State Legislative Redistricting: The Effectiveness of Traditional Redistricting Principles

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 traditional regressions consistently understate 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 of optimal gerrymandering 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.

While several earlier studies look at TDPs (Altman 1998ab; Barabas and Jerit 2004; Klarner 2007; Winburn 2008; Forgette, Garner, and Winkle 2009; Makse 2012 among others), we lack a study that looks at all TDPs collectively, across all states, while properly accounting for the econometric complexities we describe below. Our contribution to the literature comes from the following five steps: (i) 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. Those TDPs are: compactness, respect for natural geography, respect for communities of interest, respect for political subdivisions such as county lines, and a directive to preserve the core of an existing district. (ii) We analyze the full set of maps from the 2010 redistricting wave so as to avoid inadvertently selecting an unrepresentative handful of states. We can thus compare states where the map is drawn under partisan control to those where the map is drawn by courts and independent commissions. We can also control for the partisan balance within the chamber which often determines the ability and desire of the ruling party to expand its majority at the expense of other goals. (iii) Our analysis is conducted at the district level which improves statistical power. However, it necessitates a move away from traditional measures of partisan bias such as McGhee's (2014) efficiency gap or those derived from the seats-votes curve (Gelman and King 1994; Kastellec et al 2008; Nagle 2015; Warrington 2019). We use the population-weighted overlap between parent and offspring districts (as defined by Carson, Crespin, Finnocchiaro and Rohde 2007), a measure previously used in other district level studies (Winburn 2008, Makse 2012). We take into account the extent to which differential population growth required border adjustment simply to meet the legal obligation of equal district population. We demonstrate the connection between overlap and the search for partisan gain by showing that overlap declines in exactly those districts where gerrymandering is most advantageous—when vote margins are small, incumbent advantage is small, and chamber seat margins are tight. (iv) A district level analysis necessitates a careful understanding of how the districts interact so as to avoid misattributing the results of one district to the circumstances of another. We include spatial lags because changing the boundary of one district necessarily changes the boundary of one or more adjacent districts. (v) 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. While standard regressions estimate an average effect, we employ quantile regressions to estimate this distribution of effects. We do not believe any existing study meets these best practices.

We find that spatial correlation is important and that standard regressions, which estimate the mean effect, 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 TDPs can significantly improve overlap, suggesting that they do constrain gerrymandering behavior.

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

2. Literature Review: Traditional Districting Principles

Do traditional districting principles effectively constrain mappers from seeking partisan advantage? 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)

TDPs are also 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. Barabas and Jerit (2004) find that compactness requirements significantly affect minority representation, especially when minority voters are concentrated. 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 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. We measure whether, in practice, TDPs do indeed reduce political opportunism by partisan mapmakers.

3. Methodology

3.1 Dependent Variable: Overlap

Most studies of gerrymandering evaluate an entire map according to measures derived from some part of the seats-votes curve, such as partisan bias, partisan symmetry, and responsiveness (Gelman-King 1994) or based on the efficiency gap (McGhee 2014).[1] However, such measures

[1] The seats votes curve is the hypothetical function that translates the vote share of each party into its seat share. As only one point on this curve is actually observed in any election, calculation of the entire curve typically requires making certain assumptions about how votes would be distributed were the partisan environment to shift. Partisan bias is the difference between the seat shares when the votes are split 50-50. Partisan symmetry relates to whether the party seat shares are reversed when the party vote shares are reversed. Responsiveness is the degree to which seat share changes as vote share changes. The efficiency gap derives from how many of each party's votes are wasted in narrow losses or excessive victories.

afford one observation per state and do not permit investigation of within-state heterogeneity regarding which districts are targeted. It seems clear from the literature that TDPs are likely each effective against different types of remapping actions. To quantify this heterogeneity necessitates a district-level analysis, which requires a different measure.

The standard measure for district analysis, which we adopt as our dependent variable, is the overlap between a (parent) district from the 2000-wave map and its successor (offspring) district in the 2010-wave map. We first explain how this is calculated and how we identify the matches of parents and offspring. Then we discuss the measure's connection with partisan gerrymandering.

We define overlap as the fraction of the parent district's voting population that is preserved in the relevant offspring district. The U.S. Census provides shapefiles for the state legislative district lines for the 2000 and 2010 waves for the lower and upper chambers of each state. The Harvard Election Data Archive provides shapefiles and turnout from the 2008 election at the precinct level. We 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 population proxied by turnout, to their starting and ending districts to calculate a population-weighted 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). To every parent district, we assign as offspring the 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). The procedure is detailed in the appendix.

The histogram of overlap between parent and offspring districts is shown in Figure 1, separated by political control of the map.[2] 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. As can be seen from the fact that the three curves closely overlay, 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.

Broadly speaking, in the context of partisan control, we will be taking smaller overlap as evidence of a less constrained map-maker. There is support for this interpretation in both prior literature and our results. 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, once one has controlled for the changes necessary to equalize population, drops in overlap come usually from intent to gain political advantage.

