An Evaluation of the Partisan Bias in Indiana's 2011 Congressional and State Legislative Districting Plan

Christopher Warshaw*

May 14, 2021

Abstract

This report examines the partisan fairness of Indiana's 2011 legislative and congressional maps. It finds that the 2011 redistricting plan has led to a substantial bias in favor of Republicans in both congressional and state legislative elections. There are substantially more wasted Democratic votes in Indiana congressional and state legislative elections than wasted Republican votes. As a result, there is a substantial and durable pro-Republican bias in the translation of votes to seats in Indiana.

---

*Associate Professor, Department of Political Science, George Washington University. warshaw@gwu.edu. Note that the analyses and views in this report are my own, and do not represent the views of George Washington University.

Contents

1 Summary

The relationship between the distribution of partisan support in the electorate and the partisan composition of the government—what Powell (2004) calls "vote–seat representation"—is a critical link in the longer representational chain between citizens' preferences and governments' policies. If the relationship between votes and seats systematically advantages one party over another, then some citizens will enjoy more influence—more "voice"—over political outcomes than others.

This report examines the partisan fairness of Indiana's 2011 legislative and congressional maps. Indiana's 2011 redistricting plan was proposed by Republican leaders and passed on party lines, with nearly all Republicans voting in favor and nearly all Democrats opposed.[1] This map led to a substantial bias in favor of Republicans in both congressional and state legislative elections. In congressional elections, Democrats have only won 2 out of 9 districts in every election from 2012-2020 (Figure 1).

Figure 1: Map of U.S. House districts in Indiana from PlanScore.org

There are substantially more wasted Democratic votes in Indiana congressional and state legislative elections than wasted Republican votes. This has led to a substantial and durable pro-Republican bias in the translation of votes to seats in congressional and state legislative elections in Indiana. One simple metric to capture the ratio of wasted votes by each party is called the "Efficiency Gap."

In recent elections, Indiana has had a pro-Republican Efficiency Gap that is extreme relative to both its own historical Efficiency Gaps, and the Efficiency Gap in other states. The Efficiency Gaps in Indiana in the past decade were among the most Republican-

---

1. See `https://ballotpedia.org/Redistricting_in_Indiana_after_the_2010_census`.

leaning Efficiency Gaps the nation has ever seen. Indiana's congressional districts had a larger pro-Republican bias after its 2011 redistricting plan took effect in 2012 than 98% of the congressional election maps over the past 50 years. Indiana's new state house districts were also more pro-Republican in 2012 than 99% of previous plans and its state senate districts were more pro-Republican in 2014 than 99% of previous plans over the past five decades.[2] It exhibited a similarly large pro-Republican bias using other quantitative measures of gerrymandering, such as the mean-median and declination metrics (Krasno et al. 2018; Best et al. 2017; Warrington 2018b).

2   Background on Partisan Gerrymandering

The goal of partisan gerrymandering is to create legislative districts that are as "efficient" as possible in translating a party's vote share into seat share (McGhee 2014, 2017; Caughey, Tausanovitch, and Warshaw 2017). In practice, this entails drawing districts in which the supporters of the advantaged party constitute either a slim majority (e.g., 55% of the two-party vote) or a small minority (e.g., 20%). The former is achieved by "cracking" local opposing-party majorities across multiple districts and the latter by "packing" them into a few overwhelming strongholds. In a "cracked" district, the disadvantaged party narrowly loses, while in a "packed" district, the disadvantaged party wins overwhelmingly. The resulting *asymmetry* or *advantage* in the efficiency of the vote–seat relationships of the two parties lies at the core of normative critiques of partisan gerrymandering. Asymmetries in the translation of votes to seats "offer a party a means of increasing its margin of control over policy without winning more votes from the public" (McGhee 2014).

In addition to creating a plan that skews the vote-seat curve toward their party, the advantaged party also often seeks to build a map that is *insulated* against changes in the public's preferences. This type of unresponsive map enables the advantaged party to continue to win the majority of seats even in the face of large gains in the disadvantaged party's statewide vote share. It ensures that the gerrymander is durable over multiple election cycles.

---

2. I focus on the state senate after the 2014 elections since it took two election cycles for elections for all the districts under its new map to be held.

2.1 Partisan Asymmetry or Advantage in a Districting Plan

There are a number of approaches that have been proposed to measure partisan advantage in a districting plan. These approaches focus on asymmetries in the efficiency of the vote–seat relationships of the two parties. In recent years, at least 10 different approaches have been proposed (McGhee 2017). While no measure is perfect, much of the recent literature has focused on a handful of related approaches. The results of these metrics sometimes diverge in states where one party dominates elections. But they generally all yield similar substantive results in competitive states (see Stephanopoulos and McGhee 2018, 556).

In the analysis that follows, I use a number of these metrics to examine the historical trajectory of partisan gerrymandering in Indiana and the nation as a whole. In order to calculate these metrics, I use data on the results of legislative elections over the past few decades. For all legislative elections that were contested between two major party candidates, I use the raw vote totals to calculate various metrics that measure the degree of partisan gerrymandering. For legislative elections that are uncontested (i.e., those that lacked either a Democratic or Republican candidate), we do not directly observe the number of people that support each party's candidate. In these cases, it is necessary to estimate the two-party vote share because "determining the degree of packing and cracking requires knowing how many people in each district support each party" (Stephanopoulos and McGhee 2015, 865). Using publicly available data and statistical models, I estimate the two-party vote share in each district based on previous and future elections in that district as well as the results in similar districts elsewhere. This is similar to the approach used in a variety of other studies that estimate these gerrymandering metrics (e.g., Gelman and King 1994a; Stephanopoulos and McGhee 2015; Brennan Center 2017; Jackman 2017; McGhee 2018; Warrington 2018b).[3] I then use this information to estimate the gerrymandering metrics discussed below for congressional elections between 1972 to 2020.[4]

2.1.1 Efficiency Gap

Both cracked and packed districts "waste" more votes of the disadvantaged party than of the advantaged one (McGhee 2014; Stephanopoulos and McGhee 2015).[5] This suggests

---

3. The details of this calculation for uncontested races are described in further detail in the Appendix and in Stephanopoulos and Warshaw (2020).

4. I start the analysis in 1972 since those are the first districting plans drawn after the Supreme Court cases stemming from *Baker v. Carr* ended malapportionment and established the principle of one-person, one-vote.

5. The authors of the efficiency gap use the term "waste" or "waste" to describe votes for the losing party and votes for the winning party in excess of what is needed to win an election. Since the term is used by the efficiency gap authors, I use it here when discussing the efficiency gap.

that gerrymandering can be measured based on asymmetries in the number of wasted votes for each party. The *efficiency gap* (EG) focuses squarely on the number of each party's wasted votes in each election. It is defined as "the difference between the parties' respective wasted votes, divided by the total number of votes cast in the election" (Stephanopoulos and McGhee 2015, 831; see also McGhee 2014, 2017).[6] All of the losing party's votes are wasted if they lose the election. When a party wins an election, the wasted votes are those above the 50%+1 needed to win.

If we adopt the convention that positive values of the efficiency gap imply a Democratic advantage in the districting process and negative ones imply a Republican advantage, the efficiency gap can be written mathematically as:

$$EG = \frac{W_R}{n} - \frac{W_D}{n} \tag{1}$$

where W_R are wasted votes for Republicans, W_D are wasted votes for Democrats, and n is the total number of votes in each state.

Table 1 provides a simple example about how to calculate the efficiency gap with three districts where the same number of people vote in each district. In this example, Democrats win a majority of the statewide vote, but they only win 1/3 seats. In the first district, they win the district with 75/100 votes. This means that they only wasted the 24 votes that were unnecessary to win a majority of the vote in this district. But they lose the other two districts and thus waste all 40 of their votes in those districts. In all, they waste 104 votes. Republicans, on the other hand, waste all 25 of their votes in the first district. But they only waste the 9 votes unnecessary to win a majority in the two districts they win. In all, they only waste 43 votes. This implies a pro-Republican efficiency gap of $\frac{43}{300}$ - $\frac{104}{300}$ = -20%.

In order to account for unequal population or turnout across districts, the efficiency gap formula in equation 1 can be rewritten as:

---

6. The efficiency gap calculations here focus on wasted votes in *legislative elections* since these results directly capture voters' preferences in these elections. However, we might also calculate the efficiency gap using district-level results from presidential elections or other statewide races. These have the "advantage of being (mostly) unaffected by district-level candidate characteristics" (Stephanopoulos and McGhee 2015, 868). This feature is particularly useful for simulating efficiency gaps from randomly generated districting plans since candidate characteristics are clearly influenced by the final districting plan. Presidential elections or other statewide races are less closely tied, however, to voters' preferences in legislative races given the district lines that actually exist. In practice, though, both legislative races and other statewide races produce similar efficiency gap results for modern elections where voters are well sorted by party and ideology. Indeed, the data indicate that the correlation between efficiency gap estimates based on congressional elections and presidential elections is approximately 0.8 for elections held after 2000 and about 0.9 for elections held after the 2011 redistricting cycle.

Table 1: Illustrative Example of Efficiency Gap

District	Democratic Votes	Republican Votes
1	75	25
2	40	60
3	40	60
Total	155 (52%)	145 (48%)
Wasted	104	43

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

where S_D^{margin} is the Democratic Party's seat margin (the seat share minus 0.5) and V_D^{margin} is is the Democratic Party's vote margin. V_D^{margin} is calculated by aggregating the raw votes for Democratic candidates across all districts, dividing by the total raw vote cast across all districts, and subtracting 0.5 (McGhee 2017, 11-12). In the example above, this equation also provides an efficiency gap of -20% in favor of Republicans. But it could lead to a slightly different estimate of the efficiency gap if districts are malapportioned or there is unequal turnout across districts.[7] In the case of Indiana's congressional districts, equation 2 implies there was an efficiency gap of approximately 19% in 2012 and 9% in 2020.

The efficiency gap mathematically captures the packing and cracking that are at the heart of partisan gerrymanders. It measures the extra seats one party wins over and above what would be expected if neither party were advantaged in the translation of votes to seats (i.e., if they had the same number of wasted votes). A key advantage of the efficiency gap over other measures of partisan bias is that it can be calculated directly from observed election returns even when the parties' statewide vote shares are not equal.

2.1.2 Mean-median Gap

Another metric that some scholars have proposed to measure partisan bias in a districting plan is the *mean-median gap*: the difference between a party's vote share in the median district and their average vote share across all districts.[8] If the party wins more votes in

---

7. In general, the two formulations of the efficiency gap formula yield very similar results. Because Democrats tend to win lower-turnout districts, however, the turnout adjusted version of the efficiency gap in equation 2 tends to produce results that suggest about a 2% smaller disadvantage for Democrats than the version in Equation 1 (see McGhee 2018).

8. In this section, I focus on this straightforward definition of the mean-median gap. However, it is important to note that Wang (2016) actually proposes a slightly more nuanced version of the mean-median gap that addresses whether a particular difference was likely to arise by chance. The plaintiffs' initial complaint uses this definition of the mean-median gap.

the median district than in the average district, they have an advantage in the translation of votes to seats (Krasno et al. 2018; Best et al. 2017; Wang 2016). In statistics, comparing a dataset's mean and median is a common statistical analysis used to assess skews in the data and detect asymmetries (Brennan Center 2017). The mean-median difference is very easy to apply (Wang 2016). It is possible, however, for packing and cracking to occur without any change in the mean-median difference. That is, a party could gain seats in the legislature without the mean-median gap changing (McGhee 2017).[9] It is also sensitive to the outcome in the median district (Warrington 2018b). Finally, the mean-median difference lacks an obvious interpretation in terms of the number of seats that a party gains through gerrymandering.

District	Democratic Vote Share
6	28.8 %
8	30.8 %
3	32.2 %
4	33.4 %
9	35.6 %
2	38.5 %
5	47.9 %
1	58.3 %
7	62.4 %
Mean	40.9%
Median	35.6%

Table 2: Results in 2020 Indiana Congressional Elections

Table 2 illustrates the mean-median approach using the district-level election results in the 2020 Indiana congressional elections. It indicates that many Democratic voters were packed into just 2 districts where the Democratic candidates won by overwhelming margins. The remaining Democratic voters were cracked across the other districts. This table shows the disproportionate percentage of the statewide vote that Democrats would have needed to win a majority of Indiana's congressional seats in 2012. Across all districts, Democrats won an average of 40.9% of the vote. But they only won 35.6% in the median district (e.g., the 9th congressional district). As a result, Democrats lost at least one district that they would have won if there was no difference between the mean and median

---

9. As McGhee (2017), notes, "If the median equals the win/loss threshold–i.e., a vote share of 0.5–then when a seat changes hands, the median will also change and the median- mean difference will reflect that change. But if the median is anything other than 0.5, seats can change hands without any change in the median and so without any change in the median-mean difference." See also Buzas and Warrington (2020) who make a similar point using simulated packing and cracking.

districts. This translates into a mean-median difference in Indiana's 2020 election of 5.3%.

