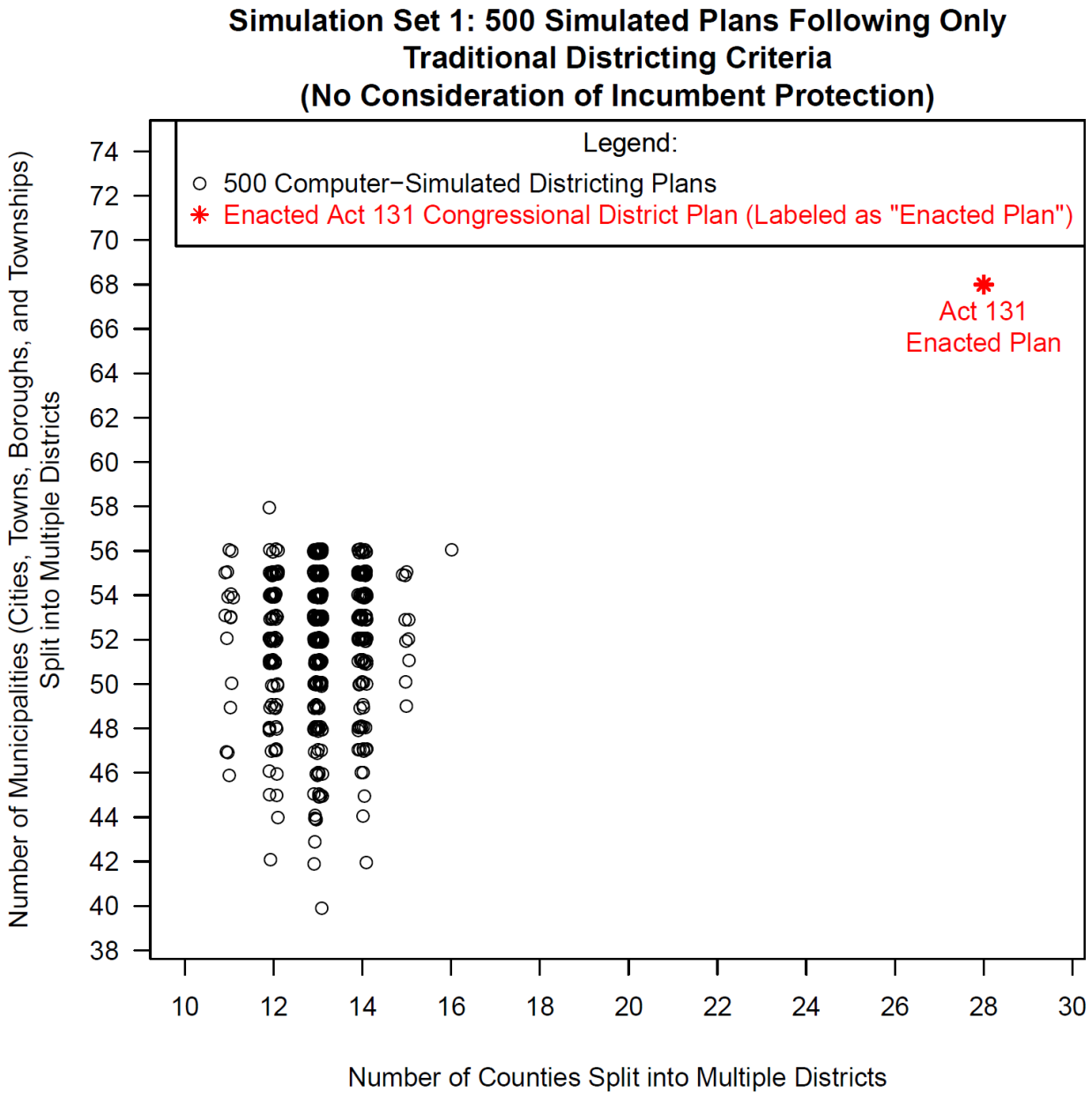
Figure 2 compares the partisan breakdown of the simulated plans to the partisanship of the enacted Act 131 plan. Specifically, Figure 2 uses the pre-redistricting (2008-2010) statewide elections to measure the number of Republican-leaning districts created by the 500 simulated plans. As measured by these election results, the simulated plans all create from 7 to 10 Republican districts out of 18 total districts. Moreover, the vast majority of simulations create 8 or 9 Republican districts; even 10 Republican districts are created in only 2% of the simulations. The 500 simulations never produce a plan that results in 11 or 12 Republican seats, let alone the 13 Republican seats of the enacted Act 131 plan. I thus conclude with overwhelmingly high statistical certainty that the enacted plan created a pro-Republican partisan outcome that would never have been possible under a districting process adhering to non-partisan traditional criteria.

Figure 2:



Did the enacted Act 131 plan represent a reasonable effort to follow non-partisan traditional districting criteria? Once again, the computer simulations are illuminating because they offer insight into the type and range of plans that would have emerged had reasonable efforts been made to adhere to traditional districting criteria. First, as illustrated along the horizontal axis in Figure 3, each of the 500 simulated plans in Simulation Set 1 splits from 11 to 16 counties; hence, it is clear that drawing a valid plan with only 16 or fewer counties split can be easily accomplished without difficulty and without sacrificing other non-partisan districting criteria, such as equal population. By contrast, the enacted Act 131 plan splits 28 counties, thus falling far outside of the 11 to 16 county splits that the computer simulations found to be reasonably necessary in all 500 of the simulated plans. This analysis allows us to conclude, with over 99.9% statistical certainty, that the enacted plan's splitting of 28 counties was an outcome that could not plausibly have emerged from a districting process that prioritizes traditional districting criteria, rather than partisan intent. Hence, it is clear that the Act 131 plan failed to follow the traditional districting criterion of avoiding the unnecessary splitting of counties.

Figure 3:

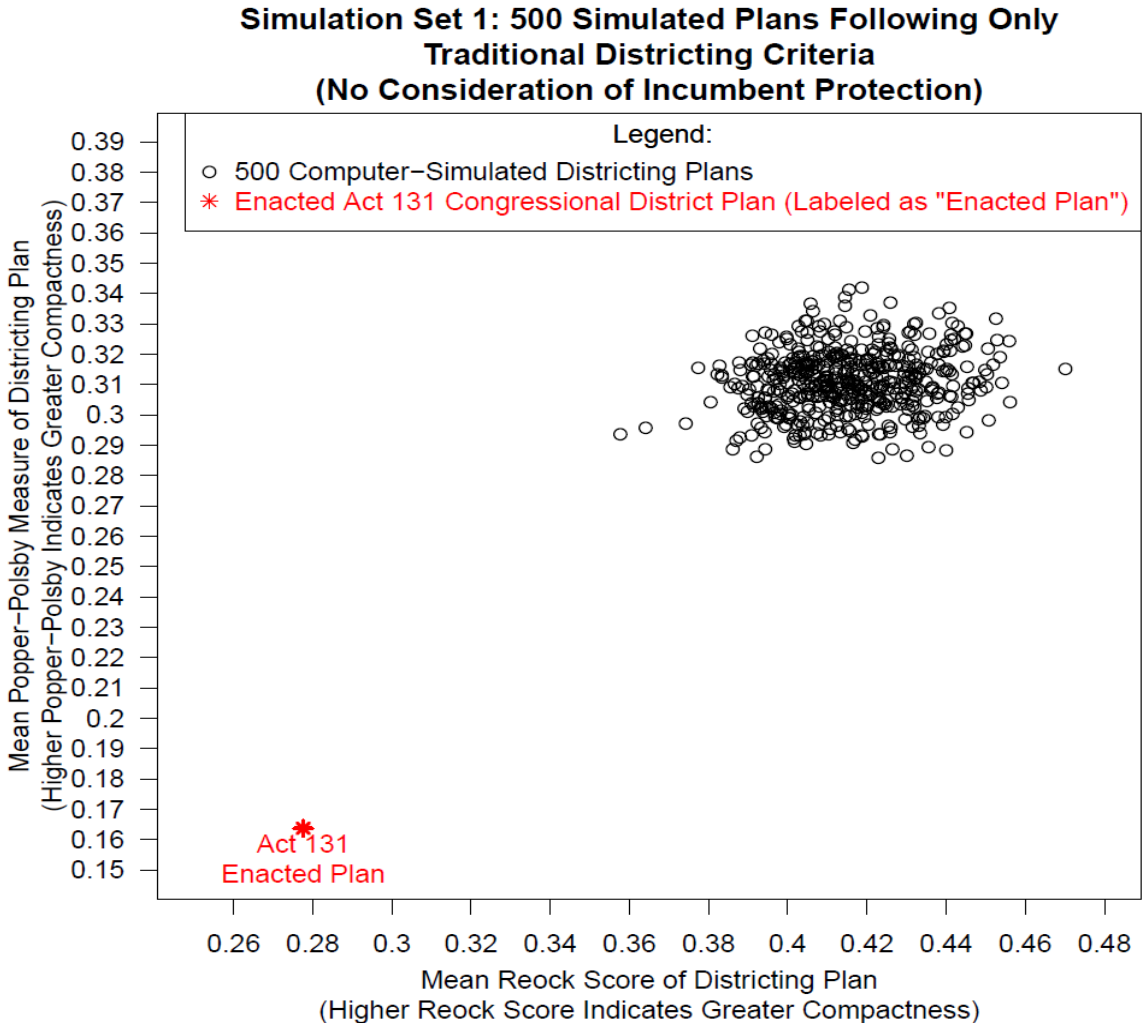


The vertical axis of Figure 3 additionally illustrates that the enacted Act 131 plan split more municipalities than was necessary. Each of the 500 simulated plans split apart a total number of municipalities ranging from 40 to 58. By contrast, the enacted plan splits 68 municipalities. Thus, the enacted plan clearly splits apart more municipalities than necessary.

Did the enacted plan make reasonable efforts to draw compact districts? In Figure 4, the right diagram illustrates the compactness of the 500 simulated plans, compared against the

compactness of the enacted Act 131 plan. In this diagram, the horizontal axis depicts the average Reock score of the districts within each plan, while the vertical axis depicts the average Popper-Polsby score. Each black circle in this diagram represents one of the 500 simulated plans, while the red star denotes the enacted Act 131 plan. Figure 4 illustrates that all 500 of the simulated plans are far more geographically compact than the Act 131 plan, as measured both by average Reock and average Popper-Polsby scores. These results allow us to conclude, with well over 99.9% statistical certainty, that the enacted plan created districts less compact than what could plausibly have emerged from a districting process that prioritizes traditional districting criteria, rather than partisan intent. In other words, the Act 131 plan clearly did not attempt to draw districts that were geographically compact, while adhering to other traditional districting criteria.

Figure 4:



Why did the enacted Act 131 plan fail to produce geographically compact districts and avoid county splits? As Figures (2) – (4) collectively illustrate, the Act 131 plan is entirely outside the range of the 500 simulated maps with respect to both geographic compactness and the partisan distribution of seats, in addition to splitting far more counties than was necessary. Collectively, these findings suggest that the Act 131 plan was drawn under a process in which a partisan goal – the creation of 13 Republican districts – predominated over adherence to traditional districting criteria. The predominance of this extreme partisan goal thus very significantly subordinated the two non-partisan, traditional districting considerations of minimizing county splits and drawing geographically compact districts.

Finally, Figure 5 compares the enacted and the 500 simulated plans using the mean-median gap, which is another accepted method that redistricting scholars commonly use for comparing the relative partisan bias of different districting plans. For any districting plan, the mean is simply calculated as average of the Republican vote shares across all 18 districts, and the median is the Republican vote share in the district where Republicans performed the middle-best (in this case, the average of the Republican vote share in the districts where Republicans performed the eighth and ninth best across the Commonwealth). Using the aggregated results of the 2008-2010 statewide elections, the districts in the Act 131 enacted plan have a mean Republican vote share of 47.5%, while the median district has a Republican vote share of 53.4%. Thus, the Act 131 plan has a mean-median gap of 5.9%, indicating that the median district is skewed significantly more Republican than the plan's average district. In other words, the enacted plan distributes voters across districts in such a way that most districts are significantly more Republican-leaning than the average Pennsylvania district, while Democratic voters are more heavily concentrated in a minority of the congressional districts. This skew in the enacted plan thus creates a significant advantage for Republicans by giving them stronger control over the median district.

