Artificial partisan advantage in redistricting°

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Abstract

I propose a measure of artificial partisan advantage in redistricting. Redistricting is the process of drawing electoral district maps. Electoral outcomes depend on the maps drawn. The measure I propose is to compare the seat share won by a party to the share of the population that lives in counties won by this party. If a party has a larger share of seats than the share of the population in counties in which the party won most votes, then the drawing of the electoral maps conferred an artificial advantage to this party. This measure takes into account the geographic sorting of partisan voters and is simple to compute. Using U.S. election data from 2012 to 2018, I find an artificial partisan advantage of sixteen House seats to the Republican party. I argue that the artificial partisan advantage in the congressional maps of North Carolina, Utah, Michigan and Ohio is excessive.

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In some democracies, including the United States, representatives to a legislative assembly are elected by drawing electoral districts and electing in each district a single legislator to represent the district.[1] In order to preserve an equal population across districts, the boundaries of these districts must change with population changes. Redistricting is the process of drawing maps that partition a given polity (a country, a state, etc.) into electoral districts.

In the United States, redistricting typically occurs every ten years, following a decennial population census. Because electoral outcomes depend on how the district maps are drawn, those in charge of redistricting have incentives to draw maps that advance their own electoral goals. The practice of drawing district maps to favor one party or class is called "gerrymandering."

In 1986, the US Supreme Court held that maps that confer too much partisan advantage to one party are unconstitutional. However, the Court could not agree upon a test or measure of partisan advantage.[2] In 2019, while the Court conceded that "*excessive partisan gerrymandering*" is "*unjust*" and *"incompatible with democratic principles"*, it ruled that "*none of the proposed tests for evaluating partisan gerrymandering claims meets the need for a limited and precise standard"* and hence that gerrymandering claims cannot be addressed in federal courts.[3] The Court suggested that gerrymandering should be addressed instead by the States, litigating in

[1] The United Kingdom uses this system, as do several other countries with a legacy of British rule, such as India and Canada.

[2] *Davis vs Bandemer* 478 U.S. 109 (1986). The Court reached a similar ruling in *Vieth vs Jubelirer* 541 U.S. 267, 310-311 (2004) and in *League of United Latin American Citizens vs Perry* 548 U.S. 399 (2006), holding that a satisfactory measure might emerge in the future.

[3] The quotes are from the summary of *Rucho v. Common Cause*, No. 18-422, 588 U.S. ___ (2019).

state courts under the guidance of state legislation, as in Florida (2015) or Pennsylvania (2018).[4] Fourteen states (California, Colorado, Delaware, Florida, Hawaii, Idaho, Iowa, Michigan, Missouri, Montana, New York, Ohio, Oregon and Washington) include explicit provisions against partisan advantage in redistricting in their state constitutions. I provide a summary of these provisions and a link in the online appendix

Traditional notions of partisan advantage (discussed below) measure the partisan asymmetry in how votes translate to seats without addressing a key question: can some (or all?) of the partisan advantage be explained by the geographic sorting of voters? Indeed, for any map with compact districts, a party with many of its voters concentrated into a small area obtains fewer seats than if its voters are better dispersed over much of the state.

I propose a precise and limited notion of partisan advantage that accounts for the natural advantage due to population sorting, and measures only the artificial partisan advantage caused specifically by the chosen redistricting map. The measure of *artificial partisan advantage* compares the seats that a party obtains to the seats that the party would obtain if seats were assigned in proportion to the population residing in counties in which the party won the popular vote.

County lines are mostly fixed, and not subject to redistricting. The measure of artificial partisan advantage credits each party for the population of any county in which it wins the

[4] The Florida and Pennsylvania supreme courts respectively ruled that the 2011 Florida and Pennsylvania congressional maps were partisan gerrymanders and ordered them replaced in *League of Women Voters of Florida v. Detzner* 172 So. 3d 363 (2015) and *League of Women Voters of Pennsylvania v. Commonwealth of Pennsylvania* 178 A.3d 737 (2018).

popular vote. This accounts for the sorting advantage: a party with a sorting advantage will win more counties, and hence it will earn more seats according to this measure. Seats won in the election in excess to those that would accrue according to county lines are evidence of an artificial partisan advantage derived from the drawing of favorable redistricting maps.

The most prominent measure of partisan advantage is the concept of "partisan bias" (Butler 1951 and 1952). The partisan bias for a Party *A* over a Party *B* at a vote share *x* is the difference between the number of seats Party *A* obtains if it gets vote share *x* and the number of seats Party *B* gets if *B* gets vote share *x*. Computing these numbers for each *x,* we draw the "vote-to-seats" curve for each party.[5]

Other concepts of partisan asymmetry include: the "efficiency gap", which compares the number of wasted votes for each party (McGhee 2014; Stephanopoulos and McGhee 2015); the mean-median vote share difference, which compares the vote share in the state to the vote share in the median district (McDonald and Best 2015; Wang 2016); and the declination, which compares the distribution of vote shares above and below 50% (Warrington 2018).

These measures of asymmetry do not distinguish if the asymmetry or bias is due to the redistricting maps, or to the geographical distribution of each party's voters. If the distribution of seats is asymmetric due to the location of voters, then the existence of partisan bias is not evidence that the redistricting maps are flawed. As expressed by Justice Scalia's plurality Opinion in 2004: "*Consider, for example, a legislature that draws district lines with no objectives in mind*

[5] See Tufte (1973), Grofman (1983), King and Browning (1987) among several influential contributions; and Katz, King and Rosenblatt (2019) for a recent overview.

except compactness and respect for the lines of political subdivisions. Under that system, political groups that tend to cluster (as is the case with Democratic voters in cities) would be systematically affected by what might be called a 'natural' packing effect."[6]

The artificial partisan advantage measure embraces this logic: the partisan bias that would arise from aggregating votes by political subdivisions (specifically counties) is "natural," and what we need to measure is the partisan advantage that a map generates in addition to this natural advantage. This additional advantage is exactly what the artificial partisan advantage measures.

An alternative -more computationally heavy- approach is to compare the seat outcomes given the state's chosen redistricting map to the distribution of outcomes over a large set of randomly generated computer-simulated maps (Chen and Rodden 2013; Cho and Liu 2016; Duchin 2018). This approach also identifies the partisan advantage net of any natural advantage due to sorting. A technical drawback is that it is difficult to define the set of all possible maps, and it is also difficult to devise a truly random algorithm to draw a sample of maps.[7]

This computational approach uses all possible admissible redistricting maps that satisfy certain criteria as a comparison group. In contrast, the artificial partisan advantage measure constructs a benchmark using a state's county map.[8] The seat benchmark generated by the

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[6] Justice Scalia's plurality Opinion in *Vieth v. Jubelirer*, 541 U.S. 267, 290 (2004).

[7] See a discussion of the technical challenges of simulation methods, and a broader survey of measures of partisan gerrymander in Burden and Smidt (2019).

[8] Saxon (2018) proposes a different benchmark, using instead the most compact map. For compactness in redistricting, also see Chambers and Miller (2010).

county map has the following normative interpretation: it is the representation that the state would attain if it avoided redistricting altogether, by electing a representative per county, and adjusted for population differences by assigning voting weights to each county in proportion to its population.[9] The need to draw redistricting maps arises from the requirement that each district have one representative with one vote; the normative underpinning of the artificial partisan advantage nature is that this one-member-per-district constraint should not change the balance of power that would have materialized without it in the assembly.

I next formally define the measure of artificial partisan advantage, and present the results.

1. DEFINITION OF THE ARTIFICIAL PARTISAN ADVANTAGE MEASURE

Consider a state *S*, and an assembly *A* in which state *S* has a delegation of *k* seats. Consider a given redistricting map *m* that divides state *S* into *k* districts with approximately equal population. Consider a given voting profile *v*, which indicates how each citizen voted. For each party *p* that competes in state *S*, let $s_p(v,m)$ denote the number of seats that party *p* wins, given the voting profile *v* and the redistricting map *m.*

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[9] Note that this is, for instance, how the population criterion operates in the Qualified Majority system in the European Council: each European Union's state has one representative in the Council, with population weight proportional to the state's weight. Qualified Majority decisions require the favorable vote of states comprising 65% of the total population (they also require at least 16 states to vote in favor).

Given the voting profile *v* and a benchmark number of seats $s_p(v)$ for party *p*, I define the **artificial partisan advantage** that map *m* gives to party *p* relative to this benchmark, as

$$s_p(v,m)- s_p(v).$$

The crux in this approach is to identify a "natural" map to generate the benchmark number of seats. I propose using the existing division of the state into jurisdictional units such as counties, cities and townships, and in particular, using in each case the jurisdictional unit closest in population size to the districts that need to be drawn.

Congressional districts represent approximately 710,000 residents each, and the jurisdictional unit closest in size is -with few exceptions discussed below- the county. Hence, for most states, I use the state's county map. For each county, I credit the total county population to the party that wins the most votes in the county, and aggregating across counties, the benchmark $s_p(v)$ is proportional to the total population in counties in which party *p* won the popular vote. For instance, if there are two seats to be assigned, and party *p* wins in counties that represent 62% of the population in the state, then $s_p(v)$ is equal to $0.62 * 2 = 1.24$ seats.[10]

The exception are counties with population size greater than two congressional districts, that is, over 1,415,000 inhabitants. In these large counties, if each party is a local majority in a different area of the county, each party could win one or more districts within the county. Crediting the whole county to the county-wide majority party would hide this minority, biasing the results. We can correct this problem by splitting these large counties according to their jurisdictional smaller subunits such as cities and townships.

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[10] Table A.1 in the Appendix illustrates this procedure for New Hampshire in 2018.

Out of the 2,844 counties in the 42 states in which I measure the artificial partisan advantage, only 21 are of population size greater than two congressional districts. Wherever possible, I split these counties into smaller jurisdictional units, by iteratively taking out their largest cities or townships and treating them as independent units, until the population in the remainder of the county is less than 1,415,000 (the size of two congressional districts).[11] Table OA5.1 (in the online appendix) lists the resulting collection of jurisdictional units after splitting the largest counties in this manner.

Formally, given this set of jurisdictional units *U* in state *S*, for each jurisdictional unit *u* in *U* in state *S*, let n_u denote the population in *u*, and let *n* be the total population in the state. For each party *p,* each district *d* and each jurisdictional unit *u,* let $v_p(u,d)$ be total number of votes that party *p* obtains in the precincts of district *d* that lie within unit *u.* Party *p* wins in unit *u* if its sum of votes across all precincts in unit *u* is the greatest, that is, if $\sum_d v_p(u,d) > \sum_d v_{p'}(u,d)$ for any other party *p'*.[12]

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[11] The eighteen counties that can be split into cities and townships are: Alameda, Los Angeles, Orange, Riverside, San Bernardino, San Diego and Santa Clara in California; Bexar, Dallas, Harris and Tarrant in Texas; Maricopa in Arizona, Cook in Illinois; Middlesex in Massachusetts; Wayne in Michigan; Clark in Nevada; Suffolk in New York, and King in Washington. The three counties that cannot be split into cities or townships are Kings and Queens in New York (because they are themselves boroughs within the City of New York), and Philadelphia, because the city and county coincide. As I discuss in the online appendix, results are similar if we only split counties of population size greater than a cut-off of three, four or five districts instead.

[12] Ties are unlikely, and very rare. If two parties tie, I assign half the population of the unit to each party.

Then I calculate the natural number of seats $s_p(v)$ by assigning $\frac{n_u}{n}k$ seats to party *p* for each jurisdictional unit *u* in *U* in which party *p* won the popular vote given the election results *v*, where *k* is the total number of seats to assign.

Using an expansive definition of "county" that includes both actual counties, and the cities and townships elevated to the status of "county" by the county-splitting algorithm above, this procedure can be summarized by the following definition of artificial partisan advantage:

Definition: *The* ***artificial partisan advantage*** *conferred by a redistricting map to a given party is the difference between the seats the party obtains, and the seats that correspond to the party in proportion to the total population of counties in which the party won the popular vote.*

I next present the results.

2. RESULTS

I compute the artificial partisan advantage in the 2012, 2014, 2016 and 2018 election for 42 of the 43 states with at least two seats in the US House of Representatives. Population data by county is from the 2010 US Census.[13] Election results data is publicly available from each state's Secretary of State.[14] I exclude Florida because it does not hold elections for uncontested races, so it does not provide the data about the winner's support necessary to compute the measure.

[13] This data is publicly available at www.census.gov.

[14] For convenience, for most states I use the compilation of electoral results by county available from Dave Leip's Election Atlas. In states with a top-two primary (California, Washington and Louisiana), the run-off can feature two candidates with the same party affiliation; if so, Leip

In the aggregate across all states, and on average across all four elections the net Republican **aggregate artificial partisan advantage** is **sixteen seats**: twenty-four seats in 2012, four in 2014, fifteen in 2016 and nineteen in 2018.[15] Figure 1 compares the actual number of Republican seats in the House of Congress as a function of the Democratic vote share, to the total number of Republican seats if in the 42 states in the sample we substitute the number of Republican seats according to the county-based benchmark for the actual Republican seats.

For an election in which the Republican party wins by a large margin (such as in 2014), there is very little artificial partisan advantage. The advantage materializes only as the electoral returns of the Republican party deteriorate: as the Democratic vote share increases from 47% to just over 50%, many counties flip, but very few districts do so, and the gap between the number of seats won by Republicans, and the number of seats according to the county-based benchmark widens.

The elasticity of the county-based Republican benchmark of seats with respect to the Democratic vote share from the 2014 result (47% Democratic) to the 2016 result (50.6% Democratic) is -2.15. But the elasticity of actual Republican seats with respect to Democratic vote share is only -0.85.

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assigns her true party affiliation (Democratic or Republican) only to the winner of the seat, while coding the loser as "Other"; whereas, I code all candidates by their true party affiliation. Data to split the large counties come directly from the counties' clerk's offices.

[15] The sharp decrease in the Republican partisan advantage from 2012 to 2014 is discussed by Goedert (2015).

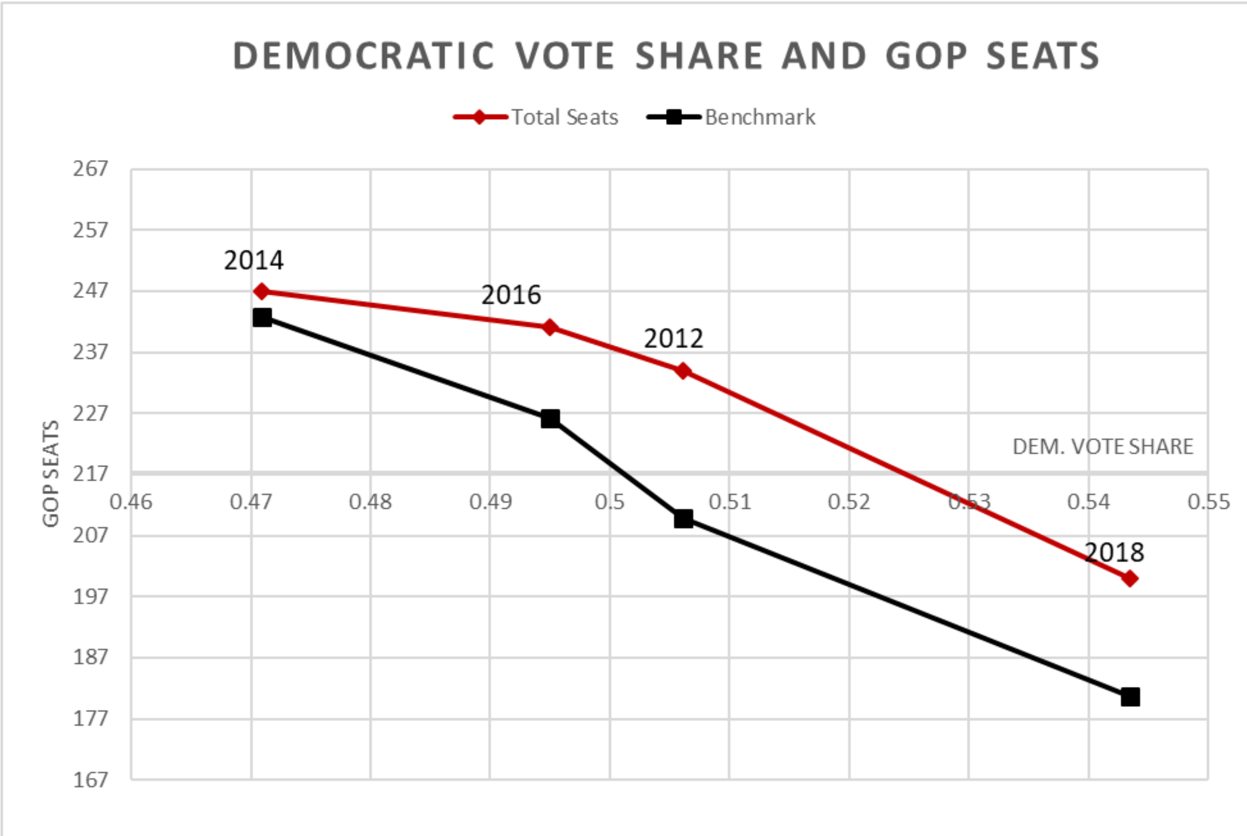

Figure 1. GOP benchmark and total seats as a function of the Dem. national vote share.

The consequence is that under the 2011 redistricting maps, elections in which the Republican party wins the popular vote by a little (as in 2016) or loses it by a little (as in 2012), deliver a seat outcome similar to the one if the Republican party wins by a lot (as in 2014).

Computing the benchmark number of seats according to (exogenously drawn) jurisdictional units allows us to answer the following question: how much of the partisan bias in favor of the GOP is due to natural factors such as the geographic sorting of voters, and how much is artificial, due to drawing biased maps? To answer this question, we can compute the partisan bias (the deviation from asymmetry) of the benchmark itself. If the popular vote in an election is tied, the population in jurisdictional units won by each party will not be tied, so the benchmark will assign more seats to one party than to the other. This is the partisan bias of the natural benchmark and it is also the portion of the total bias that is not due to the artificial drawing of biased maps.