2.1.3 Symmetry in the Vote-Seat Curve Across Parties

Basic fairness suggests that in a two-party system each party should receive the same share of seats for identical shares of votes. The *symmetry* idea is easiest to understand at an aggregate vote share of 0.5—a party that receives half the vote ought to receive half the seats—but a similar logic can apply across the "seats- votes curve" that traces out how seat shares change as vote shares rise and fall. For example, if a party receives a vote share of 0.57 and a seat share of 0.64, the opposing party should also expect to receive a seat share of 0.64 if it were to receive a vote share of 0.57. An unbiased system means that for V share of the votes a party should receive S share of the seats, and this should be true for all parties and vote percentages (Niemi and Deegan 1978; Gelman and King 1994a; McGhee 2014).

Gelman and King (1994a, 536) propose two ways to measure partisan bias in the symmetry of the vote-seat curve. First, it can be measured using counter-factual election results in a range of statewide vote shares between .45 and .55. Across this range of vote shares, each party should receive the same number of seats. Symmetry captures any departures from the standard that each party should receive the same seat share across this range of plausible vote shares. For example, if partisan bias is -0.05, this means that the Democrats receive 5% fewer seats in the legislature than they should under the symmetry standard (and the Republicans receive 5% more seats than they should).

To illustrate the symmetry metric, Table 3 calculates what each party's share of the seats would have been in Indiana's 2012 Congressional elections across a range of statewide vote shares from 45%-55%. It shows that Democrats only received 22% of the seats in most of the scenarios where they received less than 50% of the votes. This might not have been problematic under the symmetry standard if Republicans also only received 22% of the seats when they received less than 50% of the votes. However, Table 3 shows that Republicans still would have received a large majority of the seats even when they won a minority of the votes. Across this range of statewide vote shares from 45%-55%, Democrats receive an average of 38% of the seats (and Republicans win 62%). This implies a partisan bias of 12% using the symmetry metric. That is, Republicans won 12 percentage points more of the seats than they would have won if the seat-vote curve was symmetric between the two parties.

Second, symmetry can be measured based on the seat share that each party receives when they split the statewide vote 50-50.[10] In an unbiased system, each party should

---

10. This metric is identical to the 'partisan bias' metric discussed in the plaintiffs' initial complaint.

Dem. Vote Share	Dem. Seat Share	Rep. Vote Share	Rep. Seat Share
45%	22%	55%	78%
46%	22%	54%	78%
47%	22%	53%	78%
48%	33%	52%	67%
49%	33%	51%	67%
50%	33%	50%	67%
51%	33%	49%	67%
52%	56%	48%	44%
53%	56%	47%	44%
54%	56%	46%	44%
55%	56%	45%	44%
Mean Seat Share	38%		62%
Bias	12%		12%

Table 3: Symmetry Calculations for 2012's Indiana Congressional Elections

receive 50% of the seats in a tied statewide election. Here, the partisan bias statistic is the "expected proportion of the seats over 0.5 that the Democrats receive when they receive exactly half the average district vote." In fact, Democrats would have won only 33% of the seats in Indiana in 2012, 2016, 2018, and 2020 even in hypothetical tied elections where each party received 50% of the statewide vote. This implies a partisan bias of 17%.

These two symmetry metrics are closely related to the efficiency gap. In the special case where each party receives half of the statewide vote, the symmetry and the efficiency gap metrics are mathematically identical (Stephanopoulos and McGhee 2015, 856). More generally, the symmetry and efficiency gap yield very similar substantive results when each party's statewide vote share is close to 50% (as is the case in Indiana). When elections are uncompetitive, however, and one party wins a large percentage of the statewide vote, the efficiency gap and these symmetry metrics are less correlated with one another (857).

A weakness of the symmetry approach is that it requires the analyst to calculate counterfactual elections. This approach has both conceptual and empirical limitations. At a conceptual level, it is not clear that it aligns perfectly with the usual definition of a gerrymander. Indeed, "when observers assert that a district plan is a gerrymander, they usually mean that it systematically benefits a party (and harms its opponent) in actual elections. They do not mean that a plan would advantage a party in the hypothetical event of a tied election, or if the parties' vote shares flipped" (857). At an empirical level, in order to generate symmetry metrics, we need to simulate counter-factual elections by

shifting the actual vote share in each district a uniform amount (McGhee 2014).[11] In general, this uniform swing assumption seems reasonable based on past election results. Moreover, it has been widely used in past studies of redistricting. But there is no way to conclusively validate the uniform swing assumption for any particular election.

An important strength, however, of the symmetry approach is that it is based on the shape of the seats-votes curve and not any particular point on it. As a result, it is relatively immune to shifts in party performance (McGhee 2014). For instance, the bias toward Republicans in Indiana's symmetry metric was very similar in 2012-2020. Moreover, the symmetry approach has been very widely used in previous studies of gerrymandering and redistricting (Gelman and King 1994a; McGhee 2014). Overall, the symmetry approach is useful for assessing partisan advantage in the districting process.

2.1.4 Declination

Another measure of asymmetries in redistricting plans is called *declination* (Warrington 2018b, 2018a). The declination metric treats asymmetry in the vote distribution as indicative of partisan bias in a districting plan (Warrington 2018a). If all the districts in a plan are lined up from the least Democratic to the most Democratic, the mid-point of the line formed by one party's seats should be about as far from the 50 percent threshold for victory on average as the other party's (McGhee 2018).

Declination suggests that when there is no gerrymandering, the angles of the lines (θ_D and θ_R) between the mean across all districts and the point on the 50% line between the mass of points representing each party will be roughly equal. When they deviate from each other, the smaller angle (θ_R in the case of Indiana) will generally identify the favored party. To capture this idea, declination takes the difference between those two angles (θ_D and θ_R) and divides by $\pi/2$ to convert the result from radians to fractions of 90 degrees.[12] This produces a number between -1 and 1. As calculated here, positive values favor Democrats and negative values favor Republicans.[13] Warrington (2018b) suggests a further adjustment to account for differences in the number of seats across legislative

---

11. In principle, the uniform swing election could be relaxed, and swings could be estimated on a district-by-district basis. But this is rarely done in practice since it would require a much more complicated statistical model, and probably would not improve estimates of symmetry very much.

12. This equation is: $\delta = 2 * (\theta_R - \theta_D) / \pi$.

13. In order to validate my estimates of declination, I compare my estimates to the ones presented in Warrington (2018b). I find that my declination estimates are nearly identical to the estimates originally developed by Warrington in the appendix to his article. In fact, the correlation between the declination values that I calculate and those in Warrington (2018b) is .94 for the U.S. House (note that Warrington does not estimate declination values for state senate elections). Small differences between the declination estimates likely stem from minor differences in how we impute vote shares in uncontested races.

chambers. I use this adjusted declination estimate in the analysis that follows.[14]

2.2 Comparison of Partisan Bias Measures

All of the measures of partisan advantage discussed in the previous sections are closely related both theoretically and empirically (McGhee 2017; Stephanopoulos and McGhee 2018). Broadly speaking, all of the metrics consider how votes between the two parties are distributed across districts (Warrington 2018a). For example, the efficiency gap is mathematically equivalent to partisan bias in tied statewide elections (Stephanopoulos and McGhee 2018). Also, the median-mean difference is similar to the symmetry metric, since any perfectly symmetric seats-votes curve will also have the same mean and median (McGhee 2017).

Second, each of the concepts are closely related empirically, particularly in states with competitive elections. Table 4 shows the correlation between each measure in states where the average Democratic voteshare is between 40 and 60% (which is similar to the range of recent elections in Indiana). The various measures have high correlations with one another.[15] Moreover, most of the variation in the metrics can be summarized on a single latent dimension (Stephanopoulos and McGhee 2018; Stephanopoulos and Warshaw 2020). So, overall, the various metrics usually yield similar results for the degree of partisan bias in a districting plan (Nagle 2015). In the case of Indiana, they all indicate that Republicans had a large advantage in the districting process in Indiana since the 2011 plan went into place.

Table 4: Correlation between measures of partisan bias in states with more competitive elections

	Efficiency Gap	Mean-Median	Symmetry	Symmetry (50-50)	Declination
Efficiency Gap	1.00	0.50	0.67	0.61	0.94
Mean-Median	0.50	1.00	0.84	0.76	0.60
Symmetry	0.67	0.84	1.00	0.94	0.78
Symmetry (50-50)	0.61	0.76	0.94	1.00	0.72
Declination	0.94	0.60	0.78	0.72	1.00

---

14. This adjustment uses this equation: $\hat{\delta} = \delta$ * ln(seats) / 2

15. While each measure is highly correlated with one another, the efficiency gap and declination measures are particularly closed related and the symmetry and mean-median measures are very closely related. This could be because the efficiency gap and the declination consider the seats actually won by each party, while the symmetry metric and the mean-median difference do not (Stephanopoulos and McGhee 2018, 1557).

2.3 The Responsiveness of a Legislative Districting Plan to Changes in Voters' Preferences

The responsiveness of a map indicates how many seats change hands as vote shares rise and fall. Thus, it can be thought of as the slope of the seats-votes curve across a range of vote shares (McGhee 2014). An unresponsive map ensures that the bias in a districting plan toward the advantaged party is insulated against changes in voters' preferences, and thus is durable across multiple election cycles. In addition to serving as an indicator of the durability of a gerrymander, some scholars have suggested that responsiveness is another metric to measure gerrymandering itself (Cox and Katz 1999). There are a couple of approaches we might use to measure the responsiveness of a districting plan.

First, we could simply look at the number of competitive districts. In general, a plan with more competitive elections is likely to be more responsive to changes in voters' preferences than a plan with fewer competitive elections (McGhee 2014). Uncompetitive districts tend to protect incumbents and lock in the gerrymandering party's electoral advantage (Tufte 1973; Gelman and King 1994a). Following past work, I measure whether a district was competitive in an election based on whether the winning party received less than 55% of the two-party vote (Jacobson and Carson 2015, 91). Based on this definition, Indiana had only 1 competitive congressional seat in the 2012 election.

Second, we could directly measure the responsiveness of the vote-seat curve to counterfactual changes in each party's statewide vote share. Gelman and King (1994a, 535) propose a technique that measures responsiveness based on uniform swings in the two parties' counterfactual vote shares. Specifically, they propose varying each party's vote shares in the average district between 45% and 55% and then measuring the degree to which this change in vote share leads to a change in seat share. In responsive systems, a 10% in vote share from 45% to 55% will generally lead to a change in seat share of around 20%. In a unresponsive system, there could be little or no change in seat share from a 10% change in vote share.