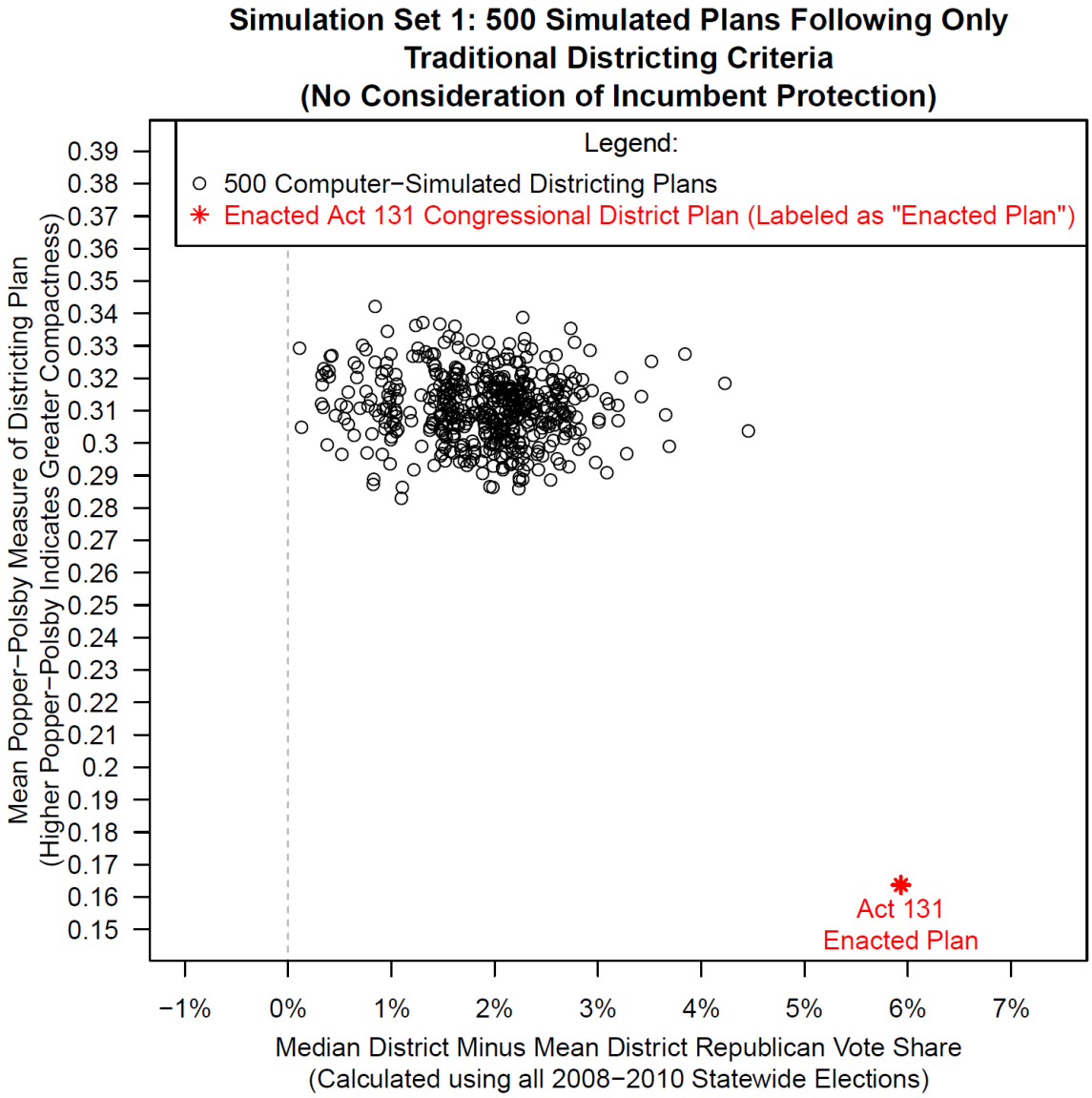
The crucial question, however, is whether this significant mean-median gap arises naturally from applying traditional districting criteria to Pennsylvania, given the state's unique voter geography. Or rather, is the skew in the enacted plan's mean-median gap explainable only as the product of an intentional partisan effort to favor one party over another in the drawing of the districts by deviating from traditional districting criteria?

To answer this question, we must examine the range of mean-median gaps that would have arisen under the sorts of districting plans produced using non-partisan, traditional districting criteria. Thus, Figure 5 illustrates comparisons of the mean-median difference for the enacted and the 500 simulated plans in Simulation Set 1 using both the 2008-2010 elections. The red star in Figure 5 represents the enacted plan's mean-median gap of 5.9%, which is entirely and significantly outside of the entire range of all 500 simulated plans, which produce mean-median gaps ranging from 0.1% to 4.5%. I thus conclude, with extremely strong statistical certainty, that the enacted plan's mean-median gap of 5.9% is not the result of Pennsylvania's natural political geography, combined with the application of traditional districting criteria.

The fact that the 500 simulated plans in Figure 5 all produce a small mean-median gap certainly indicates that voter geography is modestly skewed in a manner that slightly benefits the Republicans in districting. This modest skew in the simulated districting plans results naturally from Democratic voters' tendency to cluster in large, urban areas of Pennsylvania, as I have explained in my previous academic research.[8] But more importantly, the range of this natural skew, as shown in Figure 5, is always much smaller than the extreme 5.9% mean-median gap observed in the Act 131 enacted plan. Hence, these results confirm the main finding that the enacted Act 131 plan creates an extreme partisan outcome that cannot be explained by Pennsylvania's voter geography or by any of the traditional districting criteria. Instead, the extremity of the Act 131 mean-median gap can only be explained by a districting process that pursued a partisan goal by subordinating traditional districting criteria in the drawing of districts.

[8] Jowei Chen and Jonathan Rodden, 2013. "Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures" *Quarterly Journal of Political Science*, 8(3): 239-269; Jowei Chen and David Cottrell, 2016. "Evaluating Partisan Gains from Congressional Gerrymandering: Using Computer Simulations to Estimate the Effect of Gerrymandering in the U.S. House." *Electoral Studies*, Vol. 44, No. 4: 329-430.

Figure 5:


Simulation Set 1: 500 Simulated Plans Following Only Traditional Districting Criteria (No Consideration of Incumbent Protection)
Legend:
500 Computer−Simulated Districting Plans
Enacted Act 131 Congressional District Plan (Labeled as "Enacted Plan")
Act 131 Enacted Plan
Mean Popper−Polsby Measure of Districting Plan (Higher Popper−Polsby Indicates Greater Compactness)
0.39
0.38
0.37
0.36
0.35
0.34
0.33
0.32
0.31
0.3
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
−1%
0%
1%
2%
3%
4%
5%
6%
7%
Median District Minus Mean District Republican Vote Share (Calculated using all 2008−2010 Statewide Elections)

Simulation Set 2:

Following Traditional Districting Criteria While Protecting 17 Incumbents

Could the 13-5 Republican advantage created by the enacted Act 131 plan have resulted from an effort to simply protect the incumbent members of Pennsylvania's Congressional delegation by not pairing them into the same district? I analyzed and evaluated this possible explanation by conducting a second set of districting simulations designed to intentionally protect exactly as many incumbents as the enacted plan while otherwise adhering to the same traditional districting criteria described earlier. I found that even a districting process that intentionally protects as many incumbents as Act 131 does would not explain the 13-5 Republican advantage created by the enacted plan.

I first began by analyzing the extent to which the Act 131 plan protected Pennsylvania's Congressional incumbents. Pennsylvania had 19 Congressional incumbents as of the November 2012 elections, including 12 Republicans and 7 Democrats. By analyzing the home residential addresses of these 19 incumbents, I found that the Act 131 plan protects 17 of these 19 incumbents by placing each one into a district by himself or herself, rather than placing two or more incumbents into the same district. Only Jason Altmire and Mark Critz, the incumbents from the 4th District and the 12th District, respectively, of the previous decade's Congressional plan, were paired together into a single district (the 12th District) in the Act 131 plan. Hence, the enacted plan is considered to have protected 17 of the 19 incumbents, which is the maximum possible number of protected incumbents given the circumstances.

Next, I proceeded to analyze whether the protection of 17 incumbents is an outcome that could have naturally emerged from a districting process adhering to the traditional districting criteria described earlier. I determined that it could not. The first set of 500 simulated plans were produced following only traditional districting criteria with no intentional efforts to protect incumbents. As described in the second column of Table 1, these 500 simulated plans protected between 3 to 13 incumbents, with the vast majority of plans protecting between 5 to 10 incumbents. Hence, it is statistically implausible that the enacted plan's outcome of 17 protected incumbents could have arisen by chance as a result of traditional districting criteria, without an intentional effort to protect incumbents.

Having determined that the Act 131 plan sought to protect incumbents, I then analyzed whether a map-drawing effort to specifically protect 17 of Pennsylvania's Congressional

incumbents could have altered the partisan composition of resulting districting plans to such an extent as to explain the enacted plan's 13-5 Republican advantage.

The protection of incumbents is not a traditional districting principle in the drawing of Congressional maps. Nevertheless, I conducted a second, separate set of simulations to determine whether a non-partisan effort to protect 17 incumbents, while otherwise adhering to non-partisan, traditional districting criteria, could have plausibly resulted in a map with a 13-5 Republican advantage. Specifically, I conducted a second set of 500 simulations in which the computer algorithm was programmed to intentionally guarantee that 17 of the 19 incumbents resided in a separate district, thus avoiding any pairing of incumbents among the 17 protected incumbents. Beyond this intentional incumbent protection, the simulation algorithm otherwise prioritized the same five non-partisan traditional districting criteria followed in the first set of simulations and ignored any other political considerations. Importantly, the computer algorithm ignored the partisanship and the identities of the specific 17 incumbents to be protected. Instead, the computer simply sought to protect exactly 17 incumbents with no regard to their respective partisan affiliations.

Descriptions of this second set of 500 simulated congressional plans appear in the third column of Table 1. All 500 of these simulated plans were able to successfully place some combination of 17 of the 19 incumbents into separate districts, thus achieving exactly the same extent of incumbent protection as the enacted Act 131 plan. Moreover, the simulated plans were able to achieve this level of incumbent protection at the cost of only a small increase in split counties and a modest decrease in district compactness. As Figure 6 illustrates, the simulated plans split between 12 to 19 counties, with the vast majority of plans splitting 15, 16, or 17 counties. Hence, the enacted plan's splitting of 28 counties is still very significantly outside of the entire range of simulated plans. Similarly, Figure 7 illustrates that the simulated plans produce average Popper-Polsby compactness scores ranging from 0.19 to 0.29, while the Act 131 plan's compactness is significantly lower than and outside of the entire range of the simulated plans. Together, these findings indicate that the Act 131 plan's deviations from the traditional districting criteria of district compactness and avoiding county splits are not explained by the goal of protecting 17 incumbents.

