State Legislative Redistricting: The Effectiveness of Traditional Redistricting Principles

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Abstract

Do traditional redistricting principles constrain partisan gerrymanders? We analyze a complete set of state legislative maps from the 2010 redistricting wave, comparing maps under partisan, bi-partisan, and non-partisan control. We measure manipulation by a low degree of overlap between parent and offspring districts which we confirm is connected to the search for partisan gain. We estimate conditional quantiles so as to understand the effect of changing the legal environment on the entire range from those districts left relatively unscathed to those that are dissected. This is important as the conditional mean often understates the modal effect. We also correct for spatial correlation of errors as the adjustment of a district’s boundaries necessarily means adjusting those of its neighbor. We find that certain legal principles effectively limit adjustments with different legal principles affecting different types of strategic decisions.
1. Introduction

Partisan gerrymandering is an act for which political parties will continue to have means, motive, and opportunity for the foreseeable future. Given the sophisticated software and detailed voter files available to political parties in the modern age, the means of mischievous mapping are more effective than ever (Newkirk 2017). Given the heightened partisan polarization and commensurately intensified feeling of tribal competition, the motivation is more powerful than ever (Altman and McDonald 2015). And given the continued rarity of non-partisan commissions (Levitt 2010) and the continued reluctance of the Supreme Court to intervene against partisan gerrymandering (e.g. Rucho v. Common Cause, 588 U.S. ___ 2019), the opportunity will persist. The widespread feeling that partisan gerrymandering is a crime against democracy makes the possibility of its constraint via existing state statutes of broad interest (Engstrom 2009).

Leading models of gerrymandering (Friedman and Holden 2008, Gul and Pesendorfer 2010, Owen and Grofman 1988) presume that a mapmaker can group any set of voters together. But gerrymanders may be effectively constrained when states place a variety of legal constraints on maps such as compactness, preservation of county boundaries, and respect for natural geography and communities of interest. However, these so-called traditional districting principles (TDPs) are rarely precisely defined and leave a great deal of latitude to courts whose enforcement of them varies. There is no formal theory incorporating geography and legal constraints. As the empirical literature explicitly analyzing TDPs is both thin and disjointed, it remains an open question as to whether they are effective.

In an analysis conducted at the level of the individual district, our empirical work addressing this question offers several improvements on the existing literature. Given the incredible heterogeneity
across states of local political institutions and behavior, we analyze the full set of maps from the 2010 redistricting wave. We analyze five TDPs plus preclearance under section 5 of the Voting Rights Act simultaneously using multiple regression analysis so as to determine the role of one constraint in the context of other constraints. We include spatially correlated errors because changing the boundary of one district necessarily changes the boundary of one or more adjacent districts. Finally, we believe that strategic concerns lead mapmakers to treat districts in heterogeneous fashion. Some are ignored, some are deliberately helped or hindered, while others are targeted for dissolution. Thus the conditional mean is less useful than conditional quantiles. We do not believe any existing study meets these best practices.

We find that spatial correlation is important and that mean results frequently understate the effect on those districts actively targeted for change, which are better captured by the median. We find that overlap responds to the conditions of partisan competition exactly as predicted by standard theories of partisan gerrymandering, supporting our use of this measure as an indicator of constraint on the seeking of partisan advantage. Finally, we find that traditional districting principles can significantly improve overlap, suggesting that they do constrain gerrymandering behavior.

The paper proceeds with a review of the literature on TDPs followed by a discussion of our methodology, data, and results.

2. Literature Review: Traditional Districting Principles

It is commonly argued that *Baker v. Carr*, 369 U.S. 186 (1962) and *Reynolds v. Sims*, 377 U.S. 533 (1964) decisively shifted the focus of courts toward population equalization necessarily de-
emphasizing TDPs. Altman notes that immediately following Reynolds, traditional boundaries were violated in favor of census blocks, tracts, and streets. “[C]hanges in compactness were a result of the splitting of local boundaries by redistricters to meet the Court’s new requirements.” (Altman 1998a p160) As a result, malapportionment decreased but so did compactness. Johnson (2015) opines, “the judicial mandate to draw districts of equal population has freed them to ignore county boundaries and other traditional criteria.” (p 6)