To illustrate the concept of responsiveness, Figure 2 shows the vote-seat curve in Indiana generated by applying uniform swings in the 2018 election results.[16] Specifically, I apply a uniform swing in the actual election results until I achieve an average Democratic vote share of 30%. Then I steadily increase the average Democratic vote share until it reaches 70%. Figure 2 indicates that the vote-seat curve in Indiana in 2018 was extremely unresponsive to changes in voters' preferences. In fact, Republicans win 78% of the seats

---

16. The layout of this chart is adapted from charts of responsiveness in Royden, Li, and Rudensky (2018).
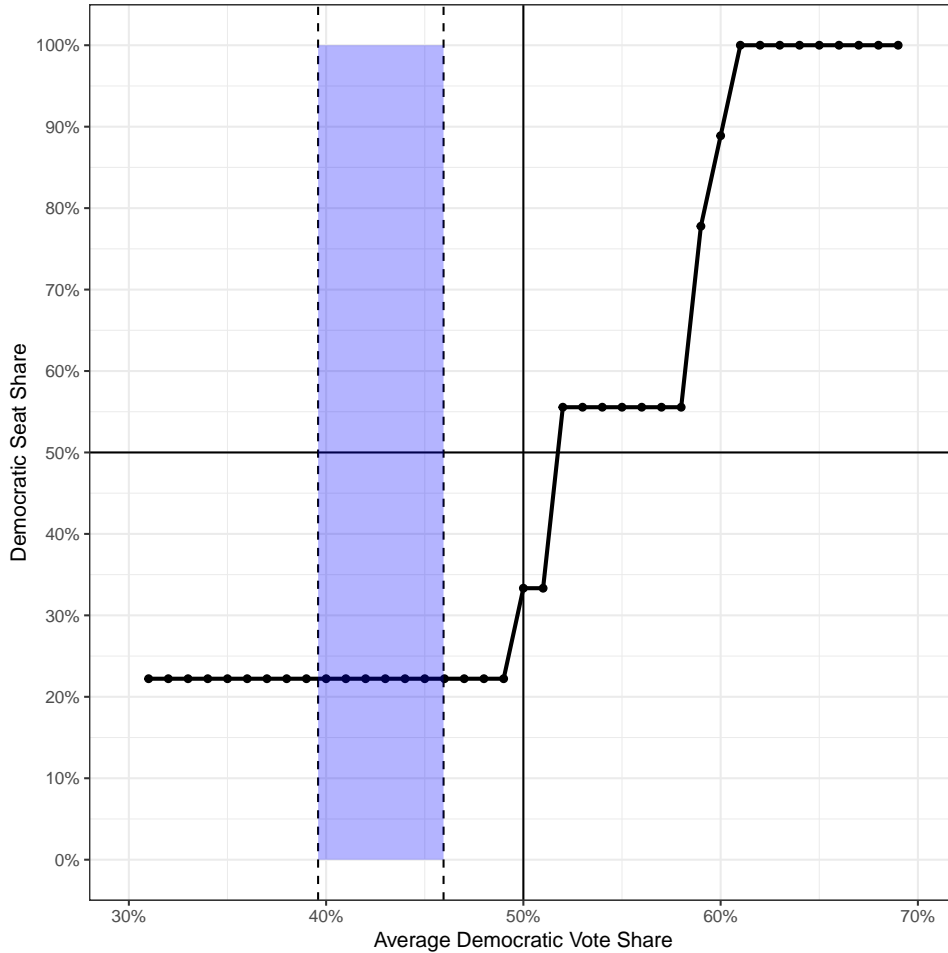
Figure 2: Vote-seat curve in Indiana using uniform swings in 2018 Election Results. The shaded area shows the range between the minimum and maximum Democratic statewide vote share from 2012-2020.

across all of the range of actual election swings over the past decade. Democrats do not gain an additional seat until they hit about 50% of the statewide vote, which they haven't done since 2008. This means that Democrats would win only 3/9 of the seats in Indiana's congressional districts even if they won 50% of the statewide vote.

2.4 Partisan Control of the Redistricting Process and Gerrymandering

While many factors could influence the degree of partisan advantage in the districting process,[17] there is a wide body of evidence from previous studies that control of the re-

---

17. Partisan advantage in the districting process can differ across states for reasons unrelated to the drawing of district lines, such as variation in how different demographic groups are distributed across

districting process has a large effect on partisan advantage in subsequent elections carried out under a given plan. Cox and Katz (2002) show that Democratic control of the redistricting process in many states during the 1960s led to a lasting partisan advantage for Democrats in House elections. More generally, Gelman and King (1994b) find that the party in control of redistricting shifts outcomes in its favor, and that "the effect is substantial and fades only very gradually over the following 10 years" (543). This result has been confirmed in numerous recent articles. McGhee (2014) finds that "parties seek to use redistricting to shift bias in their favor and that they are successful in these efforts" (74).[18] Finally, Stephanopoulos (2018) shows that partisan control of the districting process has a substantial effect on the efficiency gap.[19]

I extended the analysis in these studies to examine the effect of partisan control of redistricting on changes in the efficiency gap after the most recent redistricting – from 2010 to 2012. Figure 3 shows how the efficiency gap shifted in states with different configurations of political control of the redistricting process. It indicates that states with unified Republican control of government almost all had large pro-Republican shifts in the efficiency gap. For instance, Indiana's Efficiency Gap shifted about 20 percentage points in a pro-Republican direction. On average, the efficiency gap in states where Republicans controlled the redistricting process shifted about 11 percentage points in a pro-Republican direction. The handful of states with unified Democratic control tended to have more modest pro-Democratic shifts in the efficiency gap. States with courts or non-partisan commissions running the redistricting process tended to have a mix of different outcomes, and little net advantage for either side.

---

geographic space (Chen and Rodden 2013). It can also be affected by the intentional drawing of district lines to accomplish goals other than maximizing partisan seat share, such as ensuring the representation of racial minorities (e.g., Brace, Grofman, and Handley 1987).

18. McGhee (2014) finds that partisan control affects the districting process using both the Gelman and King (1994b) measure of partisan symmetry and the efficiency gap as outcome variables.

19. He shows that states with unified Republican control have about 5 percentage points more pro-Republican efficiency gaps than states with split control, and states with unified Democratic control have about 3 percentage points more pro-Democratic efficiency gaps than states with split control.
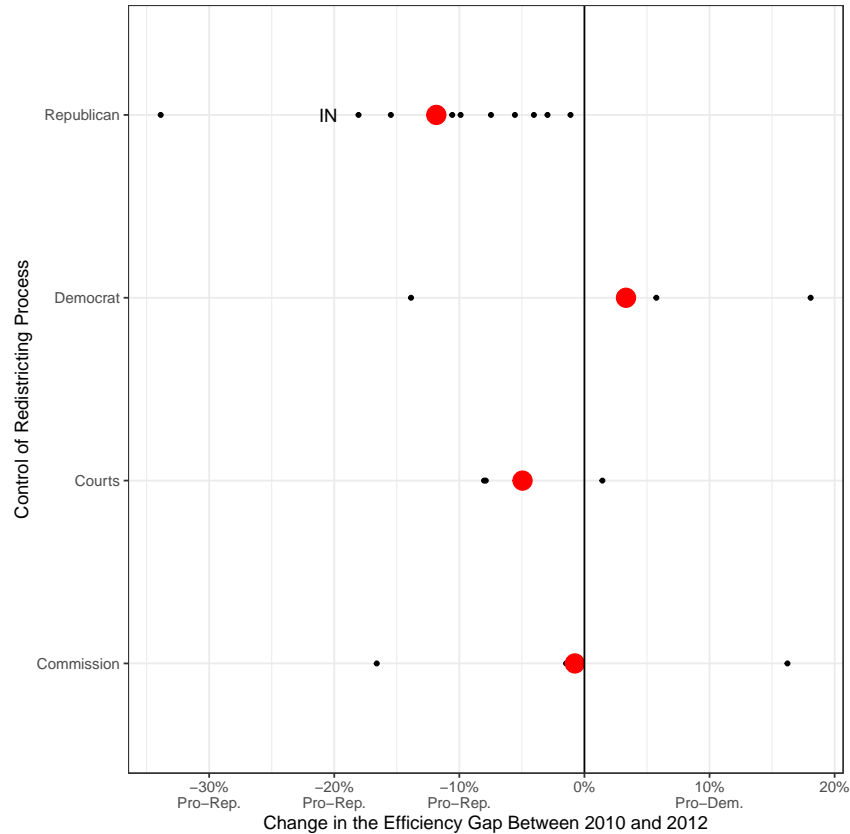
Figure 3: Partisan Control of the Redistricting Process and the Efficiency Gap. The small dots show the changes in the efficiency gap in individual states, while the large red dots show the average change in the efficiency gap in each group of states.

3   Partisan Bias in Indiana's Congressional District-ing Plans from 1972-2020

In this section, I will first provide an historical overview of the degree of partisan bias in congressional districts over the past 45 years. Next, I will show that Indiana's 2011 redistricting plan is historically extreme compared to both other states and its own plans in previous decades. I will focus the bulk of the analysis on the efficiency gap. In the last part of this section, however, I will show that other metrics also indicate that the degree of partisan gerrymandering in Indiana's congressional plan is historically extreme.

14

3.1 Efficiency Gap in Congress

Figure 4 shows the distribution of efficiency gaps between 1972 and 2020 in states with more than 6 congressional seats.[20] It shows the relative proportion of states with different values of the efficiency gap. The efficiency gap in each election year is represented in the distribution.
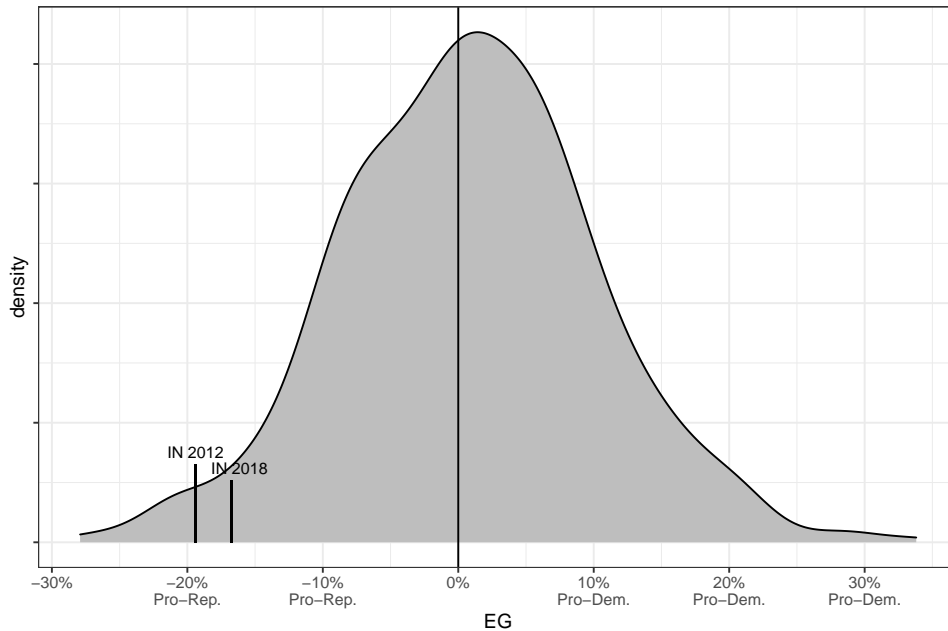

Figure 4: National Distribution of efficiency gaps for Congressional Elections in States with More than 6 Seats: 1972-2020. Indiana's 2012 efficiency gap is shown on the bottom-left of the plot.

This figure illustrates several important facts. First, it indicates that over this entire period the average state had a slightly Democratic leaning efficiency gap.[21] Second, it indicates that the bulk of efficiency gaps are small. In fact, roughly 75% of efficiency gaps lie between -10% and 10%. Only about 4% of state-level efficiency gaps have more than a 20% advantage for either party. Third, it graphically illustrates that Indiana's post-2011 congressional district plan had one of the larger values of the efficiency gap in history.

---

20. I focus on states with more than 6 congressional seats for two reasons. First, these states contribute less to the overall distribution of seats in Congress (Stephanopoulos and McGhee 2015, 868). Second, the efficiency gap in smaller states tends to be more volatile and thus less informative about partisan bias. For example, in a state with only three seats, a change in the winner of one seat could cause a huge shift in their efficiency gap.

