In the Supreme Court of Pennsylvania

Middle District

No. 159 MM 2017

LEAGUE OF WOMEN VOTERS OF PENNSYLVANIA *et al.*,

Petitioners,

v.

THE COMMONWEALTH OF PENNSYLVANIA *et al.*,

Respondents.

Review of Recommended Findings of Fact and Conclusions of Law from the Commonwealth Court No. 261 M.D. 2017

BRIEF IN OPPOSITION TO PROPOSED REMEDIAL CONGRESSIONAL DISTRICTING MAPS SUBMITTED BY PETITIONERS, GOVERNOR WOLF, LIEUTENANT GOVERNOR STACK, DEMOCRATIC CAUCUS OF THE PENNSYLVANIA SENATE AND DEMOCRATIC CAUCUS OF THE PENNSYLVANIA HOUSE OF REPRESENTATIVES

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Respondents, Michael C. Turzai and Joseph B. Scarnati, III ("Legislative Respondents"), by counsel, respectfully submit this Brief in Opposition to the Proposed Remedial Congressional Districting Maps Submitted by Petitioners ("Petitioners' Map A" and "Petitioners' Map B"), Governor Wolf ("Governor"), Lieutenant Governor Stack ("Lt. Governor"), Democratic Caucus of the Pennsylvania Senate ("Senate Democrats"), and Democratic Caucus of the Pennsylvania House of Representatives ("House Democrats").

Of the six proposed maps, three are invalid and must be rejected outright. Petitioners' Map A is not contiguous. The Governor's map eliminates Pennsylvania's majority-minority district in violation of the Voting Rights Act. The House Democrats' map violates the equal population requirement. These maps violate the January 22, 2018 Order and/or federal law and cannot be adopted.

The Legislative Respondents' February 9, 2018 Joint Submission Plan is constitutional, and is the best overall plan of those submitted to the Court according to the traditional districting criteria metrics set forth in the Second paragraph of the Court's January 22, 2018 Order. The Joint Submission Plan splits the second fewest number of counties, the fewest municipalities, and the second fewest number of precincts. And it does so without sacrificing compactness and complying with equal population and Voting Rights Act requirements.

Further, the Joint Submission Plan creates the most competitive districts—seven—of *any* of the foregoing maps. The number of "Republican seats" the Joint Submission Plan generates, 10, is well within the heartland of the plans submitted and by any objective measurement generates a fair map.

The same cannot be said for the other maps. Petitioners' Maps fail to minimize municipal splits. This Court made clear that minimization of county and municipality splits was the priority, yet, Petitioners' Maps split the most communities of all the foregoing submissions. Worse, their plans both splinter one of Pennsylvania's most populous and important communities of interest—Pittsburgh, the economic and cultural center of Western Pennsylvania. Petitioners provide no justification for splitting this important community of interest (or any of their other innumerable splits). One can only conclude they are guilty of the very act they have sought to redress with this lawsuit—packing and cracking voters for a partisan gain. Also, even though Petitioners claim they did not use partisan data to draw their maps, they explicitly used partisan data in selecting their maps to achieve their desired number of presumed Democratic seats.

The Lt. Governor's and Senate Democrats' maps underreport municipal splits, and were deliberately drawn to pack Republican voters into a limited

number of uncompetitive districts and to cement a 10-8 Democratic majority in the Commonwealth's Congressional delegation.

For these reasons, more fully set forth below, the Court should adopt the Joint Submission Plan.

I. Traditional Metrics

Due to inconsistencies in the metrics submitted by some of the parties, Legislative Respondents performed calculations of the compactness, contiguity, population equality, and county, municipal, and voter tabulation district ("VTD") splits of each map using the Maptitude for Redistricting program. A report detailing the results of these calculations is attached as **Exhibit A**. In summary, these metrics revealed the following:

1. The House Democrats' map fails the population-equality requirement, which violates the "one-person, one-vote" requirement under *Reynolds v. Sims*, 377 U.S. 533 (1964), by having a population deviation amongst districts greater than 1. The remaining plans all comply with this requirement.

2. Petitioners' Map A violates the contiguity requirement. As detailed below, Petitioners' Map A draws proposed CD-16 with a portion of the district not connected to the balance of the district, rendering the map non-contiguous. The remaining plans all comply with the contiguity requirement.

3. With respect to minimizing the number of county and municipal splits, the Joint Submission Plan has the least, or second-least, number of splits in each category:

	Joint Submission	Governor	House Democrats	Senate Democrats	Stack	Petitioners' Map A	Petitioners' Map B
County	15	16	17	15	14	14	15
Municipality	17	40	18	17	18	45[1]	25[2]
VTD	17	27	15	19	20	17	20

4. The Joint Submission Plan has compactness scores that are comparable to the other plans—and the Joint Submission Plan is considerably more compact than Act 131.

These traditional districting metrics establish that the Joint Submission Plan complies with the Court's January 22, 2018 Order in all material respects, and many of the other maps do not.

II. Partisan Performance And District Competitiveness

Not only does the Joint Submission Plan fully comply with the Court's January 22, 2018 Order with respect to traditional districting criteria performance, the Joint Submission Plan produces a map that is fair and the most competitive.

[1] Petitioners assert that their map A splits 50 municipalities.
[2] Petitioners assert that their map B splits 32 municipalities.

Dr. M.V. Hood, III, a political science professor at the University of Georgia engaged by Legislative Respondents, computed a Partisan Voting Index ("PVI") consisting of all statewide election returns from 2012-2016. (Report of M.V. Hood, III (the "Hood Rep."), attached as **Exhibit B**). Dr. Hood then calculated the number of expected seats for the Joint Submission Plan and the other plans referenced above, using this neutral criteria, to compare the plans on an "apples-to-apples basis."[3] Dr. Hood was able to calculate the number of "safe" and "competitive" Republican- and Democratic-leaning seats in each plan. (Hood Rep., Tables 1-7). Dr. Hood defines a competitive district conservatively—as a district won by 5% or less of the vote. (Hood Rep. at 2 n.2). Dr. Hood's results are as follows:

Table 8. Summary of Partisan Classifications Across Proposed Plans (Party Vote Index)

Plan	Safe (D)	Competitive (D)	Competitive (R)	Safe (R)
Joint Legislative[4]	4	3	3	7
Senate	6	4	1	7
Stack	6	4	1	7
House	6	3	3	6

[3] The Executive Respondents' expert, Dr. Moon Duchin, calculated partisanship using only 2010 and 2016 U.S. Senate races—a "high-water mark" for Republican support in the Commonwealth. Dr. Pegden used only 2010 Senate returns. These ignored the 2012 U.S. Senate race, where the Democratic candidate won by 9 points. Their deliberate choice of those specific elections skewed their analysis. Dr. Chen, like Dr. Hood, relied on a 2012-2016 PVI in his analysis.

[4] District 8 was an exact tie – a 50%/50% district – and is not included in the table. Suffice to say, an even district is also "competitive."

Gubernatorial	7	0	4	7
LWV-A	5	4	2	7
LWV-B	6	3	2	7

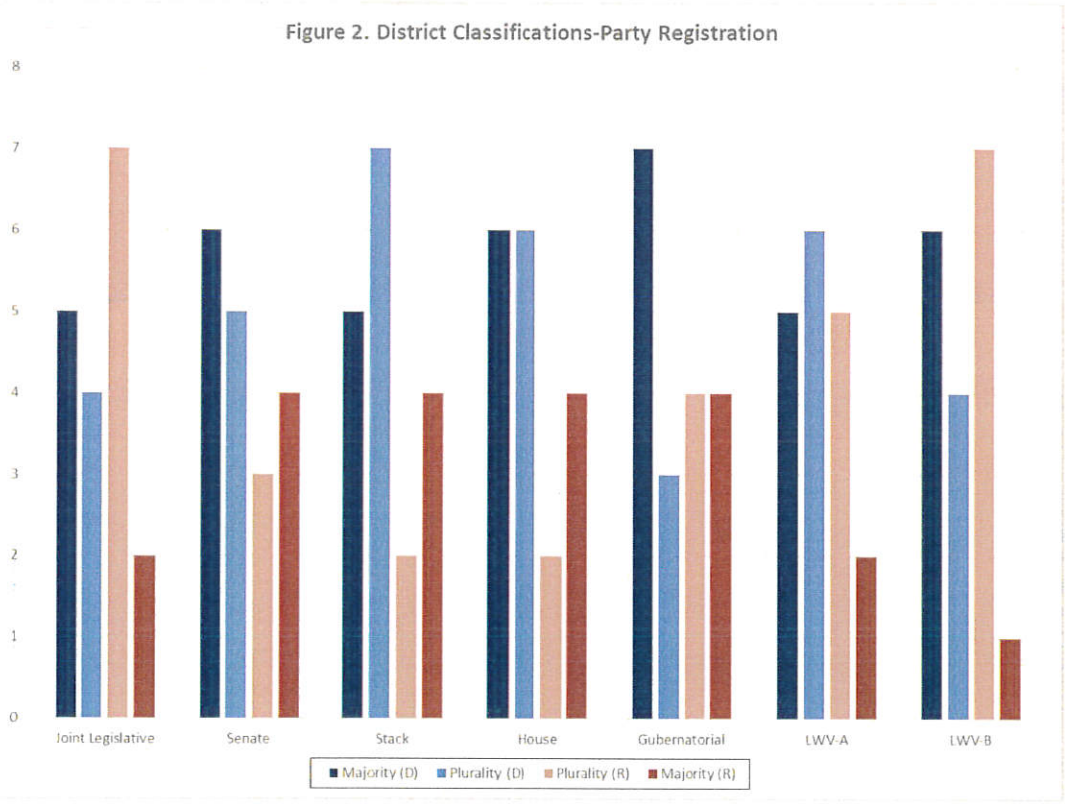
Thus, the Joint Submission Plan creates 10 expected Republican districts, seven expected Democrat districts, and one tie. (Hood Rep., Table 1). 10 expected Republican seats is within the heartland of expected Republican seats from the other plans. Moreover, the Joint Submission Plan further creates seven competitive seats—more than *any* other plan, and accounting for 39% of the total seats. (*Id.*).

In sharp contrast, the Senate Democrats' map and Lt. Governor Stack's map produce uncompetitive maps that pack Republican voters into only eight districts and create a 10-8 Democratic Congressional majority. (*Id.*, Tables 2-3). The Gubernatorial map contains the fewest number of competitive seats at four (all of which are razor-thin Republican leaning districts). (*Id.*, Table 5).

Dr. Hood conducted a similar analysis using party registration data, rather than a PVI, and this analysis likewise concludes that the Joint Submission Plan is the most fair. Across six of the plans, more than half of the districts contain a plurality or majority of Democratic registrants. (Hood Rep., Tables 9-15). For example, two-thirds of the districts under the House Democrats Plan contain a majority or plurality of Democratic registrants. (*Id.*, Table 12). Six of the districts (33%) under the House Democrats Plan contain a majority of Democratic

registrants. (*Id.*). The two plans submitted by Petitioners contain only one to two majority Republican districts by registration, while maintaining five to six majority Democrat districts. (*Id.*, Tables 14-15). The Joint Submission Plan is the sole exception to this pattern. Under that plan Democrat majority/plurality districts are evenly split with Republican majority/plurality districts, at nine a piece. (*Id.*, Table 9). Further, under the Joint Submission Plan, Democrat registrants are a majority in five districts (28%), while Republican registrants comprise a majority in only two districts (11%). (*Id.*).

The below chart from Dr. Hood's report summarizes the competitiveness of districts using party registration as follows:



In sum, the Joint Submission Plan creates the fairest districts while meeting each of the Court's mandated criteria.