Figure 6:

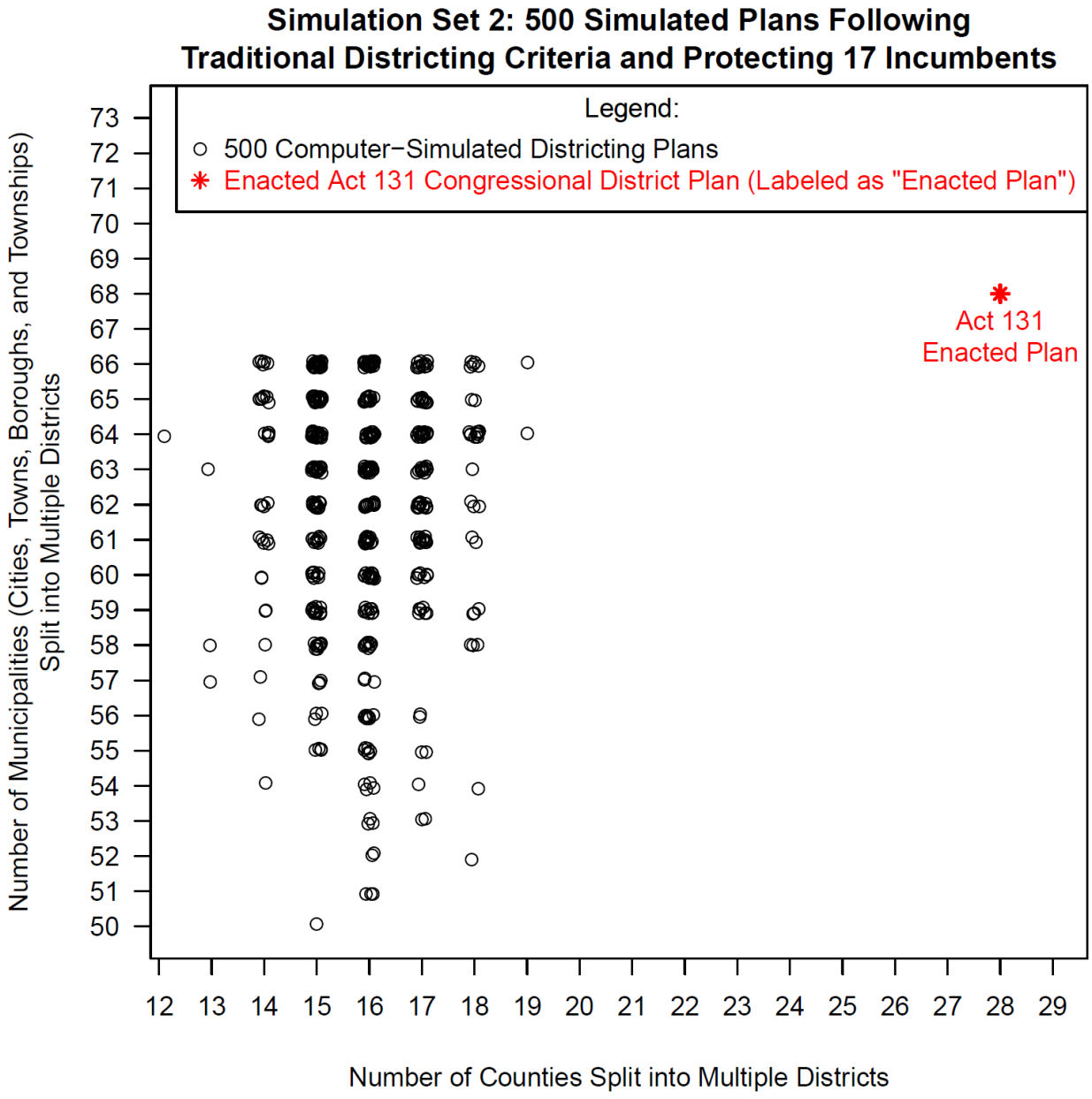
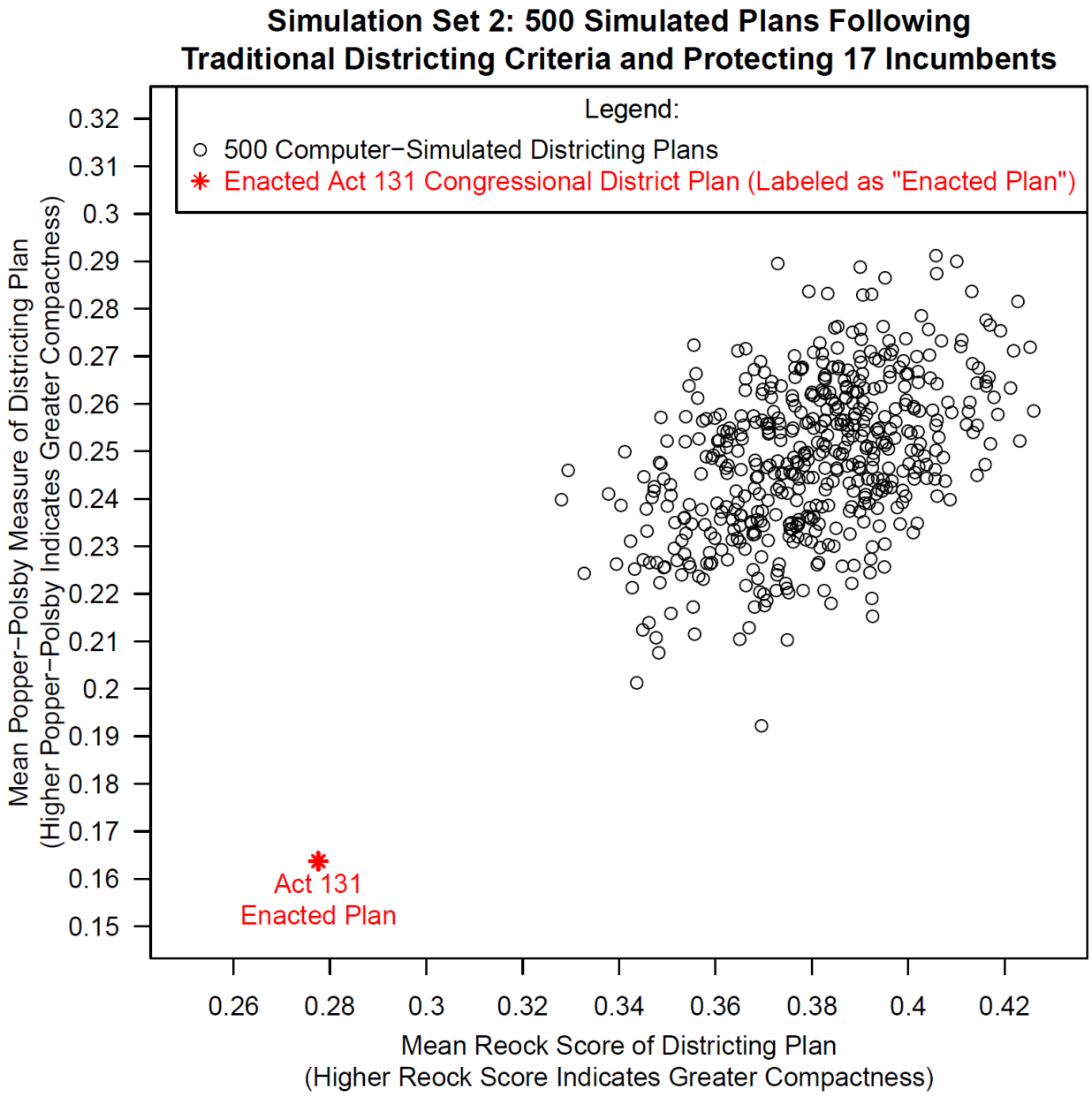

Simulation Set 2: 500 Simulated Plans Following
Traditional Districting Criteria and Protecting 17 Incumbents
Legend:
500 Computer−Simulated Districting Plans
Enacted Act 131 Congressional District Plan (Labeled as "Enacted Plan")
Act 131
Enacted Plan
Number of Municipalities (Cities, Towns, Boroughs, and Townships)
Split into Multiple Districts
73
72
71
70
69
68
67
66
65
64
63
62
61
60
59
58
57
56
55
54
53
52
51
50
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
Number of Counties Split into Multiple Districts

Figure 7:

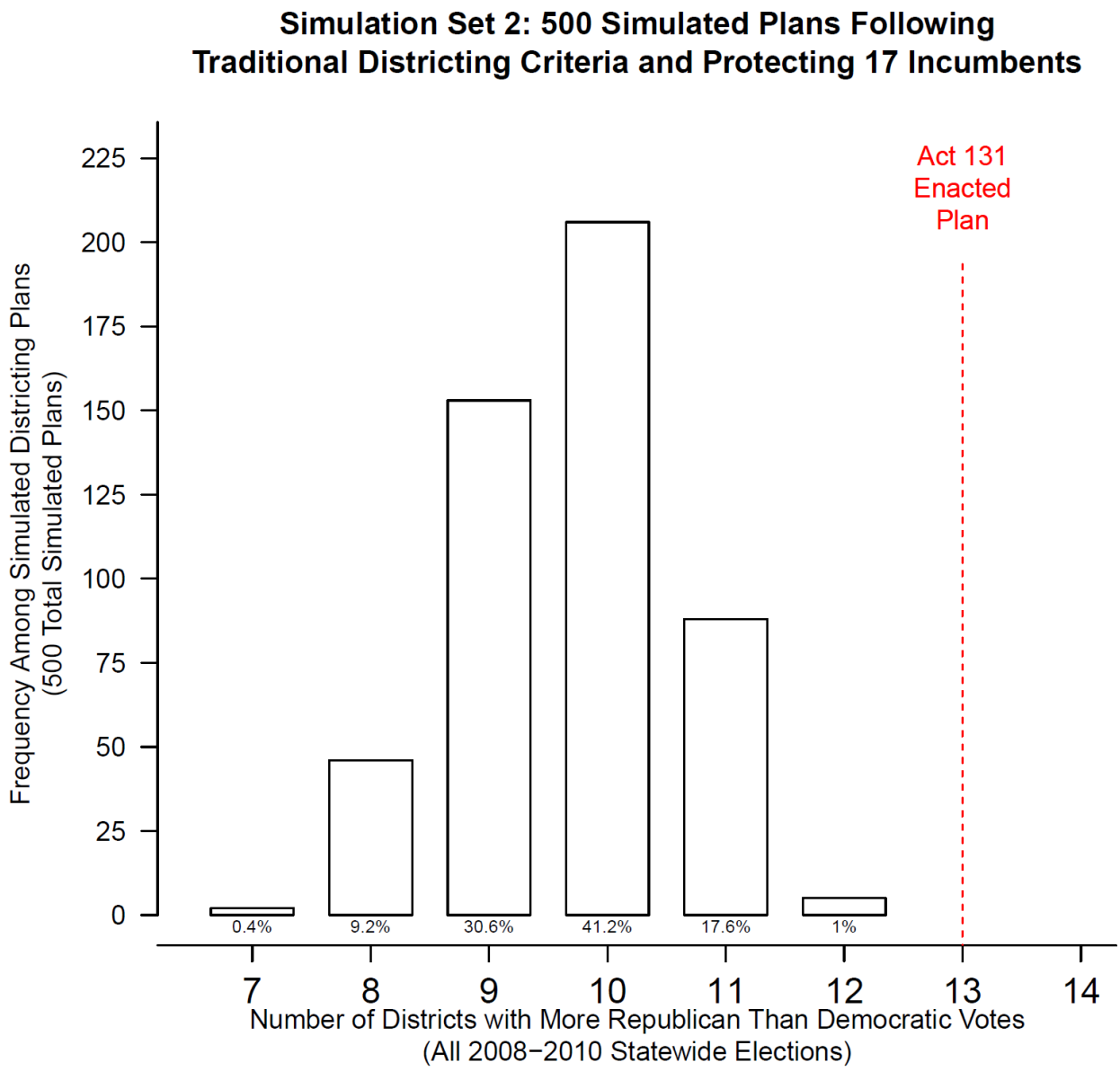

Simulation Set 2: 500 Simulated Plans Following
Traditional Districting Criteria and Protecting 17 Incumbents
Legend:
500 Computer−Simulated Districting Plans
Enacted Act 131 Congressional District Plan (Labeled as "Enacted Plan")
Act 131
Enacted Plan
Mean Popper−Polsby Measure of Districting Plan
(Higher Popper−Polsby Indicates Greater Compactness)
0.32
0.31
0.3
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.26
0.28
0.3
0.32
0.34
0.36
0.38
0.4
0.42
Mean Reock Score of Districting Plan
(Higher Reock Score Indicates Greater Compactness)

Does the protection of 17 House incumbents make the creation of a 13-5 Republican advantage in Pennsylvania's congressional districting plan a plausible outcome? Figure 8 illustrates the distribution of partisan seats across the 500 simulated plans, with partisanship measured using the pre-redistricting elections. This Figure illustrates that the partisan distribution of seats under these incumbent-protecting simulated plans is only slightly more favorable to Republican candidates than the first set of simulations, which ignored incumbency protection entirely. When 17 incumbents are protected in separate districts, the simulation algorithm most commonly produces a plan with 9 or 10 Republican districts, as measured by the 2008-2010 elections. The enacted plan's creation of 13 Republican districts is an outcome never achieved in a single one of these 500 simulations. Hence, I conclude with overwhelmingly high statistical certainty that even an extensive effort by the General Assembly to protect as many incumbents as possible, while otherwise adhering to non-partisan traditional districting criteria, would not explain or somehow necessitate the creation of a congressional map with a 13-5 Republican advantage.