The current search for a measure of partisan bias (e.g. Stephanopoulos and McGhee 2015) highlights the importance of simple yet precise measures. Yet TDPs are hampered by the fact that many state laws requiring their consideration nonetheless fail to define them (Robinson 2012). Niemi et al (1990) and Altman (1998a) show how varying the definition of compactness can lead to different judgements of the fitness of individual districts. In a case study of North Carolina, Robinson (2012) notes that the lack of a clear definition of compactness hampered legal challenges, allowing incumbents the freedom to achieve partisan goals. And Altman (1998b) shows the difficulty in setting an appropriate standard for compactness, no matter the measure. And yet compactness is easier to define than communities of interest or geographic boundaries. As Winburn notes, communities of interest admit multiple cross-cutting definitions including “media markets, economic markets, and racial and ethnic neighborhoods.” (Winburn p29) Having conducted surveys of residents in a single mid-sized city (Santa Barbara), Phillips (2016) concludes that communities of interest defined by the demographic and land use variables universally available to state authorities do not always correspond to the cognitive definitions of communities of interest held by local residents.
Finally, TDPs may come in direct conflict with each other. Cain (1984) argues that compactness and communities of interest are often in conflict as the community does not naturally subscribe to a compact area. Areas defined by political sub-divisions and natural geography are likewise not necessarily compact. Thus it is not surprising that Engstrom (2009) writes that TDP are “generally viewed by students of redistricting to be minor impediments to partisan gerrymandering, especially in the days of computer-assisted redistricting” (Engstrom p227).

And yet, Friedman and Holden (2009) find that incumbent gerrymandering is declining in effectiveness, a result they argue is consistent with legal constraints becoming tighter over time. Moreover, the few explicit studies of TDPs have found them to be effective. In a close study of eight states from the 2000 redistricting cycle focusing on a specific TDP, Winburn (2008) finds that enforcement of restrictions on splitting political subdivisions effectively prevented partisan gerrymandering in Michigan, Ohio, and Kentucky while failure to enforce these rules permitted a partisan gerrymander in Georgia. Makse (2012) also analyzes state legislative maps from the 2000 wave, finding that rules protecting towns, counties, and other jurisdictions inhibit the tendency of the majority party to shift opposition incumbents’ districts so as to break the personal connection between voter and representative. As a result, such rules improve the symmetry of treatment between the majority and minority parties. Altman (1998a) questions the effect of compactness on partisan bias but notes that it does affect turnout. As Niemi et al (1990) note, “as questions of discrimination became more prominent... concerns other than population equality—compactness among them—again became relevant.” (p1156)

How can TDPs be effective given the frequent lack of a clear definition, the competition between TDPs, and the requirement of population equity? Election law expert Justin Levitt notes “litigation
is a sure thing” with hundreds of challenges to state maps each cycle (Newkirk 2017). Given the current legal reluctance of courts to intervene against partisan gerrymanders, partisan challengers might well seize on other flaws to overturn maps not to their liking. Thus a map-maker will be at pains not to deliver any clear violation of statutes on which a judge might seize, potentially leading to a full or partial loss of control of the map. As Cox and Katz (2002) explain, the threat of legal action can function as an off-the-equilibrium path action which affects the map-maker’s optimal choice. The vagueness of the statutes might actually enhance rather than diminish their deterrent effectiveness. One reason why the natural packing of Democrats into cities (Erikson 1972, Hirsch 2003, Chen and Rodden 2013, Geodert 2014) might be especially robust is because it does not violate the TDPs—compactness, communities of interest, political subdivisions, or natural geography—and thus cannot be easily challenged on justiciable grounds. But where desirable partisan gerrymandering does run afoul of TDPs, parties may choose to steer clear to avoid loss of control. Thusly might TDPs reduce partisan gerrymandering.

3. Methodology

3.1 Dependent Variable: Overlap

Our dependent variable measuring the extent of gerrymandering is the overlap between a (parent) district from the 2000-wave map and its successor (offspring) district in the 2010-wave map. We define overlap as the fraction of the parent district’s population that is preserved in the relevant offspring district. We explain below how we identify the matches of parents and offspring.
The idea of using overlap as a measure of gerrymandering requires some defense. Maps are subject to inertia for two important reasons: because representatives would prefer not to lose voters to whom they are known and because the existing map has cleared prior legal challenges. As a result, drops in overlap come usually from intent to gain political advantage. Yoshinaka and Murphy (2009) have shown that one way of hurting the opposing party is to interrupt the connection between the incumbent and her voters by dispersing her previous voters across multiple new districts. This is one reason why previous studies have consistently found that opposition districts exhibit less overlap than majority party districts (Makse 2012). It also justifies overlap as a measure of the extent to which map-makers engaged in manipulation. Like Makse (2012), we find that in many respects, the pattern of overlap fits neatly with this notion. Namely, overlap is smaller in chambers that are competitive and smaller for districts that are competitive.