III. A 9-9 Proportional Representation of Seats is Not A Fair Distribution of Congressional Seats in Pennsylvania.

Legislative Respondents note that Petitioners have claimed, using an analysis from Dr. Chen and others, that a fair distribution of seats in Pennsylvania would be to have nine Republican and nine Democrat seats. Dr. Chen, Dr. Pegden, and an expert retained by the Executive Respondents, Dr. Duchin, have all contended the Joint Submission Plan is allegedly excessively partisan and the plans of the Petitioners and the Governor are not. Aside from the fact that the U.S.

Supreme Court has expressly rejected proportional representation, a 9-9 seat share is not the "fairest" outcome in Pennsylvania.

An analysis of these claims by Dr. Wendy Cho, a political scientist and operational research scholar at the University of Illinois Champaign-Urbana demonstrates that is not true. (*See* Supplemental Report of Wendy Cho ("Cho Rep."), attached as **Exhibit C**). In examining Dr. Duchin's methodology, Dr. Cho points out that nine Democrat seats is actually quite unusual, where a map that creates seven Democrat seats—like the Joint Submission Plan—is not unusual. (Cho Rep. at 6). Moreover, Petitioners champion their 9-9 maps drafted by their expert Dr. Chen as random and drawn without using any partisan data. But in reality, Dr. Chen's simulations are not random at all. Dr. Chen's algorithm has been criticized by other experts, including Dr. Pegden—one of Petitioners' experts in this case. (*Id.* at 6-7). Using Dr. Pegden's algorithm, Dr. Cho concludes that 9-9 is not a "typical" outcome. (*Id.* at 7). In fact, using Dr. Pegden's algorithm, but using efficiency gap and seat share as the evaluative property instead of mean-median, Dr. Cho concludes that even five Democrat seats under the 2011 Plan was not an outlier. (*Id.* at 7).

IV. The Other Parties' Maps Should Not Be Selected

The foregoing analysis demonstrates why the Joint Submission Plan is the fairest map that complies with the Court's January 22, 2018 Order and should be selected. Numerous problems plague the other map submissions and make them unsuitable for the citizens of the Commonwealth. These significant shortcomings are described below.

a. Governor's Plan

Although the Court announced a new standard for evaluating the constitutionality of congressional districting plans, "[n]othing [in the majority opinion] is intended to suggest that congressional district maps must not also comply with federal law, and, most specifically, the Voting Rights Act, 52 U.S.C. § 10301." (Maj. Op. at 123 n.72). The Governor's Plan completely ignores the Voting Rights Act, eliminating Pennsylvania's only majority-minority district.

Where a minority group comprises a numerical majority of the voting-age population in an area, that minority group is "politically cohesive," and the "majority votes sufficiently as a bloc to enable it . . . usually to defeat the minority's preferred candidate," Section 2 of the Voting Rights Act requires the creation of a legislative district to prevent dilution of that group's votes. *Thornburg v. Gingles*, 478 U.S. 30 (1986); *Bartlett v. Strickland*, 556 U.S. 1

(2009). "Passage of the Voting Rights Act of 1965 was an important step in the struggle to end discriminatory treatment of minorities who seek to exercise one of the most fundamental rights of our citizens: the right to vote." *Bartlett*, 556 U.S. at 10.

Since the Voting Rights Act of 1965 was enacted, Pennsylvania has had a majority-minority district, in which African-Americans comprised a majority, in the Philadelphia region. *See In re Pennsylvania Cong. Districts Reapportionment Cases*, 567 F. Supp. 1507, 1508-11 (M.D. Pa. 1982) (discussing desire to have a predominantly African-American district within Philadelphia). Both the 2011 Plan and the Joint Submission Plan contained a majority-minority district. The Governor's Plan does not. Instead, the Governor's Plan cracks the African-American vote, frustrating the purpose of the Voting Rights Act. The percentage of Black Voting Age Population under the 2011 Plan, the Joint Submission Plan, and the Governor's Plan are depicted below:

District	% Voting Age Black 2011 Plan	% Voting Age Black Joint Submission	% Voting Age Black Governor's Plan
1	32.63%	40.34%	42.47%
2	56.70%	53.32%	44.01%

Governor Wolf can hardly claim ignorance with respect to this important consideration. In addition to the Court's explicit footnote that congressional

districting plans must comply with the Voting Rights Act, Dr. Joan Duvall-Flynn, President of the Pennsylvania NAACP State Conference, specifically requested that the new map preserve an African-American majority-minority district on February 8, 2018 (see attached **Exhibit D**). Dr. Duvall-Flynn explained:

> [A] great deal of care and consideration must be taken to prevent against both the 1st and 2nd Congressional Districts being redrawn in a way that would effectively disenfranchise the vast and robust communities of color that have historically comprised these districts.

The letter urged the Governor to:

> [W]ork collaboratively with the legislative leaders of the Pennsylvania General Assembly to ensure the character, scope and racial makeup of the 1st and 2nd Congressional Districts is preserved in a fair and equitable manner.

The Governor failed on both fronts. He did not work collaboratively with the General Assembly and he cracked African-American voters. The Governor's Plan, if adopted by the Court, would therefore invite more litigation regarding Pennsylvania's Congressional districting map. The Governor's racial gerrymander should not be adopted by the Court.

While the Governor's flouting of the Voting Rights Act is significant, it is hardly the only problem with his plan. The Governor's Plan also incorrectly reports municipal splits. While the Governor professes to have only 14 municipal

splits, *see* Gov. Br. at 12, it actually splits 40. The municipalities split under the Governor's Plan are detailed on the chart attached as **Exhibit E.**

Thus, the Governor's Plan more than doubles the 17 municipal splits proposed under the Joint Submission Plan. The Court's holding states that dividing "as few subdivisions as possible" is a "deeply rooted" criterion which serves as a "neutral benchmark" that is "particularly suitable as a measure in assessing whether a congressional districting plan dilutes the potency of an individual's ability to select the congressional representative of his or her choice." (Maj. Op. at 121). The Governor's Plan is inadequate under the Court's standard.

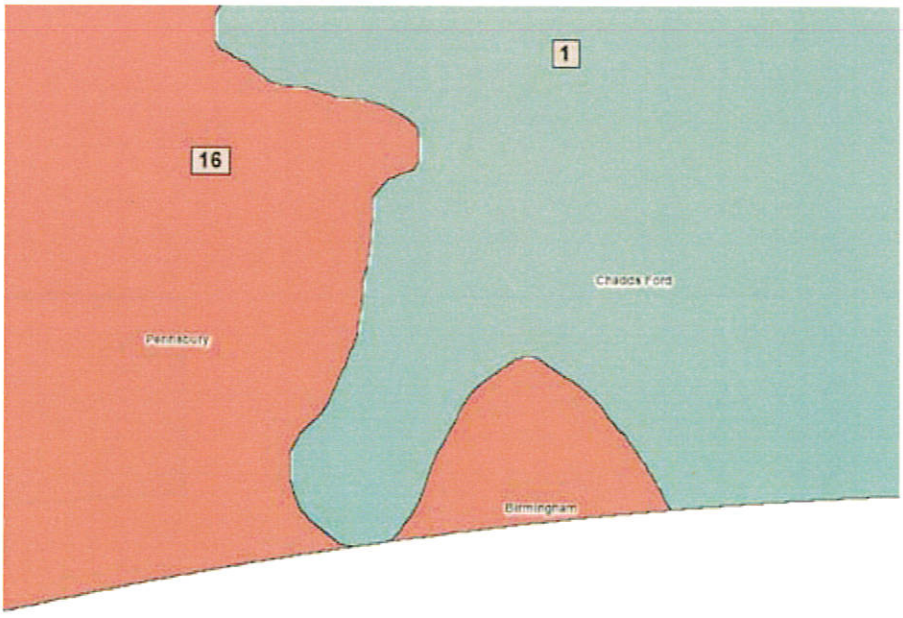
Finally, the Governor's Plan contains some of the same "geographic idiosyncrasies" that the Court discouraged in its majority opinion. For example, the Court noted that the 12th Congressional District in the 2011 Plan was a "120-mile long district that abuts four others and pitted two Democratic incumbent congressmen against one another in the next cycle's primary election, after which the victor of that contest lost to a Republican candidate who gleaned 51.2% of the general election vote." (Maj. Op. at 130). The Court viewed this as a piece of evidence which "demonstrates that the 2011 Plan subordinates the traditional redistricting criteria in service of achieving unfair partisan advantage." (Maj. Op. at 130). Yet, the 12th Congressional District under Governor Wolf's Plan stretches

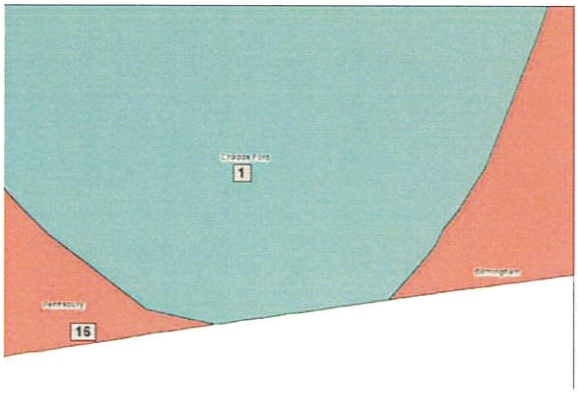
117 miles, arcing from the Ohio border around the City of Pittsburgh and southeast to the Maryland border. Whereas the 12th Congressional District abutted four other districts under the 2011 Plan, that district in the Governor's Plan abuts five. In the Joint Submission Plan, it only abuts three.

It is plain that the Governor's Plan fails to pass Constitutional muster as defined by the Court, is vastly inferior to the Joint Submission, and should be disregarded.

b. Petitioners' Maps

Petitioners' Map A does not merit any consideration by this Court because it is not even contiguous. This Court's Order requires that "any congressional districting plan shall consist of: congressional districts composed of compact and contiguous territory . . . ." (Order, 1/22/18, ¶ "Fourth"). "A contiguous district has been defined as "one in which a person can go from any point within the district to any other point [within the district] without leaving the district," or one in which "no part of the district is wholly physically separate from any other part." *Specter v. Levin*, 293 A.2d 15, 23 (Pa. 1972). Given that only 18 Congressional districts need to be created, one would think maintaining contiguity would not be too difficult. But the 16th Congressional District in Petitioners' Map A is not contiguous:





Birmingham Township in Chester County is a non-contiguous municipality. It is split by Chadds Ford of Delaware County, and the southern portion of Birmingham borders Delaware (the white region in the graphics above). By placing Chadds Ford in the 1st Congressional District and Birmingham in the 16th Congressional District, Petitioners' Map A lacks contiguity. It is impossible to travel to the southern portion of Birmingham without crossing into another Congressional district.

Just as concerning is the manner in which Petitioners' Plans were selected. Petitioners champion that both plans feature a "9-9 split" of Republican and Democrat districts. Petitioners' expert allegedly drew 500 maps, and they do not claim they used no partisan data to evaluate and select their two maps from the total 500. Under Petitioners' logic, it is inappropriate to draw districts to intentionally favor one political party, but not to draw hundreds of purported maps and intentionally *select* the one that advantages a particular political party.

Moreover, to reach their desired 9-9 seat share result, Petitioners' plans split one of Pennsylvania's most populous and important communities of interest: Pittsburgh. Pittsburgh is the economic and cultural center of Western Pennsylvania. With a population of 300,000 (less than half the population needed for each congressional district), Pittsburgh is the second largest city in the Commonwealth. By contrast, Petitioners make concerted efforts to preserve Erie County (with a smaller population) in a single district in both of their maps, while cracking the voters in Pittsburgh. Petitioners provide no justification for splitting this important community of interest. And by doing so, they are guilty of the very act they have sought to redress with this lawsuit—packing and cracking voters for a partisan gain. Indeed, redistricting plans have been historically rejected for

splitting the city of Pittsburgh. *See In re Pennsylvania Cong. Districts Reapportionment Cases*, 567 F. Supp. at 1509 (M.D. Pa. 1982).