I compute the partisan bias of the benchmark at a tied election by constructing a hybrid (mathematically, a convex combination) between the 2012 and 2016 elections, such that in this synthetic election, the two-party vote share in the 42 states I study is exactly 50% for each of the two main parties. In this synthetic tied election, the benchmark assigns 205.4 seats to the GOP, and 195.6 to the Democratic party, out of the 401 seats in these states. Thus, the GOP earns according to the benchmark 4.9 additional seats, relative to an even split. In contrast, according to the maps in use, in this synthetic tied election the seat outcomes would be 220 for the GOP and 181 for the Democratic Party, that is, the GOP would obtain 19.5 more than an even split. Since only 4.9 of this seat advantage would also hold with exogenous lines, the difference of 14.6 seats is artificially obtained through drawing biased redistricting maps. Therefore, 75% of the seat advantage (or partisan bias) that favors the GOP is an artificial advantaged obtained through drawing biased redistricting maps, and 25% due to natural factors such as geographic sorting of voters.

Put differently, we expect the magnitude of the artificial partisan advantage to be about three quarters the size of the partisan advantage calculated according to notions -such as the partisan bias or the efficiency gap- that include any source of partisan asymmetry.

These aggregate patterns are indicative of the magnitude of the artificial partisan advantage, but redistricting is conducted independently by each State, and for evidence of partisan gerrymandering we must look at each state independently.

In Table A.2 in the Appendix and tables OA5.2-OA5.4 in the online appendix I show the artificial partisan advantage in each election from 2012 to 2018 for each state -other than Florida- with at least two seats in the US House of Representatives. These tables report for each state: the size of the state's delegation; the fraction of the two-party vote obtained by the Republican party; the total population in counties won by Republicans and Democrats; the number of seats that accrue to the Republican party according to the county-based seat benchmark; the number of seats that the Republican party actually won; and in the last column, the artificial partisan advantage as the difference between the preceding two columns (negative numbers correspond to an artificial partisan advantage for the Democratic party).[16]

Because the absolute magnitude of the partisan advantage correlates with a state's size, I compare the results across states using a notion of **excess advantage** that is relative to the state's size. Since the benchmark seat allocation based on county lines is fractional, and actual seat outcomes are integers, the smallest possible artificial partisan advantage is the difference between the benchmark and the nearest integer, which can be as large as 0.5 seats. Therefore, I allow a rounding margin of 0.5 seats and I define the excess advantage as the artificial advantage in excess of this rounding margin, divided by the size of the state's delegation.

Definition: *The* ***excess artificial advantage*** *is* $\frac{artificial\ partisan\ advantage - 0.5}{state's\ delegation\ size}$ *if the artificial partisan advantage is over 0.5 seats, and zero otherwise.*

[16] The measures of artificial partisan advantage for the individual states are highly correlated across elections; see Table OA5.5 in the online appendix.

Averaging across all four elections, the encouraging finding is that twenty states feature zero excess advantage. Other states have an excess advantage, typically favoring the party that controlled the map-drawing. I highlight the greatest offenders in Table 1, noting their partisan advantage and the size of their state's delegation.

TABLE 1. STATES WITH GREATEST EXCESS ARTIFICIAL PARTISAN ADVANTAGE, 2012-2018

Excess advantage, and size	Artificial partisan advantage	Democratic advantage		Republican Advantage	Artificial partisan advantage	Excess advantage, and size
				North Carolina '16-'18	3.20	20.7% of 13
				North Carolina '12-'18	2.87	18.2% of 13
				Utah	1.05	13.7% of 4
				Michigan	1.96	10.4% of 14
				Ohio	2.15	10.3% of 16
9.8% of 8	1.29	Maryland				

The North Carolina legislature drew a remedial map for the 2016 and 2018 elections after its 2011 map was ruled to be an unconstitutional racial gerrymander. The remedial map is based on the previous map, so I compute the artificial partisan advantage both for the remedial map alone, and for the average of the two. In Table A.3 in the Appendix I provide the average artificial partisan advantage and the excess advantage for each state.

3. CONCLUSION

I have proposed a measure artificial partisan advantage in redistricting that is based on existing jurisdictional lines such as counties. This notion measures the partisan advantage that is due specifically to the way the redistricting maps are drawn, and not due to geographic sorting of the voting population. On aggregate across 2012-18 elections to the US House of

Representatives, and across 42 states with at least two representatives, I find that the aggregate artificial partisan advantage for the Republican party is sixteen seats.

State by state, I find that the redistricting maps in North Carolina, Utah, Michigan, Ohio and Maryland have the redistricting maps with the greatest excess of artificial partisan advantage.

Due to space constrains in this Letter, I relegate a more detailed discussion of the properties and limitations of the measure of artificial partisan advantage, a comparison to other measures in the literature, and additional state-by-state results, to the online appendix.

The immediate purpose of the artificial partisan advantage is to serve as a tool to identify which redistricting maps generate a partisan advantage, so that legislators and commissioners can draw neutral maps, and Courts can strike partisan gerrymanders down more confidently if these are drawn. The ultimate goal is to contribute to run elections with more equal protection, voice and opportunity to all citizens, and with a fairer representation of the citizenry's preferences in our elected bodies.

APPENDIX

TABLE A.1. ARTIFICIAL PARTISAN ADVANTAGE IN NEW HAMPSHIRE, 2018.

				Pop. counties won by	
County Name	**[1] Pop**	**[2] D Vote**	**[3] R Vote**	**[4] Dem**	**[5] Rep**
Belknap	60,088	12,256	14,125	0	60,088
Carroll	47,818	12,146	11,464	47,818	0
Cheshire	77,117	19,784	11,830	77,117	0
Coos	33,055	6,008	4,971	33,055	0
Grafton	89,118	25,627	13,499	89,118	0
Hillsborough	400,721	86,961	70,877	400,721	0
Merrimack	146,445	36,702	26,626	146,445	0
Rockingham	295,223	71,211	66,089	295,223	0
Strafford	123,143	30,819	21,469	123,143	0
Sullivan	43,742	9,200	7,553	43,742	0
N. HAMPSHIRE	**1,316,470**	**311,242**	**248,986**	**1,256,382**	**60,088**
				95.44%	4.56%
			Benchmark	1.91	0.09
			Total Seats	2.00	0.00
		Artificial Partisan Advantage		0.09	-0.09

Table A.1 demonstrates the procedure to compute the artificial partisan advantage in each state. New Hampshire has two congressional districts. For each county, column [1] indicates the population of the county; column [2] is the popular vote for the Democratic party in the county, aggregated across all races for US House seats in the county (one race for counties contained in one district and two for counties that overlap both districts); column [3] is the analogous popular vote for the Republican party in the county. In counties in which the Democratic party candidates got more votes ([2]>[3]), the population of the county is assigned to the Democratic column [4], whereas in counties in which the Republican party candidates got more votes ([3]>[2]), the county population goes to the Republican column [5]. Adding up across counties, we get the state totals. We find that 95.4% of the population is in counties won by the Democratic candidates, and 4.6% in counties won by the Republicans. So the number of seats for the Democratic party according to the county-based benchmark natural seat benchmark is 95.4% of 2 seats, that is, 1.91 seats. The Republican party's is 0.09 seats. Since the Democratic party obtained both New Hampshire seats, the artificial partisan advantage is 2.00 – 1.91 = 0.09.

Data sources: The data for column [1] is from the US Census at www.census.gov. The data for columns [2] and [3] is from the New Hampshire Secretary of State at sos.nh.gov/18GenResults.aspx. Columns [4] and [5] are computed from the first three columns.

TABLE A.2. ARTIFICIAL PARTISAN ADVANTAGE BY STATE, 2018 US HOUSE ELECTION

			Pop. in counties won		Republican Seats		
State	**[1] Seats**	**[2] R vote**	**[3] by R**	**[4] by D**	**[5] Earned**	**[6] Total**	**[7] Art. Adv.**
Alabama	7	59.0%	3,402,297	1,377,439	4.98	6	1.02
Arizona	9	49.1%	3,249,919	3,142,098	4.58	4	-0.58
Arkansas	4	64.0%	2,332,594	583,324	3.20	4	0.80
California	53	33.1%	6,549,803	30,704,153	9.32	7	-2.32
Colorado	7	44.6%	1,981,523	3,047,673	2.76	3	0.24
Connecticut	5	38.0%	189,927	3,384,170	0.27	0	-0.27
Georgia	14	52.3%	4,510,631	5,177,022	6.52	9	2.48
Hawaii	2	23.3%	0	1,360,211	0.00	0	0.00
Idaho	2	63.9%	1,498,792	68,790	1.91	2	0.09
Illinois	18	38.9%	2,798,967	10,031,665	3.93	5	1.07
Indiana	9	55.5%	4,286,018	2,197,784	5.95	7	1.05
Iowa	4	47.9%	1,307,082	1,739,273	1.72	1	-0.72
Kansas	4	54.8%	1,791,559	1,061,559	2.51	3	0.49
Kentucky	6	60.4%	3,253,183	1,086,184	4.50	5	0.50
Louisiana	6	59.1%	3,567,807	965,565	4.72	5	0.28
Maine	2	42.4%	386,245	942,116	0.58	0	-0.58
Maryland	8	33.1%	1,249,709	4,523,843	1.73	1	-0.73
Massachusetts	9	20.4%	0	6,547,629	0.00	0	0.00
Michigan	14	46.0%	4,041,237	5,842,403	5.72	7	1.28
Minnesota	8	44.2%	1,975,159	3,328,766	2.98	3	0.02
Mississippi[*]	4	54.2%	2,070,236	886,464	2.79	3	0.21
Missouri	8	56.4%	3,833,879	2,155,048	5.12	6	0.88
Nebraska	3	62.0%	1,023,824	802,517	1.68	3	1.32
Nevada	4	47.2%	749,282	1,951,269	1.11	1	-0.11
N. Hampshire	2	44.4%	60,088	1,256,382	0.09	0	-0.09
New Jersey	12	39.2%	1,659,336	7,132,558	2.26	1	-1.26

New Mexico	3	39.6%	515,164	1,544,015	0.75	0	-0.75
New York	27	31.8%	2,566,306	16,811,796	3.58	6	2.42
North Carolina	13	51.0%	4,871,767	4,663,716	6.64	10	3.36
Ohio	16	52.4%	6,253,252	5,283,252	8.67	12	3.33
Oklahoma	5	63.0%	3,032,718	718,633	4.04	4	-0.04
Oregon	5	39.8%	925,060	2,906,014	1.21	1	-0.21
Pennsylvania	18	44.9%	5,949,677	6,752,702	8.43	9	0.57
Rhode Island	2	34.9%	0	1,052,567	0.00	0	0
South Carolina	7	55.0%	3,428,681	1,196,683	5.19	5	-0.19
Tennessee	9	60.2%	4,772,993	1,573,112	6.77	7	0.23
Texas	36	51.8%	14,158,405	10,987,156	20.27	23	2.73
Utah	4	62.3%	1,688,681	1,075,204	2.44	3	0.56
Virginia	11	43.0%	2,793,698	5,207,326	3.84	4	0.16
Washington	10	36.7%	1,664,107	5,060,433	2.47	3	0.53
West Virginia	3	59.0%	1,493,074	359,920	2.42	3	0.58
Wisconsin	8	46.1%	2,882,782	2,804,204	4.06	5	0.94
TOTAL	401		114,765,462	169,292,727	161.71	181	19.29

[*] An Independent won Carrol county (MS), earning a 0.01 seat benchmark for independents.

TABLE A.3. ARTIFICIAL PARTISAN ADVANTAGE BY STATE, 2012-2018				
		Artificial Partisan Advantage		**Excess**
State	**Size**	**Democratic**	**Republican**	**Advantage**
Alabama	7		0.96	6.5%
Arizona	9	0.89		4.3%
Arkansas	4		0.82	7.9%
California	53	3.10		4.9%
Colorado	7		0.50	0%
Connecticut	5	0.20		0%
Georgia	14		1.20	5.0%
Hawaii	2	0.00		0%
Idaho	2		0.07	0%
Illinois	18	1.67		6.5%
Indiana	9		1.10	6.6%
Iowa	4		0.45	0%
Kansas	4		0.42	0%
Kentucky	6		0.29	0%
Louisiana	6		0.14	0%
Maine	2	0.11		0%
Maryland	8	1.29		9.8%
Massachusetts	9	0.00		0%
Michigan	14		1.96	**10.4%**
Minnesota	8		0.17	0%
Mississippi[*]	4		0.11	0%
Missouri	8		0.45	0%
Nebraska	3		0.72	7.3%
Nevada	4		0.14	0%
N. Hampshire	2	0.67		8.5%

New Jersey	12		0.62	1.0%
New Mexico	3	0.26		0%
New York	27		1.17	2.5%
North Carolina 12-14 **16-18**	13 13		2.54 3.19	**15.8%** **20.7%**
Ohio	16		2.15	**10.3%**
Oklahoma	5	0.01		0%
Oregon	5	0.41		0%
Pennsylvania ’12-‘16 2018	 18		1.85 0.57	7.5% 0.4%
Rhode Island	2	0.02		0%
South Carolina	7		0.45	0%
Tennessee	9		0.26	0%
Texas	36		1.74	3.4%
Utah	4		1.05	**13.6%**
Virginia ‘12 ’14-‘18	11 11		1.57 0.83	9.7% 3.0%
Washington	10		0.73	2.3%
West Virginia	3		0.51	0.2%
Wisconsin	8		0.64	1.8%
TOTAL	401		15.63	

The artificial partisan advantage is the average from 2012 to 2018, except as noted in the table. The “excess advantage” column is computed as the artificial partisan advantage minus 0.5, divided by the size of the delegation. Values above 10% are in bold. The excess advantage for states with a value of artificial partisan advantage below 0.5 is 0%.

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ONLINE APPENDIX

This is the Online Appendix to the working paper "Artificial Partisan Advantage in Redistricting," by Jon X. Eguia. This version is from August 15, 2019.

This Online Appendix contains the following sections.

OA1. JUDICIAL BACKGROUND ON PARTISAN GERRYMANDERING

"Gerrymandering" refers to the practice of drawing district maps to favor one party or class. The Voting Rights Act of 1965 made it illegal to gerrymander on racial grounds in such a way that dilutes the vote of a racial minority, and subsequent decisions by the Supreme Court of the United States (henceforth, "SCOTUS") have also limited the practice of drawing maps that artificially pack minority voters together.[1]

Recently, attention has shifted to partisan gerrymanders: is it permissible to draw maps to reduce the representation of Democratic or Republican voters?

In *Davis vs Bandemer* 478 U.S. 109 (1986), SCOTUS held that claims that a redistricting map is a political gerrymandering are justiciable; that is, the courts can resolve these claims and can strike down maps that provide too much partisan advantage to one party. However, SCOTUS could not agree upon a test or measure of what constitutes an excessive partisan advantage to actually adjudicate such claims.

In *Vieth vs Jubelirer* (2004), a plurality Opinion by Justice Scalia argued "*there are no existing manageable standards for measuring […] a political gerrymander*", and hence that partisan gerrymandering is a political question that is not subject to judicial review.[2] A minority of four justices disagreed, proposing various such standards. In his decisive Opinion concurring in the judgment, Justice Kennedy rejected all the proposed standards and agreed that an "*easily administrable standard*" did not exist, but it also crucially held that the desired standard could be found in the future: "*that no such standard has emerged in this case should not be taken to prove that none will emerge in the future*."[3] Therefore, claims that a redistricting map is a partisan gerrymandering remained justiciable, pending the development of an appropriate standard.

In *LULAC v Perry* (2006), the majority Opinion by Justice Kennedy reaffirmed that the Courts can, in principle, determine whether a redistricting map is an illegal partisan gerrymander, but in practice it once again failed to find the necessary but elusive "*reliable standard for identifying unconstitutional political gerrymanders*."[4]

In 2016, a federal court for the first time struck down a redistricting map on grounds that it was an unconstitutional partisan gerrymander: In *Whitford v Gill*,[5] a 3-judge District Court invalidated the Wisconsin state election maps. In January 2018, another federal court invalidated the North Carolina congressional map, ruling it a partisan gerrymander in favor of the Republican party in *Common Cause v. Rucho*.[6] Both *Whitford v Gill* and *Common Cause v Rucho* were appealed to SCOTUS. In a unanimous Opinion in June 2018, SCOTUS resolved *Gill v. Whitford* by sidestepping the key substantive issues and

[1] *Shaw v. Reno*, 509 U.S. 630 (1993), *Miller v. Johnson*, 515 U.S. 900 (1995), *Bush v. Vera*, 517 U.S. 952 (1996).
[2] *Vieth vs Jubelirer* 541 U.S. 267 (2004), quoting from the syllabus.
[3] Vieth vs Jubelirer 541 U.S. 267, 310-311 (2004).
[4] *League of United Latin American Citizens vs Perry* 548 U.S. 399, 423 (2006).
[5] *Whitford v. Gill*, 218 F. Supp. 3d 837 (W.D. Wis. 2016).
[6] *Common Cause v. Rucho,* 279 F. Supp. 3d 587 (M.D.N.C. 2018).

remanding the case back to lower courts on technical issues about judicial standing.[7] A week later, it also vacated and similarly remanded *Rucho v Common Cause* back to lower courts.[8]

In November 2018, a 3-judge District Court invalidated the Maryland congressional map, ruling it an unconstitutional partisan gerrymander in favor of the Democratic party in *Benisek v. Lamone*.[9] The North Carolina and Maryland cases (*Common Cause v. Rucho* and *Benisek v Lamone*) returned on appeal to the Supreme Court in 2019. While SCOTUS considered these cases, federal courts also struck down the congressional maps for Michigan and Ohio, declaring them unconstitutional partisan gerrymanders.[10]

In June 2019, SCOTUS overturned the lower court rulings in *Common Cause v. Rucho* and *Benisek v Lamone,* ruling that claims of partisan gerrymander are "*not justiciable*" under federal law; that is, they cannot be addressed or adjudicated in federal courts. In the Opinion of the Court, Chief Justice Roberts explains that we "*lack judicially discoverable and manageable standards for resolving* [partisan gerrymandering cases]" because "*none of the proposed tests for evaluating partisan gerrymandering claims meets the need for a limited and precise standard that is judicially discernible and manageable*." The Opinion goes further, reversing the precedents of *Davis vs Bandemer* (1986), *Vieth vs Jubelirer* (2004) and *LULAC v Perry* (2006): whereas Justice Kennedy's decisive Opinion in *Vieth* argued "*that no such standard has emerged in this case should be taken to prove that none will emerge in the future*" so the claims remain justiciable, Roberts' Opinion of the Court leaves no room for future standards, and finding no standard today, rules the claims not justiciable.[11]

Roberts' Opinion of the Court in *Rucho v. Common Cause* concedes that: "*Excessive partisanship in districting leads to results that reasonably seem unjust"* and states as a fact that "*such gerrymandering is incompatible with democratic principles.*" While it concludes that federal courts cannot address the problem, it argues that this conclusion "*does not condone excessive partisan gerrymandering.*" SCOTUS finds a solution instead in state courts: "*Provisions in state statutes and state constitutions can provide standards and guidance for state courts to apply.*"

Roberts' Opinion of the Court cites Florida, where in 2015, the state's Supreme Court "*struck down that State's congressional plan as a violation of the 'Fair Districts Amendment' to the Florida Constitution*."[12] The Opinion also highlights several other states -including Michigan, Missouri, Iowa and Delaware- where state legislation prohibits partisan favoritism explicitly. For instance, see the Iowa Code 42.4(5) (2016): "*No district shall be drawn for the purpose of favoring a political party, incumbent legislator, or member of Congress, or any other group*." Here is a summary of states' legal restrictions against partisan advantage in redistricting, by State:

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[7] *Gill v. Whitford*, 585 U.S. ___ (2018).