Why wouldn’t we just use the change in the partisan vote share of the district? While this might seem to be a natural measure, it is complicated by changes in fund-raising, effort, candidate quality, and the national political climate. The national political climate introduces unrelated noise. The more serious issue is that districts seen as uncompetitive draw less qualified challengers while incumbents in safe districts siphon time and money from their campaigns to other political activities. As a result, the change in partisan vote share is not likely to be a clean measure of the change in the baseline competitiveness of the district. We could use the change in normal democratic vote (Sabouni-Shelton 2019) to control for annual fluctuations. However this too has drawbacks. Namely, the state parties and representatives have greater information about their neighborhoods than is recorded in the vote share (Newkirk 2017). They have a better sense of where those neighborhoods are headed over the next decade, the addresses of current candidates

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1 Overlap is also reduced by necessary border changes resulting from differential rates of population growth.
and potential challengers, and the location of favored donors and constituents. As a result, a large fraction of the changes in borders has nothing to do with shifting the normal democratic vote and yet might be thought of as manipulation to the gain of officeholders and parties.

In addition, overlap has the great virtue that it directly measures the stability of the district boundaries, this stability being itself desirable for fostering connection between representatives and their communities, thereby enabling more informed representatives, better representation, and easier monitoring by voters.

We thus use the overlap between a parent and its offspring district as a measure of the extent to which the map-makers were able to adjust districts in order to meet their goals. Broadly speaking, in the context of partisan control, we will be taking smaller overlap as evidence of a less constrained map-maker. As we point out below, our results are consistent with our justification.2

We have shapefiles for the state legislative district lines for the 2000 and 2010 waves from the U.S. Census TigerLines database for the lower and upper chambers of each state. But because we wish a measure of population overlap rather than area overlap, we do not simply calculate the overlap of these districts. Instead, we use GIS shapefiles at the precinct level, from the Harvard Election Data Archive. Once projected into a common coordinate reference system (CRS) through Environmental Systems Research Institute’s (ESRI) ArcMap software, we use ESRI’s intersect tool to find the shared area between our precinct level data and the respective upper and lower chamber state legislative district lines for 2000 and 2010. We can thus assign portions of precincts, with their proper populations, to their starting and ending districts to calculate a population-weighted

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2 One might question whether the laws serve simply to ensconce a previous gerrymander. To address this fear, we can compare chambers where control of the map has shifted between the 2000 and 2010 waves to those where control has remained the same. We find broadly similar results suggesting that TDPs constrain partisan control similarly no matter the status quo.
measure of the overlap between each district from the 2000 map and each district from the 2010 map. The remaining step is to match each district from 2000 (parent) with a district from 2010 (offspring). For every parent district, we assign the offspring district that got the biggest piece of the parent. This procedure for determining parent and offspring districts is the same one used by Carson et al (2007) and Winburn (2008). See the appendix for more details.

The histogram\(^3\) of overlap between parent and offspring districts is shown in Figure 1, separated by political control of the map. Districts are clearly treated heterogeneously. The modal district is essentially untouched and unchanged, with overlap of nearly 100%. At the other end, there are districts that are so completely dissected that the maximal overlap is less than 50% meaning there is no single dominant parent. In between are districts that are meaningfully changed while still maintaining a clear lineage and incumbent. Interestingly, control of the map has essentially no effect on the overall distribution of overlap suggesting that no matter who controls the map, some districts are slated for dissection in service of larger goals (possibly including pursuit of partisan advantage) while other districts are untargeted and unchanged. However, as we show, which districts are protected and which are adjusted depends a great deal on who controls the map.

\[3.2\] \textit{Econometric Approach}

\[3.2.1\] \textit{The Baseline Specification}

We regress our measure of the parent-offspring overlap of district, \(d\), in a chamber, \(c\), on indicators of whether a chamber is subject to traditional redistricting principles plus controls including

\[^3\] Histograms were used rather than kernel densities because the latter have difficulty with endpoints and our distribution is bounded on \([0,100]\) with interesting action at the upper end.
whether the seat is held by the party in control of the map (“control”), the seniority of the incumbent, the partisan vote margin of the district prior to redistricting (e.g. R+7 or D+22), an interaction between “control” and vote margin, and the partisan seat margin of the chamber.