21. Stephanopoulos and McGhee (2015, 870) reach similar findings.

3.1.1 Historical Trajectory of the Efficiency Gap in Indiana

Next, I examine the historical trajectory of the efficiency gap. Figure 5 shows trends in the efficiency gap in Indiana between 1972 and 2016 and compares the efficiency gap in Indiana to other states. Each dot in the chart represent a particular state's efficiency gap for congressional elections in that state that year. Indiana had a relatively neutral efficiency gap in the 1970s and 1990s, with no clear, persistent advantage for either party. Democrats had a small advantage from 2002-2010.
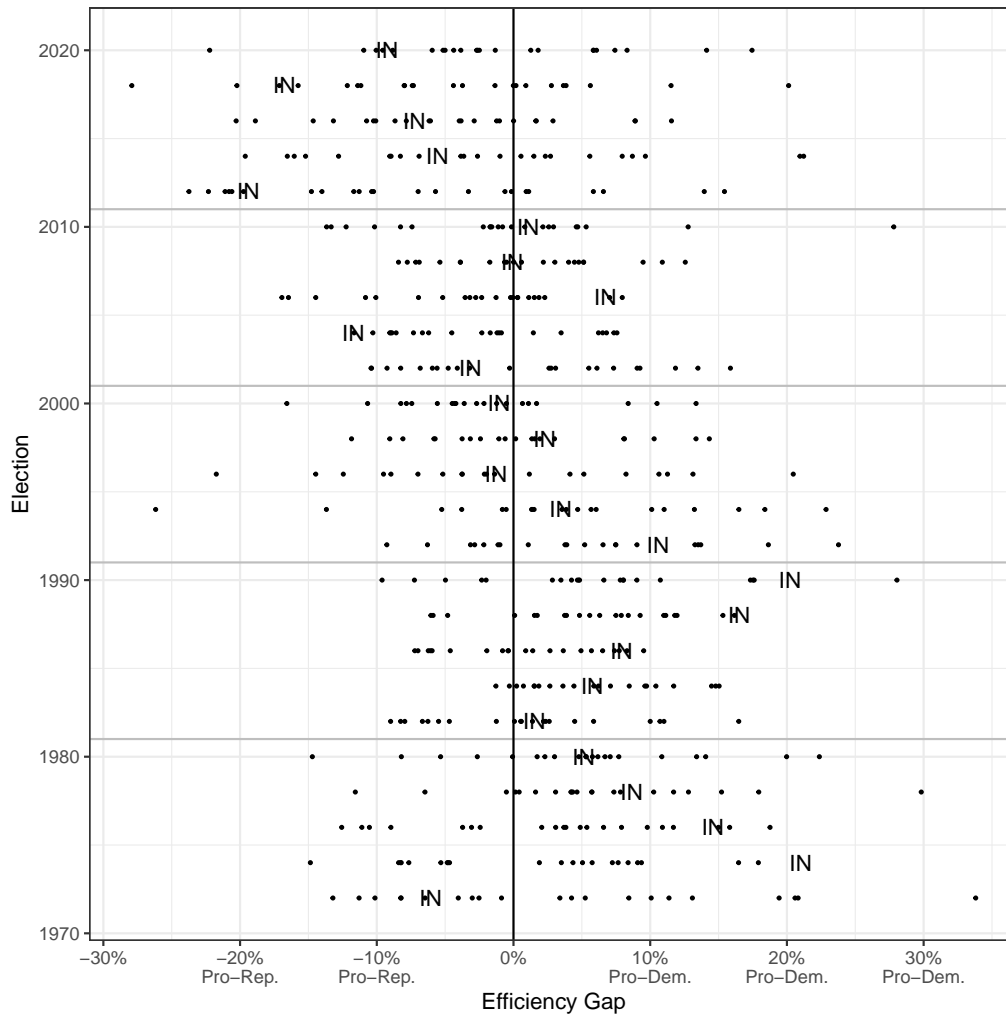
Figure 5: Efficiency Gap in Indiana Relative to Other States. The dots represent the efficiency gaps in individual states. The efficiency gaps in Indiana are labelled to distinguish them from other states.

However, the 2011 redistricting plan led to a large Republican advantage in Indiana congressional elections unlike what the state experienced after previous redistricting periods. After being relatively neutral for the past three decades, Indiana's congressional map

16

developed a large and persistent pro-Republican efficiency gap after the 2011 redistricting. In 2012, Republican candidates won 54.2% of the statewide two-party congressional vote, but they won 7 of 9 – or 78% – of Indiana's congressional seats. This led to a huge pro-Republican efficiency gap of approximately 19%. The results in the next two elections were similar to those in 2012. In 2014 -20, Republican candidates retained the same 78% share of Indiana's seats. This corresponded to an average efficiency gap between 2012-2020 of about 12% (see also Stephanopoulos and McGhee 2015; Brennan Center 2017, for similar estimates).

The chart also shows that the recent efficiency gaps in Indiana are extreme relative to both its own historical efficiency gaps, and the efficiency gap in other states. After the most recent redistricting, Indiana had more extreme pro-Republican efficiency gaps than it has ever had before. There is also a substantial increase in the efficiency gap from 2010, before redistricting, to 2012, after redistricting. This further suggests that geographic factors are unlikely to be the root cause of the large efficiency gap in Indiana in recent elections.

3.2 Other Measures of Partisan Bias in Indiana's Congressional Districts

Other measures of gerrymandering show a similarly large pro-Republican bias in Indiana's congressional districting plan.

3.2.1 Mean-Median

As we saw in section 2.1.2, the mean-median difference is an alternative approach for measuring partisan bias in a districting plan (Krasno et al. 2018; Best et al. 2017; Wang 2016). If the party wins more votes in the median district than in the average district, they have an advantage in the translation of votes to seats (Krasno et al. 2018; Best et al. 2017).

Figure 6 shows the mean-median differences in Indiana and other states with more than 6 congressional seats from 1972-2020. It indicates that Indiana's 2011 plan had a gap between the mean and median district of between 1.4 and 5.3% between 2012-2020. This was a sharp shift from the slightly pro-Democratic mean-median gaps before the 2011 plan went into place.
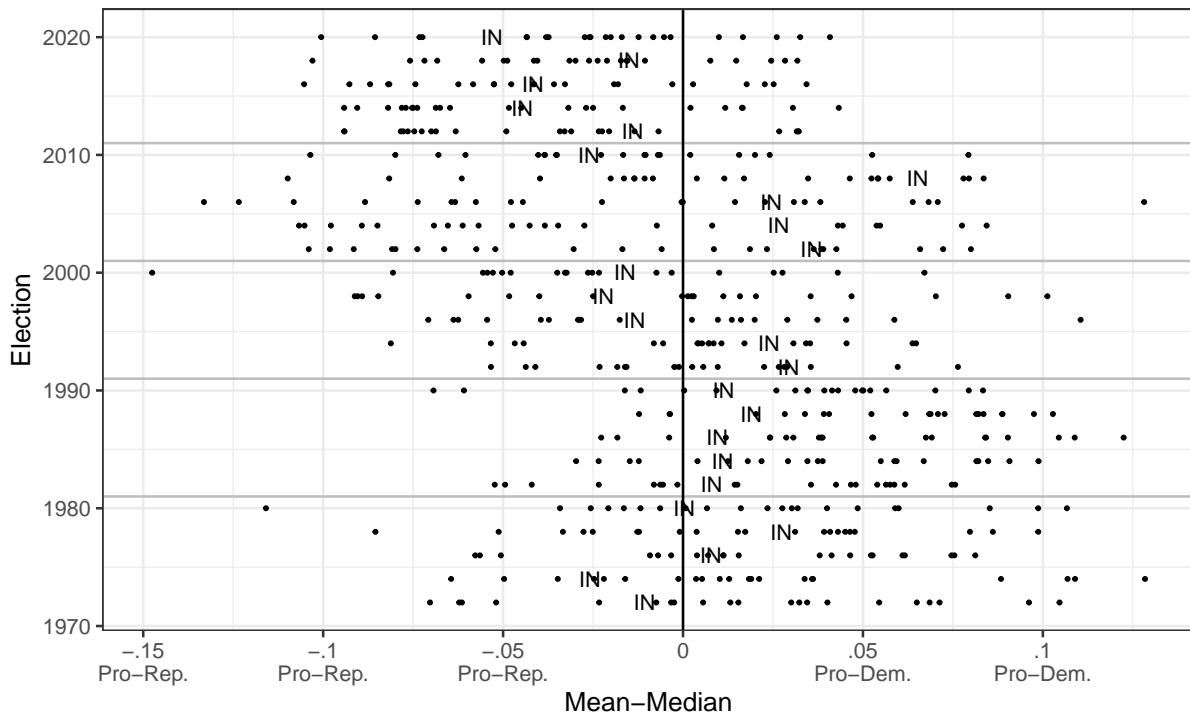
Figure 6: Mean-median differences in Indiana Relative to Other States. The dots represent the mean-median gaps in individual states. The mean-median gaps in Indiana are labelled to distinguish them from other states.

3.2.2 Declination

The declination metric is another alternative approach for measuring partisan bias in a districting plan (Warrington 2018b). The declination metric starts from the assumption that a plan that advantages one party will arrange the distribution of district vote shares in a way that treats the 50 percent threshold for victory differently than other vote values (Warrington 2018b; McGhee 2018).
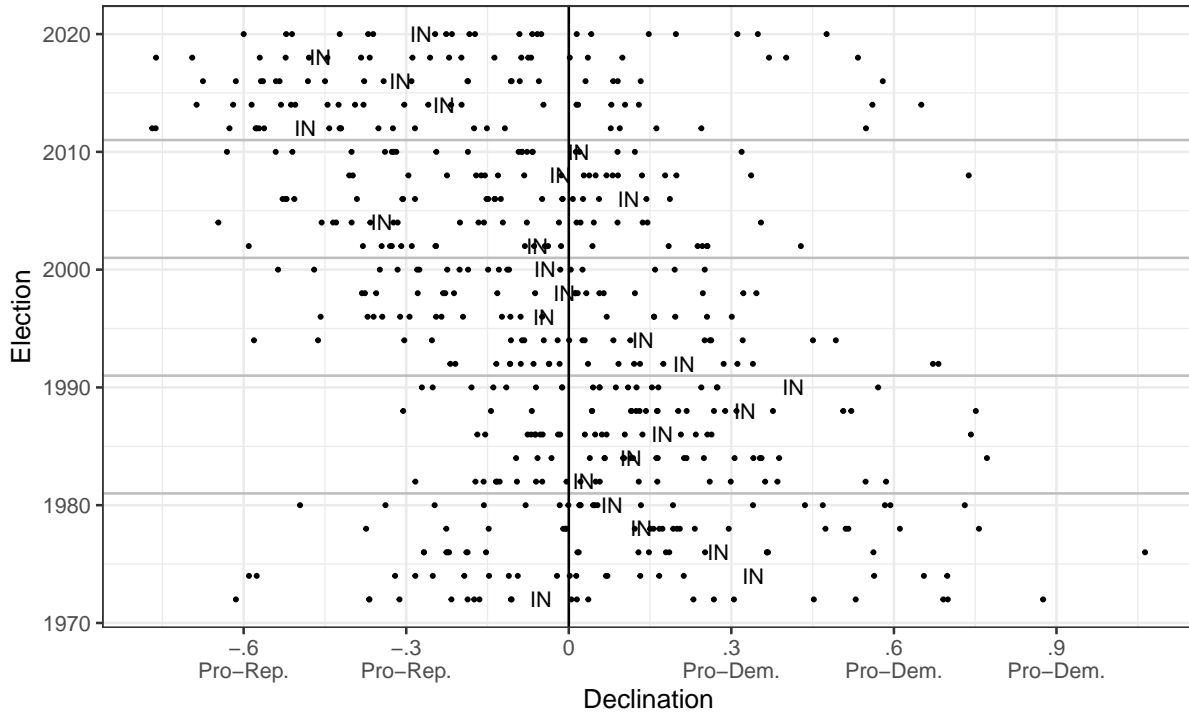

Figure 7: Declination in Indiana Relative to Other States. The dots show the declination metric in each state. The dots in Indiana are labelled to distinguish them from other states.

Figure 7 shows the declination metric in Indiana and other states with more than 6 congressional seats from 1972-2020. The declination approach too shows the extremity of Indiana's recent plans. Indiana's post-2011 plans had some of the most extreme declinations in Indiana's history. In fact, Indiana's 2012 election had a declination score of -0.49.[22] This was more extreme than 86% of previous elections and more pro-Republican than 92% of the previous U.S. congressional elections over the past 45 years.

---

22. It is worth noting that this score, which is based on my own analysis, is nearly identical to the one presented in Warrington (2018b).