[8] *Rucho v. Common Cause*, 138 S. Ct. 2679 (2018).

[9] *Benisek v. Lamone*, 348 F. Supp. 3d 493 (D. Md. 2018).

[10] The Michigan case is *League of Women Voters v. Benson*, No. 2: 17-cv-14148 (E.D. Mich. Apr. 25, 2019). The Ohio case is *Phillip Randolph Institute v. Householder*, No. 1: 18-cv-357 (S.D. Ohio May 3, 2019).

[11] The quotes of Roberts' Opinion are from the summary of *Rucho v. Common Cause,* No. 18-422, 588 U.S. ___ (2019). The quote from Kennedy's Opinion is from pages 310-311 in *Vieth vs Jubelirer* 541 U.S. 267 (2004).

[12] Pages 30 and 31 of *Rucho v. Common Cause,* No. 18-422, 588 U.S. ___ (2019). The Florida case was *League of Women Voters of Florida v. Detzner* 172 So. 3d 363 (2015).

i. California: Districts cannot be drawn with the purpose of favoring or discriminating against a candidate, incumbent (CAL. CONST. art. XXI, § 2(e)).
ii. Colorado. Districts cannot be drawn to protect incumbent members, candidates, or any political party (COLO. CONST. art V, § 48.1(4)(a)).
iii. Delaware. Districts may not "unduly favor any person or political party" (DEL. CODE § 29.805).
iv. Florida. No favoritism towards incumbent or party (FLA. CONST. art. III, § 21(a)).
v. Hawaii. No undue favoritism towards a person or political faction (HAW. CONST. art. IV, § 6).
vi. Idaho. Counties cannot be divided to protect an incumbent or party (IDAHO statute 72.1506(08)).
vii. Iowa, No favoritism towards any person, party, or group (IOWA CODE § 42.4(5))
viii. Michigan. Cannot draw districts with a disproportionate advantage to any political party (using accepted measures of partisan fairness) (MICH. CONST. art. IV, § 6(13)(d)).
ix. Missouri. The efficiency gap must be as close to zero as practicable (MISSOURI CONST. art. III, §3).
x. Montana. Cannot favor a political party or incumbent (MONT. CODE ANN. § 5-1-115(3)).
xi. New York. Cannot favor incumbents, candidates, or parties (N.Y.CONST. art. III, § 4(c)(5))
xii. Ohio. A map passed with a simple majority shall not be drawn primarily to favor or disfavor a political party (OHIO CONST. art. XI, § 6(A))
xiii. Oregon. No purposeful favoritism towards person or party (OREGON Code 188.010 (2017)).
xiv. Washington. Districts shall not purposefully favor or political party (WASH. CONST. art. II, § 43(5)).

Partisan gerrymanders in any of these states can be challenged in state courts as violations of these state provisions.

Legal challenges in state courts may also succeed in states without such explicit prohibitions. For instance, the Pennsylvania Supreme Court ruled in 2018 that the 2011 Pennsylvania congressional maps *"clearly, plainly and palpably"* violate the Pennsylvania constitution, in particular the "*free and equal elections*" clause in Art. I Sec. 5, by favoring the Republican party, and ordered a new set of maps drawn for the 2018 congressional election.[13]

With action in federal courts precluded for the foreseeable future, further litigation over partisan gerrymandering appears likely in states' courts during the next redistricting cycle (2021-2030).

OA2. COMPARISON TO OTHER MEASURES OF PARTISAN ADVANTAGE

In this section I discuss five alternative measures of partisan advantage in redistricting: partisan bias; the median-mean difference; the declination; the efficiency gap; and the location of the actual map in a distribution over simulated maps. In the discussion I relate the artificial partisan advantage to each of these measures.

I. Partisan bias

The notion of partisan bias measures asymmetries in how parties convert votes to seats. For each of two main parties *A* and *B,* (and holding constant the votes for minority parties), we construct the party's "vote-to-seats" curve by mapping the number of seats that the party obtains if it gets fraction *x* of the two-party vote, for each *x* between 0 and 1. The partisan bias in favor of *A* at vote share *x* is the difference between the number of seats that Party *A* obtains if it gets a fraction *x* of the two party

[13] *League of Women Voters of Pennsylvania v. Commonwealth of Pennsylvania* 178 A.3d 737 (2018).

votes, and the number of seats that Party *B* obtains if *B* gets fraction *x* of votes (Butler 1951 and 1952). The axiom of partisan symmetry holds if the partisan bias is zero for any *x,* so that the two vote-to-seats curves are equal (Tufte 1973; Grofman 1983; King and Browning 1987).

The partisan bias is a pointwise measure, at each vote share *x.* Aggregating across all possible vote shares and comparing the two full vote-to-seats curves, we can obtain a global estimate of partisan bias. The most sophisticated measure of this global partisan bias is to estimate the probability measure over possible vote splits, and to integrate the difference between the two vote-to-seat curves weighed by this probability measure, so that the global partisan bias is the expectation over the pointwise bias (Katz, King and Rosenblatt 2018).

The computation of the partisan bias presents a technical difficulty: it requires estimating counterfactual seat outcomes given counterfactual vote shares. The standard approach to estimate the seat outcomes given a counterfactual vote share is to start with the actual vote share, and to assume a uniform swing across all districts in the magnitude appropriate to generate the desired counterfactual vote share. The estimate of partisan bias therefore relies on hypothetical –rather than actual— voting profiles. Courts have expressed some reluctance to his reliance on counterfactuals. Quoting from SCOTUS's Opinion of the Court in *LULAC* (2006): "*we are wary of adopting a constitutional standard that invalidates a map based on unfair results that would occur in a hypothetical state of affairs.*"[14] Nevertheless, partisan bias remains the most prominent notion of partisan advantage in the academic literature.[15]

The notion of partisan bias measures any deviation from symmetry across parties in the mapping from vote shares to seats. It does not examine the causes or mechanisms that generate this deviation. In particular, the notion of partisan bias does not distinguish whether the asymmetry is due to the redistricting maps, or to other factors such as the geographical distribution of each party's voters.

If the distribution is asymmetric due to the location of voters, then the existence of partisan bias is not evidence that the redistricting maps are flawed. As expressed by Justice Scalia's plurality Opinion in *Vieth* (2004): *"Consider, for example, a legislature that draws district lines with no objectives in mind except compactness and respect for the lines of political subdivisions. Under that system, political groups that tend to cluster (as is the case with Democratic voters in cities) would be systematically affected by what might be called a 'natural' packing effect."*[16]

Or, as expressed by Justice Kennedy's Opinion of the Court in *Vieth* (2006), because "*the existence or degree of asymmetry may in large part depend on conjecture about where possible vote-switchers will reside*" […] "*I would conclude asymmetry alone is not a reliable measure of unconstitutional partisanship.*"[17]

Whereas the partisan bias measures the total partisan advantage that a party enjoys in its mapping from voting profiles to seats, without distinguishing the factors that contribute to this advantage, the artificial partisan advantage measures the partisan advantage that accrues to a party due to the redistricting maps in place.

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[14] Justice Kennedy's Opinion of the Court in *LULAC v. Perry*, 548 U.S. 399, 420 (2006).

[15] See for instance influential work by Cox and Katz (1999) or Grofman and King (2007), among others.

[16] Justice Scalia's plurality Opinion in *Vieth v. Jubelirer*, 541 U.S. 267, 290 (2004).

[17] Justice Kennedy's Opinion of the Court in *LULAC v. Perry*, 548 U.S. 399, 420 (2006).

The relation between the partisan bias and the artificial partisan advantage is that the partisan bias measures the total advantage, and the artificial partisan advantage measures the advantage net of the natural advantage due to geographical sorting of voters, so it captures only the partisanship or bias inherent to the redistricting map in use. The two measures can be used together to compute the natural advantage due to sorting, by subtracting the artificial partisan advantage (net advantage) from the partisan bias (total advantage). I compute this natural advantage for a hypothetical, synthetic, tied election composed as a convex combination of the 2012 and 2016 elections, weighed such that each party receives 50% of the vote in the 42 states I study (all 43 states with at least two congressional districts, minus Florida). I find that the natural advantage for the GOP is 4.9 seats in this election, and the artificial advantage is 14.5 seats, for a total partisan bias of 19.4 seats.

The two concepts capture different notions of fairness. If we consider that a redistricting map is "fair" if it does not introduce any partisan advantage, then we ought to minimize the artificial partisan advantage; whereas, if we consider that a map should fully compensate any natural advantage that accrues to a party due to geographic sorting by drawing maps that help the opposite party so as to cancel out this advantage, then we should strive for partisan symmetry. Chief Justice Roberts poses this normative dilemma in the majority Opinion in *Rucho* (2019): "*Should a court "reverse gerrymander" other parts of a State to counteract "natural" gerrymandering caused, for example, by the urban concentration of one party*?[18]

We can illustrate it by example. Consider a hypothetical State consisting of three islands of equal population, named Left I., Center I., and Right I., and the distribution of votes is as follows:

EXAMPLE OA2.1. *An archipelago with three districts.*

	Left Island	Center Island	Right Island	Total
Party A	90%	30%	30%	50%
Party B	10%	70%	70%	50%

If each island constitutes its own district, Party A wins one district, and Party B wins two; a large partisan bias. The asymmetry in this case is not due to an artificial drawing of districts, but due to the sorting of voters across the three islands. To attain party symmetry, we would need to artificially gerrymander cross-island districts in favor of Party A. This "reverse-gerrymandering" approach is advocated, for instance, in Katz and King (1999): "*Most of the especially effective partisan gerrymanders take a political system severely biased in favor of one party and make it slightly biased in favor of the other, hence reducing the overall bias.*"

Example OA2.1 is designed to illustrates how the partisan bias and the artificial partisan advantage can differ. Results from the US House of Representatives from 2012 to 2018 show that, aggregating across all states, in practice the two measures align closely: the number of seats according to the county benchmark (approximately) satisfies party symmetry (Figure 1 in the body of the paper). Hence, a collection of maps with no aggregate artificial partisan advantage would show no aggregate partisan bias; despite their conceptual differences, the partisan bias and artificial partisan advantage align in practice.

[18] Page 19 of Justice Roberts' Opinion in *Rucho v. Common Cause,* No. 18-422, 588 U.S. ___ (2019).

II. Other measures of asymmetry: median-mean difference, efficiency gap, and declination

The Supreme Court's objections to the reliance on counterfactuals (Footnote 14 above) spurred an interest in measures that only use actual voting results.

The first of these is the difference between the mean vote share in the state, and the vote share in the median district, shortened to "median-mean" difference. As noted as far back as Edgeworth (1898), one may think that this difference should be zero. Butler (1951 and 1952) finds that in the UK elections of 1950 and 1951 it was not zero; in fact, in 1951 the median district the Tory party vote was higher even though the Labour mean vote share across the UK was higher. The explanation for this difference is that Labour won a few (urban) districts by large margins, whereas Tories won more districts on smaller margins.

Erikson (1972) identifies a similar phenomenon in the United States, and refers to this pattern of large wins for Democrats in urban districts, and smaller wins for Republicans elsewhere as "accidental gerrymanders" that favour the Republican Party.

McDonald and Best (2015) note that we can identify partisan gerrymanders by finding the states with a large median-mean vote difference. Gerrymandering affects the median-mean difference because it leaves the mean vote across the state unchanged, but by changing the composition of districts, it can elevate the vote share of a favored party in the median district, generating a positive difference between median and mean. However, since this difference can also arise accidentally with neutral maps through the residential patterns of voters, "*in order to distinguish unintentional from intentional gerrymanders, a benchmark of what naturally would result from any neutral line drawing has to be established*."

This is the same motivation underpinning the artificial partisan advantage: to compute asymmetries net of the effects of the geographic sorting of voters, by resorting to a "natural" benchmark. For instance, in Example OA2.1 above, the vote for Party *B* in the median district is 70%, while the party's mean vote is 50%, so the difference is 20%, but this difference is entirely natural, due to the distribution of voters across islands, so this would be an unintentional or accidental gerrymander.

The most substantive difference between McDonald and Best's (2015) approach and mine is that in the computation of the artificial partisan advantage, the variable of interest is the number of seats won, whereas for McDonald and Best (2015), the variable of interest is vote shares. They argue that a partisan gerrymander should be illegal if "*the median-mean value of bias in a districting plan must outstrip what could reasonably be expected to result when compared against the levels of bias in a set of neutrally drawn maps*." I argue instead that the districting plan should be illegal if the seat outcome is very different from the seat outcome according to a neutral benchmark.

The median-mean difference is arguably a more relevant measure in closely contested states in which either party can win a majority of districts under some map. It is less informative in states with one dominant party. In these states, the median district will not be competitive under any map, and partisan gerrymandering will focus on the few competitive districts in the state.

More recently, Warrington (2018) proposed a new measure of asymmetries in the distribution actual results across districts is the declination (Warrington 2018). The "declination" measures whether there is a discontinuity in the distribution of results at 50% vote share. This discontinuity would be anomalous if districts were naturally drawn, but it will happen by design if districts are gerrymandered.[19]

The most influential of the new measures of partisan advantage in redistricting developed in the past few years is the “efficiency gap” (McGhee 2014; Stephanopoulos and McGhee 2015). This measure compares the ability of each party to translate votes to seats, by computing the number of votes for each party that are “wasted.” Wasted votes are those cast for a losing candidate, or for a winning candidate in excess of the 50%+1 number of votes necessary to win.

The efficiency gap is the difference in this share of wasted votes for each party. With equal turnout across constituencies, the efficiency gap simplifies: it is the difference between the seat share in excess of 50% for the largest party, and the vote share margin. That is, zero gap requires party symmetry and a slope of two in the conversion of votes to seats.

A 2018 amendment to the Missouri Constitution enshrined the efficiency gap as the measure to use to guarantee partisan fairness in redistricting in this state:

> “*Wasted votes are votes cast for a losing candidate or for a winning candidate in excess of the fifty percent threshold needed for victory. In any plan of apportionment and map of the proposed districts submitted to the respective apportionment commission, the non-partisan state demographer shall ensure the difference between the two parties' total wasted votes, divided by the total votes cast for the two parties, is as close to zero as practicable.”* (Art III, Sect. 3).

Nevertheless, the efficiency gap has elicited criticism (Chambers, Miller and Sobel 2017; Bernstein and Duchin 2017; Katz, King and Rosenblatt 2019). I highlight two limitations. First, the efficiency gap measure, if interpreted literally, produces non-sensical implications in states with lopsided results: If one party wins all votes and seats, it wastes 50% of all votes, while the other party wastes no votes because it gets none, so the state appears gerrymandered *against* the party with all the seats. Stephanopoulos and McGhee (2018) concede this limitation, and thus suggest that the efficiency gap be used only in states in which the largest party is likely to obtain no more than 75% of the vote.

Uncontested races create a second, related problem for the computation of the efficiency gap: because the winner gets all votes, it wastes half of them, inducing the measure to identify the map as gerrymandered against winners of uncontested races.[20] The artificial partisan advantage does not face these problems: one can compare actual results to the county-based benchmark result in any state that tallies election results, even if these results are lopsided or uncontested.

The efficiency gap and the artificial partisan advantage differ in the variable they seek to measure. The efficiency gap, like partisan bias, is a measure of partisan asymmetry in the mapping from votes to seats, regardless of the cause of this asymmetry. Whereas, the artificial partisan advantage is a measure of the asymmetry introduced specifically by the redistricting maps, and is

[19] See Wang (2016) as well for other tests of symmetry in the distribution of votes across districts.

[20] Attempts to remedy this problem by imputing the electoral result that would have occurred had the race been contested, using either previous results, or up- or down- ballot results, reintroduce the problem of reliance on counterfactuals, rather than on actual results for the seat in question.

net of pre-existing advantages due to geographic sorting of voters. The two measures are thus, conceptually different.

The artificial partisan advantage is closer in spirit to the computational approach of Chen and Rodden (2013 and 2015), Chen and Cottrell (2016), Cho and Liu (2016), Duchin (2018), Cho (2019) and others. This approach also seeks to measure the partisan advantage that is attributable specifically to a given redistricting map, and not to the geographic distribution of voters. Instead of assessing the fairness of a given map by comparing the seat outcomes under this map to those under a "natural" benchmark map, it compares the actual seat outcome against the distribution of outcomes under a large sample of alternative possible maps, computationally simulated from a pool of admissible maps.

By drawing a large distribution of maps, and hence of outcomes, this computational approach can then report where is the actual seat outcome located in the distribution of possible outcomes. If the actual seat outcome is extreme, at the tail of the distribution of outcomes according to simulated maps, we can regard the current map as a partisan gerrymander.

I find this result compelling, with a couple technical caveats. First, it is difficult to define the set of admissible maps from which to draw simulated maps. Say we determine that in order to be admissible, maps ought to be somewhat compact: how compact? If admissible maps ought to satisfy the Voting Rights Acts (VRA) minority protections, then to determine if a map is included, we'll first need to determine its compliance with the VRA, which in many cases will be questionable and hard to establish. Once we overcome (or put aside) this caveat, and we settle on a set of admissible maps, a second problem emerges: it is difficult to devise a truly random algorithm to draw a sample from the set of admissible maps. See Burden and Smidt (2019) or Katz, King and Rosenblatt (2019) for a discussion of these challenges.