\[ \text{Overlap}_{cd} = \beta_0 + \beta_1 \text{Seat held by Party in Control of Map("Control")}_d \]
\[ + \beta_2 \text{Seniority of Incumbent}_d + \beta_3 \text{Vote Margin of District}_d \]
\[ + \beta_4 \text{Control} \times \text{Vote Margin}_d + \beta_5 \text{Seat Margin of Chamber}_c \]
\[ + \beta_6 \text{Compactness Requirement}_c + \beta_7 \text{Natural Geography Requirement}_c \]
\[ + \beta_8 \text{Communities of Interest Requirement}_c + \beta_9 \text{County Lines Requirement}_c \]
\[ + \beta_{10} \ln(\text{Counties per District} \times \text{County Line Requirement})_c \]
\[ + \beta_{11} \ln^2(\text{Counties per District} \times \text{County Line Requirement})_c \]
\[ + \beta_{12} \text{VRA Preclearance}_c + \beta_{13} \text{Preserve Prior Core}_c + \epsilon_d \]

We separate the sample by control of the redistricting process. Table 1 is restricted to the 52 chambers in which legislators from a single party control the process. The literature suggests these should produce partisan gerrymanders. We can then also analyze the 24 chambers where the map was produced by an independent commission or a court appointed commission. These ought to be maps with no intent to manipulate for reelection of incumbents (Table 2). Finally, we look at the 20 chambers where politicians from both parties share control of the map (Table 2) as the literature suggests these might deliver incumbent gerrymanders. These data behind these categories are explained in section 3.3.
3.2.2 Determining the Functional Form

In the absence of a clear theoretical prediction on which to base a structural estimation, we must determine the proper functional form. Our first step in each case is to investigate the factor on its own by fitting a two-term fractional polynomial. Fractional polynomials provide flexible, parsimonious parameterization by fitting a succession of different polynomial terms, selecting the small number of terms that provides the best fit as judged by information criterion. In only one case—counties per district—were there significant rewards to departing from a linear specification. In that case, the fractional polynomial regression suggested including counties per district in both log and log-squared form. Thus our multivariate regression (Table 1) includes log and log² of counties per district plus each of the other factors linearly.

3.2.3 Spatial Correlation

Because adjusting the boundary of one district necessarily adjusts the boundaries of the adjacent district, overlap depends mechanically on the overlap of the adjacent districts, creating spatial correlation. Moreover, one district might be adjusted to provide aid to an adjacent district rather than on its own merits. The p-value of Moran’s I is 0.02 in the sample for partisan control, confirming the importance of spatial dependence. While the logic above suggests a model with spatial lags of the independent variables, Lagrange multiplier tests support both spatial error and spatial lag models, preferring the former. Thus we have estimated and reported models with spatial error and spatial lags of both the independent and district-specific dependent variables (columns 2-4 of Table 1 and all of Table 2). We employ a binary weighting matrix indicating whether two districts are in the same chamber and geographically adjacent prior to redistricting.
3.2.4 Quantile Regressions

The factors that limit dissection are likely to differ from those that limit partisan tinkering. Thus, in addition to pooled-OLS (Table 1, columns 1-4), we estimate conditional quantiles using quantile regressions (Table 1, column 5). In our context, a standard regression estimating the conditional mean answers the question: for a given legal environment, what is the average overlap? Then one can ask how this average changes as the legal environment changes. But this would miss changes in the legal environment that result in mean-preserving spreads of overlap. For instance, suppose a compactness requirement inhibits minor tinkering but does nothing to prevent major changes. Possibly, without the requirement, every offspring district retains 90% overlap with its parent as the district extrudes spindly tentacles to grab a few favorable neighborhoods. But once the compactness requirement inhibits this behavior, two thirds of the districts are left untouched (overlap 100%) while one third undergo major changes requiring more territory swaps (overlap 70%). Estimating conditional quantiles lets us document the effect of the legal constraints on the entire distribution of adjustments. In our hypothetical example, the standard regression would find no change in overlap as a result of the change in laws, while the quantile regression would note that the low and high ends of the distribution were affected differently.

3.3 Sample

Our sample consists of 96 chambers; we are missing lower chambers for Vermont, New Hampshire, and West Virginia due to problems with the underlying data stemming from the handling of multi-member districts. Data on control of the map and legal constraints on the mapmakers—the so-called traditional redistricting principles—come from Justin Levitt’s website All
About Redistricting. This delivers a six-fold typology of control: control by Republican party legislators (38), control by Democratic party legislators (14), control by a combination of both party’s legislators (12), control by a bi-partisan commission of politicians (8), control by a politically independent commission (12), or allocation by the courts (12). We combine these, two-by-two, into three categories: uni-partisan control (52), bi-partisan control (20), and a-partisan control (24).