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 (Yoshinaka and Murphy 2009, Desposato and Petrocik 2003). This is one reason why previous studies have consistently found that opposition districts exhibit less overlap than majority party districts (Makse 2012). Thus

[2] 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.

overlap is a decent proxy for the extent to which map-makers are able engage in manipulation and measuring the effects of TDP on overlap estimates the extent to which TDP constrains such manipulation. Moreover, like Makse (2012), we find that declines in overlap occur precisely when gerrymandering is most likely to be productive. Namely, overlap is smaller in chambers that are competitive and for districts that are competitive. Thus our results are consistent with our justification.[3]

In sum, we 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. We estimate the connection between TDPs and overlap by regressing overlap on a full set of indicators marking which states employ each TDP. Where TDPs are associated with higher overlap, we infer that they have constrained the map-maker. Given results from prior studies, we expect that overlap will be higher for TDPs that are more likely to result in a lawsuit when violated, either because they are more easily defined and adjudicated or because there is an organized interest with standing. Specifically, we expect compactness (well-defined), communities of interest (organized interest), and preclearance under the VRA (both) to be more effective than respect for natural geography (neither) and respect for political sub-divisions (neither). We also expect that competitive chambers, competitive districts, and districts held by the opposition will exhibit less overlap when the map is under partisan control, while there should be no such difference for maps drawn by nonpartisan actors.

[3] 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.

3.2 Econometric Approach

3.2.1 The Baseline Specification

To measure the effect of TDPs on overlap, 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[4] plus controls including 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*, the partisan seat margin of the chamber, and *population misalignment*, a measure of the extent to which differential population growth over the last decade necessitates reduced overlap simply to meet the equal population requirement. We detail its calculation in the appendices.

$$
\begin{aligned}
Overlap_{cd} = \beta_0 &+ \beta_1 Seat\ held\ by\ Party\ in\ Control\ of\ Map("Control")_d \\
&+ \beta_2 Seniority\ of\ Incumbent_d + \beta_3 Vote\ Margin\ of\ District_d \\
&+ \beta_4 Control * Vote\ Margin_d + \beta_5 Seat\ Margin\ of\ Chamber_c \\
&+ \beta_6 Compactness\ Requirement_c \\
&+ \beta_7 Compactness_c * Nested\ Lower\ Chamber_c \\
&+ \beta_8 Natural\ Geography\ Requirement_c
\end{aligned}
$$

[4] The requirement to respect county lines where possible likely varies in effectiveness based on the distribution of population across counties. We discuss the functional form in section 3.3. The interaction of compactness with nesting, which was suggested to us by an anonymous reviewer, is also discussed in section 3.3.

$$+\beta_9 Communities\ of\ Interest\ Requirement_c$$

$$+ \beta_{10}(Counties\ per\ District * County\ Line\ Requirement)_c^{0.5}$$

$$+ \beta_{11}(Counties\ per\ District * County\ Line\ Requirement)_c$$

$$+ \beta_{12} VRA\ Preclearance_c + \beta_{13} Preserve\ Prior\ Core_c$$

$$+\beta_{14} Population\ Misalignment_c + \epsilon_d$$

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). We also analyze the 20 chambers where politicians from both parties share control of the map (Table 2). The data behind these categories are explained in section 3.3.

3.2.3 Spatial Correlation

One challenge to a district-level analysis arises from the interaction among districts in the same chamber. Because adjusting the boundary of one district necessarily adjusts the boundaries of the adjacent district, the overlap of one district depends mechanically on the overlap of the adjacent districts. Moreover, one district might be adjusted to provide aid to an adjacent district rather than on its own merits. This implies that the characteristics of one district might affect the overlap of neighboring districts, necessitating using neighbors' characteristics as explanatory variables (termed *spatial lags*). It also implies that neighboring districts might share common un-modeled factors. One such example would be the desire to move the lines so as to force a candidate to run in a different district; this will clearly enter the error term for both districts near that candidate's address. These common shocks result in spatially correlated errors which must be accounted for to correctly judge statistical significance.

The p-value of Moran's I, a common test statistic for spatial dependence, is 0.02 in the sample for partisan control, rejecting the null of no spatial dependence. Lagrange multiplier tests support both spatial error and spatial lag models thus we have estimated and reported models with both spatial error and spatial lags of the district-specific independent variables. We employ a binary weighting matrix indicating whether two districts are in the same chamber and geographically adjacent prior to redistricting. That is, we only allow spillovers between districts who share a border.

3.2.4 Quantile Regressions

As we argued in the introduction, districts are treated heterogeneously by map-makers: some are ignored, some are deliberately helped or hindered, while others are targeted for dissolution. The factors that limit dissection are likely to differ from those that limit partisan tinkering. While traditional OLS estimates the average effect of a TDP on overlap across all districts, we would also like to estimate the distribution of effects. One TDP may prevent mostly minor tinkering while another may work primarily to prevent complete evisceration.

In our context, a standard regression estimating the conditional mean answers the question: for a given legal environment, what is the average (mean) overlap? Then one can ask how this average changes as the legal environment changes. For instance, we find that requiring preclearance under the VRA raises district overlap by just under 6 percentage points. Is this effect felt equally by all districts? If so, then a district A that would have been modestly adjusted in the absence of the constraint (overlap 94%) would be completely unadjusted (overlap 100%) when the constraint is operative, a district B that would have been significantly altered (overlap 70%) would be only slightly less changed (overlap 76%), and a district C that would have been dispersed (overlap 30%) would still be completely unrecognizable (overlap 36%) were the constraint imposed. On the other hand, suppose preclearance mitigates only the largest reorganizations such that the same average 6% effect is concentrated in the districts with the lowest overlap. In this case, after imposing the constraint, district A would remain modestly adjusted (94%), district B would remain significantly altered (70%), but district C is no longer so unrecognizable (overlap 48%). These two scenarios represent a TDP with fundamentally different effects. It is worth distinguishing between them.