The artificial partisan advantage resolves both problems resorting to simplicity: instead of comparing the actual outcome to the distribution of outcomes from a (hard to draw) random sample out of a (hard to define) set of admissible maps, it compares the actual outcome to one, very easy to compute benchmark outcome deemed natural and salient: the seat outcome that would emerge if we bypassed districting altogether, and we assign (weighted) seats according to the state's county map.

The computational approach and the artificial partisan advantage can be used in conjunction with each other: if we create a distribution of outcomes according to a large sample of maps, we can place both the actual outcome with the map in place, and the outcome according to the county-based benchmark in this distribution. Such information provides context to any value of the measure of artificial partisan advantage, by noting how extreme is the result used as benchmark.

A pragmatic map-drawer may wish to compute many or all these measures, together with the artificial partisan advantage, for any proposed plan. Ideally, the selected map will perform well according to all measures; if it performs well in some and poorly in others, we can use this information to evaluate the merits of the plan; if it performs poorly in the measures deemed more compelling by the map-drawer, the map should be redrawn.

State courts evaluating the partisan fairness of a given maps must first answer the normative question posed by SCOTUS in the ruling in *Rucho v. Common Cause* (2019):[21] should "partisan fairness" measure the total, absolute partisan advantage regardless of its source? or should it measure instead the advantage that is due specifically to the redistricting map, net of any natural advantage due to other factors such as the geographic sorting of voters or differential turnout rates? If the criterion is the absolute advantage, this can be measured by the partisan bias, the median-mean difference, the declination or the efficiency gap (or a combination thereof). Whereas, if the criterion is the net advantage, this advantage can be measured using the computational methods or using the artificial partisan advantage, or both.

OA3. RESULTS BY STATE

States differ in their redistricting procedures. In most of them, the legislature draws the maps, with or without veto power for the governor. In some states, a commission, either appointed by legislators or drawn from a pool of volunteer citizens, controls the process. While the number of states in each category of process is too small to draw rigorous statistical inferences about the effect of control of the redistributing process over the resulting partisanship of the maps, some comparisons are instructive.

The five maps with the greatest excess artificial advantage were drawn by legislatures controlled by one party: the GOP in North Carolina, Utah, Michigan and Ohio, and the Democratic Party in Maryland. In all four cases the excess advantage is at least close to 10%, and in all four cases it favors the party that drew the maps.

Maps drawn by legislatures under split partisan control in Colorado, Iowa, Kentucky, Mississippi and New Mexico drew neutral maps, with no excess advantage. Maps drawn by appointed bipartisan commissions in Hawaii, Idaho, New Jersey and Washington drew maps that are either neutral, or exhibit a very small excess partisan advantage for the GOP. Maps drawn by judicial courts in New York, Pennsylvania, Virginia and Texas also show a very small (from 0% to 3%) excess artificial advantage for the GOP. The two independent citizens' commissions in Arizona and California drew maps with an excess artificial advantage between 4% and 5% for the Democratic Party.

In the remainder of this section I describe the redistricting process and the results in the five states with an excess artificial advantage greater than 10% of the state's delegation (North Carolina, Utah, Michigan and Ohio), or near this cut-off (Maryland), as indicated in Table 1 in the main paper. For comparison, I also discuss the six states in which the maps were drawn by independent citizens' commissions (Arizona and California), or by the Courts (New York, Pennsylvania, Texas and Virginia).

Note that all four states' congressional maps that were declared unconstitutional partisan gerrymanders by federal courts –the maps of North Carolina, Maryland, Michigan and Ohio- are among the top five worst offenders according to the excess artificial advantage measure.[22]

I. North Carolina

[21] See footnote 18.

[22] As referenced above, these rulings were later vacated by the Supreme Court ruling in *Rucho v. Common Cause* (2019), where it held that partisan gerrymandering claims are not justiciable in federal courts.

In North Carolina, district maps are drawn by the legislature, which throughout 2011-18 has been under Republican control. The state's delegation has 13 seats. The congressional maps were struck down in 2016 as a racial gerrymander, forcing the legislature to draw remedial maps for the 2016 and 2018 elections.[23]

North Carolina is on a class of its own, because it is the only state in which the map-drawers have explicitly acknowledged that the deliberately designed the redistricting maps to be a partisan gerrymander. Mark Lewis, chair of the NC General Assembly's redistricting committee, argued that the redrawn maps are not a racial gerrymander, because their design is partisan, not racial; their intent is to elect as many Republicans as possible. In Lewis's words: "*I think electing Republicans is better than electing Democrats. […] So I drew this map to help foster what I think is better for the country."* And*: "I propose that we draw the maps to give a partisan advantage to 10 Republicans and three Democrats because I do not believe it's possible to draw a map with 11 Republicans and two Democrats*."[24]

These redrawn maps were challenged in Court, and ruled unconstitutional in a series of *Common Cause v Rucho* cases (consolidated with *League of Women Voters v Rucho*): a panel District Court found these remedial maps unconstitutional in January 2018; in July 2018 SCOTUS vacated the January 2018 district court ruling and sent the case back to the district court for reconsideration; and in August 2018 the district panel reaffirmed its previous decision, once again declaring the remedial maps unconstitutional and requiring a second set of remedial maps.[25] SCOTUS decided in September 2018 to let the 2018 election be held under the challenged maps, and in June 2019, it vacated the lower court ruling, declaring partisan gerrymandering "not justiciable" under federal courts.[26]

Because the North Carolina maps are known to be a partisan gerrymander, they provide a test of minimum efficacy for a measure: any new measure of partisan gerrymandering ought to identify North Carolina's 2016 remedial maps as a partisan gerrymandering. The artificial partisan advantage measure passes this test.[27]

[23] Vid. Footnote 39, supra.

[24] *Common Cause v Rucho,* 318 F. Supp. 3d 777, 808-809 (M.D.N.C 2018)

[25] The three rulings are, respectively, *Common Cause v. Rucho*, 279 F. Supp. 3d 587 (M.D.N.C. 2018); *Rucho v. Common Cause*, 138 S. Ct. 2679 (2018) and *Common Cause v. Rucho*, 318 F. Supp. 3d 777 (M.D.N.C. 2018).

[26] *Rucho v. Common Cause,* No. 18-422, 588 U.S. ___ (2019).

[27] Because the 2016 remedial map is based on the original 2011 congressional redistricting map, I measure the artificial partisan advantage both for the 2016 specifically, and for the 2012-18 average of the two similar versions of the maps.

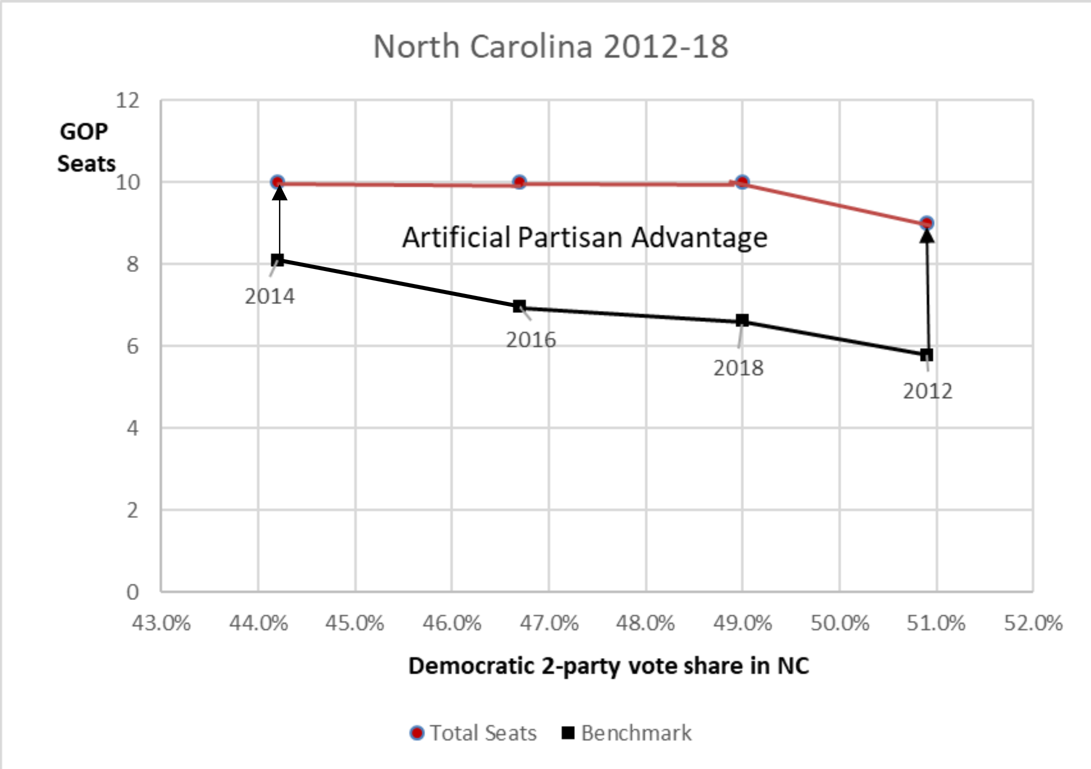

Figure 1. Artificial Partisan advantage in North Carolina, 2012-2018.

North Carolina exhibits the greatest artificial partisan advantage of any state. The 2016 remedial maps were drawn to attain a 10-3 Republican majority delegation, and they attain this outcome for all likely election results. In 2016 and 2018, the Republican party obtained 53% of the two-party vote, and it won in counties with 5,121,000 citizens, or 53.7% of the total population, earning close to 7 of the 13 seats according to the county-based seat benchmark. But it won 10 seats, as designed by the plans. In 2018, its vote share decreased to 51.0%, and the population in counties it won decreased to 51.1% of the state, earning 6.5 seats. And yet, on Election Day the Republican party won 10 seats.[28] The artificial partisan advantage for the GOP averaged over the two elections is 3.2 seats. The excess artificial partisan advantage is over 18%.

II. Utah

The size of Utah's delegation is four seats. The legislature draws the congressional districts' map, and its map has not been challenged in Court.

The Democrats have won Salt Lake county in every election in this cycle. Salk Lake is the largest of the state, home to just over a million citizens, and hence worth one and a half congressional districts. Nevertheless, in 2014 and 2016 the state delegation was a GOP 4-0

[28] Evidence of election fraud later led to not certifying the result in the NC-9 district, and to run a new election for this seat.

majority (in 2012 and 2018 the Democratic party obtained one seat). The GOP's artificial partisan advantage of over one and a half seats in 2014 and 2016, and over half a seat in 2012 and 2018 averages to 1.05 seats over these elections; the excess artificial advantage is 13.7%.

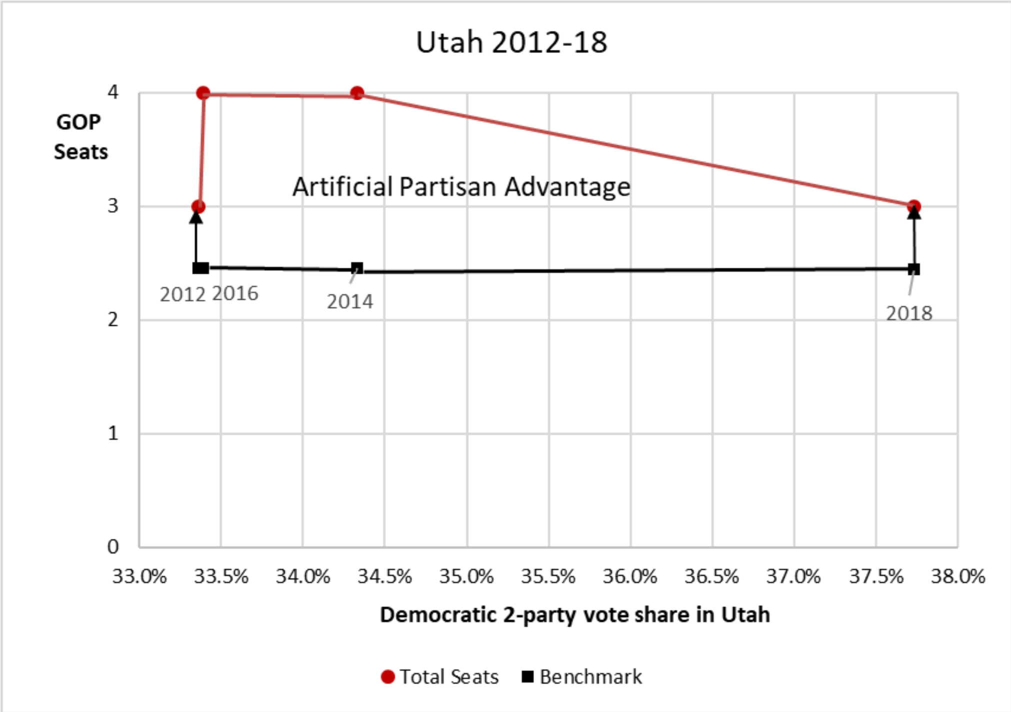

Figure 2. Artificial Partisan advantage in Utah, 2012-2018.

Utah voters have approved a ballot initiative to create a commission with some powers to influence the redistricting process after the 2020 census. With current voting patterns, the state delegation should alternative between 1 or 2 Democrats, as opposed to alternating between 0 or 1 as it has occurred during the 2012-20 redistricting cycle.

III. Michigan

In Michigan, the state legislature drew the districts for the 2012-2020 election cycle, but after an amendment to the Michigan Constitution passed in a ballot initiative in 2018, an independent citizens' commission will draw the maps for the 2022-2030 cycle. The state had a delegation of 14 seats. From 2011 to 2019, the Michigan legislature has been controlled by the Republican Party. The maps drawn in 2011 by the legislature were ruled to be an unconstitutional partisan gerrymander in *League of Women Voters v. Benson* (2019) (see footnote 10). As noted above, this ruling was later voided by SCOTUS's ruling that partisan gerrymandering claims are not justiciable in federal courts, in *Rucho v. Common Cause* (2019).

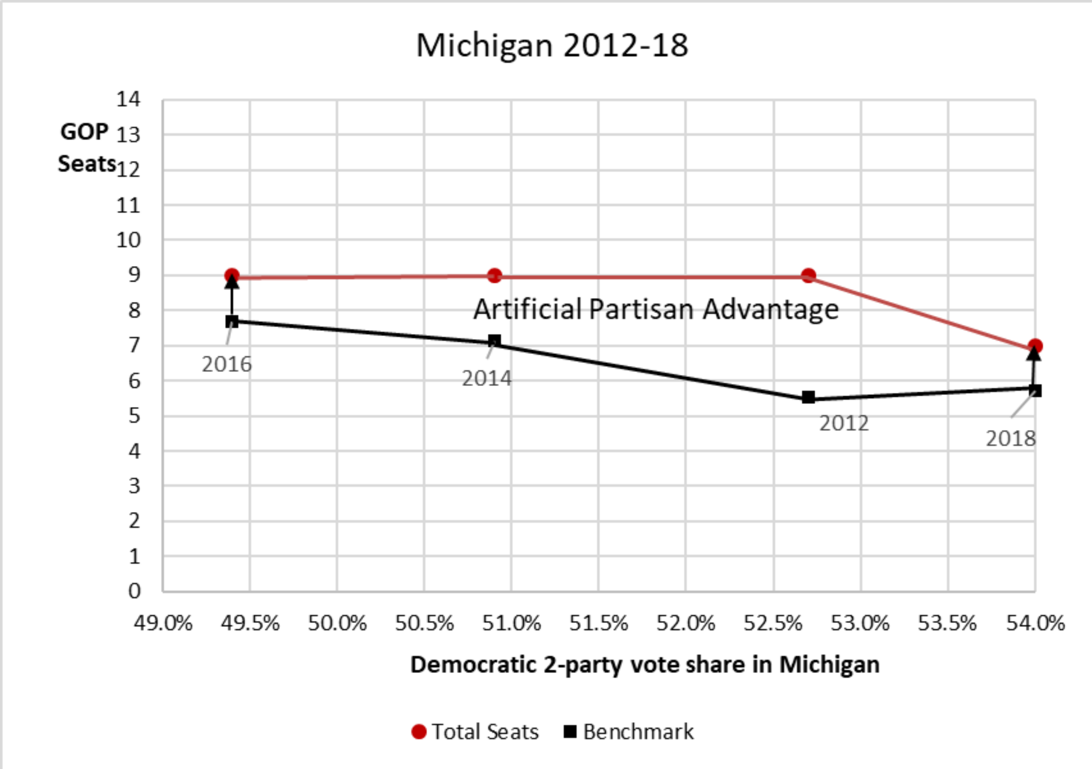

Figure 3. Artificial Partisan advantage in Michigan, 2012-2018.

In 2012, the Republican Party obtained 47.3% of the two-party vote in Michigan, and only won in counties with 39.4% of the population, corresponding to 5.52 seats according to the county-based benchmark. However, the party obtained a 9-5 seat majority, which it kept in 2014 and 2016, despite obtaining only approximately 50% of the two-party vote and winning in counties with little over 50% of the population in each election. In 2018, the Republican party share of the two-party vote decreased to 46%, and the share of population in counties it won decreased to 40.9%, corresponding to 5.72 seats according to the benchmark, but the party won 7 seats. Thus, the artificial partisan advantage averaged to almost two seats over the four elections, with an excess artificial advantage above 10%.[29]

IV. Ohio

In Ohio, the state legislature draws the district maps. The state delegation has 16 seats. The legislature has been under GOP control since 2011. In May 2018, voters approved a ballot initiative to reform the redistricting process. In response, the legislature changed its redistricting rules, to encourage a more bipartisan drawing of maps, and to make it more difficult –but not impossible- for a majority to draw a partisan gerrymander. In 2019, a federal

[29] After Republican legislators pushed to draw maps that would generate a 10-4 GOP majority in most elections, consultant Bob LaBrant insisted they draw a more cautious 9-5 map instead: "*We needed for legal and PR purposes a good looking map that did not look like an obvious gerrymander*," LaBrant wrote (Michael Wines, "New Emails Show Michigan Republicans Plotting to Gerrymander Maps", *New York Times,* July 25th, 2018). I argue that to attain this goal, they should have drawn an 8-6 map, with a partisan advantage of one seat, not two.

District Court ruled the 2011 maps to be an unconstitutional partisan gerrymander in *Phillips Randolph Institute v Householder* (2019) (see footnote 10); as noted above, this ruling was voided by SCOTUS's subsequent ruling that partisan gerrymandering claims are not justiciable by federal courts in *Rucho v. Common Cause* (2019).