19

3.2.3 Partisan Symmetry

The symmetry metric captures whether each party receives the same share of seats for identical shares of votes. Gelman and King (1994a) propose two ways to measure partisan bias in the symmetry of the vote-seat curve. Asymmetries in seat share when the parties each win 50% of the vote is a simple approach for measuring partisan bias in a districting plan. In an unbiased system, each party should receive 50% of the seats in a tied statewide election. In contrast, Democrats would have won only 33% of the seats in Indiana even in a hypothetical tied election.
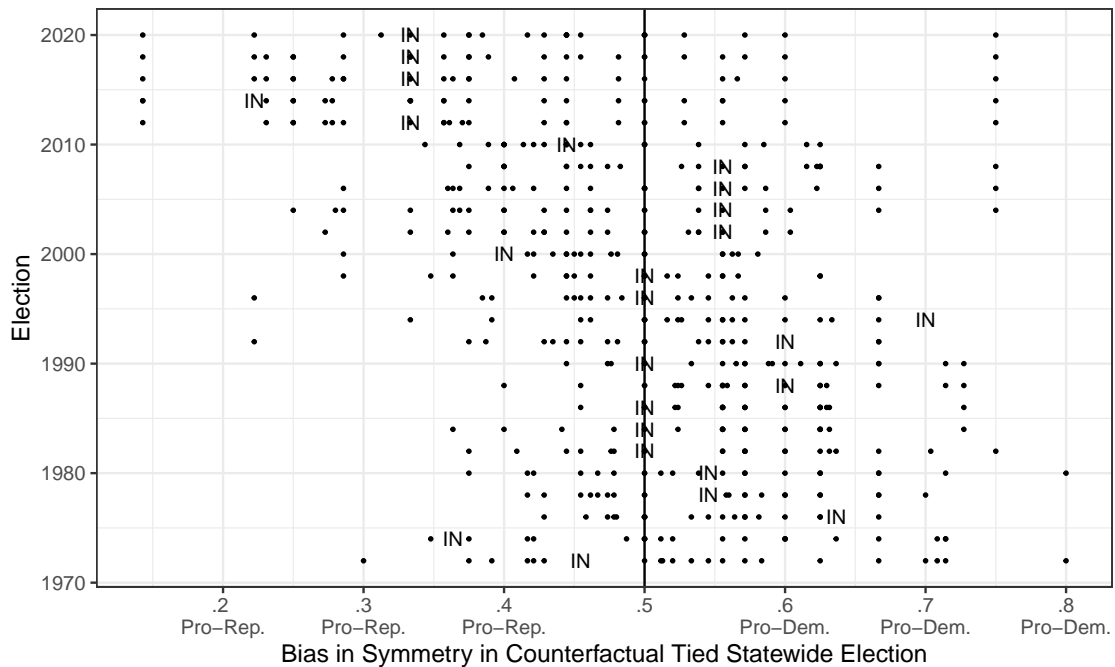

Figure 8: Symmetry in Indiana Relative to Other States. The dots represent asymmetries in counterfactual tied elections in individual states. The asymmetries in Indiana are labelled to distinguish them from other states.

Figure 8 compares the partisan bias in hypothetical tied elections in Indiana to other states with more than 6 congressional seats over the past several decades. It shows that there was much more bias in Indiana's plan in hypothetical tied statewide elections in 2012 than in previous elections. Moreover, the level of bias in 2012 was more extreme than 86% of previous elections and more pro-Republican than 91% of previous U.S. congressional elections over the past 45 years.

A more general approach to measuring symmetry is to use counter-factual election results in a range of statewide vote shares between .45 and .55 (536). Across this range of vote shares, each party should receive the same number of seats. Symmetry captures any

departures from the standard that each party should receive the same seat share across this range of plausible vote shares.
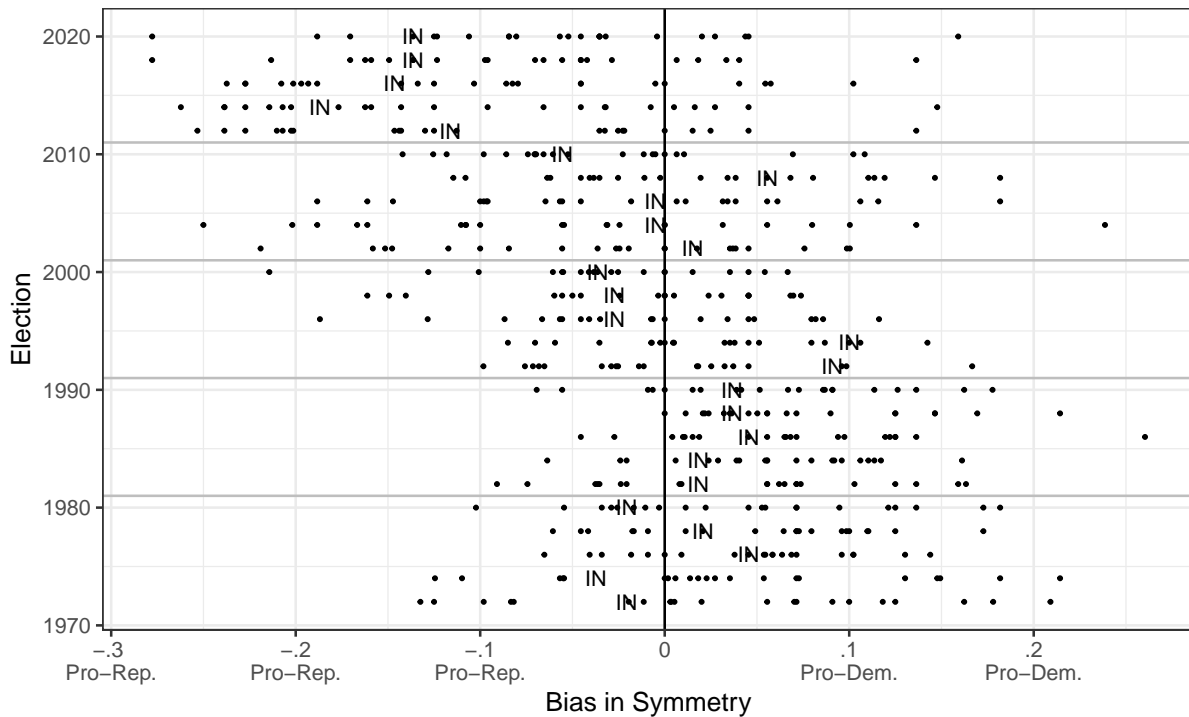

Figure 9: Symmetry in Indiana Relative to Other States. The dots represent asymmetries in individual states. The asymmetries in Indiana are labelled to distinguish them from other state.

Figure 9 compares the level of symmetry in Indiana's elections to other states with more than 6 congressional seats from 1972-2020. It shows that Indiana's post-2011 elections were more asymmetric than previous congressional elections in Indiana. Moreover, the figure shows that the asymmetry in Indiana's plan in 2012 was more extreme than 76% of previous elections and more pro-Republican than 86% of previous U.S. congressional elections over the past 45 years.

3.3 Durability of Bias in Indiana's Congressional Districts

The pro-Republican bias in Indiana's congressional plans is also very durable. Figure 10 is a figure from PlanScore.org that shows that Indiana's congressional map would have a large Efficiency Gap in favor of Republicans even if the statewide vote swung 5 percentage points in favor of either Democrats or Republicans.[23]

---

23. PlanScore is a non-partisan website from a team of legal, political science, and mapping technology experts that helps tackle the challenge of making redistricting fair and easy to understand. For more
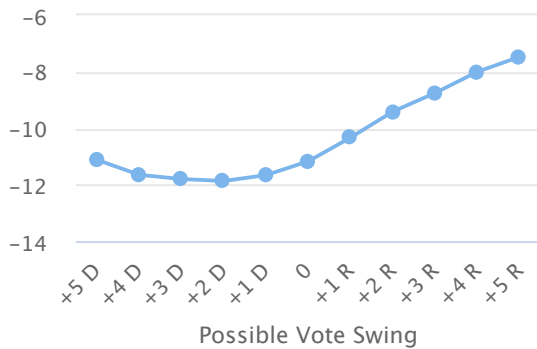
Sensitivity Testing

Sensitivity testing shows us a plan's expected efficiency gap given a range of possible vote swings. It let us evaluate the durability of a plan's skew.

Figure 10: Sensitivity of the Efficiency Gap in Indiana's state house to changes in the statewide vote (PlanScore.org)

4 Partisan Bias in Indiana's State Legislative Districts

In this section, I provide an historical overview of the partisan bias in Indiana's state legislative districts over the past 50 years. For simplicity, I focus on the Efficiency Gap. I will show that Indiana's 2011 redistricting plan is historically extreme compared to both other states and its own plans in previous decades. Just as in Congress, the Efficiency Gaps in Indiana's state legislative districts in the past few elections were among the most Republican-leaning Efficiency Gaps the nation has ever seen.

Figure 11 shows trends in the Efficiency Gap in Indiana's state legislative districts between 1972 and 2018.[24] It indicates that the 2011 redistricting plan led to a large Republican advantage in Indiana state legislative elections unlike what the state experienced after previous redistricting periods. In the 1970s-1990s, Indiana had very neutral Efficiency Gaps with few clear advantages for either party. The partisan advantage was mixed in the 2000s.[25]

Indiana's state legislative map, however, developed a large pro-Republican Efficiency Gap after the 2011 redistricting (see map of this plan in Figure 12). In the state house elections in 2012, Democratic candidates won 47.4% of the statewide vote, but they won only 31% of Indiana's state house seats. This led to a pro-Republican Efficiency Gap of approximately -13.7%. The results in the next few state house elections were fairly similar

---

information, see http://PlanScore.org.

24. Note that detailed nationwide data on state legislative elections in 2020 is not yet available.

25. Indeed, the state house maps were probably somewhat gerrymandered to benefit Democrats, while the state senate maps were somewhat gerrymandered to benefit Republicans. See http://archive.fairvote.org/index.php?page=304.

(a) Indiana State House
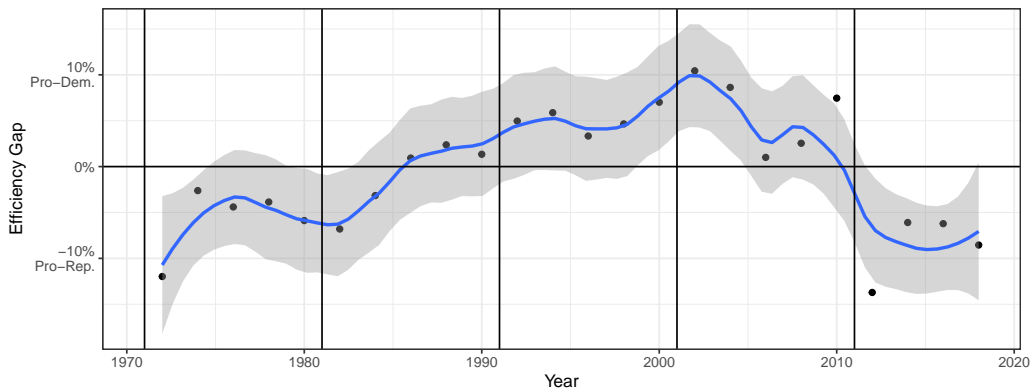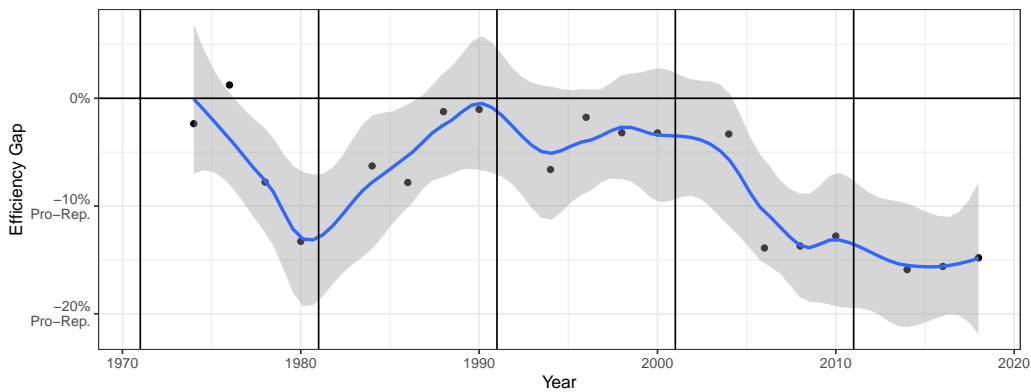

(b) Indiana State Senate

Figure 11: Historical Trajectory of the Efficiency Gap in Indiana. Each vertical line shows the demarcation between decennial redistricting plans. The blue line shows the moving average and the grey bar is a confidence interval. The dots represent the Efficiency Gaps in each year in Indiana.

to those in 2012. Democrats won 42% of the votes, but only 29% of the seats in the 2020 state house elections. Thus, Indiana's state house had a pro-Republican efficiency gap of 4.8% in 2020. The state senate is similar. Over the 2012-18 period, the state senate had a pro-Republican Efficiency Gap of about 15%. Democrats only controlled 20% of the seats after the 2018 election and 22% of the seats after 2020, despite winning over 42% of the statewide vote in each election.