Quantile regressions allow us to estimate not just the average effect of a TDP across the entire spectrum of districts, but the effect at any quantile of overlap (Koencker and Hallock 2001). That is, we can separately estimate how a TDP affects the hypothetical districts A, B, and C from the previous example. By doing so, we can glean insight into what type of mapping actions are constrained by any given TDP. Thus, in addition to pooled-OLS we estimate conditional quantiles using quantile regressions. We report the effect at the median in Tables 1 and 2. Figure 3 displays the entire spectrum of estimates along with confidence intervals.

We are unable to estimate quantile regressions with spatially correlated errors, but we do incorporate spatial lags (the effect of neighboring districts on a district in question.) Our feeling is that the OLS estimates of the conditional mean including both spatially correlated errors and spatial lags are the best available estimates of the average effect. The quantile regressions with spatially correlated independent variables are a high quality guide to how those effects vary across districts.

3.3 Sample

Our analysis is conducted on state legislative maps from the 2000 and 2010 redistricting waves. 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.[5] Data on control of the map and 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,

[5] In the New Hampshire Assembly, only a very small fraction reported elections data in the Klarner dataset. With such a small reporting rate and no way of knowing what determined whether a district reported or not, we felt it was better to drop the chamber than deal with unknown selection. Vermont and West Virginia changed the allocation of MMDs between 2000 and 2010. E.g. in year 2000, there might have been 5 seats from district A and 3 seats from district B and then in year 2010 there were 2 seats from 4 different districts. The 2000 and 2010 map were made under completely different rules. This made it impossible to identify parent-offspring pairings in a manner consistent with the rest of the states.

into three categories: unified partisan control (52), bi-partisan control (20), and nonpartisan 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 and VRA preclearance. There are two special cases requiring further attention.

First, 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 population, 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. The distribution of population across counties matters more than the number of counties. For instance, In Arizona, where over half the population resides in a single county (Maricopa), most districts can mix and match voters without straying outside the county boundary.[6] We thus use a measure of *effective counties* that is modeled on Laakso and Taagepera's (1979) calculation of the effective number of political parties. Denoting the population share of each county *i*, by p_i, their formula for the effective number of counties in state *s* is simply the inverse of the sum of the squared population shares of each county.

$$effective\ counties_s = \sum_{i=1}^{n} \left(\frac{1}{p_i}\right)^2$$

If all the population is clustered in one county, then this measure is 1. If the population is spread evenly, then this measure returns the actual number of counties in the state, n. We then allow this measure to enter non-linearly with exponents chosen via fractional polynomial regression.

Second, nesting—the practice employed in some states whereby an integer number of Assembly districts partition each Senate district—may impact the effects of TDPs. Nesting is another constraint on how the mapper may draw districts. As such, it may either complement or substitute

[6] We are indebted to two anonymous reviewers for noting the importance of the population distribution.

for each TDP. Our preliminary investigation found that the sole interaction of note is that between nesting and the legal requirement for compactness. Hence our inclusion in all our specifications of this interaction term. We conjecture as to why this is a significant interaction in section 4.

3.5 Control variables

The political situation of a district determines the potential benefits of a partisan gerrymandering of its borders. Districts that are competitive and those within chambers that are competitive are natural targets. We wish to estimate the effect of TDPs on a district, controlling for these effects. But we also wish to use these known effects to check the validity of our dependent variable, overlap. This section explains how we define and measure these 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: Partisan redistricting is a bargaining process among members of the party in charge. 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

4.1 Traditional Redistricting Principles

The primary results can be gleaned from Table 1, columns [2] and [5] which are the investigations of the full sample of maps produced under unified partisan control. The first clear result is that rules requiring respect for communities of interest are effective in raising overlap (up 3.3%) while rules requiring respect for natural geographic boundaries are not. Given that both of these TDPs seem difficult to operationalize, subject to cross-cutting cleavages and affording multiple interpretations, we suggest this difference is likely due to the differential probability of a lawsuit. We suspect any map requires violating these principles on occasion and that mappers can usually point to another principle they believe takes precedence and justifies the violation in question. The question is thus whether a violation that is useful for partisan purposes will be challenged. Splitting a community of interest produces an organized victim with standing and may lead to a lawsuit while cutting a natural boundary is unlikely to do so.

Secondly, requiring respect for compactness raises overlap by 2.5% on average. What is most interesting is that this effect is nearly tripled (7.2%) in state assemblies that require districts to be nested within upper chamber districts.[7] Nesting naturally reduces the degrees of freedom afforded the mapper of the lower chamber. In the case of two Assembly districts per Senate district, there is simply one line to draw across each Senate district. Under fewer degrees of freedom, the compactness constraint binds more tightly.

Third, VRA clearance greatly increases overlap (5.7%). We suspect this is a strategy for avoiding legal challenges. The more a district looks like its predecessor, which was previously approved, the less likely a legal challenge can be mounted. Fourth, requiring the core of the district be preserved unsurprisingly has the desired effect of increasing overlap (10.1% on average).