It is instructive to look first at the results in the 2014 election, a Republican landslide. In Ohio, the Republican party won over 60% of the two-party vote, and counties with over 75% of the population of Ohio, corresponding to almost exactly 12 seats according to the county-based benchmark. The party won precisely a 12-4 seat majority so on the evidence of 2014 alone, the redistricting map would seem neutral.

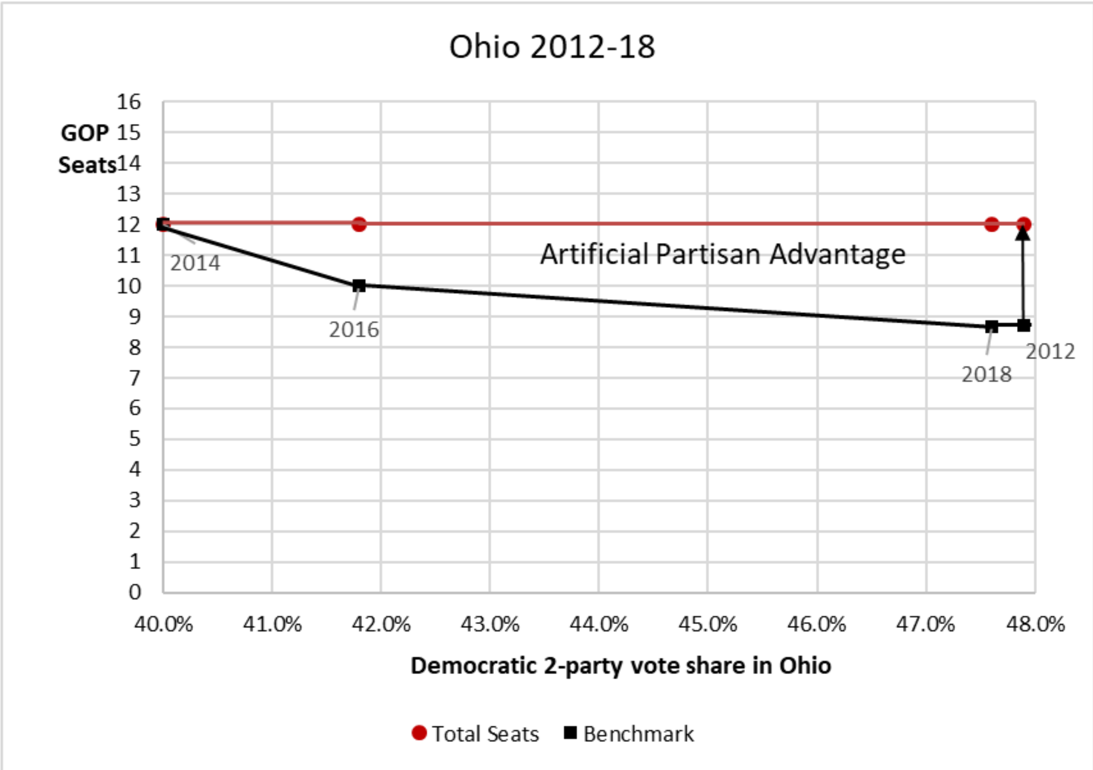

Figure 4. Artificial Partisan advantage in Ohio, 2012-2018.

When we consider other election years, we find that as the electoral environment worsens for the Republican party, its seat outcome does not. In 2016 the party's share of the two-party vote dropped to 58%, and in 2018 to 52% (the same as in 2012); the share of population in counties won by the party dropped to 62% in 2016 and to 54% in 2018 (as in 2012), and hence the seat benchmark dropped to 10 in 2016 and 8.7 in 2018 (and in 2012)… and yet, the Republican party kept the same 12-4 seat majority across all these elections. With the 2011 redistricting maps, for any voting tally within the range of plausible scenarios, the seat outcome is the same as if the Republican party had won in a landslide: a 12 to 4 majority.

The average artificial partisan advantage is over two seats, and the excess artificial advantage is above 10%.

The four Republican partisan gerrymanders (NC, UT, MI and OH) together account for an average artificial partisan advantage of eight seats to the GOP, half the party's artificial advantage aggregated across all 42 states under consideration.

V. Maryland

In Maryland, the state legislature draws the districts' map. The state delegation has 8 seats. The legislature has been under Democratic control since 2011.

In 2013, a group of voters challenged the Democratic-drawn maps in Court as a partisan gerrymander. A district judge dismissed the case in 2014 and the US Courts of Appeals affirmed this decision,[30] but in 2015 SCOTUS vacated these lower court decisions and remanded the case back to the District Court, requiring that it be addressed by a panel.[31] In 2018, a District Court panel ordered that new maps be drawn.[32] In 2019 SCOTUS overturned the lower court ruling, holding that partisan gerrymandering claims are not justiciable, in *Lamone v. Benisek.*[33]

The evidence shows that the 2011 congressional map confers a large artificial partisan advantage to the Democratic party, with an excess artificial advantage near 10%.

In 2016, the Democratic party obtained 63.0% of the two-party vote, and won in counties with 64.0% of the population, earning 5.12 seats (out of 8) according to the county-based benchmark. In 2018 the Democratic party obtained 66.9% and it won in counties with 78.4% of the population, hence earning 6.27 seats according to the benchmark. With the 2011 redistricting maps, the Democratic party obtained a majority of 7-1 seats in both elections. Results for 2014 and 2012 are similar, 2014 mirroring 2016 and 2012 mirroring 2018: as in North Carolina or Ohio, the 7-1 majority for the party that drew the maps is impervious to varying electoral returns.

[30] *Benisek v. Mack*, 11 F. Supp. 3d 516 (D. Md. 2014) and *Benisek v. Mack,* No. 14-1417 (4th Cir. Oct. 7, 2014).
[31] *Shapiro v. McManus*, 136 S. Ct. 450, 577 U.S., 193 L. Ed. 2d 279 (2015).
[32] *Benisek v. Lamone*, No. 1: 13-cv-03233-JKB (D. Md. Nov. 7, 2018).
[33] *Lamone v. Benisek*, 139 S. Ct. 783 (U.S. 2019).

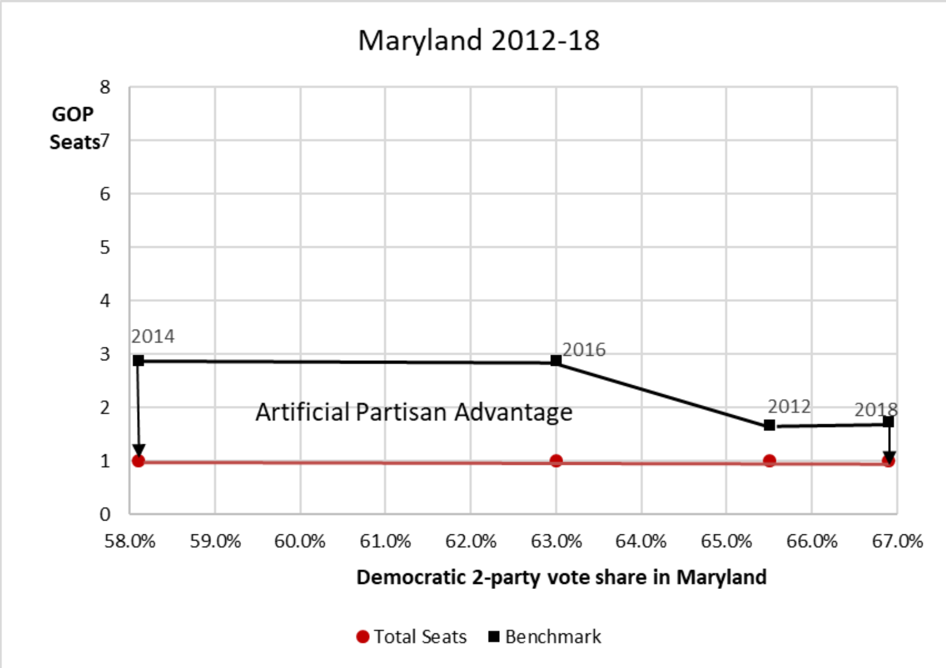

Figure 5. Artificial Partisan advantage in Maryland, 2012-2018.

Averaging across all four elections, the artificial partisan advantage for the Democratic party was 1.29 seats, which corresponds to an excess artificial advantage of 9.8%.

VI. Arizona

In Arizona, an independent citizens' commission draws the districts. The state's delegation has nine seats. Its 2011 maps were perceived to favor the Democratic party.[34] In November 2011, the Arizona Senate dismissed the commission's Chair, but soon after the Arizona Supreme Court reinstated her. The Arizona legislature filed suit to regain the power of redistricting, but once again lost.[35]

The perception that the Commission's 2011 maps favored Democrats is understandable: from 2012 to 2018, on average the Republican party has obtained more than 54% of the two-party vote, while the Democratic party obtained less than 46%, and yet both parties have alternated equally between four and five seats.

Noting that I treat the cities of Phoenix and Mesa (both in Maricopa) as an independent county each (see Table OA5.1), in 2012 and 2014, the Democratic party won in counties with close to 44% of the population, earning close to 4 seats according to the county-based seat benchmark. It obtained 5 seats in 2012 and 4 in 2014. In 2016, the Democratic party lost Phoenix, and the total population in counties it won dropped to 24%, earning only a little over

[34] Aaron Blake. *Redistricting draft map in Arizona favors Democrats*. Washington Post, Oct. 4, 2011.
[35] *Arizona State Legislature v. Arizona Independent Redistricting Commission,* 576 U.S. ___ (2015).

2 seats according to the county-based benchmark. It won 4 seats. In 2018, the Democratic party recovered Phoenix and other jurisdictions in Maricopa county, the total population in units it won returned to almost a half, earning 4.4 seats according to the benchmark. It won 5 seats in the election. Averaging across all elections, it earned fewer than 4 seats on average according to the benchmark, but it held 4.5 seats on average across all four terms, for an artificial partisan advantage of 0.89 seats, corresponding to an excess artificial advantage of 4%.

In short, the Commission's maps allowed the Democratic party to win almost an extra seat in each election.

VII. California

In California, redistricting maps are drawn by an independent citizens' commission. The state delegation has 53 seats.

Note that I divide the -very large- California counties of Los Angeles, San Diego, Orange and Riverside into smaller jurisdictions (see Table OA5.1), extracting their largest cities to generate a set of jurisdictional units closer in size to congressional districts.

With this set of jurisdictional units, in 2012, the Democratic party won in units with 68% of the population, earning 36 seats according to the benchmark. It won 38 seats. The 2014 result is a bit anomalous: the Democratic vote share and the population in jurisdictional units won by Democrats dropped, but the Democrats picked up another seat, to 39, while their benchmark dropped to 32 seats. This gap closed in 2016, when the Democratic vote share increased, and the Democrats won in units with over 73% of the population earning a benchmark of over 38 seats, obtaining 39 seats once again. Finally, in 2018 they won in jurisdictional units with 82% of the population, earning 44 seats according to the benchmark, and winning 46 seats. Averaging across all four elections, the artificial partisan advantage for the Democratic party is 3 seats, and the excess advantage is almost 5%.

VIII. New York

In New York, the state's legislature is responsible for redistricting. The size of the state delegation is 27 seats. In 2011, the legislature was under divided control and was unable to agree on maps, so in 2012 a District Court adopted a map drawn by Stanford Law Professor Nathaniel Persily (then at Columbia U.).

In 2012, the Republican party won 35% of the two-party vote and it won in counties with 15.3% of the population, corresponding to 4.1 seats according to the county-based benchmark, and it won 6 seats. In 2014, the numbers increased to close to 44% of vote share, close to 36% of population in counties won, 9.8 seats according to the benchmark, and 9 seats won. In 2016, the Republican party obtained 36.2% of the two-party vote, and it won in counties with 26.8% of the population, earning 7.71 seats. It won 9 seats in the election. In

2018, it won 31.8% of the vote, and it won in counties with 13% of the population, earning 3.6 seats. It won 6 seats in the election.

The average artificial partisan advantage for the Republican party is 1.17 seats, and the excess artificial advantage is 2.5%.

IX. Pennsylvania

In Pennsylvania, the state legislature draws district maps. The delegation contains 18 seats. In 2011, the legislature was under Republican control.

The 2011 maps were struck down in 2018 by the Pennsylvania Supreme Court,[36] which adopted instead its own remedial map, drawn under the advice of the specially appointed master Stanford Law Professor Persily. Hence the Republican legislature's 2011 maps were used up to the 2016 election, and Court maps in the 2018 election.

The legislature's 2011 maps conferred an average artificial partisan advantage of 1.85 seats to the Republican party in the 2012, 2014 and 2016 elections. As in Ohio, or in the aggregate across all states (see Figure 1 in the main text), this artificial advantage was smallest (less than one seat) in 2014, when it was least needed because the party won by a large margin in votes and seats; and the advantage was greatest (over 3 seats) when it was most useful, in 2012, when the Democrats narrowly won the popular vote and the seat benchmark.

The 2018 Court map almost entirely eliminated this advantage: the Republican party won 44.9% of the vote, and it won counties with 46.8% of the population, earning 8.43 seats according to the benchmark. The party won nine districts, for an average artificial partisan advantage of 0.57 seats, and an excess artificial advantage of 0.4%, an almost neutral map.

X. Texas

In Texas, the state legislature is responsible for drawing congressional districts, but in the 2011-2020 cycle, the adoption of maps in Texas has been convoluted, involving the Courts and the legislature. The delegation has 36 seats. The state legislature has been under Republican control since 2011.

The legislature drew a first set of maps in 2011, and these maps were challenged in court as a racial gerrymander. While these maps awaited pre-clearance as required by the Voting Rights Act, a District Court issued interim maps, which were struck down by SCOTUS. The District Court issued a second set of interim maps in 2012, and in 2013, the legislature adopted permanent maps based on these second interim maps. In 2017, a District Court ruled the 2013 maps a racial gerrymander,[37] but in 2018 SCOTUS overturned this ruling and dismissed the claims against the 2013 congressional maps.[38]

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[36] *League of Women Voters v. Commonwealth*, 178 A.3d 737 (Pa. 2018). See an analysis of this case by Grofman, Bernard and Jonathan R. Cervas. *Can state courts cure partisan gerrymandering: Lessons from League of Women Voters v. Commonwealth of Pennsylvania.* 17(4) Election L. J. 264 (2018).

[37] *Perez v. Abbott*, 274 F. Supp. 3d 624 (W.D. Tex. 2017).

[38] *Abbott v. Perez*, 138 S. Ct. 2305 (2018).

In 2012 the Republican party won in jurisdictional units (within my collection) with just over 61% of the population, corresponding to a benchmark of 22 seats. Since it won 24 seats, its artificial partisan advantage was 2 seats. In 2014 and 2016, the Republican party won in additional jurisdictional units, so its seat benchmark increased to around 24 seats; since it won 25 seats, its artificial partisan advantage lowered to around 1 seat. In contrast, in 2018 the Republican party share of the two-party vote dropped sharply to 51.8% and the party lost many counties it had previously won. Only 56.3% of the population remained in jurisdictional units won by the Republican party, corresponding to 20.3 seats according to the benchmark. The party obtained 23 in the 2018 election.

Aggregating over all four elections, the artificial partisan advantage is 1.74 seats, which corresponds to an excess artificial advantage for the Republican party over 3%.

XI. Virginia

In Virginia, the state legislature draws district maps. The state's delegation has 11 seats. Virginia's General Assembly was under divided control in 2011 and it was unable to agree on redistricting maps on that year. Once the GOP gained unified control of the state's legislature, it approved redistricting maps in 2012. In 2015, these maps were struck down as a racial gerrymander by a District Court.[39] Since the legislature was unable to draw new maps, the Court adopted instead a map drawn by a panel of federal judges. This Court-drawn map was in use in the 2016 and 2018 election.

The legislature's 2012 congressional map conferred an average artificial partisan advantage of 1.57 seats to the Republican party in the 2012 and 2014 elections. As in Pennsylvania, Ohio, Michigan or in the aggregate of the nation, the partisan advantage was greatest (two seats) when it was most useful in 2012, helping to turn a Democratic narrow victory in votes and benchmark seats into a Republican majority in the House. The advantage was smallest (only one seat) in 2014, when it was less relevant. The excess artificial advantage of these racially gerrymandered maps was near 10%.

The Court-drawn map reduced this Republican advantage. In 2016, the Republican party obtained 49.8% of the two-party vote, and won in counties with 50% of the population, earning 5.5 seats according to the county-based seat benchmark. It won 7 districts. In 2018, it obtained 43% of the two-party vote, and it won in counties with 34.9% of the population, earning 3.84 seats according to the benchmark. It won 4 districts. Averaging over the two elections, the artificial partisan advantage is 0.83, with an excess artificial advantage of only 3%.

[39] *Page v. Virginia State Board of Elections*, Civil Action No. 3: 13cv678 (E.D. Va. June 5, 2015).

OA4. LIMITATIONS AND SUGGESTED REMEDIES

In this section I discuss all the caveats and limitations of the measure of artificial partisan advantage that I am aware of, and I suggest some remedies.

I. States with missing data: Florida.

To compute the artificial partisan advantage, we need voting tallies in every race, including uncontested races. Two states do not run elections for uncontested seats: Oklahoma, and Florida.

In Oklahoma, the absence of data on uncontested races is inconsequential: because the Republican party obtains most votes in every county despite collecting no votes in seats it wins uncontested, the seat benchmark is unaffected by missing data from uncontested seats.

In contrast, in several counties in Florida, not counting votes in uncontested districts determines which party gets the most votes: in these counties, if the election for an uncontested seat had been held and the votes for the winner tallied, the party of the winner of the uncontested race would have won the county, but if we do not hold an election for this seat (and hence we do not tally any votes for the winner of this seat), the opposite party wins.

A possible solution to compute the artificial partisan advantage in Florida despite this missing data is to impute the votes that the party that won an uncontested seat would have obtained in each precinct had an election been held. This imputation can be based on results from past elections, or from up-ticket or down-ticket races. But this is not satisfactory: the resulting measure relies on counterfactuals and vote imputations, not on actual voting results, and hence it would not be directly comparable to the measure obtained with actual election results in the other 42 states.

Therefore, I adopt a more modest approach: insisting on using only real election results, I accept as a limitation that the state of Florida does not provide the necessary data to adequately compute the artificial partisan advantage.