3.4 Traditional Redistricting Principles

We code five traditional redistricting principles (TDP) as dummy variables indicating whether (i) compactness, (ii) natural geography, (iii) communities of interest, or (iv) counties and other political subdivisions are to be respected in the process and (v) whether the mappers are directed to preserve the core of districts from the previous map. We also encode (vi) whether a state is required to submit its entire map for pre-clearance under section 5 of the Voting Rights Act. Compactness is the most common consideration, required in 57 chambers. Communities of interest are required in 40, county lines and other political subdivisions required in 26, natural geography is required in 21 chambers, 20 chambers mention the preservation of prior district cores, and 18 chambers require preclearance of the entire map. The corresponding indicator variables are not highly correlated (no bivariate correlation higher than 0.33). The mean chamber is subject to 1.9 of these constraints, only six are subject to more than three, none are subject to all six, and thirteen are subject to none at all. Thus we have good independent variation in the independent variables of interest. Figure 2 illustrates the incidence of the TDP.

Unlike natural geography and communities of interest, county lines are clearly defined. However, the extent to which this constraint binds likely depends on the relative size of counties and
districts. If counties and districts are roughly equal in size, then violations will frequently be necessary to achieve population targets, which always take legal precedence. Thus the constraint will not, in practice, bind. When counties are much larger than districts, reaching across county lines need not take place on population grounds and can thus be prevented by invoking the TDP. When counties are much smaller than districts, there is no excuse not to include the entire county in one district or another, again constraining certain opportunistic behavior that would mix and match counties. Hence we expect the importance of the county line TDP to depend non-monotonically on the relative size of counties and districts. Thus we also include a measure of the relative populations of counties and districts calculated as the ratio of the number of counties in the state over the number of districts in the chamber. Across chambers, this number ranges from 0.25 to 8.2 with a mean of 1.08.

3.5 Control variables

Data for measures of seat shares of the major parties in each chamber, the vote shares of a district in the most recent election prior to the 2010 redistricting wave, and the identity of the incumbent come from Klarner (2018). Republican seat share varied from a low of 4% in the Hawaii state senate to a high of 87% in the Wyoming state senate. The sample mean is 53.6%.

Control: Whether the party in control of redistricting is also in control of the district in question. Prior studies have shown that opposition districts are subject to more shifts as the mapmakers are less concerned with preserving the connection between incumbent and voters (Makse 2012).
Vote margin: We define the vote margin as the absolute difference between the two-party democratic vote share and 50%. Thus it is a measure running from 0 to 50% indicating how many voters needed to switch parties in order to shift the result. In the most recent election prior to the 2010 redistricting, this runs the whole range from 0 to 50%. The 25th percentile is 8.3%, the 75th percentile is the maximum 50%, reminding us that many state legislative general elections are unopposed. The median is 18.1%.

Seniority: Sabouni and Shelton (2019) argue that redistricting is a bargaining process. We might believe that more senior members of the caucus have greater bargaining power to grab the voters they covet. Conversely, perhaps they are more secure or have a deeper connection with existing voters and thus do not wish to change their district boundaries. From Klarner’s data, we calculated the seniority of the currently seated representative as of the 2010 wave redistricting (the victor in the most recent election). Seniority ranges from 0 to 42 years with a mean of 6.6 and virtually no difference between Upper and Lower chambers.

Partisan Competitiveness: All things equal, a representative would presumably prefer to keep her district intact so as to maintain her connection with the voters. We should thus expect to see adjustment of boundaries rise as the need for it rises. In particular, in chambers that are more competitive (chamber margin) and seats that are more competitive (vote margin).

4. Results

We will discuss the mean and median responses first, as reported in Tables 1 and 2, and then delve into what is added by the quantile regressions, illustrated in Figure 3. As one would expect, the
mean and median responses are extremely similar; essentially the same coefficients are significant. The main difference is that the conditional median effect is frequently larger than the conditional mean effect. Thus OLS may underestimate by up to 50% the impact of TDPs by averaging across the quantiles.