More surprisingly, contra Winburn and Makse, we find that requiring respect of county lines and other political subdivisions has no effect on overlap in maps control by a single party.[8] The quantile regression plots indicate that this lack of significance is true at all quantiles. This may be because

[7] We are indebted to an anonymous reviewer for suggesting we investigate the effects of nesting.
[8] We have reported the non-parametric interaction with effective counties per district but we have tried a number of specifications including simply allowing the restriction to enter as an indicator variable without reference to counties per district. It remains statistically insignificant in all specifications. Available on request.

there are multiple competing political subdivisions (e.g. metropolitan areas that spill across county lines) or because this principle is subordinated to other competing principles such as respect for communities of interest. We suspect it is simply because county lines are inevitably violated to satisfy equal population requirements and once the principle is breached, it is easy to adjust the placement of those breaches to satisfy partisan goals.

4.2 Political and Geographic Context

The political variables (table 1a, columns [2] and [5]) are consistent with the interpretation that overlap captures the search for partisan gain. When a seat is held by the party in control of the map it enjoys, at the median, a 7.4% increase in overlap. 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. Seats that were competitive in the last election (*lower* votemargin) are more likely to be adjusted, ending up with lower overlap. If the race were 10 percentage points closer, then the overlap would decline by 1.4% (10% of $-\beta_3$). But notice this is true only of those districts that were held by the opposition. Because $\beta_4 \approx -\beta_3$, the effect of vote-margin is roughly zero in seats held by the party controlling the map. This is consistent with the idea that the party controlling the map faces two competing instincts when looking to safeguard narrowly won districts: adjusting the district to grab favorable voters, and preserving the incumbent-voter connection. Finally, seats are far more likely to shift when the chamber is competitive. The median district in a chamber that is split 55-45 will have 5.9% lower overlap than the median district in a chamber split 65-35 (Table 1, column 5). This is clearly consistent with a cost-benefit analysis:

changing districts to eke out extra seats brings greater benefit, and is thus more likely worth the cost, the narrower the seat majority of the party in control of the map.

The results of the spatial lags tell us that, unsurprisingly, neighbors make a big difference. In particular, being adjacent to a competitive district vastly decreases a district's overlap. If one decreases the vote margin of *all surrounding districts* by 10 percentage points, one's overlap declines by 10.9 percentage points. Moreover, we estimate significant spatial correlation of the errors, suggesting that unmodeled considerations tend to cluster spatially as well. The combination validates our sense that proper estimation at the district level requires accounting for spatial spillovers.

4.3 Quantiles and the "Typical" Effect

We can also compare results from the quantile regressions and the OLS. The purpose of the quantile regressions is to show that each of the effects we discuss above is heterogeneous and to characterize that heterogeneity. One important result is the comparison of mean and median effects (table columns [2] and [5]). As in other contexts, when a distribution is not symmetric, the median often gives a better sense of the typical experience than does the mean. In this case, we find that median effects are consistently significantly larger than mean effects, consistent with a distribution that is left skewed.

To understand this result, consider the effect of vote margin (β_3). The mean effect of a 10 percentage point decline in vote margin is a 1.4 percentage point decline in overlap. But the median effect is 2.3 percentage point rise, 60% larger.

At any given vote margin (seats won by 5%, seats won by 10%, seats won by 15%, etc), there will be a distribution of overlap. The positive coefficient β_4 from the OLS regression, column [2], tells us that as vote margin rises, so does the mean of the distribution of overlap. Districts with higher vote margin have, on average, higher overlap. But not every part of that distribution rises. For instance, at the highest quantiles of overlap, near 100%, districts are essentially unchanged. This is true no matter what their vote margin, implying that the marginal effect of vote margin on overlap is essentially zero at some parts of the distribution. The quantile plot associated with vote margin (Figure 3, third row, second column) shows the marginal effect of vote margin at different points in the distribution. The OLS coefficient is essentially an average over all the quantiles.

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. As a result, the mean 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. Because the conditional mean averages across districts where the mapper is and is not interested in altering boundaries, we would argue that the conditional median is usually more indicative of whether a TDP is effective at constraining mapper behavior. Thus OLS may underestimate by up to 50% the impact of TDPs by averaging across the quantiles.

The quantile regression plots reveal a few other results that are obscured by a focus on mean effects. For instance, while the requirement to respect natural geography has no effect on average, it does have a consistently positive effect on overlap among districts that suffer only minor changes. We speculate that adherence to natural geographic boundaries 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. Meanwhile, 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.

On the other hand, respect for communities of interest has its greatest effect at the lowest quantiles of overlap, indicating that it is effective in preventing the complete dispersal of districts. Likewise, preclearance requirements tend to operate at the lower ends of overlap, again indicating that they mitigate severe splintering.

4.4 Independent and Bi-partisan control of the map

When control of the map shifts to nonpartisan bodies, so do the marginal effects of TDPs. We believe the differences indicate that TDPs work differently when the mapper views them as principles to follow rather than constraints to elude.

Compactness is no longer significant, suggesting that the violations of it are connected to the search for partisan advantage. Requiring preservation of the core of the district is, unsurprisingly, still consistent with greater overlap.[9]

[9] There are no states requiring preservation of the core whose maps were under bipartisan control in 2010.