Pittsburgh is hardly the only municipality Petitioners splinter. Rather, Petitioners' state their two proposed plans split 50 and 32 municipalities (though Legislative Respondents calculate them as 45 and 25), respectively, compared to only 17 in the Joint Submission Plan. As discussed *supra*, minimizing municipality splits is one of the Court's "deeply rooted" "neutral criteria" used to evaluate plans. (Maj. Op. at 130). On this score, both of Petitioners' Maps fall far short of the Joint Submission Plan.

c. House Democrats' Map

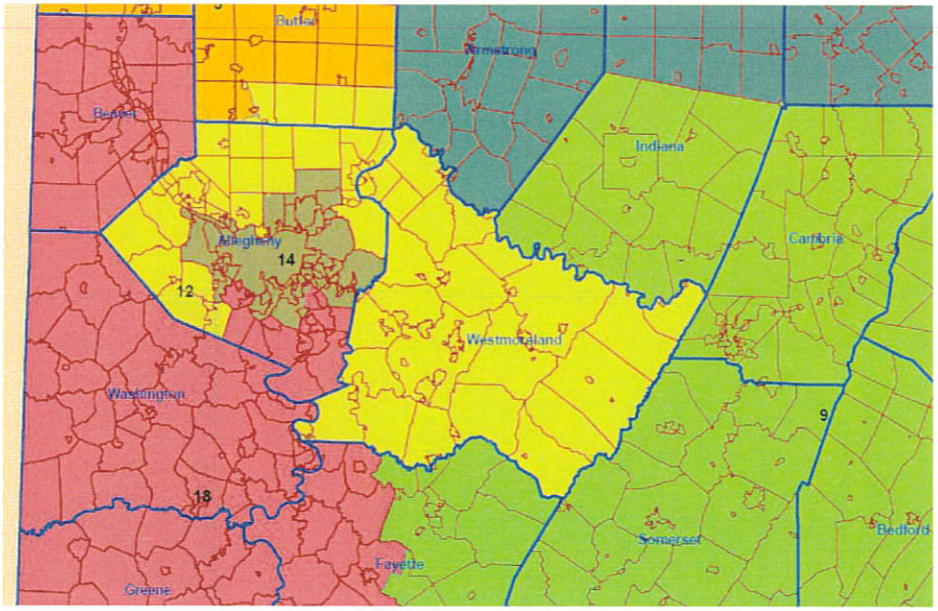
The House Democrats' plan violates the equal population "one-person, one-vote" requirement set forth by the U.S. Supreme Court. The United States Constitution requires that each congressional district in a state contain equal population. *See Wesberry v. Sanders*, 376 U.S. 1, 18 (1964) (holding that Art. I, § 2 of the Constitution requires that "as nearly as is practicable one man's vote in a congressional election is to be worth as much as another's"). The Supreme Court has been exceedingly clear in requiring lower courts to balance population among the districts with precision. *See Karcher v. Daggett*, 462 U.S. 725, 734 (1983) ("there are no *de minimis* population variations, which could practicably be

avoided, but which nonetheless meet the standard of Art. I, § 2 without justification."); *Kirkpatrick v. Preisler*, 394 U.S. 526, 531 (1969) ("The 'as nearly as practicable' standard requires that the State make a good-faith effort to achieve precise mathematical equality. Unless population variances among congressional districts are shown to have resulted despite such effort, the State must justify each variance, no matter how small."). In *Vieth v. Jubelirer*, 541 U.S. 267 (2004), the Court rejected a Pennsylvania Congressional redistricting plan with a deviation of 19 people.

This Court also recognized the importance of maintaining equal population as one of the "neutral criteria" in assessing the constitutionality of Congressional districting plans. (Maj. Op. at 120). This Court ordered that all proposed remedial maps submitted by the parties must create Congressional districts "as nearly equal in population as practicable." (Order, 1/22/18, ¶ "Fourth"). The House Democrats' plan includes districts whose population vary between 705,687 and 705,689, a variation of 2 people, rather than the constitutionally-mandated one. *See* House Democrats Ex. 5; Ex. A. Obviously, it is practicable to draw Congressional districting plans with smaller population deviation, as the Joint Submission Plan (and others) adhered to this standard. The failure to maintain equal population

among districts in the House Democrats' Plan renders the map invalid and unconstitutional.

Moreover, the House Democrats' Plan consists of the same "geographical idiosyncrasies" criticized by the Court in its majority opinion. This includes the 12th Congressional District, a district in the 2011 Plan which this Court described disapprovingly for its length (120 miles long) and the fact that it abutted four other districts. (Maj. Op. at 130). The Court viewed this as a piece of evidence which "demonstrates that the 2011 Plan subordinates the traditional redistricting criteria in service of achieving unfair partisan advantage." (Maj. Op. at 130). The 12th Congressional District under the House Democrats' plan arces around most of Allegheny County to pack Republican-leaning voters in North Fayette and Collier Township with Westmoreland County. Whereas the 12th Congressional District abutted four other districts under the 2011 Plan, that district in the House Democrats' Plan abuts five. In the Joint Submission Plan it only abuts three. Below is an image of the 12th Congressional District in the House Democrats' plan, resembling a "claw" circling around the city of Pittsburgh:



The House Democrats' Plan also splits 17 counties and 18 municipalities, both exceeding those in the Joint Submission Plan. This Court should therefore disregard the House Democrats' plan as both unconstitutional and inadequate.

d. Senate Democrats' Plan & Lt. Governor's Plan

The Senate Democrats' plan and the Lt. Governor's plan impermissibly attempt to remediate one gerrymander with another. By packing Republicans into a limited number of districts, both of these plans are guilty of using the same partisanship considerations that the Court found plagued the 2011 Plan.

The Senate Democrats' plan and the Lt. Governor's plan underreport the number of precinct splits. The Senate Democrats' plan states that it splits 11

precincts, when it actually splits 18. The Lt. Governor's plan notes that it splits 16 precincts, when it actually splits 20.

But the devil is in the details. While the Senate Democrats and Lt. Governor boast similar metrics with respect to splits and compactness as the Joint Submission Plan, the Senate Democrats and Lt. Governor accomplish that result by unnecessarily packing Republicans into only eight districts, ensuring a 10-8 Democratic majority. Justice Todd, in writing the majority, warned that the "neutral criteria" of compactness, contiguity, and maintenance of political subdivisions "is not the exclusive means by which a violation of Article I, Section 5 may be established." (Maj. Op. at 124). Instead, she recognized:

> there exists the possibility that advances in map drawing technology and analytical software can potentially allow mapmakers, in the future, to engineer congressional districting maps, which, although minimally comporting with these neutral "floor" criteria, nevertheless operate to unfairly dilute the power of a particular group's vote for a congressional representative.

Id. (emphasis in bold added).

The Senate Democrats and Lt. Governor have done just that. In effect, they have created a gerrymandered 10-8 Democratic map that reduces competitive districts—exactly the opposite of what Petitioners sought during trial and strenuously argued for before this Court. (Maj. Op. at 74). Their maps are by far the most political, joining the suburban North Hills of Pittsburgh to the City of

Allegheny in a single district, when they historically have been separated. The Joint Submission Plan would create much fairer elections.

Moreover, the Lt. Governor's plan is also improper because it injects a peculiar, personal rivalry into the drawing of its lines. While the Senate Democrats' plan and Lt. Governor's Plan are strikingly similar, one significant difference exists in the 13th Congressional District, in which Brendan Boyle is the incumbent Congressman. Again using the Maptitude for Redistricting program, the Joint Submission Plan preserves 71% of the core of the existing district, while the Senate Democrat's Plan preserves 73%. But the Lt. Governor's Plan maintains only 46%. The Stack and Boyle families have, as outlined in numerous articles over the years, become the Philadelphia political equivalent of the Hatfields and McCoys. *See* Nick Feld, *HD-170: Boyle-Stack Power Struggle Threatens Party*, POLITICS PA (Jan. 14, 2015), *at* http://www.politicspa.com/hd-170-boyle-stack-power-struggle-threatens-party/62943. This political rivalry has apparently devolved into obscene hand gestures and thrown sodas.[5] Replacing more than 50% of the electorate in Congressman Boyle's district appears to be another example of politicians picking their voters, rather than the other way around. Just as this Court

[5] *See* Ryan Briggs, *State Lawmaker: Pa. Lt. Gov. Mike Stack's Wife Flipped Me Off and Threw Soda on Me*, PHILLY.COM (Apr. 13, 2015), *at* http://www.philly.com/philly/news/politics/State_lawmaker_Pa_Lt_Gov_Mike_Stacks_wife_flipped_me_off_and_threw_soda_on_me.html.

has held that Congressional districts cannot be drawn for partisan reasons, such districts cannot be drawn for the purpose of disadvantaging a personal rival of those in power.

VI. Conclusion

For the foregoing reasons, the Joint Submission Plan complies with the Court's January 22, 2018 Order, minimizes political subdivision splits, is a fair map, and is the map that produces the greatest number of fair elections of the submissions. The Court should accordingly adopt it.

Dated: February 18, 2018

Respectfully submitted,

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EXHIBIT "A"

	Joint Submission	Governor	House Dems	Senate Dems	Stack (Rev)	LWV Map A	LWV Map B
Population Deviation Range	+/- 1	-1 to +1	-1 to +1				
Compactness - Reock	0.41	0.43	0.42	0.44	0.45	0.46	0.46
Compactness - Polsby-Popper	0.3	0.32	0.3	0.31	0.31	0.32	0.32
County Splits	15	16	17	15	14	14	15
Counties Split 2x	11	13	14	11	10	11	3
Counties Split 3x	4	3	3	4	1	3	2
Counties Split 4x	0	0	0	0	3	0	0
County Segments	33	35	37	33	33	31	32
Total MCDs Split	17	40	18	17	18	45	25
Total MCDs Split 2x	16	38	17	16	10	41	24
Total MCDs Split 3x	1	1	1	1	4	4	1
Total MCD Segments	35	82	37	35	33	93	51
Split VTDs	17	27	15	19	20	17	20
VTDs Split 2X	17	27	15	11	20	0	13
VTDs Split 3x	0	9	0	4	0	0	2
Total VTD Segments	34	60	30	33	40	34	32
BPOP for Highest District	55.48	46.73	58.4	59.21	60.2	61.48	60.78
BVAP For Highest District	53.32	44.01	55.26	56.56	58.71	57.14	57.13
BVAP for Next Highest Districts	40.34	42.47	28.76	32.99	28.91	25.27	27.38

EXHIBIT "B"

IN THE SUPREME COURT OF PENNSYLVANIA

MIDDLE DISTRICT

LEAGUE OF WOMEN VOTERS, *et al.*, **Petitioners,** **v.** **THE COMMONWEALTH OF PENNSYLVANIA, *et al.*,** **Respondents.**	**No. 159 MM 2017**

EXPERT REPORT OF M.V. HOOD III

I, M.V. Hood III, affirm the conclusions I express in this report are provided to a reasonable degree of professional certainty. I reserve the right to update the opinions contained herein prior to trial. In addition, I do hereby declare the following:

I. INTRODUCTION AND BACKGROUND

My name is M.V. (Trey) Hood III, and I am a tenured professor at the University of Georgia with an appointment in the Department of Political Science. I have been a faculty member at the University of Georgia since 1999. I also serve as the Director of the School of Public and International Affairs Survey Research Center. I am an expert in American politics, specifically in the areas of electoral politics, racial politics, election administration, and Southern politics. I teach courses on American politics, Southern politics, and research methods and have taught graduate seminars on the topics of election administration and Southern politics.