Geographic spillovers are clearly important. The spatially correlated errors are highly significant, with t-statistics in excess of 5. A district’s overlap is also strongly determined by the competitiveness of the adjacent districts. Opposition-held districts are more likely to be adjusted (lower overlap) if their neighbors were uncompetitive. Since it is from the uncompetitive districts that a gerrymanderer would pull votes, this result is consistent with the strategy of crack and pack. This interpretation is reinforced by our finding that the competitiveness of adjacent districts exhibits no influence in maps under non-partisan control (Table 2).

4.1 Partisan Variables

We first consider the partial effects of the partisan political variables: whether the seat is held by the party controlling the map (control), the partisan balance of seats in the chamber (chamber margin), and the vote margin in the most recent election in the district (vote margin). These results each further corroborate the hypothesis that adjusting districts is an attempt to seek partisan advantage so it will occur in those times and places where the partisan benefits are largest as, in the absence of that pressure, politicians would prefer to leave boundaries intact to preserve connections to voters. The results are also consistent with our assumption that overlap is an appropriate measure of attempts to gain political advantage.
When a single party is in control of the map, seats already held by members of the party enjoy 6.4% greater overlap at the median ($\beta_1$), 5.0% at the mean (Table 1 columns 5 and 2). This is essentially consistent with Makse (2012), who found a difference of 7.3% and with Winburn (2008), who found a difference of 4% for Michigan and 10% for Georgia. The interaction term between vote margin and own district, $\beta_4$, is negative, large, and highly significant, showing that the privileging of one’s own party by allowing stability is most pronounced in competitive districts. This is consistent with our maintained assumption that overlap is related to seeking partisan advantage and thus a reasonable indicator of partisan gerrymandering.

In chambers where the map is controlled by a single party, more competitive districts suffer from lesser overlap ($\beta_3$). Likewise, with seat margin, overlap rises as the chamber becomes less competitive suggesting that the adjustment of districts is made in search of a robust seat majority. This effect of chamber competitiveness is large. The median district in a chamber that is split 55-45 will have 6.6% lower overlap than the median district in a chamber split 65-35 (Table 1, column 5).

Many of these effects disappear when the map is not controlled by a single party, confirming that these are the result of a partisan effort. Neither vote margin nor seat margin are significant when the map is controlled by a non-partisan body or when the map is jointly controlled by both parties (Table 2).

Earlier, we sketched a rough typology of districts: those subjected to only minor tinkering, those enduring significant shifts, and those that are so dissected as to have dubious parentage. Having noted that the political environment affects the degree of boundary adjustment, we can look at the quantile regression plots to see which type of adjustment is the product of the search for partisan advantage (Figure 3). Almost by definition, districts that remain largely intact are little
affected by the partisan balance. More surprisingly, the likelihood of a district being completely eviscerated is also not driven by the political environment. The effects of vote margin, seat margin, and district partisan control are concentrated in the middle quantiles. These are the districts undergoing significant shifting of population where the competitive balance of a recognizably persistent district is potentially significantly affected. Here is the scene of packing and cracking for partisan advantage. As a result, the mean treatment effect—which would be the output of a traditional regression—would underestimate the importance of these factors on district continuity in those districts that are most clearly of interest.

4.2 Traditional Redistricting Principles

Some of the legal principles have significant effects on overlap while others have no discernable effect. Unsurprisingly, a provision requiring that mappers preserve the core of prior districts results in large and significant increases in overlap. The increase is 10.1% in partisan maps and 9.0% in maps drawn by independent commissions and courts4 (Table 1 column 2 and Table 2 column 1). Nor is it only due to the prevention of complete evisceration; the effect is surprisingly consistent up to the 80th percentile (figure 3).

On the other hand, the principle of respect for natural geography has no effect on overlap at the median when the map is under partisan control, implying it does not meaningfully constrain. This would seem to accord with Winburn’s intuition that certain principles are too vague to be justiciable. Indeed, when looking at the quantile regression plots for unified legislative control

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4 There were no instances in the 2010 wave of a state with this provision being under bipartisan control, hence the exclusion of this variable in Table 2.
(Figure 3), we see that there is a small, statistically significant (and positive) effect only for those districts at the highest quantiles of overlap. It would seem that natural geography quantizes changes, preventing small adjustments, limiting minor tinkering to the tune of a few percentage points when few changes were intended. E.g., one can’t reach a finger across a river to grab the favorable voters in a single neighborhood on the other side. Perhaps if larger changes are in the offing, a mapper can argue that the existing natural geography is superseded by other needs or simply find a rationale in a different natural boundary.