II. Sensitivity.

Any measure that relies exclusively on actual election results evaluates a map based on very few data points: only one per election. We may wonder about the sensitivity of the measure to small changes in election outcomes. We can evaluate whether the measure of the artificial partisan advantage is robust to small changes in voting outcomes by computing the measure for a counterfactual election with similar results.

Recall that SCOTUS is "*wary of adopting a constitutional standard that invalidates a map based on unfair results that would occur in a hypothetical state of affairs.*"[40] I follow SCOTUS' guidance on this point: the measure of artificial partisan advantage relies exclusively on actual election results. I suggest using counterfactuals only as a sensitivity analysis, following a principle of caution: if actual election results induce a presumption that a plan is a partisan gerrymander, we can give the plan a second chance by using counterfactuals to check whether the plan performs sufficiently better under alternative hypothetical scenarios to undermine the initial finding against the map… but I do not suggest using counterfactuals to criticize a map that performs well with actual data. This use of counterfactuals makes the standard to invalidate a map more stringent.

[40] Justice Kennedy's Opinion of the Court in *LULAC v. Perry*, 548 U.S. 399, 420 (2006).

I conduct a sensitivity analysis of the artificial partisan advantage for the maps in the states of North Carolina, Utah, Michigan, Ohio and Maryland maps for each of the four elections. I recompute the seat benchmark and the artificial partisan advantage for any counterfactual in which a fixed fraction up to 1% of Republican votes in each county and district switched to the Democratic party; and for any counterfactual in which up to 1% of Democratic votes switched to the Republican party.[41]

Figure 2 shows the results of this sensitivity analysis in North Carolina.

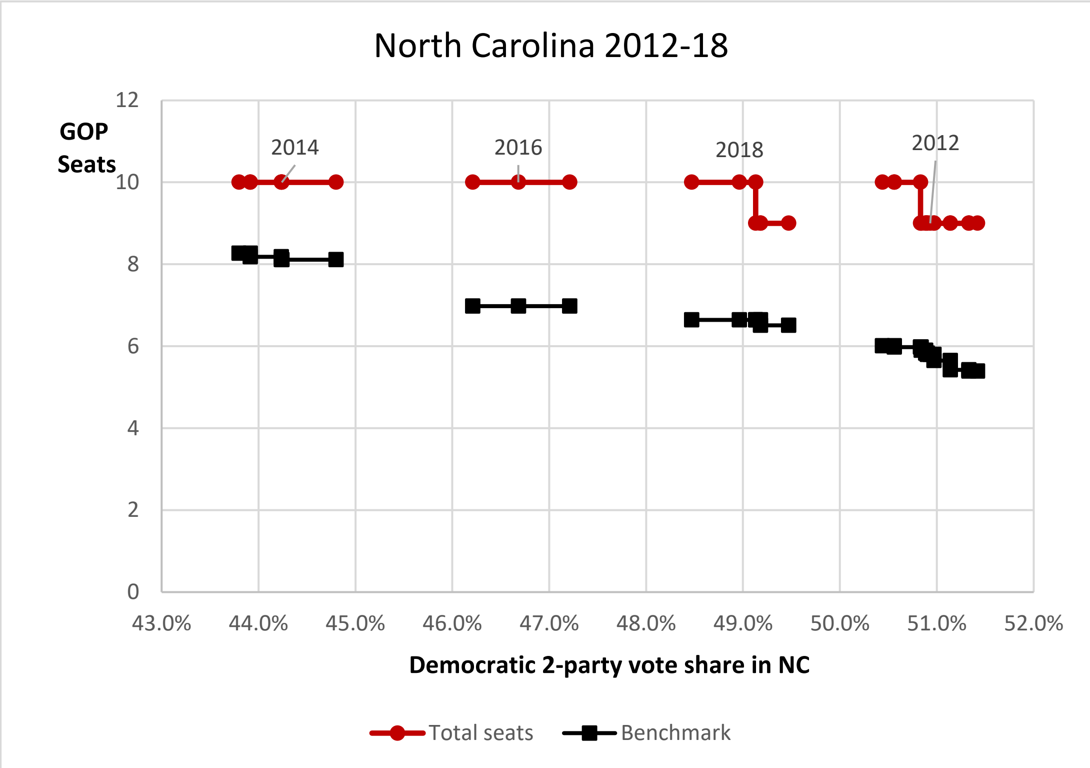

Figure 6: Sensitivity analysis for North Carolina, number of seats.

In Figure 6, the graph of the benchmark number of seats jumps at each vote share at which the popular vote in a county flips from one party to the other; the size of the jump varies in proportion to the county's population. The total number of seats jumps by one seat at the counterfactual vote share at which a district flips. Lines connect counterfactuals associated to the actual election result used to generate them.[42]

We see that the benchmark and measure are largely robust to small variations in votes: in 2012 the Republican party almost won a 10th seat, and in 2018 it barely held on to 10 seats, so minor vote swings would have led the party to get either 9 or 10 seats in these elections. Figure 7 shows that the

[41] A different counterfactual in which a common share of votes switched in all counties generates absurdities such as votes over 100% or below 0% for a party in counties in which only one party runs. The counterfactuals I run avoid this problem, and always generate meaningful results, by switching a fixed fraction of the votes cast for a party, not of the total number of votes

[42] Admitting counterfactual arguments to exonerate plans requires a limit on which counterfactuals are admissible. These must be only those close to actual election results: without this limit, any map performs well for some counterfactual. I only consider counterfactuals in which up to 1% of voters for a given party switch their vote.

artificial partisan advantage is excessive for each election and for any counterfactual result in the range from the worst to the best result for the GOP that we observed since 2012.

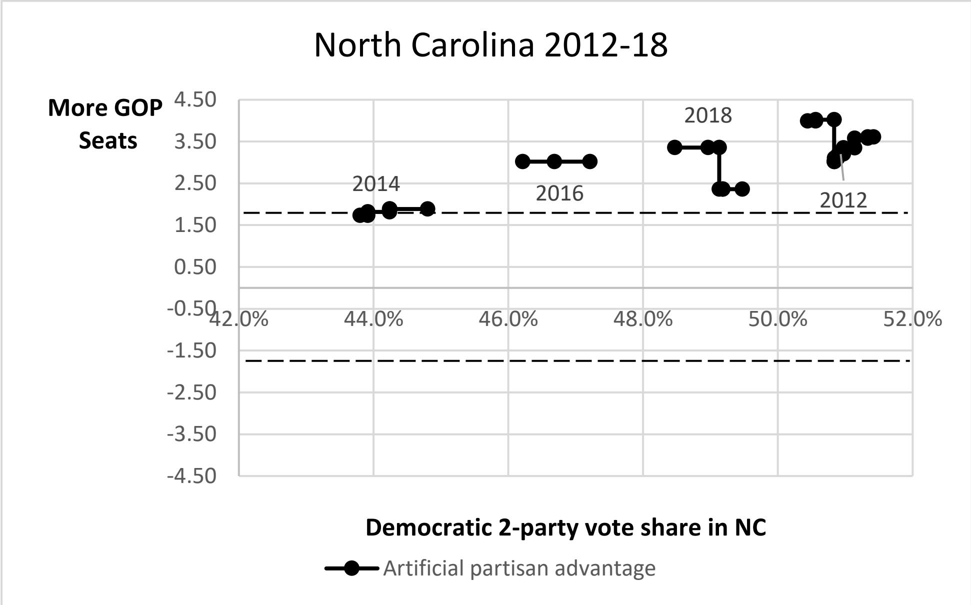

Figure 7. Sensitivity analysis in North Carolina; artificial partisan advantage

The band limited by the dashed lines is the range of values with excess artificial advantage no greater than 10%. North Carolina's map is outside this range for any counterfactual vote share in the range from the smallest to the largest vote share in an actual election.

The maps in North Carolina, Utah, Michigan and Ohio perform similarly -or slightly worse- under the counterfactual voting results (see figures 8-13). The sensitivity analysis provides no evidence to overcome the presumption derived from actual election results that these maps are partisan gerrymanders with an excessive artificial advantage.

On the other hand, the map in Maryland, which conferred an average excess artificial advantage close to 10%, performs better in some of the counterfactuals. The map confers an artificial advantage to the Democratic party in every counterfactual, but the magnitude is smaller in some of these counterfactuals. This sensitivity analysis weakens the evidence against the Maryland map, evidence that was the weakest among these five states to begin with.

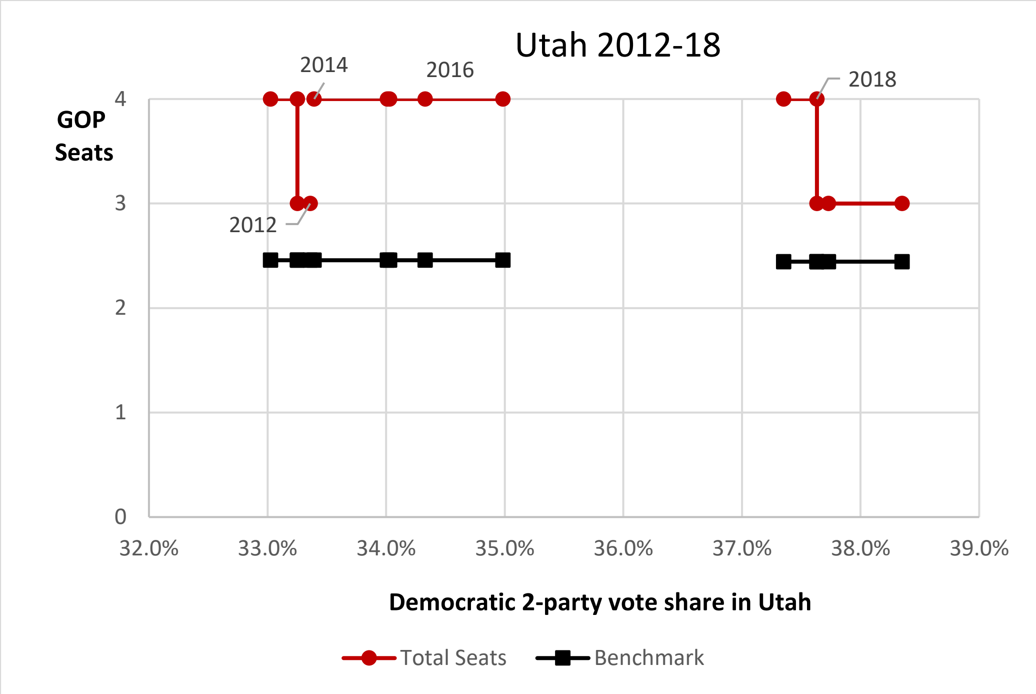

Figure 8. Sensitivity analysis for Utah, number of seats.

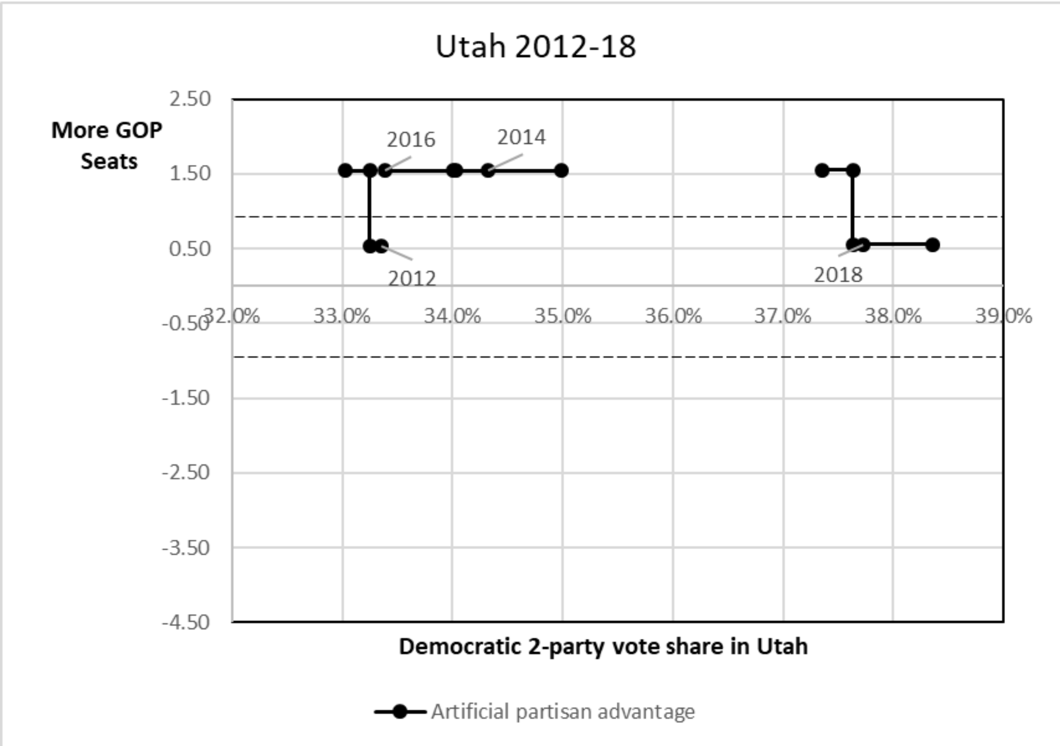

Figure 9. Sensitivity analysis for Utah, artificial partisan advantage. [43]

[43] The counterfactuals with up to 1% of one party's vote switching computed with respect to each election overlap in Utah. When they do, I only plot the counterfactual closest to an actual election result, and not the

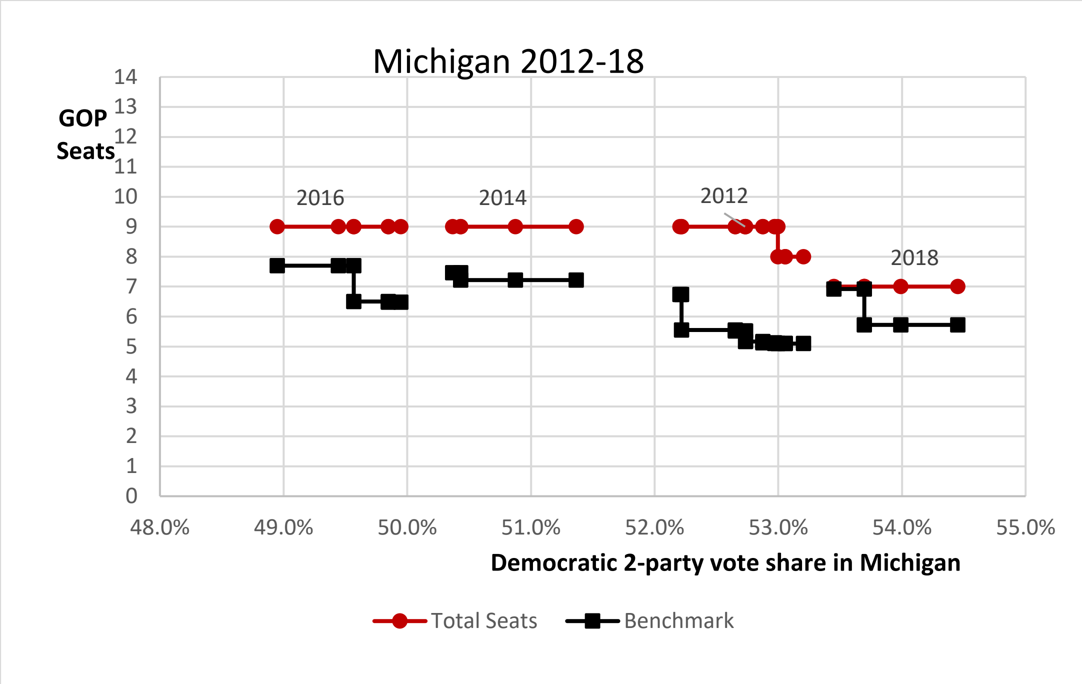

Figure 10. Sensitivity analysis for Michigan, number of seats.

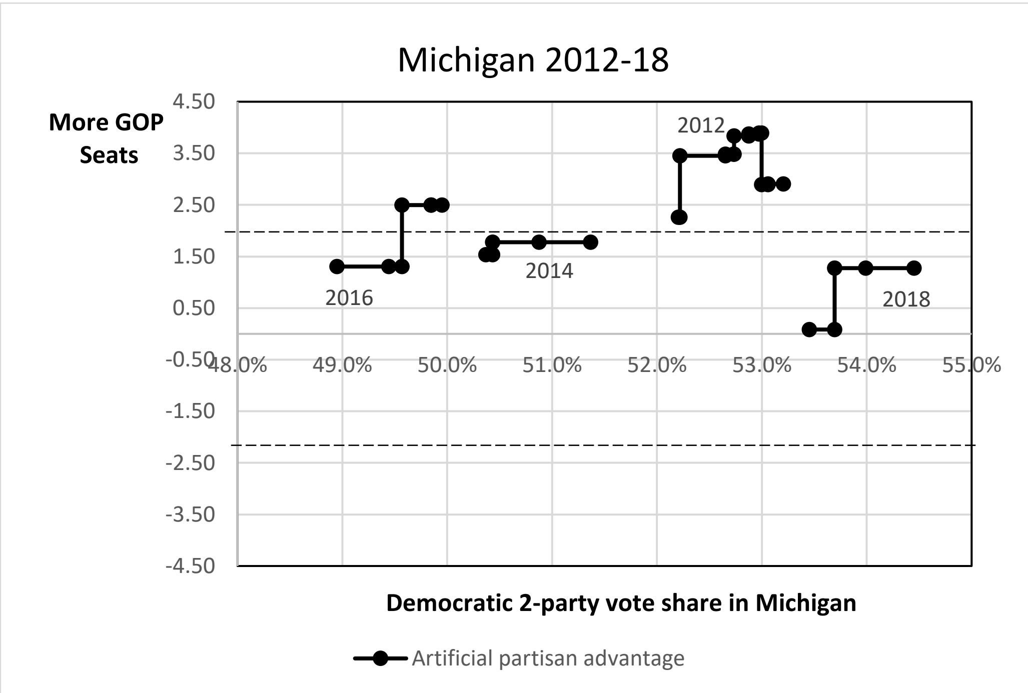

Figure 11. Sensitivity analysis for Michigan, artificial partisan advantage.

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one derived from a greater deviation from an actual election result. For instance, for the counterfactual in which at least 0.4% of all Democratic voters in 2016 had switched to the Republican party, the Republicans would win Salt Lake county, and their benchmark number of seats would increase to close to 4, but for such a counterfactual vote share, the 2012 actual election result is a closer base point.