I have received research grants from the National Science Foundation and the Pew Charitable Trust. I have also published peer-reviewed journal articles specifically in the areas of redistricting and vote dilution. My academic publications are detailed in a copy of my vita that is attached to the end of this document. Currently, I serve on the editorial boards for *Social Science Quarterly* and *Election Law Journal*. The latter is a peer-reviewed academic journal focused on the area of election administration.

During the preceding six years, I have offered expert testimony in nineteen cases, *State of Florida v. United States*, 11-1428 (D.D.C.), *NAACP v. Walker*, 11-CV-5492 (Dane County Circuit Court), *League of United Latin American Citizens (LULAC) of Wisconsin v. Deininger*, 2:12-cv-00185 (E.D. Wis.), *Frank v. Walker*, 2:11-CV-01128 (E.D. Wis.), *South Carolina v. United States*, 12-203, D.D.C, *Rios-Andino v. Orange* County, 6:12-cv-01188 (M.D. Fla), *Veasey v.* Perry, 2:13-cv-193 (S.D. Tex.), *United States v. North Carolina,* 1:13-CV-861 (M.D. N.C), *Bethune-Hill v. Virginia State Board of Elections*, 3:14-cv-00852 (E.D. Va.), *The Ohio Democratic Party v. Husted,* 2:15-cv-1802 (S.D. Ohio), *The Northeast Ohio Coalition v. Husted,* 2:06-CV-00896 (S.D. Ohio), *One Wisconsin Institute v. Nichol,* 3:15-CV-324 (W.D. Wis.), *Covington v. North Carolina,* 1:15-cv-00399 (M.D. N.C.), *Green Party of Tennessee v. Hargett*, 3:11-cv-00692 (M.D. Tenn.), *Vesilind v. Virginia State Board of* Elections, CL15003886-00 (Richmond Circuit Court), *Common Cause v. Rucho*, 1:16-CV-1026 (M.D. N.C.), *Greater Birmingham Ministries v. Merrill*, 2:15-CV-02193 (N.D. Ala), *Feldman v. Arizona Secretary of State's Office*, CV-16-01065 (Ari.), and *Harding v. County of Dallas*, 3:15-CV-00131 (N.D. Tex.).

In assisting the Respondents in analyzing proposed congressional district maps for the Commonwealth of Pennsylvania, I am receiving $325 an hour. In reaching my conclusions, I have drawn on my training, experience, and knowledge as a social scientist who has specifically conducted research in the area of redistricting and vote dilution analyses. My compensation in this case is not dependent upon the outcome of the litigation or the substance of my opinions.

II. PLAN COMPARISONS

This report compares seven proposed congressional district plans: the joint legislative plan submitted to the Governor; the Democratic State Senate Plan; the revised Lt. Governor's Plan; the Democratic State House Plan; the Governor's Plan; and the two plans submitted by the petitioners. Hereafter, I may refer to these plans as the Joint Plan, Senate Plan, Stack Plan, House Plan, Gubernatorial Plan, LWV-A, and LWV-B respectively.

III. DISTRICT PARTISANSHIP

A. Vote Index

I was asked to comment on the partisan composition for seven of the proposed plans under examination. I did so in two ways. For this section I created a partisan index based on recent contested statewide races in Pennsylvania. More specifically, I calculated a partisan vote index based on the Republican share of the two-party vote from eleven statewide races. The partisan vote index was calculated by congressional district for each of the seven proposed plans under examination. In order to create the vote index I used returns from the following elections: 2012 U.S. President; 2012 U.S. Senate; 2012 Attorney General; 2012 Auditor General; 2012 Treasurer, 2014 Governor; 2016 U.S. President; 2016 U.S. Senate; 2016 Attorney General; 2016 Auditor General; and 2016 Treasurer.[1] Using a vote average also helps to mitigate against election-specific effects that may be tied to a particular candidate, election-cycle, or contest.

Since the partisan index is based on the two-party vote share, it can be easily partitioned into four categories: Safe Democrat (0.0%-44.9%); competitive Democrat (45.0-49.9%); competitive Republican (50.1%-54.9%); and safe Republican (55.0% to 100%).[2] Tables 1-7 below detail the partisan vote index by congressional district for the seven proposed plans. Table 8 and Figure 1 provide a summary of seat distributions across the seven plans.

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[1]The exact formula I used is as follows: [((R) percentage of the two-party vote for 2012 U.S. President + (R) percentage for the two-party vote for 2012 U.S. Senate + (R) percentage of the two-party vote for 2012 Attorney General + (R) percentage of the two-party vote for 2012 Auditor General + (R) percentage of the two-party vote for 2012 Treasurer + (R) percentage of the two-party vote for 2014 Governor + (R) percentage of the two party vote for 2016 U.S. President + (R) percentage of the two-party vote for 2016 U.S. Senate + (R) percentage of the two-party vote for 2016 Attorney General + (R) percentage of the two-party vote for 2016 Auditor General + (R) percentage of the two-party vote for 2016 Treasurer) / 11].

[2]Classifying competitive seats in the +/-5% range is a conservative measure of competition. Some political scientists use an even more stringent definition classifying a race won by less than 60% of the total vote (+/-10%) as being a *marginal* victory and, as such, a very competitive contest (for example see Gary Jacobson. 1987. "The Marginals Never Vanished: Incumbency and Competition in Elections to the U.S. House of Representatives, 1952-82." *American Journal of Political Science* 31(1): 126-141 and Paul S. Herrnson. 2004. *Congressional Elections*. Washington, D.C.: CQ Press).

Table 1. Partisan Classification of Pennsylvania Congressional Districts under the Joint Legislative Plan

District	Percent Republican	Classification
1	17.0%	Safe Democrat
2	8.3%	Safe Democrat
3	55.6%	Safe Republican
4	62.8%	Safe Republican
5	61.3%	Safe Republican
6	52.4%	Competitive Republican
7	49.0%	Competitive Democrat
8	50.0%	Tie
9	61.6%	Safe Republican
10	62.3%	Safe Republican
11	53.2%	Competitive Republican
12	52.2%	Competitive Republican
13	33.8%	Safe Democrat
14	29.2%	Safe Democrat
15	47.9%	Competitive Democrat
16	56.2%	Safe Republican
17	45.1%	Competitive Democrat
18	56.0%	Safe Republican

Table 2. Partisan Classification of Pennsylvania Congressional Districts under the Senate Plan

District	Percent Republican	Classification
1	19.4%	Safe Democrat
2	12.1%	Safe Democrat
3	56.9%	Safe Republican
4	61.5%	Safe Republican
5	63.9%	Safe Republican
6	49.5%	Competitive Democrat
7	44.5%	Safe Democrat
8	49.5%	Competitive Democrat
9	58.4%	Safe Republican
10	63.3%	Safe Republican
11	53.7%	Competitive Republican
12	55.6%	Safe Republican
13	33.4%	Safe Democrat
14	33.1%	Safe Democrat
15	47.9%	Competitive Democrat
16	60.6%	Safe Republican
17	43.6%	Safe Democrat
18	48.4%	Competitive Democrat

Table 3. Partisan Classification of Pennsylvania Congressional Districts under the Stack Plan

District	Percent Republican	Classification
1	18.5%	Safe Democrat
2	6.9%	Safe Democrat
3	56.9%	Safe Republican
4	61.4%	Safe Republican
5	64.0%	Safe Republican
6	48.3%	Competitive Democrat
7	39.0%	Safe Democrat
8	49.3%	Competitive Democrat
9	58.4%	Safe Republican
10	63.3%	Safe Republican
11	54.6%	Competitive Republican
12	55.6%	Safe Republican
13	44.4%	Safe Democrat
14	33.1%	Safe Democrat
15	47.9%	Competitive Democrat
16	59.7%	Safe Republican
17	43.6%	Safe Democrat
18	48.4%	Competitive Democrat

Table 4. Partisan Classification of Pennsylvania Congressional Districts under the House Plan

District	Percent Republican	Classification
1	32.3%	Safe Democrat
2	9.9%	Safe Democrat
3	54.1%	Competitive Republican
4	63.6%	Safe Republican
5	60.7%	Safe Republican
6	48.4%	Competitive Democrat
7	43.3%	Safe Democrat
8	50.2%	Competitive Republican
9	63.9%	Safe Republican
10	63.6%	Safe Republican
11	50.3%	Competitive Republican
12	56.8%	Safe Republican
13	25.7%	Safe Democrat
14	31.0%	Safe Democrat
15	46.1%	Competitive Democrat
16	62.7%	Safe Republican
17	44.1%	Safe Democrat
18	49.5%	Competitive Democrat

Table 5. Partisan Classification of Pennsylvania Congressional Districts under the Gubernatorial Plan

District	Percent Republican	Classification
1	24.0%	Safe Democrat
2	10.9%	Safe Democrat
3	52.0%	Competitive Republican
4	60.9%	Safe Republican
5	63.7%	Safe Republican
6	51.1%	Competitive Republican
7	43.2%	Safe Democrat
8	51.1%	Competitive Republican
9	61.2%	Safe Republican
10	61.0%	Safe Republican
11	56.6%	Safe Republican
12	57.0%	Safe Republican
13	30.9%	Safe Democrat
14	31.2%	Safe Democrat
15	45.0%	Safe Democrat
16	60.2%	Safe Republican
17	43.7%	Safe Democrat
18	50.4%	Competitive Republican

Table 6. Partisan Classification of Pennsylvania Congressional Districts under the LWV-A Plan

District	Percent Republican	Classification
1	37.9%	Safe Democrat
2	7.9%	Safe Democrat
3	64.0%	Safe Republican
4	60.4%	Safe Republican
5	61.0%	Safe Republican
6	57.9%	Safe Republican
7	43.7%	Safe Democrat
8	47.7%	Competitive Democrat
9	53.6%	Competitive Republican
10	58.8%	Safe Republican
11	57.9%	Safe Republican
12	46.1%	Competitive Democrat
13	22.5%	Safe Democrat
14	35.9%	Safe Democrat
15	47.7%	Competitive Democrat
16	51.4%	Competitive Republican
17	45.7%	Competitive Democrat
18	55.4%	Safe Republican

Table 7. Partisan Classification of Pennsylvania Congressional Districts under the LWV-B Plan

District	Percent Republican	Classification
1	30.4%	Safe Democrat
2	7.6%	Safe Democrat
3	57.8%	Safe Republican
4	56.2%	Safe Republican
5	66.2%	Safe Republican
6	53.3%	Competitive Republican
7	46.4%	Competitive Democrat
8	46.9%	Competitive Democrat
9	60.4%	Safe Republican
10	58.4%	Safe Republican
11	53.1%	Competitive Republican
12	42.0%	Safe Democrat
13	29.3%	Safe Democrat
14	41.1%	Safe Democrat
15	47.7%	Competitive Democrat
16	57.5%	Safe Republican
17	45.0%	Safe Democrat
18	30.4%	Safe Republican

Table 8. Summary of Partisan Classification across Proposed Plans (Party Vote Index)