We might think respect for communities of interest is a similarly vague principle complicated by cross-cutting cleavages, yet we find this constraint has a positive and significant effect, increasing overlap by a meaningful 5.4 percentage points at the median (Table 1, column 5). The quantile regression plots indicate that this positive effect is operative across most quantiles of overlap. And yet, notice (Table 1, column 3) that the effect is not present when a party first gains control over the map; it only constrains a partisan mapper who is redrawing their own map. We suspect such a restriction gives legal protection to the status quo—the currently grouped community of interest—as a focal point, thereby preventing tinkering. And yet, the larger changes enacted by a new party could be justified by switching to a different definition of communities.

Further support of this view comes from analysis of maps drawn by courts and independent commissions. The median district from a map drawn by courts and independent commissions has 14.5 percentage points less overlap when required to take into account communities of interest (Table 2, column 1). Our supposition is that switching selection from one definition to another could lead to rather severe shifts as districts are reshuffled to meet the new definition of community. This reshuffling from old to new definitions would be particularly strong when moving
from an old map drawn by politicians to a map drawn by non-partisan actors. Restricting to those chambers where control had changed from the decade prior (column 3) supports this contention as we find that the effect is more than twice as strong when the nonpartisan control is new.\(^5\)

In sum, we find that when control of the map changes, there are shifts in how communities of interest are defined. When an independent commission is adopted, they bring a new definition of communities of interest and this leads to large shifts in districts. Likewise, when a party first gains control of the map, they are unconstrained by this prescription. On the other hand, when a party is revising its own map, the principle of respecting communities of interest does seem to constrain opportunistic behavior, leading to modestly greater overlap. Whether the party’s inability to overturn its previous definition is due to internal deliberations within the party or to the legal defense of the map in court is unclear.

By contrast, compactness is a relatively well-defined concept. While states have different definitions, various compactness measures are highly correlated. This constraint has the expected effect, increasing the overlap in maps drawn by a single party. Presumably this comes by preventing the most egregious and justiciable “fingers” that reach out to grab a favorable set of voters. Indeed, looking at the quantile regression plots, we see that here too the effect is concentrated in the middle quantiles. Total dissections are neither prevented nor ameliorated but districts in the 30\(^{\text{th}}\)-45\(^{\text{th}}\) percentiles (60%-70% overlap) enjoy 3-5% greater overlap when compactness is listed as a guiding principle.

Winburn and Makse concluded that the principle of respect for county lines and other political subdivisions has a strong and significant effect on overlap. Using a different approach, we find no

\(^5\) Using an interaction effect yields a similar change in magnitude.
significant effect when a single party controls the process. Worried that this was because we chose to interact the political subdivisions restriction with counties per district, we reran the baseline specification allowing the legal principle to enter by itself. Again, we find no significant effect. The quantile regression plots indicate that this lack of significance is true at all quantiles.

However, we do find a significant effect of this principle when the map is under bi-partisan control. Recall that we have hypothesized that the effect depends on the relative size of counties and districts. Figure 4 shows the estimated partial effect on overlap of this legal principle as the relative size of counties and districts in the chamber varies. As expected, the relationship is U-shaped, with the constraint binding strongly when there are relatively few counties. We do not yet have a good understanding of why counties would be important constraints in bipartisan commissions but not in partisan commissions.

The effect of requiring pre-clearance under the VRA is rather muted. The constraint increases overlap in partisan maps but the effect disappears once we restrict to those chambers over which control has changed since the previous decade (Table 1, columns 2 and 3). The quantile regressions confirm this is true for all district types. Preclearance is intended to preclude racial gerrymandering. As there are strong correlations between race and partisan preferences, one might suspect the pre-clearance constraint would alter the relationships we have explained hereto. Thus we have rerun our preferred specification in the subsample that does not require pre-clearance. While this reduces the sample size by 28% and some of the significant coefficients change in magnitude, the basic picture we have presented does not change from which we conclude that our story is not driven by pre-clearance under the VRA.