Figure 13 compares the Efficiency Gap in Indiana to other states. Each dot in the chart represent a particular state's efficiency gap for state house and state senate elections in that state that year. The chart shows that the Efficiency Gap in Indiana was generally similar to that of other states until the most recent redistricting. However, recent Efficiency Gaps in Indiana's state legislative districts are extreme relative to both
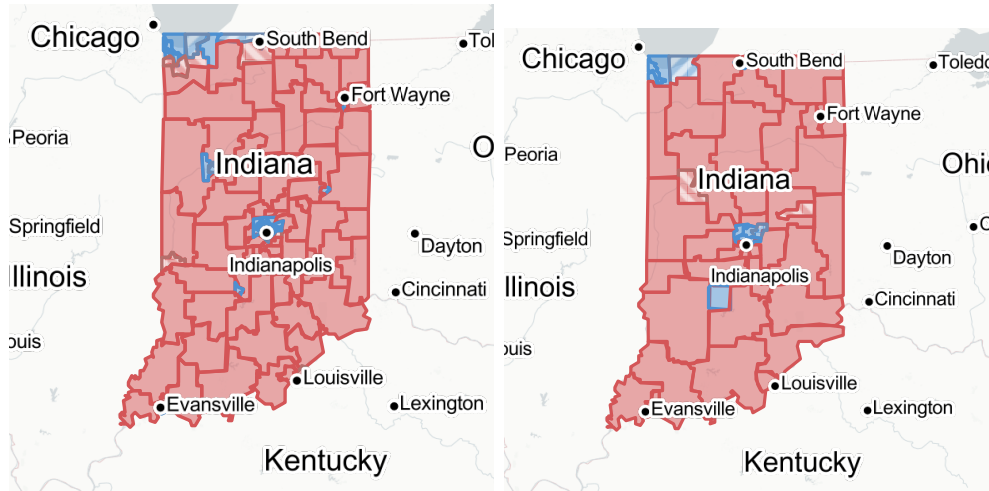
Figure 12: Map of 2011 Districting Plan for State House and Senate Districts from PlanScore.org
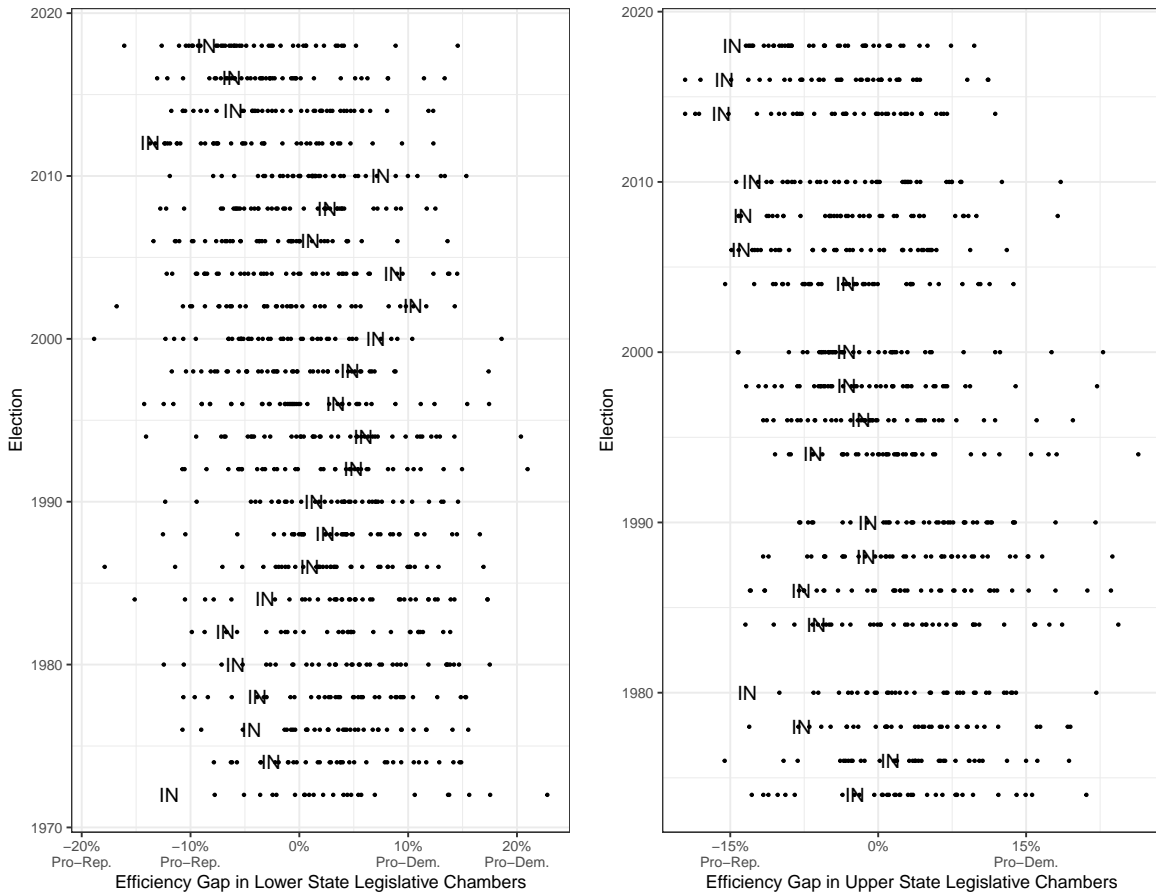

Figure 13: Efficiency Gap in Indiana Relative to Other States. The dots represent the Efficiency Gaps in individual states. The Efficiency Gaps in Indiana are labelled to distinguish them from other states.

its own historical Efficiency Gaps, and the Efficiency Gap in other states. After the most recent redistricting, Indiana's state legislative plans for both its state house and senate generally had more extreme pro-Republican Efficiency Gaps than it has ever had before. This further suggests that geographic factors are unlikely to be the sole cause of the large Efficiency Gap in Indiana in recent elections. Finally, I re-examined my analysis using estimates of the Efficiency Gap from two other sources that account for uncontested districts in slightly different ways (Jackman 2015; Stephanopoulos and McGhee 2015). I obtain very similar results using each of these alternative Efficiency Gap measures.

In sum, the pro-Republican bias in Indiana's state legislative plans in the past few elections were very large. For example, Indiana's state house election in 2012 had a larger pro-Republican bias in its Efficiency Gap than 99% of the state house elections over the past five decades, and it had a larger absolute bias than 95% of previous plans. Turning to other metrics of partisan bias in districting plans, it also had:

- A more extreme difference between the mean and median district than 85% of previous state house elections and a larger pro-Republican bias than in 99% of previous elections.

- A more extreme declination value than 96% of previous state house elections and a larger pro-Republican bias in its declination than 99% of the previous elections.

Likewise, Indiana's state senate results in the first election after its 2011 plan fully went into place in 2014 had a larger absolute Efficiency Gap than 96% of previous state senate elections, and it had a larger pro-Republican bias than 99% of the state senate elections over the past five decades. Using other metrics of partisan bias in districting plans, it also had:

- A more extreme difference between the mean and median district than 71% of previous state senate elections and also a larger pro-Republican bias in the difference between the mean and median district than 79% of previous elections.

- A more extreme declination value than 95% of previous state senate elections and a larger pro-Republican bias in its declination than 98% of the previous elections.

4.1   Durability of Bias in Indiana's State Legislative Districts

The pro-Republican bias in Indiana's state legislative plans is also very durable. For instance, Figure 14 is a figure from PlanScore.org that shows that Indiana's state house map would have a large Efficiency Gap in favor of Republicans even if the statewide vote swung 5 percentage points in favor of either Democrats or Republicans.
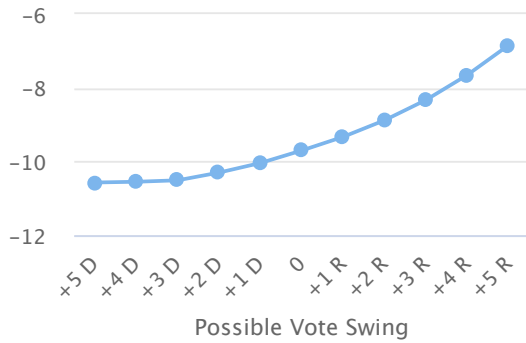
Sensitivity Testing

Sensitivity testing shows us a plan's expected efficiency gap given a range of possible vote swings. It let us evaluate the durability of a plan's skew.

Figure 14: Sensitivity of the Efficiency Gap in Indiana's state house to changes in the statewide vote (PlanScore.org)

5 Conclusion

Overall, there is a substantial and durable Republican bias in the translation of votes to seats in congressional and state legislative elections in Indiana.

- Indiana's 2011 districting plan had a very large pro-Republican bias. Based on a variety of metrics, the pro-Republican bias in Indiana's congressional and state legislative districting plans is extremely large relative to other states.

- The pro-Republican bias in Indiana's plan cannot solely be a function of geography: Based on a variety of metrics, Indiana's congressional and state legislative plans are much more pro-Republican than prior to the 2011 redistricting. Thus, the current Efficiency Gap in Indiana cannot solely be a product of geography.

- The pro-Republican advantage in congressional and state legislative elections in Indiana causes Democratic voters whose votes are wasted to be effectively shut out of the political process in Congress. Due to the growing polarization in Congress, there is a large difference between the roll call voting behavior of Democrats and Republicans. In today's Congress, a representative from one party increasingly does not represent the views of a constituent of the opposite party. Thus, Democratic voters whose votes are wasted are unlikely to see their preferences represented by policymakers.

6 Background on the Author

Christopher Warshaw is an Associate Professor of Political Science at George Washington University. Prior to that, he was an Associate Professor at the Massachusetts Institute of Technology from July 2016 - July 2017, and an Assistant Professor at MIT from July 2012 - July 2016.

His Ph.D. is in Political Science, from Stanford University, where his graduate training included courses in political science and statistics. He also has a J.D. from Stanford Law School. His academic research focuses on public opinion, representation, elections, and polarization in American Politics. His work is published in peer-reviewed journals such as: the *American Political Science Review*, the *American Journal of Political Science*, the *Journal of Politics*, *Political Analysis*, the *Annual Review of Political Science*, *Political Science Research and Methods*, the *British Journal of Political Science*, *Political Behavior*, the *Election Law Journal*, *Nature Energy*, *Public Choice*, and edited volumes from Cambridge University Press and Oxford University Press. He has also served as an expert witness in a number of legal cases on partisan gerrymandering and on the U.S. Census.

References

Best, Robin E, Shawn J Donahue, Jonathan Krasno, Daniel B Magleby, and Michael D McDonald. 2017. "Considering the Prospects for Establishing a Packing Gerrymandering Standard." *Election Law Journal: Rules, Politics, and Policy.*

Brace, Kimball, Bernard Grofman, and Lisa Handley. 1987. "Does Redistricting Aimed to Help Blacks Necessarily Help Republicans?" *Journal of Politics* 49 (1): 169–185.

Brennan Center. 2017. *Extreme Maps.* https://www.brennancenter.org/publication/extreme-maps.

Buzas, Jeffrey S, and Gregory S Warrington. 2020. *Simulated packing and cracking.* arXiv preprint arXiv:2006.10665.

Campagna, Janet, and Bernard Grofman. 1990. "Party control and partisan bias in 1980s congressional redistricting." *The Journal of Politics* 52 (4): 1242–1257.

Caughey, Devin, Chris Tausanovitch, and Christopher Warshaw. 2017. "Partisan Gerrymandering and the Political Process: Effects on Roll-Call Voting and State Policies." *Election Law Journal* 16 (4).

Chen, Jowei, and Jonathan Rodden. 2013. "Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures." *Quarterly Journal of Political Science* 8 (3): 239–269.

Cox, Gary W., and Jonathan N. Katz. 1999. "The reapportionment revolution and bias in US congressional elections." *American Journal of Political Science:* 812–841.

———. 2002. *Elbridge Gerry's Salamander: The Electoral Consequences of the Reapportionment Revolution.* New York: Cambridge University Press.

Dunham, James, Devin Caughey, and Christopher Warshaw. 2016. *dgo: Dynamic Estimation of Group-Level Opinion. R package version 0.2.3.* https://jamesdunham.github.io/dgo/.

Gelman, Andrew, and Gary King. 1994a. "A unified method of evaluating electoral systems and redistricting plans." *American Journal of Political Science* 38 (2): 514–554.

———. 1994b. "Enhancing Democracy Through Legislative Redistricting." *American Political Science Review* 88 (03): 541–559.

ICPSR. 2006. *State Legislative Election Returns in the United States, 1968-1989.*

Jackman, Simon. 2015. *Assessing the Current Wisconsin State Legislative Districting Plan.* Expert Analysis by Political Scientist, Stanford, CA: Stanford University.