Instead, a comparison of Figures 2 and 8 suggests that an intentional effort by the General Assembly to protect 17 congressional incumbents would generally cause Republicans to control approximately one additional congressional district in Pennsylvania. The enacted Act 131 plan's creation of 13 Republican seats is thus an outcome that is still far outside of the entire range of all 500 simulated plans that protected 17 incumbents while otherwise following traditional districting criteria. These simulation results statistically exclude any notion that an effort to protect incumbents can explain the extreme partisan bias observed in the General Assembly's enacted plan.

Hence, I conclude, with extremely strong statistical certainty, that even an extensive effort by the General Assembly to protect 17 congressional incumbents would not have explained or necessitated the creation of a congressional map with a 13-5 Republican advantage. Instead, it is clear that the enacted plan was drawn through a process in which a particular partisan goal – the creation of 13 Republican districts – predominated over adherence to the traditional districting criteria of drawing compact districts and avoiding county splits. The predominance of this partisan goal resulted in the creation of 2 to 5 additional Republican seats beyond what would have normally resulted from following traditional districting criteria, combined with an effort to protect 17 incumbents.

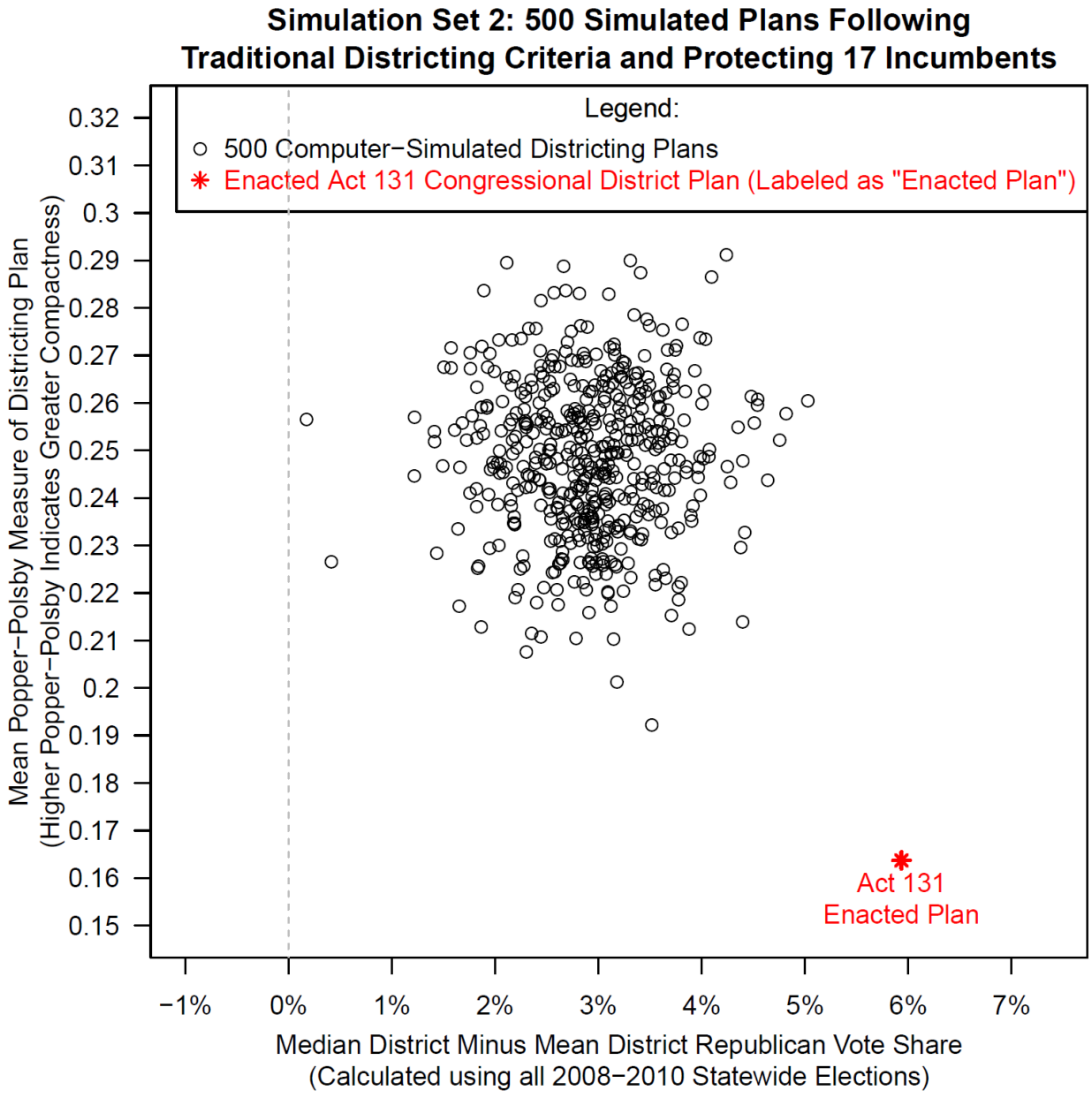
Figure 8:


Simulation Set 2: 500 Simulated Plans Following
Traditional Districting Criteria and Protecting 17 Incumbents
Act 131
Enacted
Plan
Frequency Among Simulated Districting Plans
(500 Total Simulated Plans)
225
200
175
150
125
100
75
50
25
0
0.4%
9.2%
30.6%
41.2%
17.6%
1%
7
8
9
10
11
12
13
14
Number of Districts with More Republican Than Democratic Votes
(All 2008−2010 Statewide Elections)

Finally, Figure 9 compares the enacted Act 131 plan to the 500 simulated plans using the mean-median gap described earlier. As before, for each plan, this measure is calculated by determining the Republican vote share of each district during the 2008-2010 statewide elections and subtracting the mean district vote share from the median district vote share.

Figure 9 illustrates that the Act 131 plan's mean-median gap is entirely outside of the entire range of all 500 simulated plans. The Act 131 plan's mean-median gap of 5.9% is far larger than and entirely outside of the range observed among all 500 simulated plans, which produce mean-median gaps ranging from 0.1% to 4.5%. Together, these calculations generally confirm the earlier finding that the enacted Act 131 plan is a partisan outlier that cannot be explained by Pennsylvania's political geography or by any General Assembly effort to protect 17 incumbents or to follow traditional districting criteria in producing the Act 131 congressional plan. Instead, I conclude, with extremely strong statistical certainty, that the Republican skew in the Act 131 plan's mean-median gap reflects the intentional pursuit of a partisan outcome that subordinated the traditional districting criteria of avoiding county splits and drawing compact districts.

Figure 9:



The Pairing of Representatives Jason Altmire and Mark Critz:

In any Pennsylvania congressional plan protecting 17 of 19 incumbents, two of the incumbents must be paired into the same district. In the enacted Act 131 plan, only Representatives Jason Altmire and Mark Critz, the incumbents from the 4th District and the 12th District, respectively, of the previous decade's Congressional plan, were paired together into a single district (the 12th District). I sought to analyze whether this choice to pair Representatives

Altmire and Critz, who are both Democrats, was one that could have plausibly resulted from a partisan-neutral districting process that protects 17 incumbents while otherwise adhering to traditional districting principles.

Under a map-drawing process following traditional districting principles, two incumbents are more likely to be paired in a single district if they are geographically closer to one another, if they reside within the same county, and particularly if they reside within the same municipality. Hence, over a large number of simulated districting plans attempting to protect 17 incumbents, we are likely to see certain pairs of incumbents placed together in a single district quite frequently, while other pairings will occur infrequently or never occur at all. For example, it would obviously be impossible to pair within the same district an incumbent residing in Pittsburgh and a Philadelphia-based incumbent, without engaging in significant violations of traditional districting principles.

Hence, I analyzed which pairings of Pennsylvania's 19 incumbents are more or less likely to occur under a districting process that protects 17 incumbents while otherwise following traditional districting principles. I conducted this analysis in order to determine whether the Act 131 plan's decision to pair Representatives Altmire and Critz could plausibly have emerged under a non-partisan effort to protect incumbents.

Table 2 lists all of the different pairings of incumbents within the same district that occur among the 500 simulated districting plans produced in Simulation Set 2. Ten different combinations of incumbents are paired among these 500 simulated plans, and, not surprisingly, incumbents who reside geographically close to one another or within the same county are most likely to be paired.

Among the 500 simulated districting plans, *not a single map* pairs together Representative Altmire and Critz into the same district. In fact, Representative Altmire is never paired together with another incumbent in any of the 500 simulations. On the other hand, Representative Critz is paired together with another incumbent in three different simulated plans, but in all three of these simulations, Representative Critz is paired together with Representative Bill Shuster, a Republican. Given that the simulation algorithm produces more geographically compact districts, it is not surprising that the pairing of Representatives Critz and Shuster, whose residences are more geographically proximate, is more likely to occur than the pairing of Representatives Critz and Altmire, whose residences are more geographically distant. Hence, I

conclude, with strong statistical certainty, that the Act 131 plan's pairing of Representatives Altmire and Critz, two Democrats, was not the product of a non-partisan attempt to protect Pennsylvania's Congressional incumbents.

Table 3: Paired Incumbents under Simulation Set 2
(Simulations Protecting 17 of 19 Incumbents
While Following Traditional Districting Criteria)

Incumbent Pair:	Percent of simulated plans in which incumbent pair is placed into the same district:
Jim Gerlach & Pat Meehan	**40.2%**
Bob Brady & Pat Meehan	**34.4%**
Bob Brady & Chakkah Fattah	**18.2%**
Jim Gerlach & Joe Pitts	**0.6%**
Pat Meehan & Joe Pitts	**4.8%**
Bill Shuster & Mark Critz	**0.6%**
Glenn Thompson & Tom Marino	**0.4%**
Tim Murphy & Mike Doyle	**0.4%**
Bill Shuster & Glenn Thompson	**0.2%**
Bob Brady & Allyson Schwartz	**0.2%**