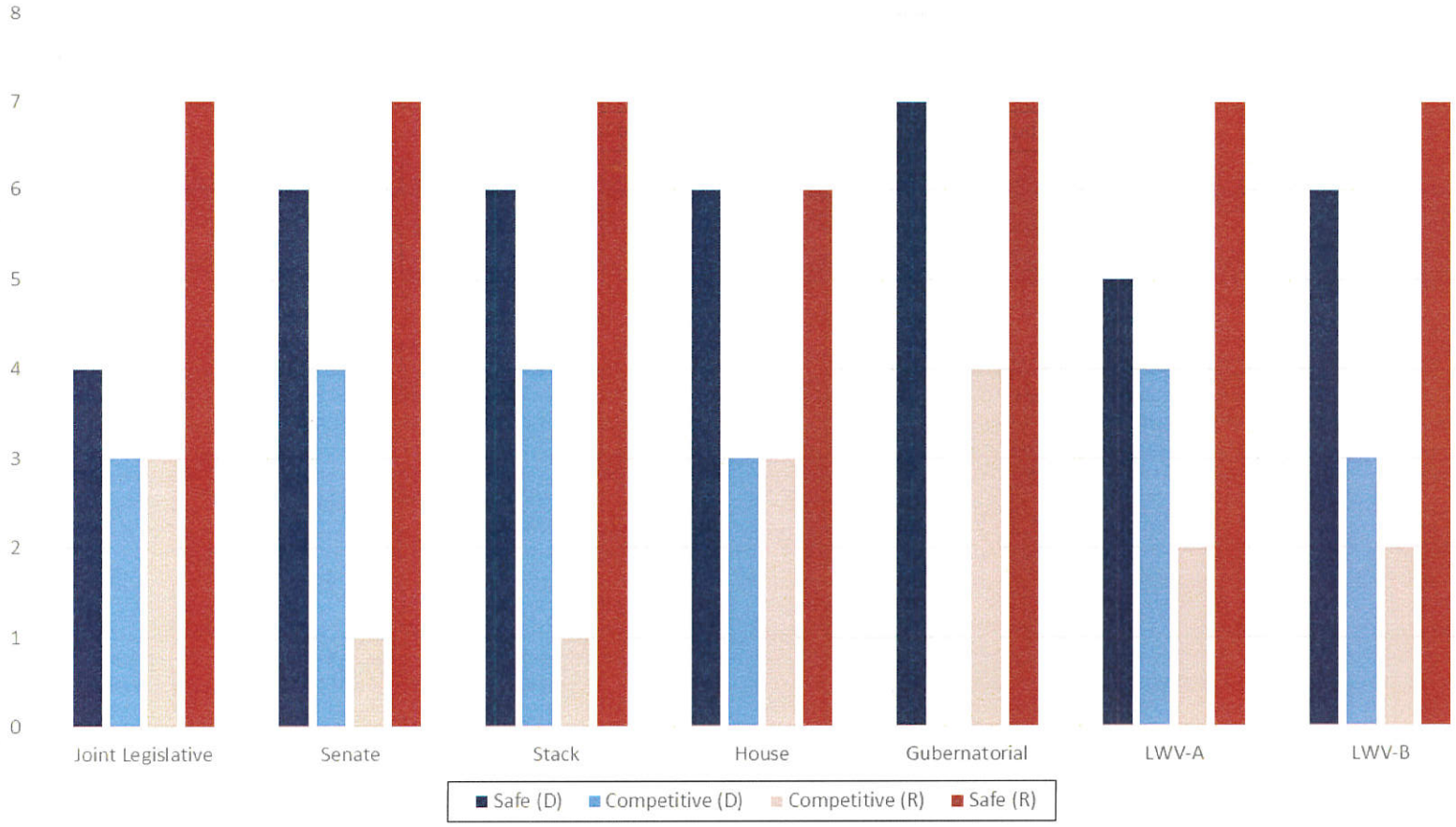
Plan	Safe (D)	Competitive (D)	Competitive (R)	Safe (R)
Joint Legislative[3]	4	3	3	7
Senate	6	4	1	7
Stack	6	4	1	7
House	6	3	3	6
Gubernatorial	7	0	4	7
LWV-A	5	4	2	7
LWV-B	6	3	2	7

Based on the computed partisan index, the Joint Legislative Plan contains four safe Democratic seats, three competitive Democratic seats, three competitive Republican seats, and seven safe Republican seats. One seat (District 8) was exactly tied on the partisan vote index at 50.0% Republican and 50.0% Democrat. As such, District 8 does not fall into either the competitive Republican or competitive Democratic categories. If one were to combine the competitive and safe categories into simply a binary classification scheme (Republican seat verses Democratic seat), the Joint Legislative Plan would be a 10-7-1 plan.

Table 8 indicates that six of the seven plans have seven safe Republican seats. The House Plan is the sole exception, containing only six safe GOP districts. The number of safe Democratic seats does vary by plan. The modal figure of six safe (D) seats is contained in four of the seven plans, with the other plans containing seven, five, and four safe Democratic seats respectively. Much of the difference between plans appears to lie with the numbers of competitive Republican and Democratic seats. The Joint Legislative Plan has seven competitive seats (three Democratic, three Republican, and one a toss-up in partisan terms). The House plan contains an even split of three competitive Democratic seats and three competitive Republican seats. The Senate and Stack Plans contain a total of five competitive seats, but only one seat in each of these plans is a competitive Republican seat. The Gubernatorial Plan contains the fewest number of competitive seats at four (all of which are Republican). The League of Women Voters Plan A contains six competitive seats (4 Democratic and 2 Republican), while Plan B contains a total of five competitive seats (3 Democratic and 2 Republican). Across the seven plans, the Joint Legislative Plan contains the greatest percentage (39%) of competitive seats.

[3]District 8 was an exact tie and is not included in the table.

Figure 1. District Classifications-Party Vote Index



B. Party Registration

I also made use of party registration data as a second method to study the partisan distribution of Pennsylvania's congressional districts under these seven proposed plans. While not every registrant in Pennsylvania is a registered as a Democrat or Republican, 86% are registered under one of the two-major parties. In Tables 9-15 I provide the distribution of party registrants, by district, for the seven proposed plans under study. I also classify each district as containing a majority of Democrats, a plurality of Democrats, a plurality of Republicans, or a majority of Republicans. A summary of these classifications by plan is located in Table 16 and Figure 2.[4]

Table 9. Party Registration of Pennsylvania Congressional Districts under the Joint Legislative Plan

District	Democratic Registrants	Republican Registrants	Classification
1	72.4%	15.6%	Majority (D)
2	81.7%	7.7%	Majority (D)
3	42.8%	44.1%	Plurality (R)
4	32.5%	52.1%	Majority (R)
5	36.0%	49.7%	Plurality (R)
6	39.6%	43.6%	Plurality (R)
7	38.2%	46.6%	Plurality (R)
8	42.5%	41.4%	Plurality (D)
9	40.7%	48.7%	Plurality (R)
10	32.9%	53.0%	Majority (R)
11	42.6%	44.3%	Plurality (R)
12	48.3%	38.8%	Plurality (D)
13	59.5%	27.7%	Majority (D)
14	66.8%	19.5%	Majority (D)
15	47.6%	35.1%	Plurality (D)
16	37.8%	46.7%	Plurality (R)
17	50.7%	35.5%	Majority (D)
18	47.7%	40.9%	Plurality (D)

[4]The Republican and Democratic percentages do not sum to 100% because some registrants are registered with no party affiliation.

Table 10. Party Registration of Pennsylvania Congressional Districts under the Senate Plan

District	Democratic Registrants	Republican Registrants	Classification
1	69.9%	17.9%	Majority (D)
2	78.0%	11.5%	Majority (D)
3	41.9%	45.5%	Plurality (R)
4	33.1%	51.4%	Majority (R)
5	33.3%	52.7%	Majority (R)
6	38.4%	45.0%	Plurality (R)
7	47.3%	36.8%	Plurality (D)
8	42.8%	40.9%	Plurality (D)
9	45.2%	43.5%	Plurality (D)
10	33.8%	53.0%	Majority (R)
11	41.5%	44.9%	Plurality (R)
12	43.7%	43.1%	Plurality (D)
13	61.2%	26.8%	Majority (D)
14	63.6%	22.5%	Majority (D)
15	47.6%	35.0%	Plurality (D)
16	32.3%	52.2%	Majority (R)
17	52.4%	33.9%	Majority (D)
18	54.7%	34.2%	Majority (D)

Table 11. Party Registration of Pennsylvania Congressional Districts under the Stack Plan

District	Democratic Registrants	Republican Registrants	Classification
1	73.7%	13.7%	Majority (D)
2	83.6%	6.6%	Majority (D)
3	41.9%	45.4%	Plurality (R)
4	33.3%	51.3%	Majority (R)
5	33.3%	52.7%	Majority (R)
6	42.9%	40.3%	Plurality (D)
7	48.0%	38.8%	Plurality (D)
8	43.0%	40.8%	Plurality (D)
9	45.2%	43.5%	Plurality (D)
10	33.7%	53.1%	Majority (R)
11	39.7%	46.6%	Plurality (R)
12	43.7%	43.1%	Plurality (D)
13	46.8%	38.4%	Plurality (D)
14	63.6%	22.5%	Majority (D)
15	47.6%	35.0%	Plurality (D)
16	33.8%	50.6%	Majority (R)
17	52.4%	33.9%	Majority (D)
18	54.7%	34.2%	Majority (D)

Table 12. Party Registration of Pennsylvania Congressional Districts under the House Plan

District	Democratic Registrants	Republican Registrants	Classification
1	57.1%	31.6%	Majority (D)
2	79.9%	8.7%	Majority (D)
3	44.3%	42.7%	Plurality (D)
4	30.7%	54.3%	Majority (R)
5	37.3%	48.6%	Plurality (R)
6	42.0%	40.9%	Plurality (D)
7	46.1%	38.4%	Plurality (D)
8	42.5%	41.3%	Plurality (D)
9	36.9%	51.6%	Majority (R)
10	32.4%	53.4%	Majority (R)
11	42.1%	42.4%	Plurality (R)
12	44.5%	42.7%	Plurality (D)
13	68.9%	18.8%	Majority (D)
14	65.5%	20.8%	Majority (D)
15	48.8%	33.2%	Plurality (D)
16	32.7%	52.9%	Majority (R)
17	54.0%	34.6%	Majority (D)
18	53.7%	35.1%	Majority (D)

Table 13. Party Registration of Pennsylvania Congressional Districts under the Gubernatorial Plan

District	Democratic Registrants	Republican Registrants	Classification
1	64.5%	24.3%	Majority (D)
2	79.4%	9.0%	Majority (D)
3	46.6%	40.6%	Plurality (D)
4	33.5%	50.9%	Majority (R)
5	35.2%	52.1%	Majority (R)
6	37.8%	45.4%	Plurality (R)
7	46.1%	38.1%	Plurality (D)
8	41.7%	41.8%	Plurality (R)
9	37.3%	49.0%	Plurality (R)
10	36.6%	50.5%	Majority (R)
11	38.0%	48.3%	Plurality (R)
12	45.1%	42.7%	Plurality (D)
13	64.4%	23.9%	Majority (D)
14	65.5%	20.9%	Majority (D)
15	51.4%	31.6%	Majority (D)
16	33.3%	51.4%	Majority (R)
17	52.2%	34.1%	Majority (D)
18	52.3%	36.2%	Majority (D)

Table 14. Party Registration of Pennsylvania Congressional Districts under LWV-A Plan

District	Democratic Registrants	Republican Registrants	Classification
1	51.1%	36.5%	Majority (D)
2	81.1%	7.2%	Majority (D)
3	36.7%	51.5%	Majority (R)
4	33.6%	50.8%	Majority (R)
5	36.6%	49.6%	Plurality (R)
6	38.7%	46.4%	Plurality (R)
7	45.7%	38.5%	Plurality (D)
8	44.4%	39.8%	Plurality (D)
9	44.5%	42.7%	Plurality (D)
10	39.1%	48.0%	Plurality (R)
11	36.3%	49.3%	Plurality (R)
12	53.0%	33.6%	Majority (D)
13	72.4%	16.8%	Majority (D)
14	62.1%	24.6%	Majority (D)
15	47.9%	34.7%	Plurality (D)
16	38.1%	44.7%	Plurality (R)
17	50.0%	36.4%	Plurality (D)
18	49.8%	39.3%	Plurality (D)