———. 2017. *Assessing the Current North Carolina Congressional Districting Plan.* Expert Analysis by Political Scientist, Stanford, CA: Stanford University.

Jacobson, Gary C. 2015. "It's nothing personal: The decline of the incumbency advantage in US House elections." *The Journal of Politics* 77 (3): 861–873.

Jacobson, Gary C, and Jamie L Carson. 2015. *The politics of congressional elections.* Rowman & Littlefield.

Kastellec, Jonathan P, Andrew Gelman, and Jamie P Chandler. 2008. "Predicting and dissecting the seats-votes curve in the 2006 US House election." *PS: Political Science & Politics* 41 (1): 139–145.

King, Gary, and Andrew Gelman. 1991. "Systemic consequences of incumbency advantage in US House elections." *American Journal of Political Science:* 110–138.

Klarner, Carl, William Berry, Thomas Carsey, Malcolm Jewell, Richard Niemi, Lynda Powell, and James Snyder. 2013. *State Legislative Election Returns (1967–2010).* ICPSR34297-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2013-01-11. doi:`10.3886/ICPSR34297.v1`.

Kollman, K., A. Hicken, D. Caramani, D. Backer, and D. Lublin. 2017. *Constituency-level elections archive [data file and codebook].* Ann Arbor, MI: Center for Political Studies, University of Michigan.

Krasno, Jonathan S, Daniel Magleby, Michael D McDonald, Shawn Donahue, and Robin E Best. 2018. "Can Gerrymanders Be Detected? An Examination of Wisconsin's State Assembly." *American Politics Research.*

McDonald, Michael P. 2014. "Presidential vote within state legislative districts." *State Politics & Policy Quarterly* 14 (2): 196–204.

McGhee, Eric. 2014. "Measuring Partisan Bias in Single-Member District Electoral Systems." *Legislative Studies Quarterly* 39 (1): 55–85.

———. 2017. "Measuring Efficiency in Redistricting." *Election Law Journal: Rules, Politics, and Policy.*

McGhee, Eric. 2018. *Assessing California's Redistricting Commission: Effects on Partisan Fairness and Competitiveness.* Report from the Public Policy Institute of California. Available at `http://www.ppic.org/publication/assessing-californias-redistricting-commission-effects-on-partisan-fairness-and-competitiveness/`.

MIT Election and Data Science Lab. 2017. *U.S. House 1976–2016.* Available on the Harvard Dataverse at `http://dx.doi.org/10.7910/DVN/IG0UN2`.

Nagle, John F. 2015. "Measures of partisan bias for legislating fair elections." *Election Law Journal* 14 (4): 346–360.

Niemi, Richard G, and John Deegan. 1978. "A theory of political districting." *American Political Science Review* 72 (4): 1304–1323.

Powell, G. Bingham, Jr. 2004. "Political Representation in Comparative Politics." *Annual Review of Political Science* 7:273–296.

Rogers, Steven. 2017. "Electoral Accountability for State Legislative Roll Calls and Ideological Representation." *American Political Science Review* 111 (3): 555–571.

Royden, Laura, Michael Li, and Yurij Rudensky. 2018. *Extreme Gerrymandering & the 2018 Midterm.*

Stephanopoulos, Nicholas. 2018. "The Causes and Consequences of Gerrymandering." *William and Mary Law Review* 59.

Stephanopoulos, Nicholas O, and Christopher Warshaw. 2020. "The impact of partisan gerrymandering on political parties." *Legislative Studies Quarterly* 45 (4): 609–643.

Stephanopoulos, Nicholas O., and Eric M. McGhee. 2015. "Partisan Gerrymandering and the Efficiency Gap." *University of Chicago Law Review* 82 (2): 831–900.

———. 2018. "The measure of a metric: The debate over quantifying partisan gerrymandering." *Stan. L. Rev.* 70:1503.

Tufte, Edward R. 1973. "The relationship between seats and votes in two-party systems." *American Political Science Review* 67 (2): 540–554.

Wang, Samuel. 2016. "Three Tests for Practical Evaluation of Partisan Gerrymandering." *Stan. L. Rev.* 68:1263–1597.

Warrington, Gregory S. 2018a. "Introduction to the declination function for gerrymanders." *arXiv preprint arXiv:1803.04799.*

Warrington, Gregory S. 2018b. "Quantifying Gerrymandering Using the Vote Distribution." *Election Law Journal* 17 (1): 39–57.

Wright, Gerald, Tracy Osborn, Jon Winburn, and Jennifer Hayes Clark. 2009. "Patterns of representation in the American states and Congress." In *annual conference on State Politics and Policy, Chapel Hill, NC.*

Supplementary Appendix

A   Measurement Model for Uncontested Races

A factor that complicates the computation of the Efficiency Gap (as well as any other measure of partisan bias) is that many seats are uncontested. As Stephanopoulos and McGhee (2015, 865) put it, "Since gerrymanders redistribute voters in order to pack and crack the opposition, determining the degree of packing and cracking requires knowing how many people in each district support each party."[26] In uncontested races, however, it is not possible to calculate a two-party vote share. Thus, we have no way of knowing based on the election returns alone how many people supported each party.

As a result, we need some strategy to impute the two-party vote shares in these districts in order to estimate the Efficiency Gap. There are a variety of potential approaches to address this problem. The simplest strategy is to simply assume that the winning candidate receives 75% of the vote and the losing candidate receives 25% of the vote. Many political science studies have adopted this approach (e.g., Gelman and King 1994a; Kastellec, Gelman, and Chandler 2008).[27] However, Kastellec, Gelman, and Chandler (2008) point out that "there is no way to know whether the losing candidate would have actually received 25% of the vote. For example, in a heavily Democratic district in Philadelphia, this probably over-estimates the vote share a Republican candidate would have gotten. In contrast, it might under-estimate the Republican vote share in a more suburban, swing district."

A more sophisticated strategy to address uncontested races is to estimate the two-party vote share in district$_i$ based on previous and future elections in that district as well as the results in similar districts elsewhere. A variety of recent analyses have used this approach. The Brennan Center's recent report uses a variant of this approach for its estimates of Efficiency Gaps between 1992-2016 (Brennan Center 2017, 16).[28] This

---

26. A variety of other scholars have noted this problem. For instance, Campagna and Grofman (1990, 1247) note that "One key issue [for studies of redistricting] is how to handle uncontested seats. [One needs] to avoid using 100% as the vote share for a party in an uncontested seat (which, for Congress, tends to bloat ... vote share)."

27. Kastellec, Gelman, and Chandler (2008) justify this strategy by noting that King and Gelman (1991) and Gelman and King (1994a) examined the "vote shares received in the last election before a district became uncontested and the first election after a district became uncontested. The average of these values was about 0.75 for the incumbent party and represents the average 'effective support' for the party in uncontested races."

28. Brennan Center (2017, 16) states that 'For districts without both a Democrat and Republican running in the general election, we estimated the vote share both parties would have received in a contested two-party election based on the prior election's House results, the most recent district-level

strategy is also used by the Public Policy Institute of California for its estimates of the Efficiency Gap over the last decade (McGhee 2018), and by Professor Simon Jackman in his expert reports for litigation in Wisconsin and North Carolina (Jackman 2015, 2017). One downside of this approach, however, is that it relies on less transparent assumptions than the simpler strategy described above.

Unfortunately, there are no publicly available, published estimates of the Efficiency Gap that span the past four decades for all three legislative chambers, including congressional, state house, and state senate districts. As a result, I build my own estimates using both approaches described above for imputing uncontested districts. That is, I build one set of Efficiency Gap estimates based on the assumption that the winning party receives 75% of the vote in uncontested districts and another version using a model that imputes the vote shares in uncontested districts based on previous and future elections in that district as well as the results in similar districts elsewhere. I use the latter estimates in the main body of the report. But it is important to note that the substantive results in the report are robust to the precise details of how we calculate the Efficiency Gap.

A.1 Overview of Data

A.1.1 Congressional Districts

For congressional districts, the foundation of my analysis was congressional election results from 1972-2018 collected by the Constituency-Level Elections Archive (CLEA) (Kollman et al. 2017). The results from 1972-1990 are based on data collected and maintained by the Inter-university Consortium for Political and Social Research (ICPSR) and adjusted by CLEA. The data from 1992-2018 are based on data collected by CLEA from the Office of the Clerk at the House of the Representatives. I supplemented this dataset with election results collected by the MIT Election and Data Science Lab (MIT Election and Data Science Lab 2017). I used data on presidential election returns and incumbency status in Congressional elections collected by Professor Gary Jacobson (University of California, San Diego). This dataset has been used in many Political Science studies and has canonical status in the political science profession (Jacobson 2015). I group elections by decade and estimate the Efficiency Gap for each state's plan in each election year.

Presidential results using totals calculated and compiled by Daily Kos Elections for both 2012 and 2016, a district's Cook Partisan Voter Index, and the winning candidate's incumbency status."

A.1.2 State Legislative Districts

For state legislative districts, the foundation for my analysis was a large canonical data set on candidacies and results in state legislative elections from 1972-2018 collected by Carl Klarner and a large team of collaborators. The results from 1972-2012 are based on data maintained by the Inter-university Consortium for Political and Social Research (ICPSR) (Klarner et al. 2013). I obtained data from 2013-2018 directly from Klarner. I obtained Indiana's returns in 2020 directly from the state government's website.

I used a variety of sources of data on presidential election returns in state legislative districts. For elections between 1972 and 1991, I used data on county-level election returns from 1972-1988 collected by the Inter-university Consortium for Political and Social Research (ICPSR 2006) and mapped these returns to state legislative districts in order to estimate presidential, senate, and governor election results by state legislative district. For elections between 1992 and 2001, I used data on presidential election returns in the 2000 election collected by McDonald (2014) and Wright et al. (2009). For elections between 2002 and 2011, I used data on the 2004 and 2008 presidential elections collected by Rogers (2017). For elections between 2012 and 2018, I used data on presidential election returns for the 2012 and 2016 elections from the DailyKos website.

I group each state's elections based on its redistricting plan using data from Carl Klarner. In most cases, redistricting plans are constant over the course of a decade. However, a handful of states have redistricted mid-decade for various reasons. In general, I drop these states from my analysis. I also drop state legislative elections from my analysis where I am unable to match to data on presidential vote share. I also drop state senate elections in the first cycle after a redistricting from my analysis because it is not clear whether each district in the chamber is using the post-redistricting map.

Many state legislative elections are conducted in multimember districts. Previous studies have dropped the bulk of these districts from their analyses (e.g., Jackman 2015). However, I include multimember districts in my analysis of the Efficiency Gap in state legislative elections. For multimember districts with posts, I treat each post as if it's a separate district. For multimember systems without posts, I match each winner with a maximum of one loser of the opposite party, and assume that they ran against each other in a post election. Specifically, I match the worst-performing winner with the best-performing loser of the opposite party, and then the next-worst performing winner with the second-best performing loser of the opposite party, etc. If there are more winners than losers, then there will be some "uncontested" races.