On the other hand, respect for natural geography and respect for county lines and other political subdivisions can be consequential principles when no single party is in control. The principle of respect for natural boundaries raises overlap under independent commissions. Under bipartisan rule, requiring respect for county lines increases overlap when there are sufficient effective counties per district (Figure 4). We conjecture that it becomes a principle on which the parties can agree; a focal point for bargaining.

More strikingly, the estimated effect of requirements for preclearance under the VRA (β_{12}) and respecting communities of interest (β_9) flip sign when the map is controlled by a non-partisan body. While these restrictions led to greater overlap in maps drawn under unified party control, they lead to less overlap in maps drawn by non-partisan bodies. Preclearance likewise leads to less overlap in maps drawn under bi-partisan control. We believe that under unitary partisan control of the map these are viewed as constraints, inhibiting movement of the lines which might achieve partisan goals, thereby raising overlap. By contrast, when the map is drawn by a politically independent body, these are viewed as principles to be achieved, often requiring reorganization which reduces overlap. Why preclearance reduces overlap when the map is under bipartisan control remains a puzzle that we suspect requires deeper understanding of the bargaining between and within parties.

Seat margin of the chamber are insignificant in maps drawn by non-partisan bodies and bi-partisan cooperation. Vote margin of the district is insignificant in maps drawn by non-partisan bodies, but is once-again positive and significant when the map is under bi-partisan control. This is consistent with the interpretation that overlap is related to the search for partisan gain which, under bi-partisan control, leads both parties to focus on marginal districts.

5. Summary and Future Work

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. The second take-away is that some traditional redistricting principles do 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. They also provide a focus for courts and independent commissions and may do likewise for bargaining between parties when the map is determined jointly by both parties. We believe our conclusions are at odds with the widespread notion that TDPs have been made obsolete by the current focus on population equality.

There is room for future work that continues to analyze a comprehensive set of maps at the district level. First, repeating this analysis with the maps that will be produced in the 2020 redistricting wave, enabling a second observation of overlap, would help determine which of our results are enduring effects of TDPs. It would also enable an analysis of how change in the control of the map matters for overlap. Do parties behave differently when inheriting a map that was drawn by the opposition rather than a map they drew themselves a decade before?

Perhaps more importantly, we have consistently interpreted TDPs as drawing their power from the threat of legal action. But in many instances, the extent to which TDPs are justiciable is unclear. It would be very helpful to marry our district-specific measures of overlap with an analysis of the court cases citing TDPs to determine what mapping actions induce a credible legal challenge. One could then compare how the risk of lawsuit compares across states with and without TDPs.

In the meantime, we expect traditional districting principles to moderately constrain partisan gerrymandering in chambers controlled by a single party, and provide influential principles for independent commissions and courts during the coming redistricting wave.

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Appendix A1: Population Misalignment

Because district populations grow at different rates during the decade between redistricting, the equal population requirement necessitates some shifting of the boundaries quite apart from attempts to gain political advantage. Thus some decline in overlap is inevitable and ought not be misattributed to gerrymandering. For each district, we calculate the decline in overlap associated with correcting population misalignments as follows.

Using GIS shapefiles, we identified all census tracts from the 2000 and 2010 waves whose centroids were within the 2000 wave state legislative districts. We then calculated the population growth rates of each parent (i.e. 2000 wave) legislative district, designated g_d. We similarly calculated the population growth rate of each state, designated g_s. The degree to which a district's shape must be adjusted simply to equalize population is then given by

$$population\ misalignment_d \equiv \frac{|g_d - g_s|}{g_d}$$

For example, suppose a chamber's districts all start the decade with population 100. if the state population grows by 20% over the decade while the district grew by 25%, the unchanged district would be of size 125 while the average district in the state after redistricting must be of size 120, requiring cutting $\frac{125-120}{125} \approx 4\%$ to achieve proper size. Another district in the same state whose population actually shrank by 5% would require adding $\frac{95-120}{95} \approx 26.3\%$ to achieve the proper size.

Appendix A2: 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 A1: Three-District Example 1				
% of parent in offspring		Offspring		
		A'	B'	C'
Parent	A	20	45	35
	B	75		25
	C		48	52

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.[10] In this case, the *(parent, offspring)* pairs are (A,B'), (B,A'), (C, C')

[10] 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 A2: Three-District Example 2				
% of parent in offspring		Offspring		
		A'	B'	C'
Parent	A	20	45	35
	B	75		25
	C		52	48

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%.

Table A3: Five district example						
% of parent in offspring		offspring				
		A’	B’	C’	D’	E’
parent	A	20	45		35	
	B	60		40		
	C		70	30		
	D			20	80	
	E			5		95

Achieving a one-to-one and onto mapping requires the second method, which necessitates a backup method of matching.[11] 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.

[11] 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.