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6 Available on request.
5. Summary

The first clear message from our results is that overlap is connected to the search for partisan gain. Adjustment of district lines is greater, and overlap consequently lesser, when electoral competition is greater. Specifically, this occurs when the chamber or district is more finely balanced or when one can interrupt the connection between incumbent and voters enjoyed by opposition office holders. However, as Figure 1 showed, conveying control to nonpartisan commissions doesn’t necessarily increase overlap as they adjust old maps to meet the criteria as they see fit. The second take-away is that some traditional redistricting principles reduce the extent to which district lines are adjusted during redistricting. Respecting natural geography prevents only minor tinkering. On the other hand, requiring compactness and respect for communities of interest each improve overlap in those districts subject to significant adjustments by parties seeking to perfect their crack and pack. The effects are modest but non-trivial: a roughly 5% increase in overlap for most districts. By comparison, explicitly requiring mappers to preserve the core of prior districts increases overlap by about 10% for most districts. In sum, traditional redistricting principles can meaningfully increase overlap. Overlap is related to the search for partisan advantage. Thus traditional districting principles seem to provide a modest constraint on partisan gerrymandering.
References


Appendix: Matching Parents and Offspring

In the text, we have described the process of matching parent and offspring districts from successive waves. Ideally, this mapping would be one-to-one and onto. Unfortunately, there is no single, obvious method by which to produce a mapping that is one-to-one and onto and yet some choices in this mapping method affect the outcome. Nonetheless, we believe we have the proper mapping and believe our results are robust to alternative appropriate mappings and thus relegate this more detailed explanation to the appendix.

Our mapping procedure was this: for every parent district from the prior wave, assign as its offspring district that district from the successor wave to which it (the parent) donated the largest number of voters. Thus if district A were split across districts A', B', C' 20-45-35, B' would be designated as the offspring of A.

<table>
<thead>
<tr>
<th>Table A1: Three-District Example 1</th>
</tr>
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<tbody>
<tr>
<td>% of parent in offspring</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Parent</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
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<tr>
<td>C</td>
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</table>

One can imagine several other mapping procedures. The simplest change would be to match parents to offspring rather than the other way around. That is, for every offspring, assign to it as parent that district from which the greatest fraction of the offspring is derived. In the overwhelming majority of cases, this change makes no difference. Consider Table A1 illustrating a hypothetical set of three districts.\(^7\) In this case, the (parent, offspring) pairs are (A, B'), (B, A'), (C, C')

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\(^7\) Notice that while the rows must sum to 100%, the columns do not as a result of differential population growth rates. For example, if district X grows much more slowly than the rest of the state, then 100% of district X would be
no matter which direction is chosen for the matching. But if we consider the slightly modified example in Table A2, we now see that the direction of the matching matters. Matching offspring to parents produces (A,B'), (B, A'), (C, B') whereas matching parents to offspring produces (A', B), (B', C), (C', C).

<table>
<thead>
<tr>
<th>Table A2: Three-District Example 2</th>
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<tr>
<td>% of parent in offspring</td>
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<tr>
<td>Parent</td>
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<tr>
<td>A</td>
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<tr>
<td>B</td>
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This also shows how the matching is neither one-to-one nor onto. In the second case, offspring B' happens to be the largest recipient from both A and C. Likewise, parent C is the largest donor to both B' and C'. There are essentially three ways of dealing with this. The first is to accept the match as is. The second is to remove multiple matches according to some priority and rematch the leftover parents and offspring according to some alternate rule. The third is to remove the multiple matches without re-matching. None are ideal.

The first method results in a partially complete map in where either all the parents or all the offspring are used but not both. The strength of this approach is that a clear and consistent relationship between parent and offspring is maintained. The third method similarly maintains a clear relationship between the parent and offspring of the maintained matches, with the added benefit of avoiding double-use of any parents or offspring, but at the cost of an incomplete map and a choice over how to prioritize among multiple matches.

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insufficient to furnish the full population of successor district X' which would need some fraction, say 10%, of district Y in which case the X' column would sum to 110%.
Achieving a one-to-one and onto mapping requires the second method, which necessitates a backup method of matching.\textsuperscript{8} Unfortunately, in most cases, one is left matching parents and offspring that have zero overlap. To understand why, consider the five-district example in Table A3.

The assignment of offspring to parents results in both A and C wishing to claim B'. As C clearly has greater claim to B' than does, having donated 70% rather than 45%, we assign B' to C and search for a new match for A. Unfortunately, both A' and D' have already been assigned to B and D respectively. The unassigned offspring is C', with which A shares no overlap. In this particular instance, one might argue that if we were to assign the contested offspring B' to A, then C' could be assigned to C, thus ensuring the secondary pairing also enjoys non-zero overlap. We have experimented with such schemes and found they solve relatively few cases and at the cost of significantly reducing the overlap of the first match.

\textsuperscript{8} Unlike Congressional redistricting, we almost never have to deal with the loss or gain of a seat during the 2010 wave. The exception is the NY Senate, which added a 63rd seat. In that case, we chose to allow one of the offspring to remain unmatched.