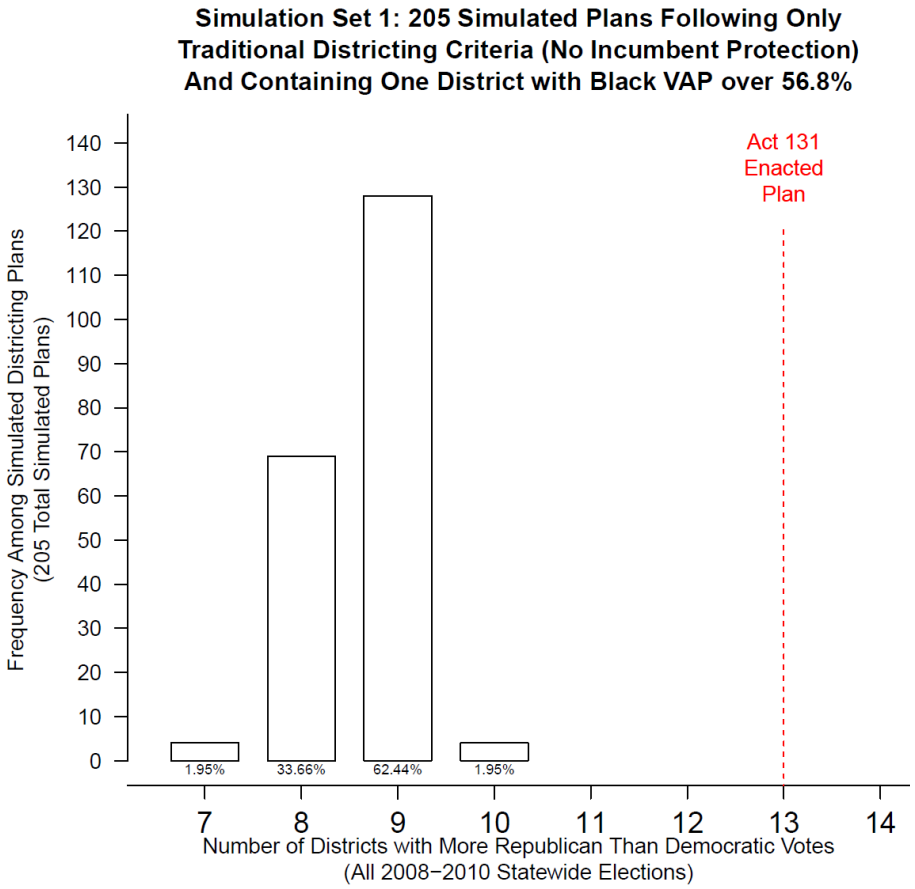
Accounting for Racial Goals in Congressional Districting:

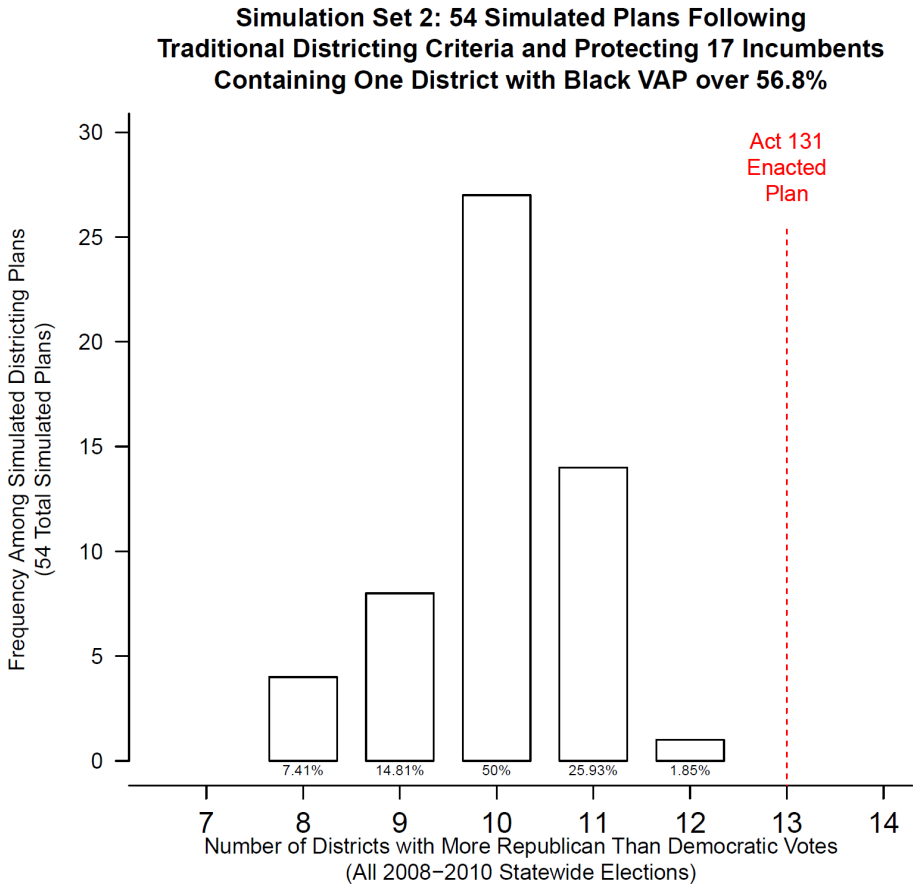
Both sets of 500 simulated districting plans algorithms I produced in this report were conducted in a race-blind, non-partisan manner. Nevertheless, the General Assembly may contend that it constructed the Act 131 plan with the racial goal of allowing a minority group to comprise the majority of the voting age population (VAP) in one or more districts. To analyze this possibility, I analyzed the racial composition of the Act 131 plan's districts using 2010 Census population counts. I found that the 2nd Congressional District (Philadelphia) of the Act 131 plan has an African-American voting-age population (VAP) of 56.8%, and it is the only district that contains an African-American majority. I thus sought to analyze whether a hypothetical goal of creating a district with at least a 56.8% African-American VAP might have caused the extreme 13-5 Republican advantage in the General Assembly's enacted plan.

To analyze this question, after conducting the 1,000 computer simulated plans in this report (500 plans in Simulation Set 1 and 500 in Simulation Set 2), I then evaluated the racial composition of each district in each simulated plan. I found that 259 of these 1,000 simulated plans contain one Philadelphia-area district with a 56.8% or higher African-American VAP. I thus analyzed only this subset of simulated districting plans that achieved this racial threshold in order to determine whether an attempt to pursue this racial goal might have caused a partisan skew in the congressional plan that accounts for the Act 131 plan's creation of a 13-5 Republican seat advantage.

Figure 10 presents the results of this analysis. For Simulation Set 1, which adhered to traditional districting criteria with no intentional protection of incumbents, the left diagram on Figure 10 describes the partisan distribution of seats only among those simulated maps that contain one district with at least 56.8% African-American VAP. These Figure 10 results show that the creation of a 56.8% African-American VAP district has almost no effect on the partisan distribution of seats in Pennsylvania's congressional plan. Whether or not such a heavily African-American district is constructed, the entire districting plan generally contains 8 or 9 Republican districts, as measured by the aggregate results of the 2008-2010 statewide elections in Pennsylvania. These simulation results clearly reject any notion that an effort to create a particular racial composition in District 2 might have warranted the extreme 13-5 Republican seat advantage observed in the General Assembly's enacted plan.

Figure 10:


Simulation Set 1: 205 Simulated Plans Following Only
Traditional Districting Criteria (No Incumbent Protection)
And Containing One District with Black VAP over 56.8%
Act 131
Enacted
Plan
Frequency Among Simulated Districting Plans
(205 Total Simulated Plans)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1.95%
33.66%
62.44%
1.95%
7
8
9
10
11
12
13
14
Number of Districts with More Republican Than Democratic Votes
(All 2008−2010 Statewide Elections)


Simulation Set 2: 54 Simulated Plans Following
Traditional Districting Criteria and Protecting 17 Incumbents
Containing One District with Black VAP over 56.8%
Act 131
Enacted
Plan
Frequency Among Simulated Districting Plans
(54 Total Simulated Plans)
0
5
10
15
20
25
30
7.41%
14.81%
50%
25.93%
1.85%
7
8
9
10
11
12
13
14
Number of Districts with More Republican Than Democratic Votes
(All 2008−2010 Statewide Elections)

The right diagram in Figure 10 presents a similar analysis on the computer-simulated districting plans in Simulation Set 2, which intentionally protected 17 incumbents while otherwise adhering to traditional districting criteria. In general, the simulated plans that contain a 56.8% African-American VAP district are very slightly more Republican-leaning than the simulated plans that do not contain such a district. This difference does not alter the strong, statistically significant results reached earlier in this report: Even if a congressional districting process requires a 56.8% African-American VAP district, in addition to protecting 17 incumbents while following traditional districting criteria, such a districting process would generally produce plans with 9, 10, or 11 Republican seats, as measured by the 2008-2010 statewide election results. Hence, even assuming that the General Assembly pursued both a racial districting goal and a goal of protecting 17 incumbents, I conclude with strong statistical significance that the enacted plan's creation of a 13-5 Republican advantage resulted from the General Assembly's predominant partisan intent, which subordinated adherence to traditional districting criteria. These simulation results thus clearly reject any notion that an effort to create a district with the African-American VAP composition found in District 2 might have warranted the extreme partisan bias observed in the General Assembly's enacted plan.

The Effect of Act 131 on Individual Petitioners

As an additional method of evaluating the actual partisan effect of Act 131 on the 18 individual Petitioners in this case, I evaluate the sort of congressional districts each petitioner would have been placed into under the enacted plan as well as under simulated districting plans. Counsel for the Petitioners provided to me a list of the 18 individual petitioners, along with their respective residential addresses. I used these addresses in order to identify the specific district that each Petitioner would have been located in under each computer-simulated plan, as well as under the enacted Act 131 plan. I then analyze the partisan characteristics of the districts each Petitioner would typically have been districted into under the simulated plans. Table 4 presents the result of this analysis. This Table lists the 18 Petitioners and describes the partisanship of each Petitioner's district of residence in the enacted plan as well as all of the simulated districting plans presented in this report.

Table 4: Petitioners' Districts in Act 131 and in Simulation Sets 1 and 2 Districting Plans
Percent of Simulated Plans Placing Petitioner into a Democratic District.

		Percent of Simulated Plans Placing Petitioner into a Democratic District:			
	Partisan Tilt of Petitioner's District In Enacted Plan (Act 131 Plan)	**Simulation Set 1**	**Simulation Set 1: Plans Containing a District with BVAP > 56.8%**	**Simulation Set 2**	**Simulation Set 2: Plans Containing a District with BVAP > 56.8%**
Carmen Febo San Miguel	1st Dist. (Democratic)	100%	100%	100%	100%
James Solomon	2nd Dist. (Democratic)	100%	100%	100%	100%
John Greiner	3rd Dist. (Republican)	7.6%	8.3%	5.2%	3.7%
John Capowski	4th Dist. (Republican)	0%	0%	0%	0%
Gretchen Brandt	5th Dist. (Republican)	1.0%	2.0%	0.4%	0%
Tom Rentschler	6th Dist. (Republican)	24.6%	12.7%	1.0%	3.7%
Beth Lawn	7th Dist. (Republican)	99.8%	100%	26.8%	11.1%
Lisa Isaacs	8th Dist. (Republican)	99.8%	100%	99.4%	98.1%
Don Lancaster	9th Dist. (Republican)	0.6%	0.5%	6.2%	7.4%
Jordi Comas	10th Dist. (Republican)	0%	0%	0.6%	0%
Robert Smith	11th Dist. (Republican)	68.4%	72.7%	94.4%	92.6%
William Marx	12th Dist. (Republican)	1.8%	1.5%	38.4%	40.7%
Richard Mantell	13th Dist. (Democratic)	100%	100%	100%	100%
Priscilla McNulty	14th Dist. (Democratic)	99.8%	100%	98.6%	100%
Thomas Ulrich	15th Dist. (Republican)	99.6%	99.0%	90.6%	77.8%
Robert McKinstry	16th Dist. (Republican)	8.8%	1.0%	7.0%	7.4%
Mark Lichty	17th Dist. (Democratic)	94.0%	95.6%	43.2%	46.3%
Lorraine Petrosky	18th Dist. (Republican)	1.8%	1.5%	37.6%	42.6%

For each Petitioner, the first column reports the enacted Act 131 district within which the Petitioner has been placed, along with the district's partisanship, as measured by aggregate election results of the 2008-2010 statewide races in Pennsylvania. As the first column of Table 4 illustrates, five of the Petitioners were placed into Democratic districts in the enacted plan (Districts 1, 2, 13, 14, and 17), while the remaining 13 Petitioners were placed into Republican districts.

The second column of Table 4 describes the districts each Petitioner was placed into in the 500 districting plans in Simulation Set 1. For each of these 500 simulated plans, I identified the simulated district in which the Petitioner resides, and I calculated whether the district cast more aggregate Republican or Democratic votes during the 2008-2010 statewide election races. Hence, each Petitioner resides within 500 different simulated districts (one district in each of the 500 simulated plans). I then identified the percentage of each Petitioner's 500 simulated districts that cast more Democratic votes than Republican votes. Thus, having used the same measure of district partisanship as was used to analyze the Act 131 districts, we can directly compare whether the Act 131 placed each Petitioner into a very different type of district than the Petitioner's district in each of the 500 simulated plans.