Finally, if only a portion of a state legislative chambers were elected in a particular year, I group these elections with the most recent previous election in each district in
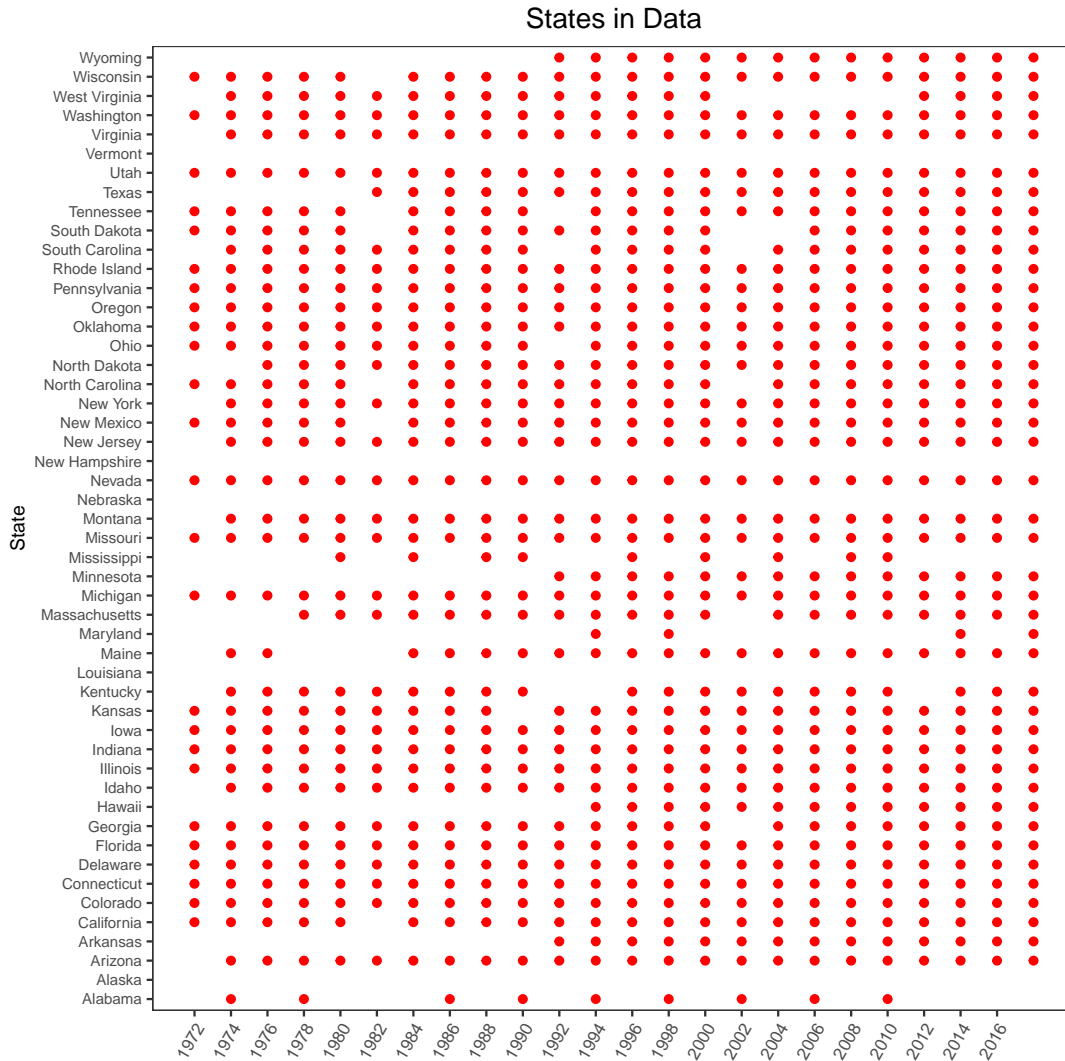
Figure A1: States and election cycles where I estimate the Efficiency Gap in State House Districts.

order to calculate each party's seat share, vote share, the number of wasted votes, the Efficiency Gap, and other statistics.

Figure A1 (above) shows the states and election cycles where I estimate an efficiency gap for state house districts. Overall, I have estimated the Efficiency Gap for 896 of the 1123 (80%) state house election years in partisan legislatures between 1972 and 2016.[29] This is substantially more than previous analyses of gerrymandering in state legislatures using the Efficiency Gap (e.g., Stephanopoulos and McGhee 2015; Jackman 2015).

---

29. I have dropped state-years for the following reasons. First, I drop state-years where I am unable to match presidential election results to state legislative districts. Second, I drop state-years that precede a mid-decade redistricting.

A-4

A.2 Details of Statistical Models

This section presents the details of the statistical models that I use to impute uncontested races.

1. First, I estimate the Efficiency Gap assuming that the winner in uncontested races receives 75% of the vote and the loser receives 25% of the vote. I estimate the statewide Democratic vote share by assuming that turnout in each district was equal and simply taking the average of the two-party vote shares in each district.

2. Second, I estimate the Efficiency Gap using a statistical model to impute both the vote share and turnout in uncontested districts. This model is closely related to the imputation strategy for uncontested districts adopted by previous studies of the Efficiency Gap (Stephanopoulos and McGhee 2015; Jackman 2015, 2017; Brennan Center 2017; McGhee 2018).

   - In order to estimate the vote shares in uncontested districts, I model the proportion of the two-party vote received by the Democrat ($p_{d,t}$) in each district (d) using a binomial model.

$$s_{d,t}^v \sim \text{Binomial}(n_{d,t}^v,\ p_{d,t}^v), \tag{3}$$

   where d indexes districts and t indexes elections. $n_{d,t}^v$ is set to 2000^{30} and $s_{d,t}^v$ is the two-party vote share multiplied by 2000. For uncontested races, we set $n_{d,t}^v$ and $s_{d,t}^v$ to zero. We then model p as a function of: previous and future results in that district, each district's presidential vote share, whether there is an incumbent running, and if so, their party, and the region (congressional districts) or state (state legislative districts) that the district is in. For state legislative races, I also include the Democrats' vote share in governors and senate races during the 1970s and 1980s as a predictor since state legislative races during this period were less nationalized than in more recent decades. More formally, for congressional districts, we model

$$p_{d,t}^v = \Phi(\gamma_t +\ p_{d,t-1}^v + \beta_1 * pvote_{d,t} + \beta_2 * incumbency_{d,t} + \alpha_{s[d]}^{region}) \tag{4}$$

---

30. This number is set for computational efficiency. However, it could be arbitrarily set to some other number, and this would not affect the model results.

where *pvote* is the percentage of the two-party presidential vote received by the Democratic candidate in each district; *incumbency* is a factor equal to 1 if there is a Democratic incumbent, 0 if there is no incumbent, and -1 if there is a Republican incumbent; regions are based on economic regions defined by the Bureau of Economic Advisors; and the normal CDF Φ maps p to the $(0,1)$ interval. I estimate the model separately each decennial redistricting period (i.e., years ending in 02 - 12) using the `dgmrp` function in the `dgo` package in `R` (Dunham, Caughey, and Warshaw 2016).[31] The mean estimate of Democratic vote share in uncontested congressional races won by Democrats is 71% and the average estimate of Democratic vote share in uncontested races won by Republicans is 31%.[32]

- In order to estimate the turnout in uncontested congressional districts, I model the proportion of the population ($p_{d,t}$) that votes in each district (d) using a similar binomial model.

$$s_{d,t}^t \sim \text{Binomial}(n_{d,t}^t, \ p_{d,t}^t), \tag{5}$$

where $n_{d,t}^t$ is set to 2000 and $s_{d,t}^t$ is the proportion of the population that voted for either the Democratic or Republican candidate multiplied by 2000. For districts with uncontested races, we set $n_{d,t}^t$ and $s_{d,t}^t$ to zero. We then model p as a function of: previous and future results in that district, whether there is an incumbent running, and if so, their party, and the region that the district is in. More formally, we model

$$p_{d,t}^t = \Phi(\gamma_t + \ p_{d,t-1}^t + \beta_1 * incumbency_{d,t} + \alpha_{s[d]}^{region}) \tag{6}$$

where *incumbency* is a factor equal to 1 if there is a Democratic incumbent, 0 if there is no incumbent, and -1 if there is a Republican incumbent; regions are based on economic regions defined by the Bureau of Economic Advisors; and the normal CDF Φ maps p to the $(0,1)$ interval. I estimate the model separately each decennial redistricting period (i.e., years ending in 02 - 12)

---

31. Due to data limitations, for both the models of turnout and vote share in congressional elections, I do not split apart states' plans due to mid-decade redistrictings. In recent decades, however, only a handful of states have conducted mid-decade redistrictings. For state legislative districts, I drop elections from districting plans established prior to a mid-decade redistricting.

32. These estimates are very similar to those of Stephanopoulos and McGhee (2015, 866). Based on a similar approach, they estimate a "mean Democratic vote share [in uncontested races] of 70 percent," and for uncontested Republicans, they estimate "a mean Democratic vote share of 32 percent."

using the `dgmrp` function in the `dgo` package in R (Dunham, Caughey, and Warshaw 2016).

- In order to estimate the turnout in uncontested state legislative districts, I take the average of the turnout in district$_d$ in other presidential or midterm years in a given decade. If no data on district$_d$ is available, I take the average of turnout in year$_t$ elsewhere in the state. I use this simpler approach due to the unavailability of population data for state legislative districts.

- Finally, for uncontested congressional and state legislative districts, I estimate the number of Democratic votes in each district by multiplying the estimated, imputed Democratic vote share ($p_{d,t}^v$) by the estimate of the total turnout. For contested districts, I use the actual number of Democratic votes and total votes in each district. Combining these approaches, I estimate the statewide Democratic vote share by simply summing the Democratic votes in each district and dividing by the total number of votes.

Now that we know voters' two-party preferences in contested districts and we have estimates of their preferences in uncontested districts, we are finally in position to estimate the partisan advantage in the congressional and state legislative districting process during each state-year. I estimate the efficiency gap in all states for each election between 1972 to 2016 using equation 2.[33]

In the discussion of congressional districts in the main body of the report, I focus on states with more than 6 congressional seats. I omit smaller states for two reasons. First, these states contribute less to the overall distribution of seats in Congress (Stephanopoulos and McGhee 2015, 868). Second, the Efficiency Gap in smaller states tends to be more volatile and thus less informative about partisan bias. For example, in a state with only three seats, a change in the winner of one seat could cause a huge shift in their Efficiency Gap.

A.3 Validation

Prior to examining our results, it is useful to validate my measures of the Efficiency Gap to make sure that it aligns closely with alternative modeling approaches for uncontested races. In fact, Figure A2 shows that the precise method used to impute uncontested congressional races makes relatively little difference for estimates of the Efficiency Gap.

---

33. I start the analysis in 1972 since those are the first districting plans drawn after the Supreme Court cases stemming from *Baker v. Carr* ended malapportionment and established the principle of one-person, one-vote.

- The correlation between estimates of the Efficiency Gap for congressional districts I calculated using the Bayesian method described above and a simpler approach that assumes the winner in uncontested races received 75% of the two-party vote is 0.95.

- The correlation between my estimates of the Efficiency Gap for congressional districts and estimates for 1992-2016 developed by the Brennan Center is 0.95.

- The correlation between my estimates of the Efficiency Gap for congressional districts and estimates for 2002-2016 developed by the Public Policy Institute of California is 0.98.
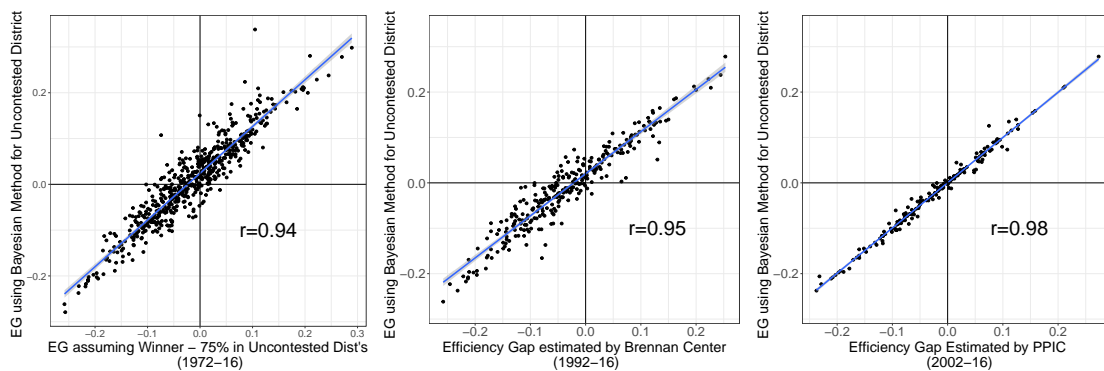

Figure A2: Validation of the Efficiency Gap Measure for Congressional Elections

I also find very high correlations between my estimates of the Efficiency Gap in state house districts and other modeling approaches for estimating the Efficiency Gap.

- The correlation between estimates of the Efficiency Gap for congressional districts I calculated using the Bayesian method described above and a simpler approach that assumes the winner in uncontested races received 75% of the two-party vote is 0.84.

- The correlation between my estimates of the Efficiency Gap for congressional districts and estimates for 1972-2014 developed by Jackman (2015) is 0.91.[34]

- I also find very high correlations between my estimates of the Efficiency Gap and the declination measures discussed in the main body of the report.

---

34. It is important to note that my methodology for estimating the Efficiency Gap differs from Jackman (2015)'s approach in three relatively minor ways which slightly attenuates the correlation between our measures. First, I adjust for unequal turnout across districts. If I do not adjust for differences in turnout, my Efficiency Gap estimates have a 0.96 correlation with Jackman's estimates. Second, I use presidential vote share as a predictor of state legislative elections throughout the entire time period to estimate uncontested districts. Finally, I include states with multimember districts in my analysis.