Table 15. Party Registration of Pennsylvania Congressional Districts under LWV-B Plan

District	Democratic Registrants	Republican Registrants	Classification
1	58.9%	29.1%	Majority (D)
2	81.6%	7.1%	Majority (D)
3	42.7%	44.9%	Plurality (R)
4	37.1%	47.8%	Plurality (R)
5	30.7%	56.6%	Majority (R)
6	35.6%	47.7%	Plurality (R)
7	43.9%	40.0%	Plurality (D)
8	44.1%	40.2%	Plurality (D)
9	44.1%	45.0%	Plurality (R)
10	39.2%	46.5%	Plurality (R)
11	45.2%	41.1%	Plurality (D)
12	55.2%	30.3%	Majority (D)
13	66.8%	21.6%	Majority (D)
14	59.7%	28.6%	Majority (D)
15	47.5%	34.8%	Plurality (D)
16	35.7%	48.5%	Plurality (R)
17	51.0%	35.9%	Majority (D)
18	42.3%	44.8%	Plurality (R)

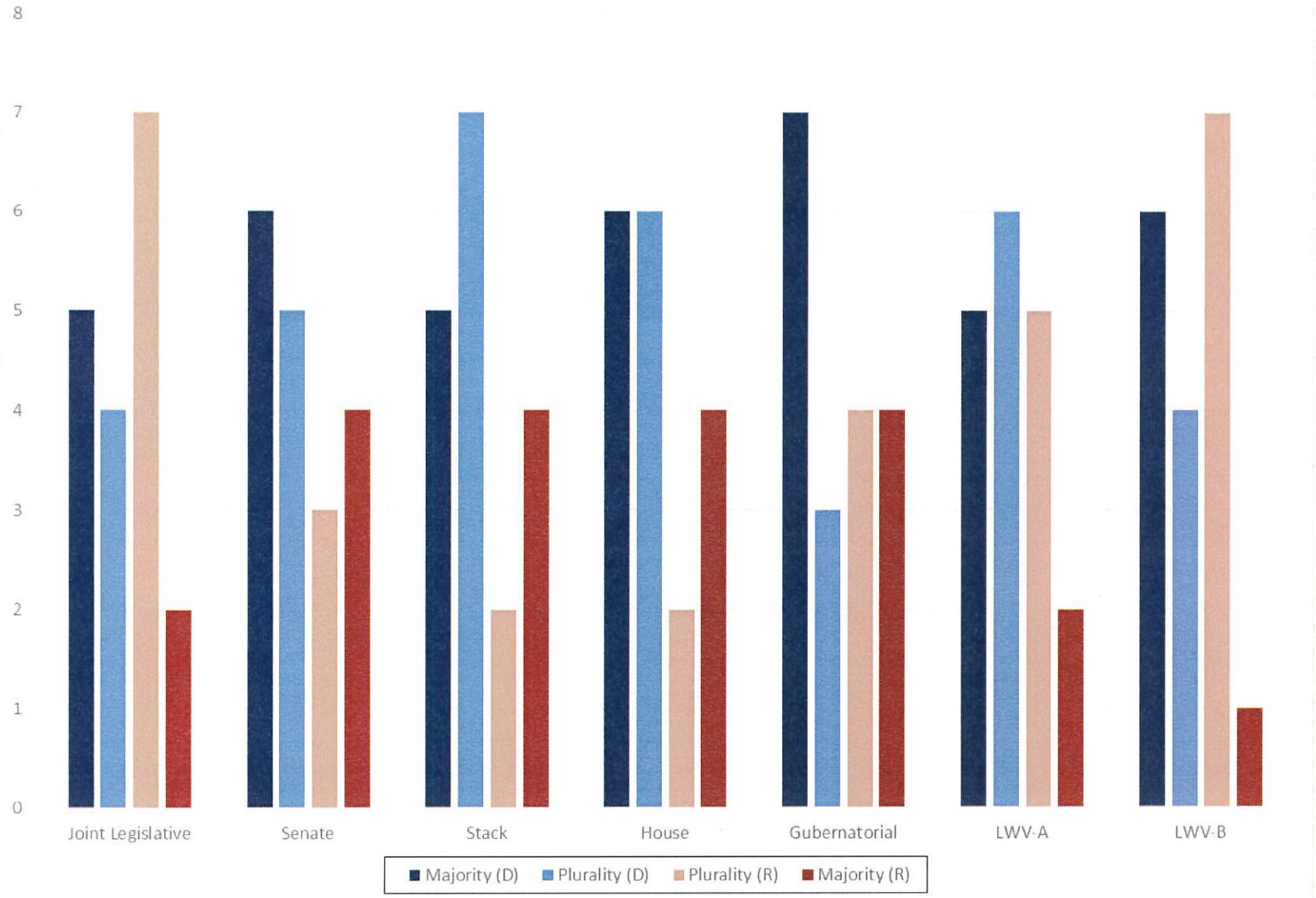
Table 16. Summary of Party Registrants across Proposed Plans

Plan	Majority (D)	Plurality (D)	Plurality (R)	Majority (R)
Joint Legislative	5	4	7	2
Senate	6	5	3	4
Stack	5	7	2	4
House	6	6	2	4
Gubernatorial	7	3	4	4
LWV-A	5	6	5	2
LWV-B	6	4	7	1

What is interesting to note is that across six plans, more than half of districts contain a plurality or majority of Democratic registrants. For example, two-thirds of the districts under the House Plan contain a majority or plurality of Democrats. Six of the districts (33%) under the House Plan contain a majority of Democratic registrants. The two plans submitted by the League of Women Voters contain only one to two majority Republican districts by registration, while maintaining five to six majority Democratic districts. The Joint Legislative Plan is the sole exception to this pattern. Under that plan Democratic majority/plurality districts are evenly split with Republican majority/plurality districts, at nine a piece. Even under this plan Democratic registrants are a majority in five districts (28%), while Republican registrants comprise a majority in only two districts (11%).

Using party registration as a metric, the raw material exists whereby Democrats should have a decided advantage in more than a majority of the state's congressional districts. Again, the exception is the Joint Legislative Plan where the party registration advantage is more evenly balanced between Democrats and Republicans.

Figure 2. District Classifications-Party Registration



IV. DECLARATION

I declare under penalty of perjury under the laws of the Commonwealth of Pennsylvania that the foregoing is true and correct to the best of my knowledge.

Executed on February 18, 2018.

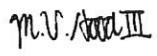


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EXHIBIT "C"

Report on Proposed Pennsylvania Plans

February 17, 2018

I am a Full Professor with appointments in the Department of Political Science, the Department of Statistics, the Department of Mathematics, the Department of Asian American Studies, and the College of Law, and a Senior Research Scientist at the National Center for Supercomputing Applications, all at the University of Illinois at Urbana-Champaign.

I have published scholarly research in the fields of political science, law, operations research, computer science, high performance computing, geography, statistics, economics, and racial and ethnic politics. My research has been supported by multiple research grants from various National Science Foundation (NSF) programs, including political science, statistics, and engineering, as well as multiple computing allocation grants on the Blue Waters Supercomputer, the fastest research supercomputer in the world, with 724,480 processor cores, and peak performance of more than 13 quadrillion calculations per second.

I have had a particular interest in redistricting for over 30 years. Recently, I was awarded a research grant from the National Science Foundation for the development of computational tools for redistricting analysis. I was also recently awarded 6.4 million normalized computing hours on the Blue Waters Supercomputer to support my computational research on redistricting. I understand and have written about redistricting from a variety of perspectives. My redistricting research has been published in many different academic fields including operations research (Liu, Cho and Wang, 2016; King et al., 2012), high performance computing (Cho and Liu, 2017, 2016*a*, 2015), engineering (Liu, Cho and Wang, 2015), law (Cho, 2017; Cain et al., 2017; Cho and Yoon, 2001, 2005), and political science (Cho and Liu, 2016*b*).

Analysis of Proposed Plans

I have been asked to comment on the plans proposed for Pennsylvania's congressional districts. I will comment on the plan submitted by Legislative Respondents (TS), the plan proposed by Governor Wolf (GOV), and the two plans submitted by Petitioners (LWV-A and LWV-B).

The analysis of these plans by Chen, Duchin, and Pegden relies heavily on a set of simulation techniques. They each conclude that the TS plan is an outlier and drawn expressly to obtain Re-

publican advantage. Dr. Chen produces plans LWV-A and LWV-B (both with a 9–9 seat split) via a simulation algorithm and claims that they are typical of plans that emerge from a non-partisan process. Pegden concurs with an analysis that relies on a different simulation technique.

Below is a table with metrics that shows how the plans fare on traditional districting principles. LWV-A splits one fewer county, though all 3 plans split a similar and fairly small number of the 67 total counties in Pennsylvania. TS splits noticeably fewer municipalities. All of the newly proposed plans improve over the Current plan on adherence to the traditional districting principles (TDP). The TS plan is arguably the best on respect for TDP.

Table 1: Adherence to Traditional Districting Principles

	. Split Counties	Split Municipalities	Split VTDs	Democratic Seats
TS	15	17	17	7
LWV-A	14	45	17	9
LWV-B	15	25	20	9
Current	28	68		5

An obvious difference between the TS plan and the LWV plans is the number of Democratic seats. There is an intuitive notion of fairness in redistricting that surrounds the concept of proportional representation (PR). The Supreme Court has repeatedly rejected PR as either a constitutional requirement or a constitutional guarantee. Nonetheless, it is difficult to dispel notions among the public that deviations from PR, even seemingly large ones, can be constitutional. In Pennsylvania, the statewide vote can be close to 50-50, which may fuel the notion that 9 Democratic seats would constitute "partisan fairness." The GOV plan has 7 Democratic districts. LVW-A has 9 Democratic seats. LWV-B has 9 Democratic seats. There is, of course, nuance in determining which seats go to which party. Some seats are competitive and not guaranteed to either party. Moreover, which statewide votes one uses to determine "partisanship" is also an issue and affords quite a bit of play. For the moment, I will accept these numbers to explore the idea of whether 9 Democratic seats is just the normative notion of fairness that pervades public discourse or if, after we consider the TDP that the Court elevates and requires, there is evidence to support the conclusion that 9 Democratic seats is what would be expected from a map drawn when considering TDPs and without partisan considerations.

One issue here is whether the TS map with fewer than 9 Democratic seats is a partisan gerrymander. Adherence to TDP does not appear to be an issue. LWV-B splits more municipalities while LWV-A splits more than twice as many municipalities as TS . One way to determine whether partisanship was the driving factor behind TS is to examine whether there were many alternative maps with the same level of adherence to TDP but had 9 Democratic seats rather than 7 Democratic seats. That is, all things equal, do we have evidence that the plan with the greatest number of Republican advantaged seats was chosen rather than focusing attention on TDP?

Assessing Partisan Fairness

Duchin employs different Markov chains in her assessment of partisan fairness. The Duchin report analyzes the TS plan, the Current plan, and the GOV plan. She compares the proposed maps to a set of alternatives from these Markov chain methods. She concludes that the TS plan is an outlier. However, when we examine the plots of her output, we see that the Markov chain methods produce *different* and conflicting comparison sets of alternative plans for comparison. That is, while comparison set A may indicate that the GOV plan is not unusual, comparison set B, generated by the same method, does indicate that the GOV plan is unusual. This raises concerns about whether this method accurately assesses outlier status.