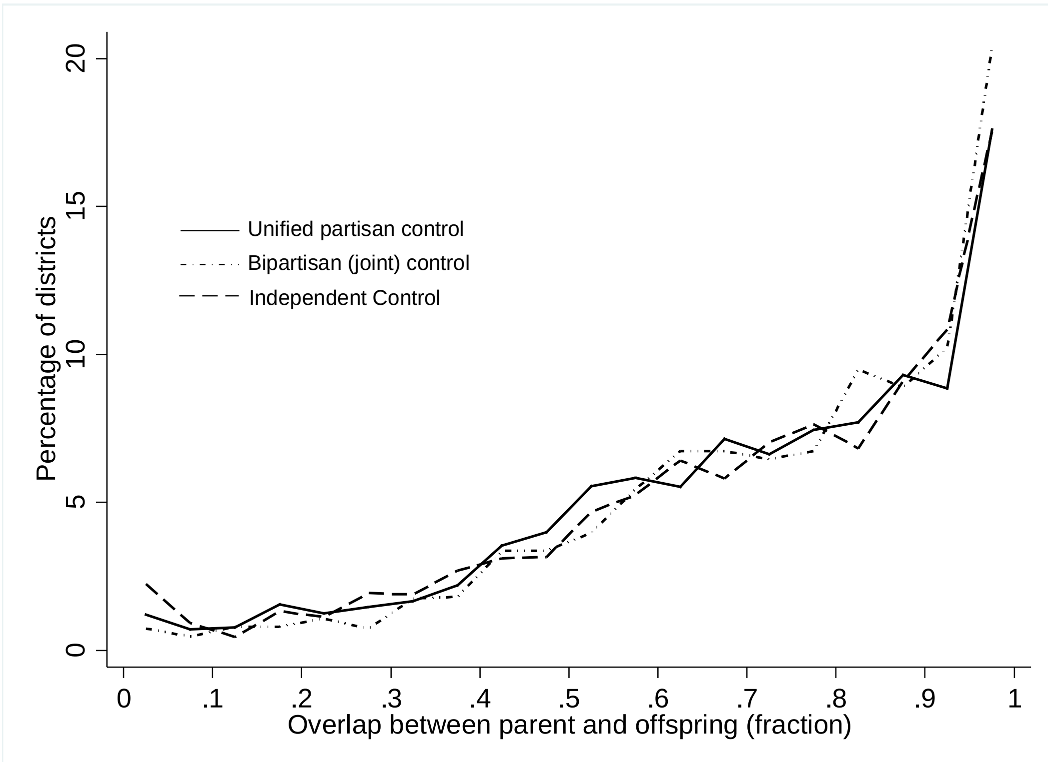

Figure 1: The distribution of parent-offspring overlap by control of the map. All three distributions are essentially the same. Each curve is a histogram where each bin is five percentage points wide. Thus, roughly 17 percent of the districts under unified partisan control exhibit overlap of greater than 95%.