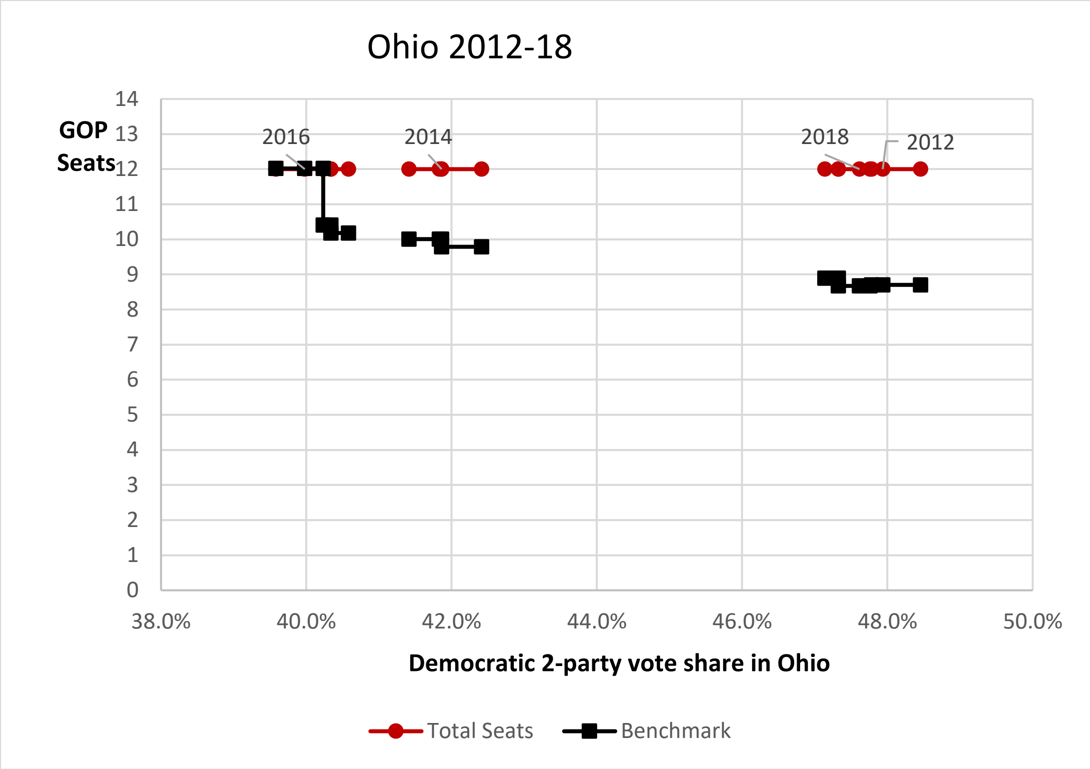

Figure 12. Sensitivity analysis for Ohio, number of seats.

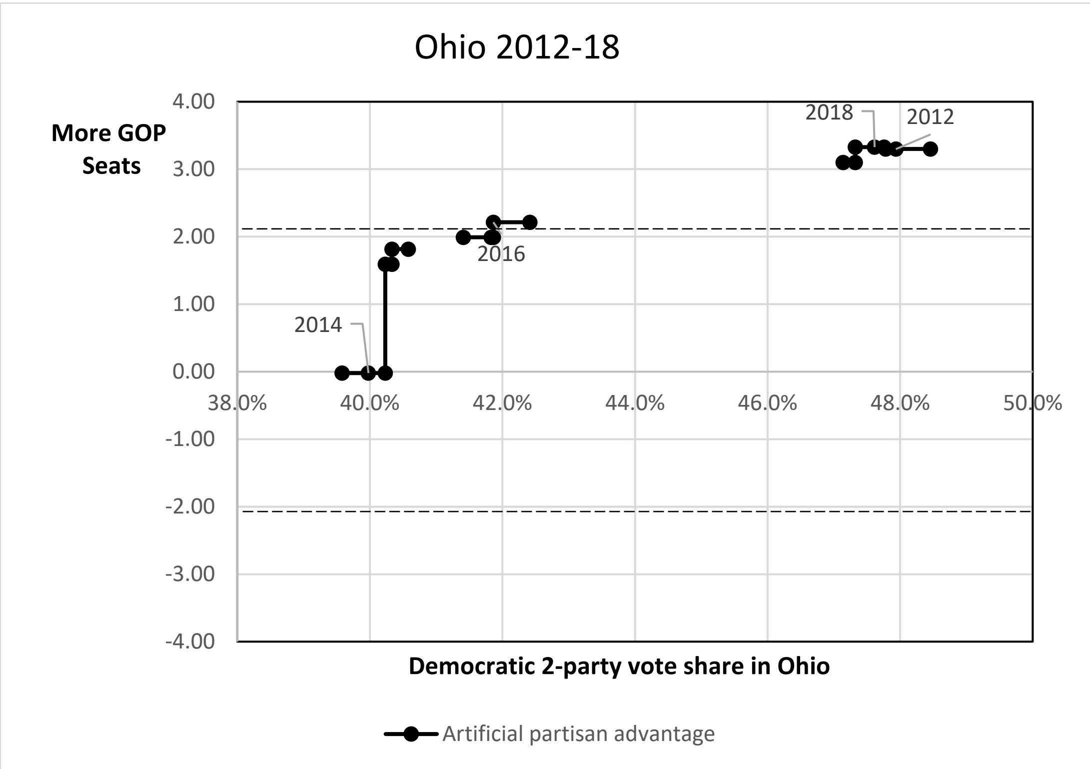

Figure 13. Sensitivity analysis for Ohio, artificial partisan advantage.

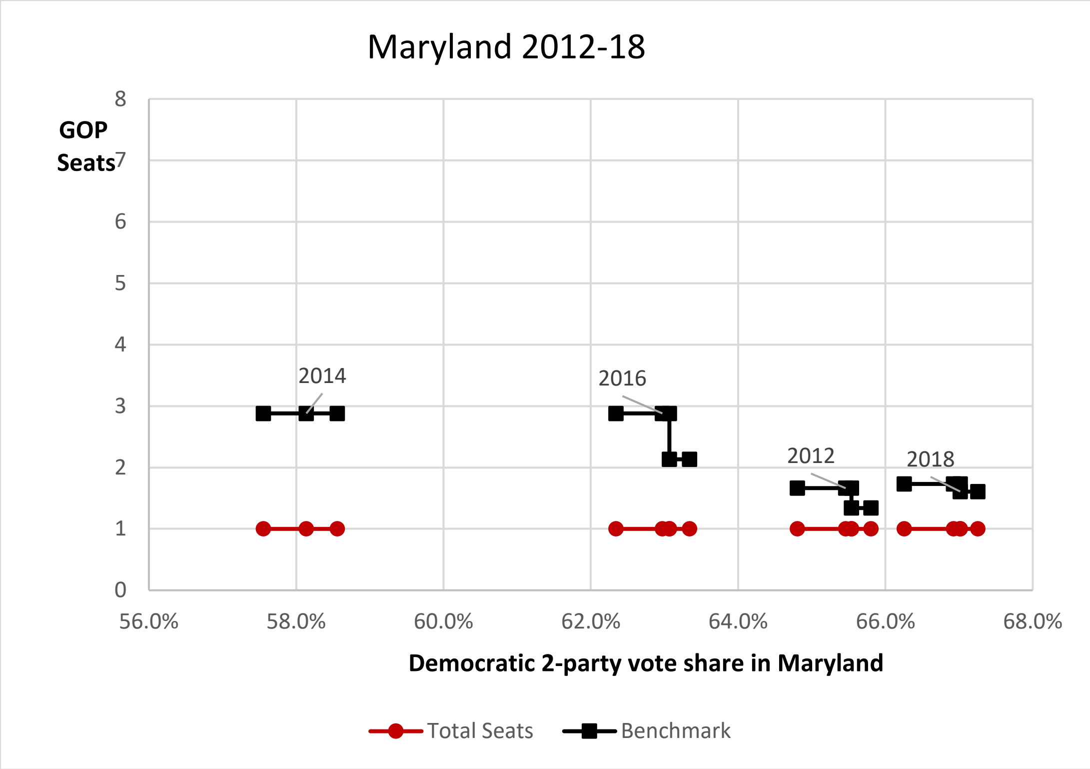

Figure 14. Sensitivity analysis for Maryland, number of seats.

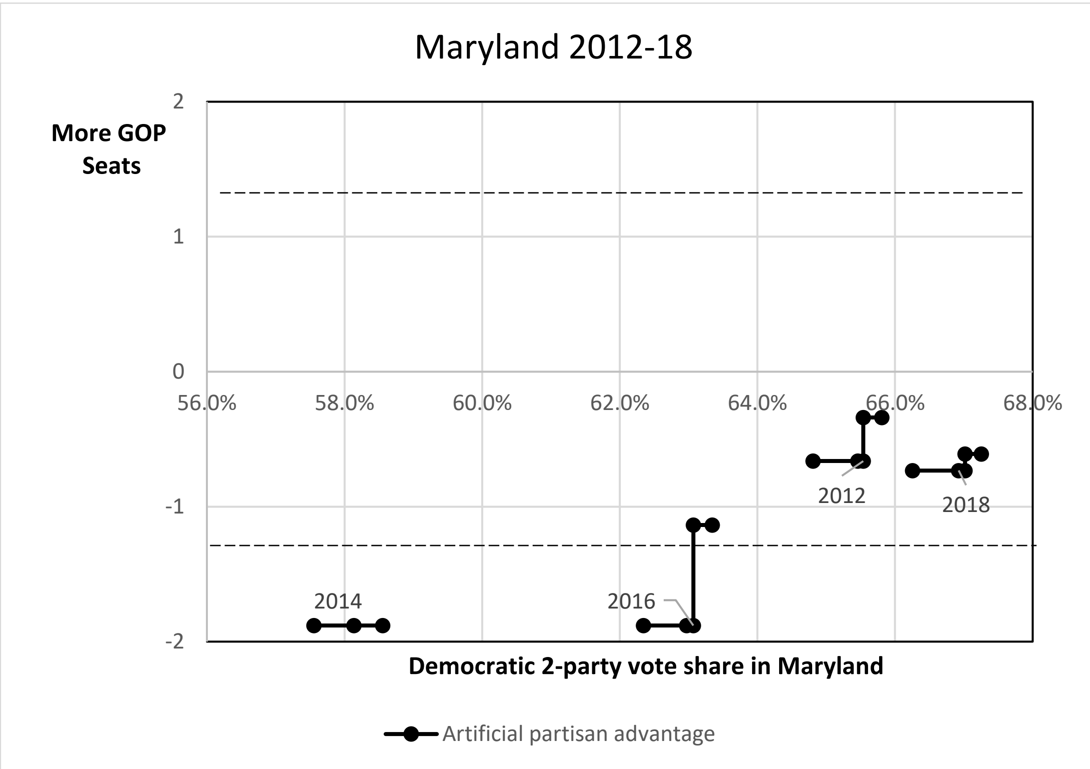

Figure 15. Sensitivity analysis for Maryland, artificial partisan advantage.

III. Incomplete judicial test.

The artificial partisan advantage provides a notion of partisan fairness in redistricting that corresponds to a clear normative benchmark: a redistricting map is "fair" if it approximates the seat share that we would obtain without drawing electoral districts, by assigning seats in the assembly to each county, with each county's share of seats being weighted by the county's population.[44] or, to be more precise,

The artificial partisan advantage is then the seat difference between the actual outcome and this benchmark. Since this absolute measure of seats will tend to be larger in states with more seats, to compare the measure across states of different sizes I also propose the excess artificial advantage, which is the measure of artificial partisan advantage in excess of a rounding margin of 0.5 seats, divided by the total number of seats in the delegation.

Given the normative standard given by the county-based benchmark, a map with zero excess partisan advantage is neutral and "fair." An open question remains: how great a deviation from fairness is tolerable, and what's the cutoff beyond which a map is illegal?

In previous drafts of this work, I suggested using a threshold of 10% of excess artificial advantage to regard a redistricting map as a partisan gerrymander if its excess artificial advantage is above this threshold. This 10% cutoff finds precedent in previous SCOTUS decisions: In 1983, and most recently in 2016, SCOTUS used 10% as the threshold of population differences across districts beyond which the difference is a *prima facie* evidence of discrimination.[45] I suggested using the same 10% threshold to evaluate redistricting plans under federal law.

As long as partisan gerrymandering claims remain non-justiciable in federal courts, the question of identifying a homogeneous federal standard to evaluate all plans under federal law is moot. The question of degree about how much partisan unfairness is tolerable and legal shifts to the states.

The answer will depend on the language requiring partisan fairness in each state's Law. The answer may take into account the excess partisan advantage; it could check the robustness of this measure against the sensitivity analysis in the previous subsection, or it could use a collection of measures to identify a robust finding of unfairness; it can take into consideration idiosyncratic explanations for a larger than normal artificial partisan advantage in a given particular case;[46] and it can weigh violations of partisan fairness compared to the map's performance in other criteria such as compactness or respect for jurisdictional boundaries… In any case, confronted with evidence of partisan unfairness in gerrymandered maps, state courts will face the same question posed by the

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[44] Or, to be more precise, by assigning seats to each jurisdictional unit (counties, cities or townships) closest in size to the current congressional districts. In most states, these units are the counties.

[45] See *Brown v. Thomson*, 462 U.S. 835 (1983) and *Harris vs Arizona Independent Redistricting Commission* 578 US __ (2016).

[46] For some configurations of the geographic distribution of voters, any redistricting map with contiguous, compact[46] districts will feature an excess advantage greater than 10%. These configurations are implausible, but here is an example. Consider a linear state (say along a road) from East to West that must be divided into three districts with equal population. Assume the easternmost and westernmost counties each have 1/6 of the population, and that Party *p* wins two thirds of the votes in the easternmost and westernmost counties, and no votes elsewhere. Party *p* wins in counties with 1/3 of the population, so it earns one seat according to the county-based benchmark. A map that yields zero seats for Party *p* confers an excessive partisan advantage for the other party. However, any map with contiguous districts would result in Party *p* winning no seats.

Opinion of the Court in *Rucho v. Common Cause* (2019): "*How much is too much?"* Staring at the evidence from North Carolina and Maryland 2011 congressional maps, Justice Kagan offered an emphatic answer in her Dissent (joined by three other justices) in *Rucho:* "*This much is too much.*"

It will next be up to the states' courts to decide whether the partisan advantage in each challenged map is acceptable, or whether it is too much under state law.

IV. Arbitrary unit selection: Modifiable Area Unit Problem (MAUP).

The definition of the artificial partisan advantage is based on a comparison to a benchmark based on a partition of the state into jurisdictional units. Change the collection of jurisdictional units used to define the benchmark (say from counties to townships), and the definition of the measure changes. It follows that the artificial partisan advantage could be subject to a standard inference problem: The Modifiable Area Unit Problem (MAUP).[47] This problem arises in application in which primary data is aggregated into geographical units, and data at the aggregated unit level is used to estimate a variable of interest; the problem is that choosing different geographical units for the aggregation can lead to different results.

I argue that the definition of the artificial partisan advantage measure is not subject to MAUP because the area unit is not modifiable. A unique collection of jurisdictional units is most salient and enjoys a normatively appealing interpretation: this collection is the collection of jurisdictional units closest in size to the districts that need to be drawn. In 33 out of 42 states, these units are the counties, and the benchmark to use is unambiguously the one constructed based on the county map. Other area units can, but should not, be used.

In nine states (AZ, CA, IL, MA, NV, NY, PA, TX and WA), some counties are too big; smaller jurisdictional units such as townships are closest in size to congressional districts.

The axiom of seeking the units closest in size to the district requires breaking up every county of population size greater than two congressional districts (1,415,000 inhabitants) into townships. There are 21 such counties in the 42 states under consideration (out of a total of 2,844 counties).

Aggregate results (available from the author) are very similar using a population cutoff equal to the population of three, four or five districts. Changing the size cutoff from two to three, four of five districts, only affects results in California (where it halves the average Democratic artificial partisan advantage from 3 to 1.46 seats if the cutoff is three, and reduces it to 2 or 2.5 seats if the cutoff is respectively four or five districts); and in Arizona, Illinois, Nevada, New York and Texas, where the effect is small (no more than 0.2 seats). The average Republican artificial partisan advantage in the aggregate across all 42 states computed with a population size cut-off to break counties into townships equal to three districts is 17.5 seats, 17 seats computed with a cutoff of four, and 16.5 seats with a cutoff of five districts, compared to 16 seats with the more compelling cutoff of size equal to two congressional districts. Using more extreme units, the GOP enjoys an average partisan advantage of 17 seats relative to the benchmark that aggregates votes at a state level (so each state becomes a winner-take-all), and of 12 seats relative to the opposite extreme benchmark in which votes are not aggregated at all, so representation is proportional to vote share.

Aggregate results -and state results in most states- are therefore robust across different benchmarks.

[47] See for instance King (1997), chapter 14 for a standard treatment of this problem.

V. Small States.

States with four or fewer seats present additional challenges to measure partisan advantage. The standard approach is to simply drop them from the analysis.[48] A strength of the artificial partisan advantage measure is that it can be applied to states of any size. However, we must be aware of a subtlety in interpreting the results, as follows.

Small states, by the very nature of their size, are more likely to generate extreme results: their maps are more likely to be measured as neutral, with zero excess artificial advantage, or as an extreme partisan gerrymander, and they are less likely to show the small or moderate excess artificial advantage typical of large states. This phenomenon is best illustrated by example: in 2016, the Republican party won the popular vote in counties with 51.6% of the population of Maine, so its county-based seat benchmark was 1.03 (out of 2 seats in the state). If the map is such that the Republican party gets exactly 1 seat, the excess artificial advantage is zero, while if the party gets 0 or 2 seats, the map is presumed to be an extreme partisan gerrymander: with an excess artificial advantage of around 25%. That is, based on the 2016 voting records, any map for Maine could only be measured as either neutral, or as the worst gerrymander in the nation.[49]

In contrast, if a party were to gain the popular vote in counties with 51% of the population of California, the excess artificial advantage is zero only if the party wins exactly 27 seats. Given that election outcomes are uncertain, the party is unlikely to obtain exactly 27 seats for any map with some competitive districts. On the other hand, if the party wins anything between 22 to 26 or 28 to 32 seats (a most likely outcome), the excess artificial advantage is positive but below 10%.