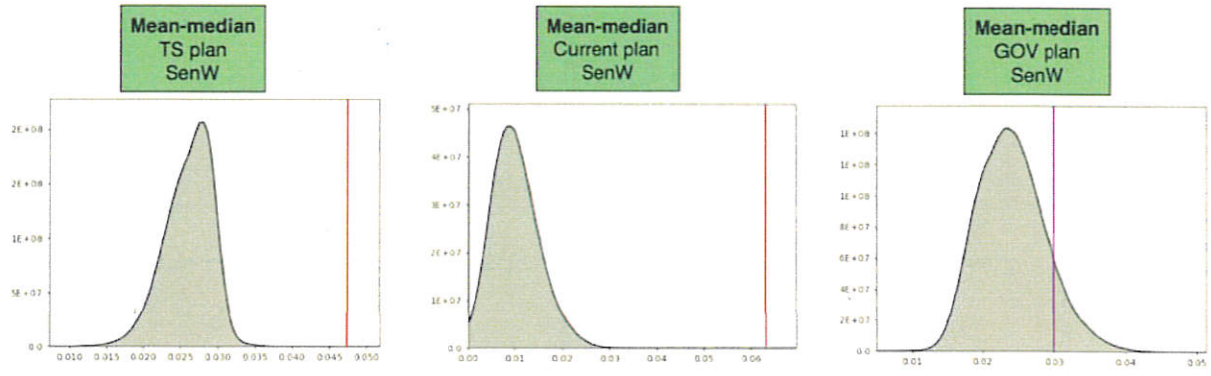

Figure 1: Duchin Mean-Median plots

Mean-Median Measure. Duchin provides two sets of histograms. One set shows how these proposed maps, along with an ensemble of maps drawn from a non-partisan process, compare on the mean-median (MM) measure. This is not an assessment of how many seats should naturally arise from a non-partisan process, but the MM is a partisan metric and is the one she chooses to provide. Her plots are reproduced in Figure 1.

For the MM, the histograms show the TS and Current map to have MMs that are not close to the ensemble of alternatives presented. On the other hand, the GOV map falls within the ensemble. Duchin states that "[o]f these districting plans, only the GOV plan falls within reasonable parameters among similar maps." Note that since the ensemble differs for each comparison, the "reasonable parameters" is a shifting standard. If we judged the Current plan and the GOV plan with the set of ensembles used to judge the Current plan, the GOV plan would also be an outlier. Indeed, if all of the ensembles were drawn in a "fair" manner using only the Court specified criteria and without partisan intent, then there is no reason for a plan to be part of a comparison set for one plan but not for another.

Notice that sometimes an MM of 0.03 falls within the "fair" set of plans while at other times, it is on the outskirts. Duchin does not offer a reason for why an MM score of 0.03 indicates that some plans are fair while another plan with the same MM score would be unfair. By the same token, sometimes an MM of 0.01 is in the middle of the fair ensemble (as for the Current map) while for the GOV ensemble, it lies completely outside the "reasonable parameters."

If we employ the ensemble used to judge the Current plan to judge the GOV plan, then the GOV plan is an outlier since it sits to the right of the distribution, which implies that it was drawn to intentionally and unjustifiably advantage the Republican party. While one might have a prior that the Republicans carefully crafted their current and TS plan for partisan gain, it seems not credible to attribute that same intent to Governor Wolf, yet that it is the implication. Since it is not credible that the GOV plan is a naked partisan attempt to favor the Republicans, these histograms call into question the process by which these ensembles were created.

Note as well that MM is highly sensitive to the underlying data that is used to calculate it. Chen reported that LWV-B has a MM score of 1.98% when 2008–2010 statewide data are used in its calculation while the MM is 2.79% when 2012-2016 statewide data are used. That is, even without a single change in the map, the MM measure can vary quite a bit just by using different data to calculate the MM. Notice in the plots that a change of almost 1% would considerably close the "large gap" between the ensemble and the TS plan.

Efficiency Gap Measure. The second set of histograms provided by Duchin show how the maps fare with the efficiency gap (EG) measure. These plots are reproduced in Figure 2. Again, the pattern that Duchin identifies is that the TS and Current plan are to the right of the ensemble EGs while the GOV plan sits well within the ensemble. The EG is also a partisan metric though

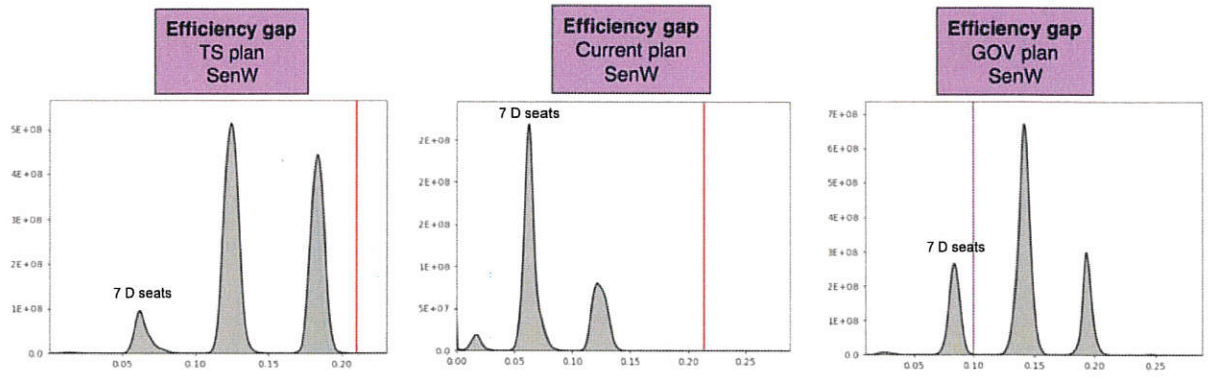

Figure 2: Duchin EG plots

also not the same as the number of seats. However, the mathematical properties of EG are such that it is closely tied to the number of seats won by each party and can easily and reliably be used as a proxy.

Electoral maps for Pennsylvania's congressional districts can take on only 1 of 18 possible EG values (Cho, 2017). That is, if we know what the value of the EG is, we can tied that value back to the number of seats won. In the EG plots, if a hump is to the right of another hump, then one more seat is judged to be a Republican seat. By the construction of the EG measure, all possible EG values must equidistant from one another. It is not possible for a plan to appear somewhere in the histogram where a hump is not possible. Hence, while the GOV plan appears to be to the right of the hump near 0.10, the line itself is more accurately placed in the center of that hump.

We know from the Table in Section 3.3 of the Duchin report that the GOV plan has 7 Democratic seats. So, in the GOV plot, the hump to the left of 0.1 corresponds to 7 Democratic seats. The tall hump to the right of that one corresponds to one more Republican seat, which amounts to 6 Democratic seats. There appears to be a very small hump to the left (almost not visible) that then corresponds 8 Democratic seats. In this analysis, the "common" fair outcome is 6 Democratic seats while 8 Democratic seats would be an uncommon outlier.

If we move to the Current plan plot, we can then deduce that the tall hump corresponds to 7 Democratic seats. The shorter hump between 0.10 and 0.15 thus corresponds to 6 Democratic seats. Since the humps must be equidistant from one another, 5 Democratic seats should appear just to the left of 0.20 (though apparently no plans with 5 Democratic seats were identified in this set of a billion maps). Given this information, we can deduce that the hump on the right in the TS

plot corresponds to 5 Democratic seats. The line, which appears to the right of this hump, should thus appear more accurately in the middle of this hump since the TS plan has 5 Democratic seats. Hence, while it appears to be an outlier and outside of the entire set of billion maps, it actually is well within the set, indicating that it is not an outlier with respect to the "fair ensemble" presented.

We also notice a discrepancy between the conclusions of what would constitute fair from the three EG histograms. In the TS and Current plots, it appears that 5 Democratic seats is unusual and "visibly extreme." However, in the GOV plot, 5 Democratic seats is as common as 7 seats while 6 Democratic seats is even more common.

These plots show that 9 Democratic seats is quite unusual when the Markov chain methods (either MCMC or Pegden's reversible Markov chain) are used to generate plans that consider only TDPs and not partisanship. At the same time, 7 Democratic seats is not unusual.

Conditional Fairness. Duchin states that "These pictures all have all of the cited districting principles turned ON, and each plot has over a billion maps in it." While this statement may be true, it is also plain that while each set of "a billion maps" is created from the same non-partisan process that "completely controls for voter distribution effects on any partisan outcomes," the set of billion maps that is used as a comparison set differs for each plan. The particular set used in each instance has consequences for the conclusions one might draw. In any case, her analysis confirms that 7 Democratic seats would not be an unusual outcome if Markov chain methods are used to draw alternative districts.

The "Fair" Division of Seats

Both LWV-A and LWV-B are 9 seat plans. Both of these plans are created via Dr. Chen's simulation algorithm. The argument favoring these plans is that the algorithm "was programmed to follow the traditional districting principles... The algorithm also intentionally ignored all partisan and racial considerations, including the protection of incumbents." Dr. Chen then proceeds to provide a histogram of 500 maps drawn via this process. In his histogram, the majority of his simulated maps have a 9–9 seat split. The implication is that 9–9 is not an arbitrary choice or one driven by a desire for PR, but is the natural and typical outcome of a non-partisan drawing process.

He provides no theoretical justification for his simulation method, so it is unclear how one might justify it in a statistically rigorous manner. As well, the heuristic strategy that he employs

has been criticized in the scholarly community and notably in print by Dr. Pegden. Nonetheless, one way in which we might explore the credibility of a 9–9 split being typical is to examine what emerges from other non-partisan procedures. While this is a far cry from a theoretical validation, we would at least feel more at ease if the outcomes were all similar.

As explained earlier, Dr. Duchin uses two different Markov chain approaches to generate maps that take traditional districting principles into account, but not partisan ones. We have already seen from Dr. Duchin's analysis, however, that the GOV map had only 7 Democratic seats, which would be an outlier in Dr. Chen's ensemble. From her outlier analysis, 9 Democratic seats was not common, and certainly not modal as it was in Dr. Chen's simulation set. The two simulation techniques provide conflicting evidence regarding the typical number of Democratic seats that should emerge from a non-partisan drawing process.

One of the Markov chain approaches employed by Dr. Duchin is the one created by Dr. Pegden. Dr. Pegden also provides analysis from his method, though he reports his output differently. Dr. Pegden provides the code to run his algorithm. It can be freely downloaded from his website. I downloaded the code and ran the algorithm beginning with the current plan for 2^{30} steps. This generated a very large set of maps simulated by Dr. Pegden's algorithm, which uses traditional districting principles, but not partisanship in drawing districts. The output I generated was similar to what Dr. Pegden reported for the Current plan. In my analysis using Dr. Pegden's code, the current plan was an outlier *if* the metric employed is MM. However, the Current plan, with 5 Democratic districts was *not* an outlier if one uses the efficiency gap as the partisan measure. As well, its test of whether 5 *seats* is an outlier was also rejected, giving us further evidence that 9–9 is not a "typical" outcome. It may be a possible outcome, but scant evidence exists that it is a typical outcome or one that would be required by the Constitution. The p-values from the analysis using Pegden's algorithm are shown in the Table below.