For example, the eighth row of Table 4 reports that Petitioner Lisa Isaacs was placed into the 8th District, a Republican-leaning district, in the enacted Act 131 plan. Yet, in 99.8% of the simulated plans in Simulation Set 1 and 99.4% of plans in Simulation Set 2, Isaacs was placed into a Democratic district. Hence, there is a significant mismatch between how Isaacs' residence was districted in the enacted plan versus in the simulated plans. Therefore, I conclude, with well over 99% statistical certainty, that under a districting process following traditional districting criteria, Isaacs would have been placed into a Democratic district. In other words, Isaacs' placement into a Republican district in the enacted Act 131 plan is an outcome that could not plausibly have resulted from a partisan-neutral districting process adhering to traditional districting criteria.

From the results described in Table 4, I reach similar conclusions regarding Thomas Ulrich (15th District). Like Isaacs, Ulrich was placed into a Republican district in the enacted Act 131 plan, but in nearly all of the 1000 simulated districting plans created under a partisan-neutral districting process, he would have been placed into Democratic districts. Hence, I conclude, with strong statistical certainty, that Ulrich would not be placed into a Republican district under a

partisan-neutral districting process. I can conclude the same for Petitioner Beth Lawn (7th District) under Simulation Set 1, and for Petitioner Robert Smith (11th District) under Simulation Set 2. Indeed, Smith would fall in a Democratic district in over two-thirds of the maps under Simulation Set 1 as well.

Data Files Produced by Speaker Michael Turzai:

The attorneys for the Petitioners in this case gave to me an electronic folder containing 13 GIS shapefiles. Petitioners' counsel informed me that these files were produced by Speaker Michael Turzai in a pending federal challenge to Pennsylvania's congressional district map, in which Speaker Turzai represented that these files reflected the "facts and data considered in creating the 2011 Plan." Separate and apart from the simulations I created and analyzed, Petitioners' counsel asked me to examine the electronic maps depicted in these 13 shapefiles and the demographic and partisan data contained within these files. Based on my extensive expertise regarding the use of computer algorithms and GIS shapefiles in redistricting and my experience as an expert in redistricting litigation, it is readily apparent what these files represent and the purposes for which they were used. Below, I describe the contents of the shapefiles that contained political data:

One filed turned over by Speaker Turzai in the federal case, entitled "Turzai – 01674.DBF," is part of a larger shapefile containing data regarding the 9,253 Voting Tabulation Districts (VTDs) in Pennsylvania. For each VTD, this file reports precinct-level election results for each statewide election, state legislative election, and congressional election held in Pennsylvania during the 2004, 2006, 2008, and 2010 general elections. For each election, the file reports each precinct's total number of votes cast for the Republican candidate and for the Democratic candidate. I checked several of the precinct-level election results reported to determine whether they were accurate and whether they align with the Pennsylvania Department of State's official election return reports. I determined that these data indeed are accurate reports of each party's vote totals in the 2004-2010 elections.

The file then uses these precinct-level election results to calculate ten different partisan indices, all of which are contained in columns 186 to 195 of this file. While the file does not describe the precise mathematical formula used to calculate each partisan index, it is clear that

these indices generally measure the partisan performance of each precinct in then-recent Pennsylvania elections.

Two of the partisan indices are called “INDEX04” (Column 186) and “INDEX08” (Column 195). The INDEX04 column contains values ranging from -930 to +1050, where precincts that vote more heavily in favor of Republican candidates have positive, higher values, whereas precincts with more Democratic votes have negative, lower values. In fact, upon analyzing the values of this index, I found that INDEX04 exhibits a near-perfect correlation with the partisan results of the 2004 Presidential and US Senate elections in Pennsylvania, suggesting that INDEX04 was a partisan index crafted using the results of various 2004 statewide elections.

The INDEX08 (Column 195) measure, which ranges from -1376 to +2957, exhibits similar properties. This measure appears to be very strongly correlated with the precinct-level Republican vote margin across a range of recent elections. Hence, the measure appears to be crafted using the results of various then-recent Pennsylvania elections. It clearly assigns positive, higher values to precincts with heavier support for Republican candidates, whereas precincts with more support for Democratic candidates have negative, lower values. It is clearly a partisan index that measures, in some way, the general tendency of each precinct to support Republican or Democratic candidates in Pennsylvania elections preceding the 2011 redistricting.

There are eight other precinct-level partisan indices contained in the “Turzai – 01674.DBF” file, and each of these indices appear to be derived from aggregations of partisan votes in various statewide and legislative election contests in Pennsylvania. Specifically, these eight partisan indices are:

- “PREZ08”: This index appears to have been calculated by comparing the number of votes cast for the Republican candidate and the Democratic candidate in the 2008 Presidential election, such that positive, higher numbers indicate a precinct with more Republican votes, whereas negative, lower numbers indicate a precinct with more Democratic votes.

- “SEN10”: This index appears to have been calculated by comparing the number of votes cast for the Republican candidate and the Democratic candidate in the 2010 US Senate election, such that positive, higher numbers indicate a precinct with more Republican votes, whereas negative, lower numbers indicate a precinct with more Democratic votes.

- “CNG10”: This index appears to have been calculated by comparing the number of votes cast for Republican candidates and for Democratic candidates in the 2010 US Congressional elections, such that positive, higher numbers indicate a precinct with more Republican votes, whereas negative, lower numbers indicate a precinct with more Democratic votes.

- “STHS10”: This index appears to have been calculated by comparing the number of votes cast for Republican candidates and for Democratic candidates in the 2010 state house elections, such that positive, higher numbers indicate a precinct with more Republican votes, whereas negative, lower numbers indicate a precinct with more Democratic votes.

- “GOV10”: This index appears to have been calculated by comparing the number of votes cast for the Republican candidate and the Democratic candidate in the 2010 Gubernatorial election, such that positive, higher numbers indicate a precinct with more Republican votes, whereas negative, lower numbers indicate a precinct with more Democratic votes.

- “ATGEN08”: This index appears to have been calculated by comparing the number of votes cast for the Republican candidate and the Democratic candidate in the 2010 Attorney General election, such that positive, higher numbers indicate a precinct with more Republican votes, whereas negative, lower numbers indicate a precinct with more Democratic votes.

- “PREZ04”: This index appears to have been calculated by comparing the number of votes cast for the Republican candidate and the Democratic candidate in the 2004 Presidential election, such that positive, higher numbers indicate a precinct with more Republican votes, whereas negative, lower numbers indicate a precinct with more Democratic votes.

- “REG10”: This index appears to have been calculated by comparing the number of registered Republicans and registered Democrats, such that positive, higher numbers indicate a precinct with more registered Republicans, whereas negative, lower numbers indicate a precinct with more registered Democrats.

The election vote counts and partisan indices contained in the “Turzai – 01674.DBF” are also calculated at different levels of geography in other files within the data folder. Specifically, a different file named "Turzai - 01653.DBF" is part of a larger shapefile depicting the boundaries of Pennsylvania’s 67 counties. For each county, the "Turzai - 01653.DBF" file contains data reporting on the same election results and the same 10 partisan indices described above. Similarly, another file named "Turzai - 01644.DBF” is part of a larger shapefile depicting Pennsylvania’s municipal boundaries. For each municipality, the file contains data describing the same election results and the same 10 partisan indices described above.

Finally, a different file named "Turzai - 01641.DBF” is part of a larger shapefile depicting Pennsylvania’s census blocks. For each census block, the file contains the total number of Republican voters and the total number of Democratic voters for all Pennsylvania statewide and legislative elections during 2004-2010.

The shapefiles produced by Speaker Turzai contain much more extensive election data than are publicly available from the Department of State’s Bureau of Elections or from any other public source of which I am aware. The shapefiles also contain sophisticated indices of partisan preference not available from the Department of State. Moreover, these shapefiles disaggregated the election data and partisan indices to much more detailed levels of geography than in any files made publicly available by the Department of State. Hence, it is clear that these files represent a significant effort at measuring and comparing the partisan performance of Pennsylvania voters during the 2004-2010 elections at several different levels of Pennsylvania geography. My simulations and my conclusions based on those simulations were independent of these shapefiles. However, my analysis of these shapefiles separately confirms that Pennsylvania’s legislature analyzed and considered the partisan voting preference of each VTD, precinct, county, municipality, and census block when they created the 2011 map.

Appendix A:

This following table presents calculations regarding the racial and ethnic composition of each of the 18 congressional districts in Pennsylvania's current enacted congressional plan (Act 131 of 2002). I obtained these population counts from the 2010 US Census Redistricting Data Summary File 1.

District	Total Voting Age Population	Hispanic Proportion of VAP	Any Part African-American Proportion of VAP	Non-Hispanic White Proportion of VAP
1	535,939	13.2%	32.8%	46.9%
2	557,093	4.8%	56.8%	32.0%
3	549,038	1.4%	4.1%	93.0%
4	544,261	4.8%	7.0%	85.6%
5	566,588	1.5%	2.3%	93.8%
6	538,997	3.9%	4.1%	87.8%
7	541,041	2.4%	4.8%	88.2%
8	542,943	3.5%	3.2%	88.4%
9	556,921	1.4%	2.8%	94.6%
10	553,896	2.9%	3.2%	92.5%
11	558,522	3.5%	4.5%	90.2%
12	558,540	0.9%	2.9%	94.2%
13	542,335	8.7%	16.2%	66.0%
14	576,701	1.6%	19.1%	75.3%
15	545,692	10.4%	3.9%	83.0%
16	526,501	13.2%	6.3%	78.5%
17	555,074	5.5%	4.9%	87.5%
18	560,142	0.9%	2.3%	94.6%

Appendix B:

This following table presents calculations regarding the racial and ethnic composition of each of the 19 congressional districts in the 2002 Congressional Plan (Act 34 of 2002). I obtained these population counts from the 2000 US Census Summary File 1 (SF 1).

District	Total Voting Age Population	Hispanic Proportion of VAP	Any Part African-American Proportion of VAP	Non-Hispanic White Proportion of VAP
1	462,587	12.7%	43.9%	38.3%
2	490,376	2.8%	58.0%	34.1%
3	489,540	1.0%	3.1%	94.9%
4	492,112	0.5%	3.1%	95.1%
5	502,496	0.8%	1.5%	96.0%
6	487,710	2.9%	6.6%	88.0%
7	491,978	1.2%	5.4%	89.3%
8	481,567	2.1%	3.4%	91.6%
9	493,576	0.8%	1.7%	96.7%
10	494,635	1.2%	1.9%	95.9%
11	502,650	2.0%	2.5%	94.5%
12	508,398	0.5%	3.2%	95.6%
13	494,307	2.6%	5.9%	87.0%
14	510,967	1.0%	19.9%	76.6%
15	491,523	6.2%	2.9%	88.9%
16	472,195	7.5%	4.4%	86.6%
17	496,104	2.6%	7.0%	89.1%
18	502,491	0.5%	2.0%	95.9%
19	493,621	2.1%	2.9%	93.5%

Appendix C:

Comparison of Enacted Plan and Simulated Districting Plans Using Post-Redistricting (2012-2016) Election Results