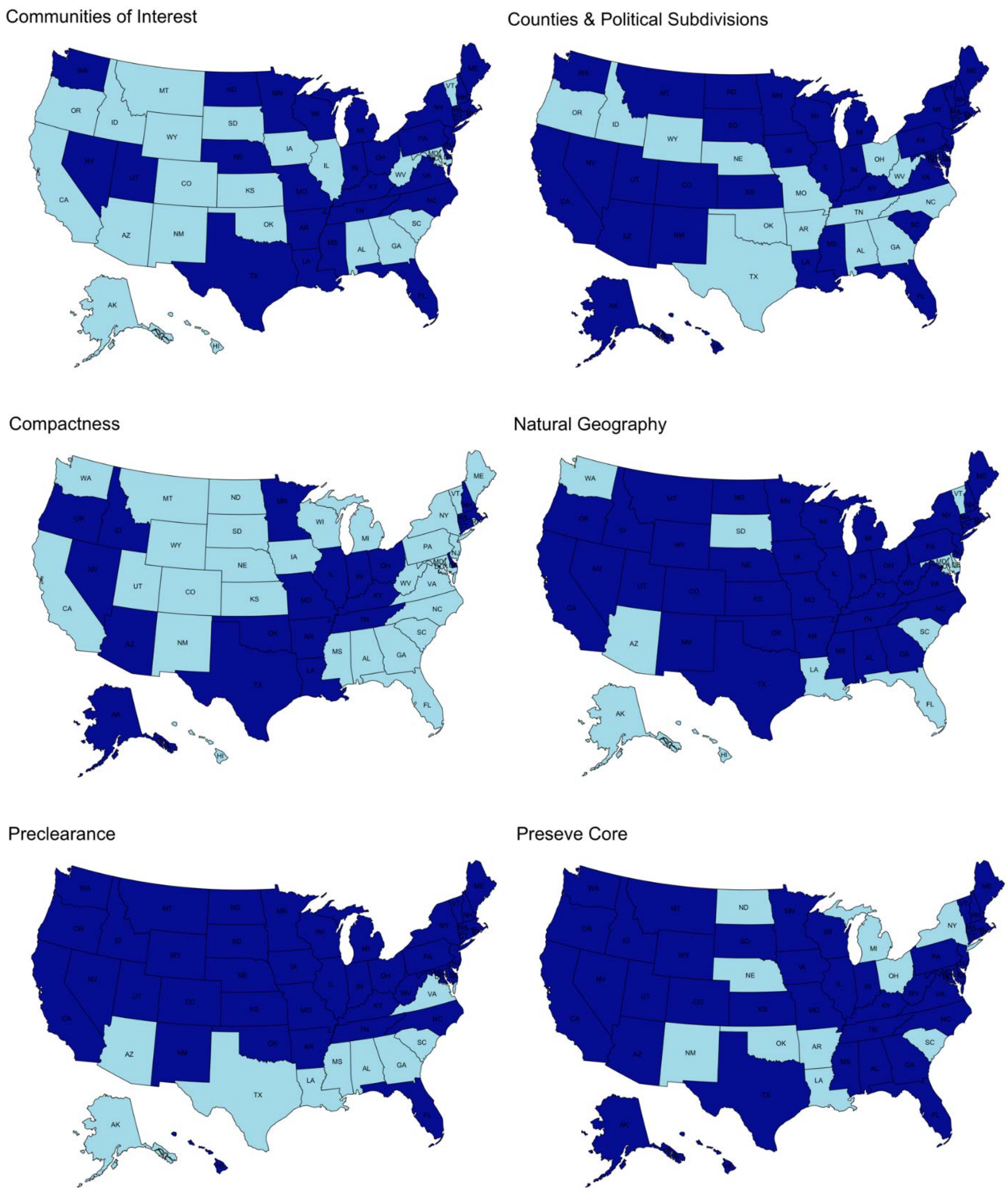

Figure 2: the incidence of traditional redistricting principles. The light states require the TDP in question.

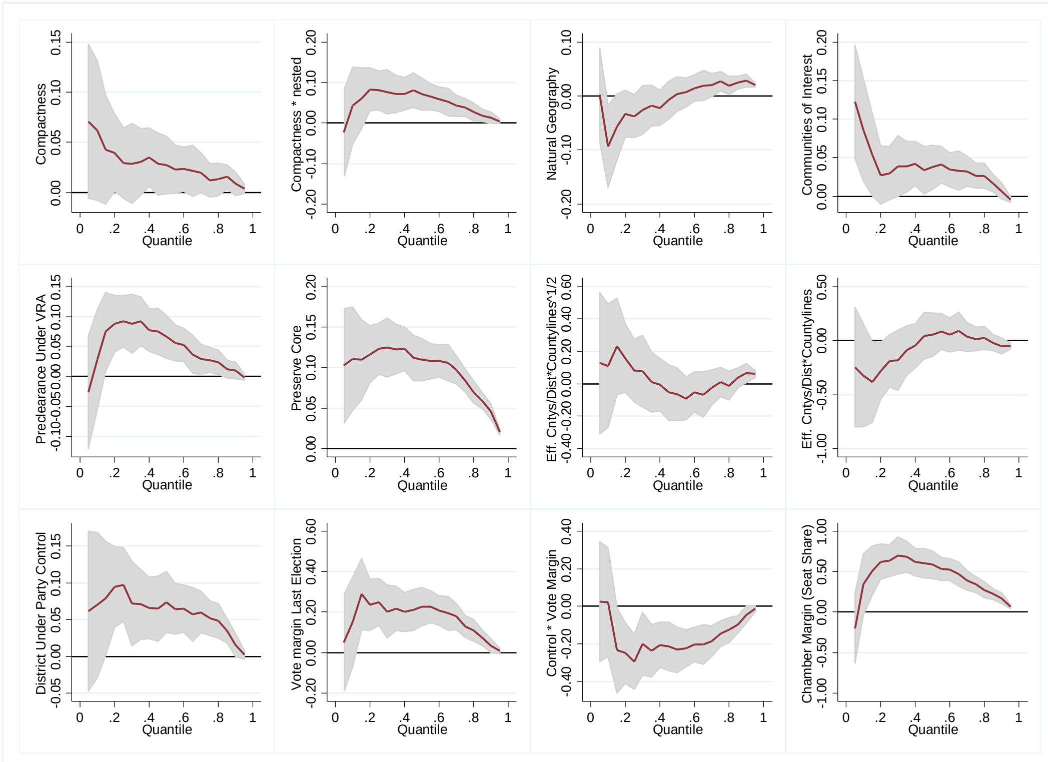

Figure 3: quantile regression plots with standard errors for the case when one party controls the map. The coefficients reported in table 2, column 1 correspond to the 0.5 quantile slice of these graphs. The important general takeaway is the variation across quantiles which means the average treatment effect may be a poor indicator of how a legal principle or political indicator will affect the drawing of a particular district.

Table 1a: Effect of Partisan Controls on Average District Overlap					
Control of map	unified partisan control				
Sample	full	full	control of map changed	preclearance not required	full
Estimation method	OLS clustered by chamber	OLS w/spatial correlation			Quantile reg. w/spatial correlation: median
	[1]	[2]	[3]	[4]	[5]
Seat Held by Party in Control ("Control ") β1	0.0630**	0.0526**	0.0608**	0.0621**	0.0739**
	(0.016)	(0.016)	(0.021)	(0.018)	(0.019)
Seniority of Incumbent (yrs) β2	0.000299	-0.0000932	-0.000711	0.000213	0.000198
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Vote Margin of District [0,1] β3	0.0850	0.141**	0.149**	0.109*	0.225**
	(0.044)	(0.037)	(0.045)	(0.047)	(0.044)
Control * Vote Margin β4	-0.116*	-0.138**	-0.150**	-0.083	-0.231**
	(0.048)	(0.047)	(0.058)	(0.059)	(0.056)
Seat Margin of Chamber [0,1] β5	0.495**	0.445**	0.420**	0.450**	0.585**
	(0.110)	(0.075)	(0.125)	(0.079)	(0.079)
Observations	3,445	3,445	2,133	2,486	3,445
Robust standard errors in parentheses: ** p<0.01, * p<0.05					