So, while the average excess artificial advantage is approximately constant in state size, by nature of the limited set of possible outcomes, maps in small states are more likely to yield an extreme measure of excess artificial advantage (either zero, or very high). Therefore, when we observe these extreme measures in a small state, we must interpret them as less exceptional than they would be for larger states.

This nuance implies that the sensitivity analysis, accumulating results from various elections, or using additional measures, may be advisable before we invalidate a map from a small state, even if its measure of excess artificial advantage appears extreme.

This is an exhaustive list of the limitations and challenges in the use of the measure of artificial partisan advantage that I am aware of. I invite and welcome further criticism, in the conviction that "*ideas should be carefully tested and subjected over time to serious critical examination before they are used to affect policy*." (Chambers, Miller and Sobel, 2017).

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[48] See for instance Li and Royden (2017).

[49] In the event, the Republican party obtained one seat, so the Maine map is measured as neutral.

TABLE OA5.1. LARGE COUNTIES SPLIT INTO SMALLER JURISDICTIONAL UNITS.

In bold, the original counties; underneath, the jurisdictional units I use.

County name	Population
Los Angeles County, California	**9,818,000**
City of Los Angeles	3,792,621
City of Long Beach	462,257
City of Santa Clarita	210,888
City of Glendale	203,054
City of Lancaster	160,316
City of Palmdale	152,750
City of Pomona	149,058
City of Torrance	145,438
City of Pasadena	137,122
City of El Monte	113,475
City of Downey	111,772
City of Inglewood	109,673
City of West Covina	106,098
City of Norwalk	105,549
City of Burbank	103,340
City of Compton	96,455
City of South Gate	94,396
City of Carson	91,714
City of Santa Monica	89,736
City of Whittier	85,331
City of Hawthorne	84,293
City of Alhambra	83,653
City of Lakewood	80,048
City of Bellflower	76,616
City of Baldwin Park	75,390
City of Lynwood	69,772
City of Redondo Beach	66,748
City of Pico Rivera	62,942
City of Montebello	62,500
City of Monterey Park	60,269
City of Gardena	58,829
City of Huntington Park	58,114
City of Arcadia	56,364
City of Diamond Bar	55,544
City of Paramount	54,098
City of Rosemead	53,764

(continued in next page)

City of Glendora	50,073
City of Cerritos	49,041
City of La Mirada	48,527
City of Covina	47,796
City of Azusa	46,361
City of Bell Gardens	42,072
City of Rancho Palos Verdes	41,643
City of La Puente	39,816
City of San Gabriel	39,718
Culver City	38,883
City of Monrovia	36,590
Temple City	35,558
City of Bell	35,477
City of Manhattan Beach	35,135
City of Claremont	34,926
City of West Hollywood	34,399
City of Beverly Hills	34,109
City of San Dimas	33,371
City of Lawndale	32,769
City of La Verne	31,063
City of Walnut	29,172
City of Maywood	27,395
Rest of LA County	1,394,724
Cook County, Illinois	**5,194,675**
City of Chicago	2,695,598
Thornton township	169,326
Wheeling township	153,630
Worth township	152,633
Proviso township	151,704
Maine township	135,772
Schaumburg township	131,288
Palatine township	112,994
Lyons township	111,688
Rest of Cook County	1,380,042
Harris County, Texas	**4,092,459**
Houston[50]	2,735,466

[50] Harris County does not report results by city. I code a precinct to be in Houston if the US Post Service assigns a “Houston” address to its polling station. Because the area of Houston according to the USPS does not coincide with the area of Houston according to the Census, and because population is not reported by precinct, I estimate

Rest of Harris County	1,356,992
Maricopa County, Arizona	**3,817,117**
City of Phoenix	1,445,632
City of Mesa	439,041
City of Chandler	236,123
City of Glendale	226,721
City of Scottsdale	217,385
Rest of Maricopa County	1,252,215
San Diego County, California	**3,095,313**
City of San Diego	1,307,402
City of Chula Vista	243,916
City of Oceanside	167,086
Rest of San Diego County	1,376,909
Orange County, California	**3,010,232**
City of Anaheim	336,265
City of Santa Ana	324,528
City of Irvine	212,375
City of Huntington Beach	191,037
City of Garden Grove	170,883
City of Orange	136,416
City of Fullerton	135,161
City of Costa Mesa	109,960
Rest of Orange County	1,393,607
Dallas County, Texas	**2,368,139**
City of Dallas	1,197,816
Rest of Dallas County	1,170323
Riverside County, California	**2,189,641**
City of Riverside	303,871
City of Moreno Valley	193,365
City of Corona	152,374
City of Murrieta	103,466
City of Temecula	100,097
Rest of Riverside County	1,336,468

the population of the collection of precincts coded as Houston to be proportional to the number of registered voters in this collection of precincts.

San Bernardino County, California	**2,305,210**
City of San Bernardino	303,871
City of Fontana	196,069
City of Rancho Cucamonga	165,269
City of Ontario	163,924
Rest of San Bernardino County	1,300,024
Clark County, Las Vegas	**1,951,269**
City of Las Vegas	583,756
City of Henderson	257,729
Rest of Clark County	1,109,784
King County, Washington	**1,931,249**
City of Seattle	608,660
Rest of King County	1,322,589
Wayne County, Michigan	**1,820,584**
City of Detroit	713,777
Rest of Wayne County	1,106,807
Tarrant County, Texas	**1,809,034**
City of Fort Worth	726,815
Rest of Tarrant County	1,082,219
Santa Clara County, California	**1,781,642**
City of San Jose	945,942
Rest of Santa Clara County	835,700
Bexar County, Texas	**1,714,773**
City of San Antonio	1,327,407
Rest of Bexar County	387,366
Alameda County, California	**1,510,271**
City of Oakland	390,724
Rest of Alameda County	1,119,547
Middlesex County, Massachusetts	**1,503,085**
City of Lowell	106,519
Rest of Middlesex County	1,396,566

Suffolk County, New York	**1,493,350**
Town of Brookhaven	486,040
Rest of Suffolk County	1,007,310
Sacramento County, California	**1,418,788**
City of Sacramento	466,488
Rest of Sacramento County	952,300

TABLE OA5.2. ARTIFICIAL PARTISAN ADVANTAGE BY STATE, 2012 US HOUSE ELECTION

			Pop. in counties won		Republican Seats		
State	**[1] Seats**	**[2] R vote**	**[3] by R**	**[4] by D**	**[5] Earned**	**[6] Total**	**[7] Art. Adv.**
Alabama	7	64.0%	3,595,329	1,184,407	5.27	6	0.73
Arizona	9	54.4%	3,596,877	2,795,140	5.06	4	-1.06
Arkansas	4	67.7%	2,209,724	706,194	3.03	4	0.97
California	53	38.0%	13,015,070	24,238,886	18.52	15	-3.52
Colorado	7	51.4%	1,807,042	3,222,154	2.52	4	1.48
Connecticut	5	34.5%	189,927	3,384,170	0.27	0	-0.27
Georgia	14	59.2%	6,456,539	3,231,114	9.33	9	-0.33
Hawaii	2	32.5%	0	1,360,211	0	0	0.00
Idaho	2	66.1%	1,508,962	58,620	1.93	2	0.07
Illinois	18	44.6%	6,908,240	5,922,392	9.69	6	-3.69
Indiana	9	54.2%	3,931,252	2,552,550	5.46	7	1.54
Iowa	4	48.5%	1,028,392	2,017,963	1.35	2	0.65
Kansas	4	79.1%	2,564,358	288,760	3.60	4	0.40
Kentucky	6	60.0%	3,214,700	1,124,667	4.44	5	0.56
Louisiana	6	77.4%	4,088,130	445,242	5.41	5	-0.41
Maine	2	38.3%	32,856	1,295,505	0.05	0	-0.05
Maryland	8	34.5%	1,199,765	4,573,797	1.66	1	-0.66
Massachusetts	9	25.1%	0	6,547,629	0	0	0.00
Michigan	14	47.3%	3,894,720	5,988,920	5.52	9	3.48
Minnesota	8	43.7%	1,233,278	4,070,647	1.86	3	1.14
Mississippi	4	63.1%	2,176,730	790,567	2.93	3	0.07
Missouri	8	56.7%	3,810,509	2,178,418	5.09	6	0.91
Nebraska	3	64.2%	1,309,231	517,110	2.15	3	0.85
Nevada	4	50.2%	749,282	1,951,269	1.11	2	0.89
N. Hampshire	2	47.8%	756,032	560,438	1.15	0	-1.15
New Jersey	12	44.4%	3,003,768	5,788,126	4.10	6	1.90
New Mexico	3	44.8%	666,801	1,392,378	0.97	1	0.03
New York	27	35.1%	2,960,613	16,417,489	4.13	6	1.87
North Carolina	13	49.1%	4,253,681	5,281,802	5.80	9	3.20
Ohio	16	52.1%	6,274,156	5,262,348	8.70	12	3.30
Oklahoma	5	67.6%	3,751,351	0	5	5	0
Oregon	5	42.0%	1,042,096	2,788,978	1.36	1	-0.36
Pennsylvania	18	49.2%	6,909,453	5,792,926	9.79	13	3.21
Rhode Island	2	41.0%	49,875	1,002,692	0.09	0	-0.09
South Carolina	7	58.0%	3,108,788	1,516,576	4.70	6	1.30
Tennessee	9	63.2%	4,669,785	1,676,320	6.62	7	0.38
Texas	36	60.0%	14,977,088	10,168,473	21.44	24	2.56
Utah	4	66.6%	1,697,906	1,065,979	2.46	3	0.54
Virginia	11	51.0%	4,287,965	3,713,059	5.90	8	2.10
Washington	10	45.6%	2,134,246	4,590,294	3.17	4	0.83
West Virginia	3	59.9%	1,391,478	461,516	2.25	2	-0.25
Wisconsin	8	49.2%	2,939,822	2,747,164	4.14	5	0.86
TOTAL	401		133,395,807	150,672,980	188.01	212	23.99

TABLE OA5.3. ARTIFICIAL PARTISAN ADVANTAGE BY STATE, 2014 US HOUSE ELECTION

			Pop. in counties won		**Republican seats**		
State	**[1] Seats**	**[2] R vote**	**[3] by R**	**[4] by D**	**[5] Earned**	**[6] Total**	**[7] Art. Adv.**
Alabama	7	68.0%	3,374,840	1,404,896	4.94	6	1.06
Arizona	9	58.6%	3,605,341	2,786,703	5.08	5	-0.08
Arkansas	4	66.7%	2,212,405	703,513	3.03	4	0.97
California	53	42.0%	14,905,586	22,348,370	21.21	14	-7.21
Colorado	7	51.6%	3,003140	2,026,056	4.18	4	-0.18
Connecticut	5	39.6%	189,927	3,384,170	0.27	0	-0.27
Georgia	14	58.5%	6,129,354	3,558,299	8.86	10	1.14
Hawaii	2	33.8%	0	1,360,211	0.00	0	0.00
Idaho	2	63.2%	1,498,792	68,790	1.91	2	0.09
Illinois	18	48.6%	7,126,914	5,703,718	10.00	8	-2.00
Indiana	9	61.2%	4,384,351	2,099,451	6.09	7	0.91
Iowa	4	53.9%	1,504,712	1,541,643	1.98	3	1.02
Kansas	4	63.4%	2,584,787	268,331	3.62	4	0.38
Kentucky	6	63.6%	3,570,599	768,768	4.94	5	0.06
Louisiana	6	67.6%	3,468,594	1,064,778	4.59	5	0.41
Maine	2	42.8%	524,715	803,646	0.79	1	0.21
Maryland	8	41.9%	2,078,729	3,694,823	2.88	1	-1.88
Massachusetts	9	17.3%	0	6,547,629	0.00	0	0.00
Michigan	14	49.1%	5,099,155	4,784,485	7.22	9	1.78
Minnesota	8	48.1%	2,227,778	3,076,147	3.36	3	-0.36
Mississippi[51]	4	58.9%	2,156,739	799,961	2.91	3	0.09
Missouri	8	62.0%	4,995,475	993,452	6.67	6	-0.67
Nebraska	3	64.8%	1,309,231	517,110	2.15	2	-0.15
Nevada	4	59.2%	1,590,767	1,109,784	2.36	3	0.64
N. Hampshire	2	48.4%	803,850	512,620	1.22	1	-0.22
New Jersey	12	49.0%	3,292,056	5,499,838	4.49	6	1.51
New Mexico	3	47.0%	910,235	1,148,944	1.33	1	-0.33
New York	27	43.6%	7,097,521	12,280,581	9.89	9	-0.89
North Carolina	13	55.8%	5,952,742	3,582,741	8.12	10	1.88
Ohio	16	60.0%	8,667,173	2,869,331	12.02	12	-0.02
Oklahoma	5	72.4%	3,751,351	0	5.00	5	0.00
Oregon	5	42.8%	1,141,289	2,689,785	1.49	1	-0.49
Pennsylvania	18	55.5%	8,488,306	4,214,073	12.03	13	0.97
Rhode Island	2	38.9%	0	1,052,567	0.00	0	0.00
South Carolina	7	65.8%	3,739,998	885,366	5.66	6	0.34
Tennessee	9	65.4%	4,791,780	1,554,325	6.80	7	0.20
Texas	36	64.6%	16,821,409	8,324,152	24.08	25	0.92
Utah	4	65.7%	1,697,906	1,065,979	2.46	4	1.54
Virginia	11	57.5%	5,061,958	2,939,066	6.96	8	1.04
Washington	10	48.4%	2,134,246	4,590,294	3.17	4	0.83
West Virginia	3	57.1%	1,491,886	361,108	2.42	3	0.58
Wisconsin	8	52.8%	3,213,336	2,473,650	4.52	5	0.48
TOTAL	401		156,598,946	127,459,244	220.68	225	4.32

[51] An Independent won Carrol county (MS), earning a 0.01 seat benchmark for independents.

TABLE OA5.4. ARTIFICIAL PARTISAN ADVANTAGE BY STATE, 2016 US HOUSE ELECTION

			Pop. in counties won		Republican		
State	**[1] Seats**	**[2] R vote**	**[3] by R**	**[4] by D**	**[5] Earned**	**[6] Total**	**[7] Art. Adv.**
Alabama	7	66.3%	3,406,840	1,372,896	4.99	6	1.01
Arizona	9	55.0%	4,855,195	1,536,822	6.84	5	-1.84
Arkansas	4	87.2%	2,533,170	382,748	3.47	4	0.53
California	53	36.3%	10,279,189	26,974,767	14.62	14	-0.62
Colorado	7	50.5%	2,547,634	2,481,562	3.55	4	0.45
Connecticut	5	36.5%	0	3,574,097	0.00	0	0.00
Georgia	14	60.3%	5,881,049	3,806,604	8.50	10	1.50
Hawaii	2	21.3%	0	1,360,211	0.00	0	0.00
Idaho	2	68.2%	1,546,206	21,376	1.97	2	0.03
Illinois	18	46.0%	6,327,569	6,503,063	8.88	7	-1.88
Indiana	9	57.8%	4,403,689	2,080,113	6.11	7	0.89
Iowa	4	54.7%	1,648,736	1,397,619	2.16	3	0.84
Kansas[52]	4	68.6%	2,575,254	268,331	3.61	4	0.39
Kentucky	6	70.7%	3,598,271	741,096	4.98	5	0.02
Louisiana	6	67.1%	3,579,010	954,362	4.73	5	0.27
Maine	2	48.0%	685,652	642,709	1.03	1	-0.03
Maryland	8	37.0%	2,078,729	3,694,823	2.88	1	-1.88
Massachusetts	9	16.1%	0	6,547,629	0.00	0	0.00
Michigan	14	50.6%	5,434,201	4,449,439	7.70	9	1.30
Minnesota	8	48.2%	2,063,674	3,240,251	3.11	3	-0.11
Mississippi	4	60.2%	2,165,059	802,238	2.92	3	0.08
Missouri	8	60.6%	3,996,521	1,992,406	5.34	6	0.66
Nebraska	3	71.6%	1,309,231	517,110	2.15	3	0.85
Nevada	4	49.5%	1,007,011	1,693,540	1.49	1	-0.49
N. Hampshire	2	48.4%	803,850	512,620	1.22	0	-1.22
New Jersey	12	45.8%	3,417,346	5,374,548	4.66	5	0.34
New Mexico	3	44.0%	684,619	1,374,560	1.00	1	0.00
New York	27	36.2%	5,535,110	13,842,992	7.71	9	1.29
North Carolina	13	53.3%	5,121,073	4,414,410	6.98	10	3.02
Ohio	16	58.2%	7,217,045	4,319,459	10.01	12	1.99
Oklahoma	5	71.9%	3,751,351	0	5.00	5	0.00
Oregon	5	41.6%	1,204,332	2,626,742	1.57	1	-0.57
Pennsylvania	18	54.1%	8,209,893	4,492,486	11.63	13	1.37
Rhode Island	2	34.9%	0	1,052,567	0.00	0	0.00
South Carolina	7	59.8%	3,739,998	885,366	5.66	6	0.34
Tennessee	9	64.7%	4,772,993	1,573,112	6.76	7	0.23
Texas	36	60.7%	16,555,597	8,589,964	23.70	25	1.30
Utah	4	66.6%	1,697,906	1,065,979	2.46	4	1.54
Virginia	11	49.8%	4,001,913	3,999,111	5.50	7	1.50
Washington	10	44.7%	2,134,246	4,590,294	3.17	4	0.83
West Virginia	3	66.5%	1,633,650	219,344	2.64	3	0.36
Wisconsin	8	47.9%	3,191,830	2,495,156	4.49	5	0.51
TOTAL	401		145,594,643	138,646,612	205.23	220	14.77

TABLE OA5.5. CORRELATION OF RESULTS ACROSS ELECTIONS

	2014		2016		2018	
2012	0.586	0.475	0.787	0.681	0.534	0.500
	0.349	0.511	0.693	0.723	0.415	0.511
2014			0.518	0.643	0.437	0.325
			0.597	0.614	0.172	0.283
2016					0.667	0.734
					0.419	0.647

For each pair of elections, the top-left cell indicates the Pearson correlation coefficient of the Artificial Partisan Advantage across states; the top-right indicates the Spearman rank-order correlation coefficient of the Artificial Partisan Advantage; the bottom-left indicates the Pearson correlation coefficient of the Excess Partisan Advantage; and the bottom-right indicates the Spearman rank-order correlation coefficient of the Excess Partisan Advantage (positive values indicate a positive correlation; negative values a negative correlation; possible values range from -1 to 1).

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