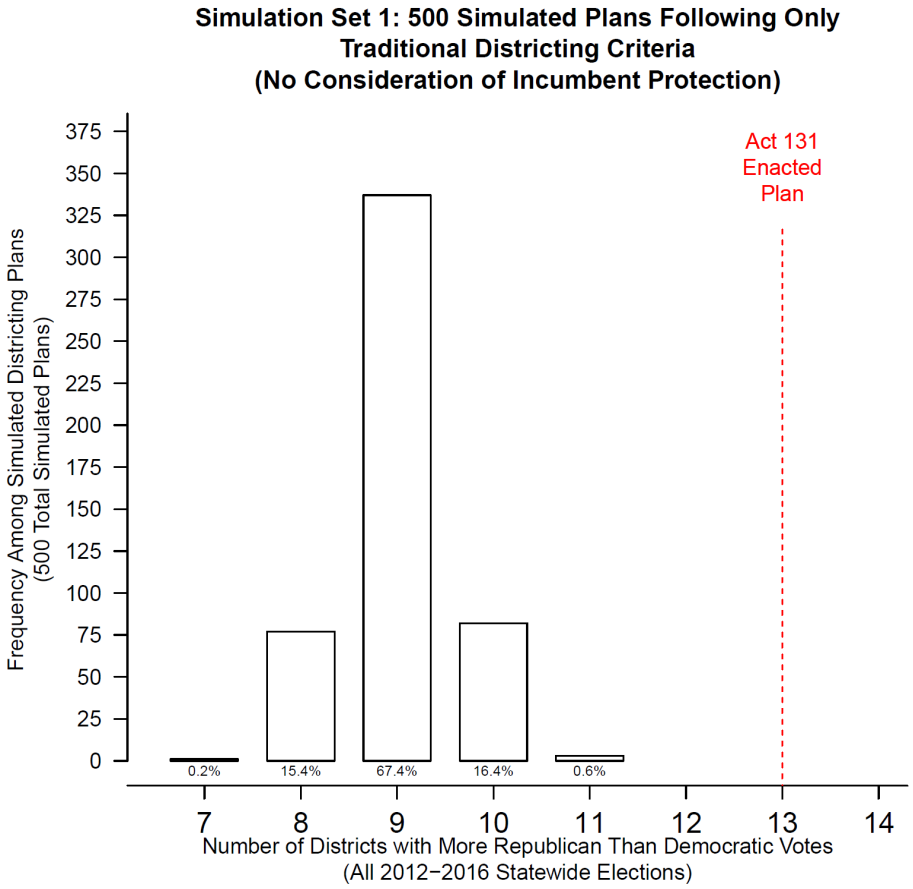
In this section, as a robustness check on my analysis, I re-calculate the partisan performance of the enacted Act 131 plan and all 1,000 simulated districting plans using post-redistricting (post-2011) elections rather than 2008-2010 elections. Pennsylvania has held 11 statewide elections since the 2011 enactment of the General Assembly's Act 131 Congressional districting plan. All eleven of these elections – which include the Presidential, US Senate, Attorney General, Auditor General, and State Treasurer elections in 2012 and 2016 and the Gubernatorial election in 2014 – were contested elections. As I did with in the report with the pre-redistricting (pre-2011) elections, I aggregate together the results of these 2012-2016 statewide elections, and I simply count whether each district contains more total Republican or Democratic voters over these 11 elections. I use these 11 statewide post-redistricting elections because they offer a reliable indicator of the partisan performance of each district during the six years since the 2011 enactment of the Act 131 plan. Hence, these election results allow us to reliably measure the actual partisan effect of the enacted plan in comparison to hypothetical computer-simulated districting plans drawn according to traditional districting criteria.

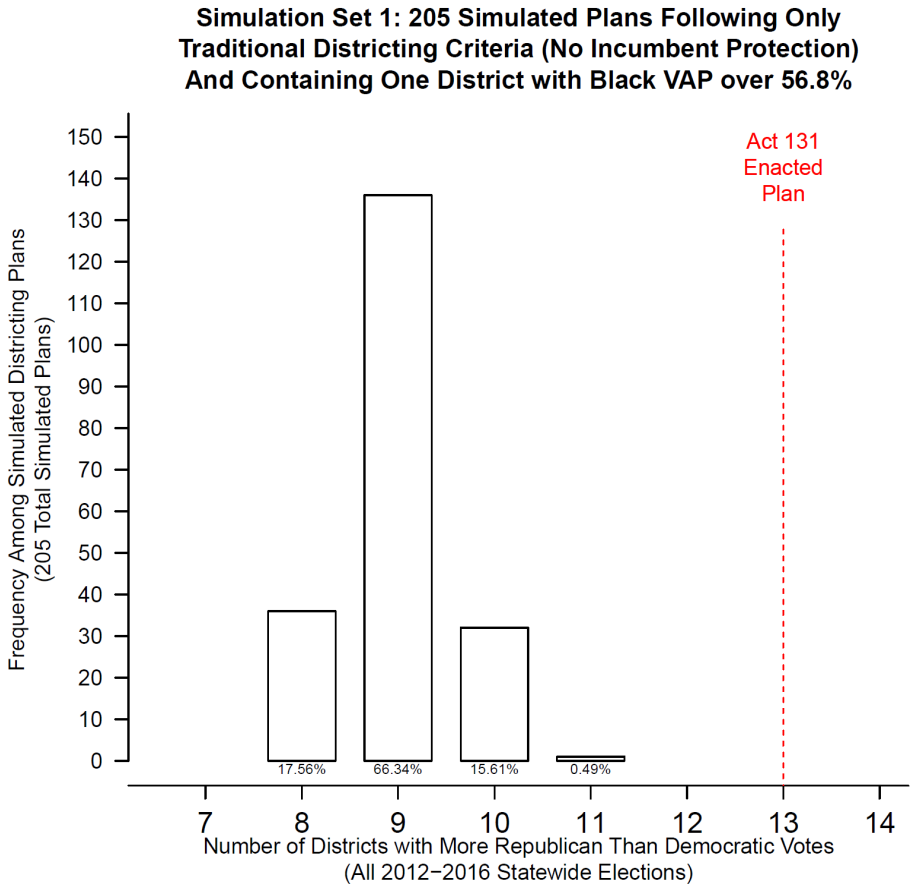
I find that, using the results of these 11 post-redistricting elections during 2012-2016, total Republican voters outnumbered total Democratic voters in 13 of 18 districts in the enacted Act 131 plan. Once again, these 13 Republican districts correspond with the same 13 districts that have consistently elected a Republican Congressional Representative during the 2012, 2014, and 2016 general elections. In the following section of this report, I use this same measure to evaluate the partisanship of each of the 1,000 computer simulated plans, and I find that not a single one of these computer simulated plans ever produces a 13-5 Republican advantage.

Figure C1 presents a comparison of the 500 plans in Simulation Set 1 and the enacted Act 131 plan using the 11 post-redistricting statewide elections to measure partisan partisanship. The left diagram in Figure C1 shows that over 99% of these 500 simulated plans create 8, 9, or 10 seats with more Republican than Democratic voters in the 2012-2016 elections. Not a single simulated plan creates over 11 Republican districts. By contrast, the enacted Act 131 plan creates

13 districts in which Republican votes outnumbered Democratic votes across these 11 statewide elections.

Figure C1:


Simulation Set 1: 500 Simulated Plans Following Only Traditional Districting Criteria (No Consideration of Incumbent Protection)
Frequency Among Simulated Districting Plans (500 Total Simulated Plans)
Act 131 Enacted Plan
0.2%
15.4%
67.4%
16.4%
0.6%
Number of Districts with More Republican Than Democratic Votes (All 2012–2016 Statewide Elections)

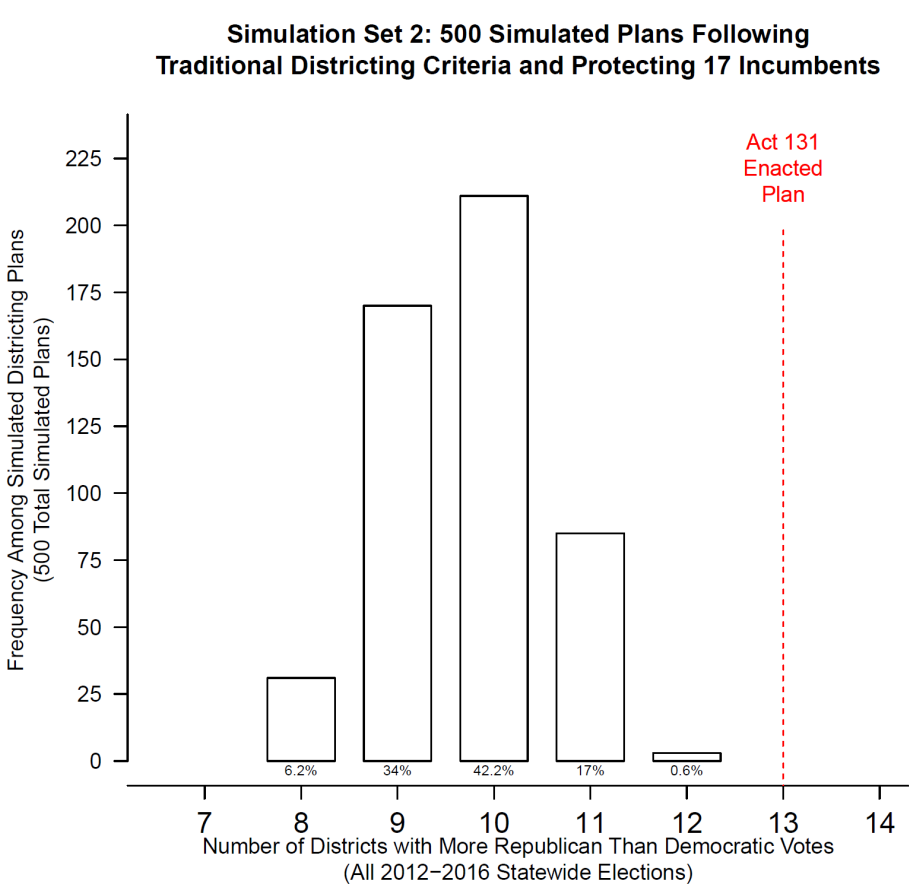

Simulation Set 1: 205 Simulated Plans Following Only Traditional Districting Criteria (No Incumbent Protection) And Containing One District with Black VAP over 56.8%
Frequency Among Simulated Districting Plans (205 Total Simulated Plans)
Act 131 Enacted Plan
17.56%
66.34%
15.61%
0.49%
Number of Districts with More Republican Than Democratic Votes (All 2012–2016 Statewide Elections)

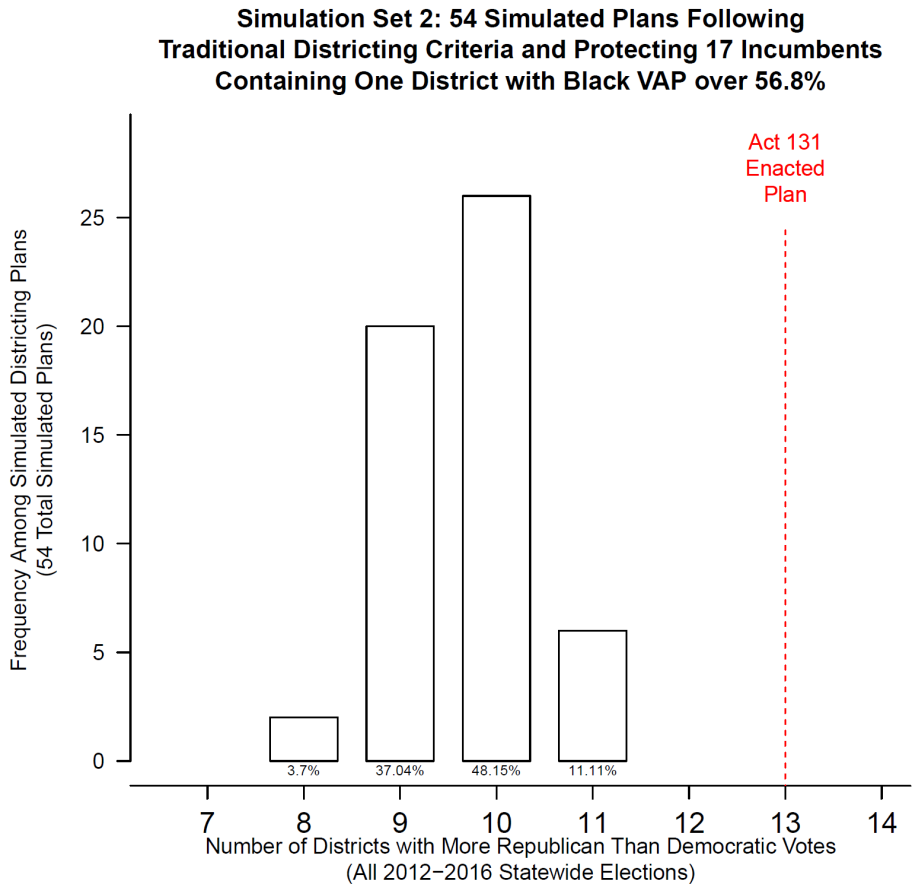
It is clear that the enacted plan is an extreme partisan outlier when compared to valid, computer-simulated districting plans. The net effect of the enacted plan's partisan efforts was the creation of at 3 to 5 additional Republican seats beyond what would almost always have been created by a non-partisan districting process adhering to traditional districting criteria. I conclude with extremely strong statistical certainty that the Act 131 plan created a pro-Republican partisan outcome that would not have been possible under a districting process adhering to non-partisan traditional districting criteria.