Table 2: Reversible Markov Chain Outlier Analysis

Map	Steps	Metric	ε	p
Current	2^{30}	MM	0.00000000014	0.000017
Current	2^{30}	EG	0.01453	0.17
Current	2^{30}	seats	0.18043	0.60

Dr. Pegden does state in the documentation for his code that "not all choices allowed by the program are equally reasonable. For example, metrics based on the efficiency gap and seat count are insensitive to small changes when the number of districts is small (say, < 50)." However, this is not a reference to whether it is interesting or germane to examine the EG or the seat change. For redistricting, this is an obviously very important substantive question. Dr. Pegden's "reasonable" statement has mathematical origins, not substantive ones and is not rooted in a substantive understanding of redistricting. It is a problem with mathematical translation of the substantive problem.

His Markov chain procedure changes only one VTD at a time. Hence, many many of his maps are substantively identical. When we look at the seat change or EG, these metrics reflect that the maps are substantively identical, as they should. This is not a substantive problem. He prefers the use of MM in this case because even when a single VTD is moved, the MM value changes. His procedure then "counts" this as a substantive difference. If there are 10,000 maps in his analysis that differ from the Current plan by one VTD, even though these 10,000 map are substantively identical, the analysis reports them as mathematical distinct, which to any actual redistricting practitioner is substantively incorrect. That is, Pegden's discouragement to use EG or seat change is removed from the reality of redistricting maps and how we understand what matters in redistricting. It is true that the mean-median difference will change for even small changes to a map, like shifting one VTD, but these changes, while resulting in different mathematical quantities, often far past the first few decimal places, are not politically consequential or interesting. For the very interesting question of seat change, his algorithm reports that the Current map is not an outlier.

Sincerely,

Wendy K. Tam Cho
Professor
Department of Political Science
Department of Statistics
Department of Mathematics
Department of Asian American Studies

College of Law

Senior Research Scientist
National Center for Supercomputing Applications

University of Illinois at Urbana-Champaign

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EXHIBIT "D"

NATIONAL ASSOCIATION FOR THE ADVANCEMENT OF COLORED PEOPLE
PENNSYLVANIA STATE CONFERENCE
P. O. BOX 922 • LEVITTOWN, PA 19058-0922
Website: www.pastatenaacp.org

February 8, 2018

Honorable Tom Wolf, Governor
Commonwealth of Pennsylvania
225 Main Capitol Building
Harrisburg, PA 17120

Re: Preservation of Pennsylvania's 1st and 2nd Congressional Districts

Dear Governor Wolf:

On behalf of the entire membership of the NAACP Pennsylvania State Conference, we urge both you and the legislative leaders of each of the Pennsylvania General Assembly's four legislative caucuses to exercise the utmost circumspect as you all collectively undertake the task of redrawing our Commonwealth's Congressional maps, per the recent and respective rulings of both the Pennsylvania Supreme Court and the United States Supreme Court.

Specifically, our membership wishes to emphasize that in addition to ensuring that our Congressional districts are drawn in a manner which ensures that districts are equal in population as is humanly practicable, that a great deal of care and consideration must be taken to prevent against both the 1st and 2nd Congressional Districts being redrawn in a way that would effectively disenfranchise the vast and robust communities of color that have historically comprised these districts.

To underscore the foregoing assertion, based upon the latest data provided by the U.S. Census Bureau, the 1st Congressional District has the following demographic makeup: 25.7 percent white, 46.6 percent black, 6.4 percent Asian and 19.3 percent Hispanic. In addition, the 2nd Congressional District has the following demographic makeup: 31 percent white, 58.6 black, 4.6 percent Asian and 5.54 percent Hispanic. It is also worth noting that both Congressional Districts combined have a total population that exceeds 1,405,000 southeastern Pennsylvanians, which includes many residents of color from Philadelphia County and other adjacent counties. These two districts can be easily drawn with contiguity and break no municipalities by being drawn inside the city limits of Philadelphia.

To be clear, while our membership certainly applauds your outstanding leadership on the critically important issue of redistricting, our purpose of contacting you directly is that we did not want to commit the following of presuming that 1st and 2nd Congressional Districts would not be subject to any drastic mapping changes.

As an organization that represents more than 10,000 plus card-carrying members in every corner of the Commonwealth, we would be negligent in upholding the tenets of our mission if we were not proactive in communicating our collective concerns about the unintended the consequences that would be engendered by depriving the citizens of color of the Congressional representation that best reflects their values, ethos and political interests. Therefore, considering the foregoing, our membership urges you to please work collaboratively with the legislative leaders of the Pennsylvania General Assembly to ensure the character, scope and racial makeup of the 1st and 2nd Congressional Districts is preserved in a fair and equitable manner.

In closing, on behalf of the Pennsylvania NAACP State Conference, I would like to thank you for your consideration of this correspondence and your continued leadership on the issues that most acutely impact our Commonwealth's communities of color. Should you wish to discuss this matter at further length with either myself or our membership, please feel free to contact me at (610) 358-1582 or duvallflynn@yahoo.com.

Sincerely,

Joan Duvall Flynn

Dr. Joan Duvall-Flynn, President
PA NAACP State Conference

Cc: Mike Brunelle, *Chief of Staff to the Governor*

Hon. Mike Turzai, *Speaker of the House of Representatives*

Hon. Joseph B. Scarnati, *President Pro Tempore of the Senate*

Hon. Dave Reed, *House Majority Leader*

Hon. Jake Corman, *Senate Majority Leader*

Hon. Frank Dermody, *House Democratic Leader*

Hon. Jay Costa, *Senate Democratic Leader*

EXHIBIT "E"

Plan Name: PACD_2018_Governor-VTD_RB16a
Plan Type:
Administrator:

Political Subdivisions Split Between Districts

Friday February 16, 2018 7:18 AM

Number of subdivisions not split:

County	51
County Subdivision	2,535

Number of subdivisions split into more than one district:

County	16
County Subdivision	40

Number of subdivision splits which affect *no* population:

County	0
County Subdivision	1

Split Counts

County

Cases where an area is split among 2 Districts: 13
Cases where an area is split among 3 Districts: 3

County Subdivision

Cases where an area is split among 2 Districts: 38
Cases where an area is split among 3 Districts: 2

County	County Subdivision	District	Population
Split Counties :			
Allegheny PA		12	195,085
Allegheny PA		14	705,688
Allegheny PA		18	322,575
Beaver PA		3	86,795
Beaver PA		12	83,744
Berks PA		6	64,981
Berks PA		15	218,608
Berks PA		16	127,853
Bucks PA		8	545,535
Bucks PA		13	79,714
Centre PA		5	84,293
Centre PA		9	69,697
Cumberland PA		4	169,309
Cumberland PA		11	66,097
Delaware PA		1	417,158
Delaware PA		6	141,821

Plan Name: PACD 2018 Governor-VTD RB16a Administrator:
Plan Type: User:

County	County Subdivision	District	Population
Split Counties (continued):			
Lebanon PA		11	75,179
Lebanon PA		16	58,389
Lehigh PA		8	113,428
Lehigh PA		15	236,069
Luzerne PA		10	109,700
Luzerne PA		17	211,218
Mifflin PA		9	152
Mifflin PA		11	46,530
Montgomery PA		7	705,688
Montgomery PA		13	94,186
Northampton PA		8	46,725
Northampton PA		15	251,010
Philadelphia PA		1	288,530
Philadelphia PA		2	705,687
Philadelphia PA		13	531,789
Somerset PA		9	16,053
Somerset PA		12	61,689
Tioga PA		5	1,886
Tioga PA		10	40,095
Split MCDs :			
Allegheny PA	Baldwin PA	14	11,823
Allegheny PA	Baldwin PA	18	7,944
Allegheny PA	Carnegie PA	14	237
Allegheny PA	Carnegie PA	18	7,735
Allegheny PA	Clairton PA	14	1,764
Allegheny PA	Clairton PA	18	5,032
Allegheny PA	Indiana PA	12	6,747
Allegheny PA	Indiana PA	14	506
Allegheny PA	Jefferson Hills PA	14	7,885
Allegheny PA	Jefferson Hills PA	18	2,734
Allegheny PA	Kennedy PA	14	5,817
Allegheny PA	Kennedy PA	18	1,855
Allegheny PA	Plum PA	12	22,824
Allegheny PA	Plum PA	14	4,302
Allegheny PA	Whitehall PA	14	5,951
Allegheny PA	Whitehall PA	18	7,993
Beaver PA	New Sewickley PA	3	3,577
Beaver PA	New Sewickley PA	12	3,783
Berks PA	Cumru PA	6	6,164
Berks PA	Cumru PA	15	6,473
Berks PA	Cumru PA	16	2,510
Berks PA	Exeter PA	6	11,275
Berks PA	Exeter PA	15	14,275
Berks PA	Maidencreek PA	15	2,552
Berks PA	Maidencreek PA	16	6,574
Berks PA	Muhlenberg PA	15	10,588
Berks PA	Muhlenberg PA	16	9,040
Berks PA	Ontelaunee PA	15	241
Berks PA	Ontelaunee PA	16	1,405

County	County Subdivision	District	Population
Split MCDs (continued):			
Berks PA	South Heidelberg PA	6	28
Berks PA	South Heidelberg PA	16	7,243
Berks PA	Spring PA	6	4,021
Berks PA	Spring PA	16	23,098
Bucks PA	Bristol PA	8	35,298
Bucks PA	Bristol PA	13	19,284
Bucks PA	Bristol PA-2	8	9,723
Bucks PA	Bristol PA-2	13	3
Centre PA	Patton PA	5	5,338
Centre PA	Patton PA	9	9,973
Cumberland PA	Hampden PA	4	15,316
Cumberland PA	Hampden PA	11	12,728
Cumberland PA	Lower Allen PA	4	7,627
Cumberland PA	Lower Allen PA	11	10,353
Delaware PA	Aston PA	1	2,311
Delaware PA	Aston PA	6	14,281
Delaware PA	Haverford PA	1	35,761
Delaware PA	Haverford PA	6	12,730
Delaware PA	Marple PA	1	3,589
Delaware PA	Marple PA	6	19,839
Lebanon PA	West Cornwall PA	11	938
Lebanon PA	West Cornwall PA	16	1,038
Lehigh PA	Salisbury PA	8	8,181
Lehigh PA	Salisbury PA	15	5,324
Lehigh PA	South Whitehall PA	8	5,047
Lehigh PA	South Whitehall PA	15	14,133
Luzerne PA	Newport PA	10	5,008
Luzerne PA	Newport PA	17	366
Luzerne PA	Plymouth PA	10	1,030
Luzerne PA	Plymouth PA	17	782
Mifflin PA	Menno PA	9	152
Mifflin PA	Menno PA	11	1,731
Montgomery PA	Abington PA	7	25,920
Montgomery PA	Abington PA	13	29,390
Montgomery PA	Cheltenham PA	7	13,194
Montgomery PA	Cheltenham PA	13	23,599
Montgomery PA	Upper Moreland PA	7	4,140
Montgomery PA	Upper Moreland PA	13	19,875
Northampton PA	Bethlehem PA	8	15,174
Northampton PA	Bethlehem PA	15	8,556
Northampton PA	Palmer PA	8	8,557
Northampton PA	Palmer PA	15	12,134
Philadelphia PA	Philadelphia PA	1	288,530
Philadelphia PA	Philadelphia PA	2	705,687
Philadelphia PA	Philadelphia PA	13	531,789
Somerset PA	Central City PA	9	1,124
Somerset PA	Central City PA	12	0
Somerset PA	Conemaugh PA	9	5,000
Somerset PA	Conemaugh PA	12	2,279

Plan Name: PACD 2018 Governor-VTD RB16a Administrator:
Plan Type: User:

County	County Subdivision	District	Population
Split MCDs (continued):			
Somerset PA	Shade PA	9	927
Somerset PA	Shade PA	12	1,847
Tioga PA	Westfield PA	5	401
Tioga PA	Westfield PA	10	646