The right diagram in Figure C1 describes only the subset of the 500 plans in Simulation Set 1 that include a district with a 56.8% or higher African-American VAP. There are 205 such plans in Simulation Set 1, and once again, over 99% of these plans contain 8, 9, or 10 Republican seats, with no plan containing more than 11 Republican seats. It is clear that the enacted plan's creation of 13 Republican seats, as measured by the 2012-2016 elections, is an outcome that would not have been possible under a districting process seeking to create a 56.8% African-American VAP district while otherwise adhering to non-partisan traditional districting criteria. With extremely high statistical certainty, these simulation results thus clearly reject any notion that an effort to create a particular racial composition in one district might have warranted the extreme 13-5 Republican seat advantage observed in the Act 131 enacted plan.

In Figure C2, I similarly re-analyze all of the 500 districting plans in Simulation Set 2 in order to re-assess whether the protection of 17 House incumbents make the enacted Act 131 plan's creation of a 13-5 Republican advantage a plausible outcome under traditional redistricting principles.

Figure C2:


Simulation Set 2: 500 Simulated Plans Following
Traditional Districting Criteria and Protecting 17 Incumbents
Act 131
Enacted
Plan
Frequency Among Simulated Districting Plans
(500 Total Simulated Plans)
0
25
50
75
100
125
150
175
200
225
6.2%
34%
42.2%
17%
0.6%
7
8
9
10
11
12
13
14
Number of Districts with More Republican Than Democratic Votes
(All 2012−2016 Statewide Elections)


Simulation Set 2: 54 Simulated Plans Following
Traditional Districting Criteria and Protecting 17 Incumbents
Containing One District with Black VAP over 56.8%
Act 131
Enacted
Plan
Frequency Among Simulated Districting Plans
(54 Total Simulated Plans)
0
5
10
15
20
25
3.7%
37.04%
48.15%
11.11%
7
8
9
10
11
12
13
14
Number of Districts with More Republican Than Democratic Votes
(All 2012−2016 Statewide Elections)

The left diagram in Figure C2 compares the partisan breakdown of the 500 plans in Simulation Set 2 to the partisan breakdown of the enacted Act 131 plan, using the 2012-2016 elections to measure the number of Republican-leaning districts in each districting plan. As measured by these election results, over 99% the simulated plans all create between 8 to 11 Republican districts out of 18 total districts. As before, not a single one of the 500 simulations ever produces a plan containing 13 Republican seats. I thus conclude with overwhelmingly high statistical certainty that the enacted plan created a pro-Republican partisan outcome that would never have been possible under a districting process adhering to non-partisan traditional criteria.

The right diagram in Figure C2 illustrates that these results hold even when focusing only on the subset of the 500 plans in Simulation Set 2 that contain one district with over 56.8% African-American VAP. Among this subset, every plan creates between 8 to 11 Republican seats, as measured by the 2012-2016 statewide elections. Hence, even assuming that the General Assembly pursued both a racial districting goal and a goal of protecting 17 incumbents, I conclude with strong statistical significance that the enacted plan's creation of a 13-5 Republican advantage resulted from the General Assembly's predominant partisan intent, which subordinated adherence to traditional districting criteria. These simulation results thus clearly reject any notion that an effort to create a district with the African-American VAP composition found in District 2 might have warranted the extreme partisan bias observed in the General Assembly's enacted plan.

Together, the calculations in this Appendix confirm, using a different set of post-redistricting elections to measure partisanship, the main finding in this report that the enacted Act 131 plan creates an extreme partisan outcome that cannot be explained by Pennsylvania's voter geography, by the possible racial goals in the General Assembly's Act 131 plan, by an effort to protect 17 incumbents, or by any of the traditional districting criteria.

I hereby certify that the foregoing statements are true and correct to the best of my knowledge, information, and belief. This verification is made subject to the penalties of 18 Pa.C.S. § 4904 relating to unsworn falsification to authorities.

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November 27, 2017

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Ph.D., Political Science, Stanford University (June 2009)
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Publications:

Chen, Jowei and Neil Malhotra. 2007. "The Law of k/n: The Effect of Chamber Size on Government Spending in Bicameral Legislatures."
***American Political Science Review*. 101(4): 657-676.**

Chen, Jowei, 2010. "The Effect of Electoral Geography on Pork Barreling in Bicameral Legislatures."
***American Journal of Political Science*. 54(2): 301-322.**

Chen, Jowei, 2013. "Voter Partisanship and the Effect of Distributive Spending on Political Participation."
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Chen, Jowei and Jonathan Rodden, 2013. "Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures"
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Bradley, Katharine and Jowei Chen, 2014. "Participation Without Representation? Senior Opinion, Legislative Behavior, and Federal Health Reform."
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***Journal of Theoretical Politics*, Volume 27, No. 1: 151-174.**

Bonica, Adam, Jowei Chen, and Tim Johnson, 2015. "Senate Gate-Keeping, Presidential Staffing of 'Inferior Offices' and the Ideological Composition of Appointments to the Public Bureaucracy."
***Quarterly Journal of Political Science*. Volume 10, No. 1: 5-40.**

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***Election Law Journal.* Volume 14, Number 4: 331-345.**

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***Electoral Studies.* Volume 44 (December 2016): 329-340.**

Chen, Jowei, 2016. "Analysis of Computer-Simulated Districting Maps for the Wisconsin State Assembly."
Forthcoming 2017, *Election Law Journal*.

Research Grants:

Principal Investigator. National Science Foundation Grant SES-1459459, September 2015 – August 2017 ($165,008). "The Political Control of U.S. Federal Agencies and Bureaucratic Political Behavior."

"Economic Disparity and Federal Investments in Detroit," (with Brian Min) 2011. Graham Institute, University of Michigan ($30,000).

"The Partisan Effect of OSHA Enforcement on Workplace Injuries," (with Connor Raso) 2009. John M. Olin Law and Economics Research Grant ($4,410).

Invited Talks:

September, 2011. University of Virginia, American Politics Workshop.
October 2011. Massachusetts Institute of Technology, American Politics Conference.
January 2012. University of Chicago, Political Economy/American Politics Seminar.
February 2012. Harvard University, Positive Political Economy Seminar.
September 2012. Emory University, Political Institutions and Methodology Colloquium.

November 2012. University of Wisconsin, Madison, American Politics Workshop.
September 2013. Stanford University, Graduate School of Business, Political Economy Workshop.
February 2014. Princeton University, Center for the Study of Democratic Politics Workshop.
November 2014. Yale University, American Politics and Public Policy Workshop.
December 2014. American Constitution Society for Law & Policy Conference: Building the Evidence to Win Voting Rights Cases.
February 2015. University of Rochester, American Politics Working Group.
March 2015. Harvard University, Voting Rights Act Workshop.
May 2015. Harvard University, Conference on Political Geography.
Octoer 2015. George Washington University School of Law, Conference on Redistricting Reform.
September 2016. Harvard University Center for Governmental and International Studies, Voting Rights Institute.
March 2017. Duke University, Redistricting Reform: Mapping our Future Conference.

Conference Service:

Section Chair, 2017 APSA (Chicago, IL), Political Methodology Section
Discussant, 2014 Political Methodology Conference (University of Georgia)
Section Chair, 2012 MPSA (Chicago, IL), Political Geography Section.
Discussant, 2011 MPSA (Chicago, IL) "Presidential-Congressional Interaction."
Discussant, 2008 APSA (Boston, MA) "Congressional Appropriations."
Chair and Discussant, 2008 MPSA (Chicago, IL) "Distributive Politics: Parties and Pork."

Conference Presentations and Working Papers:

"Ideological Representation of Geographic Constituencies in the U.S. Bureaucracy," (with Tim Johnson). 2016 APSA.

"Incentives for Political versus Technical Expertise in the Public Bureaucracy," (with Tim Johnson). 2016 APSA.

"Black Electoral Geography and Congressional Districting: The Effect of Racial Redistricting on Partisan Gerrymandering". 2016 Annual Meeting of the Society for Political Methodology (Rice University)

"Racial Gerrymandering and Electoral Geography." Working Paper, 2016.

"Does Deserved Spending Win More Votes? Evidence from Individual-Level Disaster Assistance," (with Andrew Healy). 2014 APSA.

"The Geographic Link Between Votes and Seats: How the Geographic Distribution of Partisans Determines the Electoral Responsiveness and Bias of Legislative Elections," (with David Cottrell). 2014 APSA.

“Gerrymandering for Money: Drawing districts with respect to donors rather than voters.” 2014 MPSA.

“Constituent Age and Legislator Responsiveness: The Effect of Constituent Opinion on the Vote for Federal Health Reform." (with Katharine Bradley) 2012 MPSA.

“Voter Partisanship and the Mobilizing Effect of Presidential Advertising.” (with Kyle Dropp) 2012 MPSA.

“Recency Bias in Retrospective Voting: The Effect of Distributive Benefits on Voting Behavior.” (with Andrew Feher) 2012 MPSA.

“Estimating the Political Ideologies of Appointed Public Bureaucrats,” (with Adam Bonica and Tim Johnson) 2012 Annual Meeting of the Society for Political Methodology (University of North Carolina)

“Tobler’s Law, Urbanization, and Electoral Bias in Florida.” (with Jonathan Rodden) 2010 Annual Meeting of the Society for Political Methodology (University of Iowa)

“Unionization and Presidential Control of the Bureaucracy” (with Tim Johnson) 2011 MPSA.

“Estimating Bureaucratic Ideal Points with Federal Campaign Contributions” 2010 APSA. (Washington, DC).

“The Effect of Electoral Geography on Pork Spending in Bicameral Legislatures,” Vanderbilt University Conference on Bicameralism, 2009.

"When Do Government Benefits Influence Voters' Behavior? The Effect of FEMA Disaster Awards on US Presidential Votes,” 2009 APSA (Toronto, Canada).

"Are Poor Voters Easier to Buy Off?” 2009 APSA (Toronto, Canada).

"Credit Sharing Among Legislators: Electoral Geography's Effect on Pork Barreling in Legislatures,” 2008 APSA (Boston, MA).

“Buying Votes with Public Funds in the US Presidential Election,” Poster Presentation at the 2008 Annual Meeting of the Society for Political Methodology (University of Michigan).

“The Effect of Electoral Geography on Pork Spending in Bicameral Legislatures,” 2008 MPSA.

“Legislative Free-Riding and Spending on Pure Public Goods,” 2007 MPSA (Chicago, IL).

“Free Riding in Multi-Member Legislatures,” (with Neil Malhotra) 2007 MPSA (Chicago, IL).

“The Effect of Legislature Size, Bicameralism, and Geography on Government Spending: Evidence from the American States,” (with Neil Malhotra) 2006 APSA (Philadelphia, PA).

Reviewer Service:

American Journal of Political Science
American Political Science Review
Journal of Politics
Quarterly Journal of Political Science
American Politics Research
Legislative Studies Quarterly
State Politics and Policy Quarterly
Journal of Public Policy
Journal of Empirical Legal Studies
Political Behavior
Political Research Quarterly
Political Analysis
Public Choice
Applied Geography