Table 1b: Effect of Traditional Districting Principles on Average District Overlap					
Control of map	unified partisan control				
Sample	full	full	control of map changed	preclearance not required	full
Estimation method	OLS clustered by chamber	OLS w/spatial correlation			Quantile reg. w/spatial correlation: median
	[1]	[2]	[3]	[4]	[5]
Compactness β6	0.0213	0.0251*	0.0592**	0.0380*	0.0274*
	(0.020)	(0.013)	(0.017)	(0.015)	(0.013)
Compactness*Nested Districts β7	0.0408	0.0471**	-0.0358	0.0328	0.0712**
	(0.028)	(0.018)	(0.029)	(0.018)	(0.018)
Natural Geography β8	-0.022	-0.0147	0.00641	-0.0201	0.00369
	(0.029)	(0.015)	(0.022)	(0.017)	(0.015)
Communities of Interest β9	0.0309	0.0332**	0.0115	0.0684**	0.0374**
	(0.020)	(0.013)	(0.015)	(0.015)	(0.014)
(Effective counties per district * County Lines)^0.5 β10	-0.0428	0.0132	-0.0506	0.212**	-0.065
	(0.099)	(0.072)	(0.089)	(0.096)	(0.075)
(Effective counties per district * County Lines) β11	-0.00345	-0.0561	-0.0067	-0.327*	0.0547
	(0.125)	(0.089)	(0.105)	(0.136)	(0.094)
Requiring VRA pre-clearance β12	0.0441	0.0567**	0.0254		0.0663**
	(0.027)	(0.016)	(0.021)		(0.017)
Preserve Core of District β13	0.0940**	0.101**	0.0865**	0.0929**	0.110**
	(0.016)	(0.012)	(0.020)	(0.015)	(0.012)
Observations	3,445	3,445	2,133	2,486	3,445
Robust standard errors in parentheses: ** p<0.01, * p<0.05					

Table 1c: Effect of Differential Population Growth and Neighboring Districts on Average District Overlap					
Control of map	unified partisan control				
Sample	full	full	control of map changed	preclearance not required	full
Estimation method	OLS clustered by chamber	OLS w/spatial correlation			Quantile reg. w/spatial correlation: median
	[1]	[2]	[3]	[4]	[5]
Population Misalignment β14	-0.186**	-0.139**	-0.153**	-0.148**	-0.202***
	(0.043)	(0.035)	(0.048)	(0.043)	(0.041)
spatial lag: control		-0.0682	-0.0501	-0.0468	-0.0776
		(0.056)	(0.059)	(0.061)	(0.061)
spatial lag: seniority		0.00397	-0.00302	0.00459	0.00675**
		(0.003)	(0.003)	(0.003)	(0.003)
spatial lag: vote margin		-1.094**	-0.708**	-1.070**	-1.201**
		(0.129)	(0.123)	(0.167)	(0.146)
spatial lag: control * vote margin		0.735**	0.484**	0.568*	0.972**
		(0.194)	(0.186)	(0.234)	(0.215)
spatial lag: error		0.405**	0.297**	0.345**	
		(0.050)	(0.054)	(0.055)	
Constant β0	0.533**	0.588**	0.624**	0.555**	0.587**
	(0.023)	(0.020)	(0.025)	(0.024)	(0.022)
Observations	3,445	3,445	2,133	2,486	3,445
Robust standard errors in parentheses: ** p<0.01, * p<0.05					

Table 2a: Effect of Partisan Controls and Traditional Criteria in Non-partisan and Bi-partisan Maps

Control of map	non-partisan control by independent commission or court		bipartisan control by legislature or politician commission	
Sample	full	full	full	full
Estimation method	OLS w/spatial correlation	Quantile reg. w/spatial correlation: median	OLS w/spatial correlation	Quantile reg. w/spatial correlation: median
	[6]	[7]	[8]	[9]
Seniority of Incumbent (yrs) β2	0.00136	0.00145	0.000701	0.000454
	(0.001)	(0.001)	(0.001)	(0.001)
Vote Margin of District [0,1] β3	0.0539	0.115*	0.0762*	0.0887*
	(0.034)	(0.049)	(0.035)	(0.043)
Seat Margin of Chamber [0,1] β5	0.0249	0.073	0.271	0.408*
	(0.102)	(0.133)	(0.172)	(0.185)
Observations	2,047	2047	1,527	1,527
Robust standard errors in parentheses: ** p<0.01, * p<0.05				

Table 2b: Effect of TDP in Non-partisan and Bi-partisan Maps

Control of map	non-partisan control by independent commission or court		bipartisan control by legislature or politician commission	
Sample	full	full	full	full
Estimation method	OLS w/spatial correlation	Quantile reg. w/spatial correlation: median	OLS w/spatial correlation	Quantile reg. w/spatial correlation: median
	[6]	[7]	[8]	[9]
Compactness β6	0.043	0.00171	-0.0537*	-0.0764**
	(0.027)	(0.035)	(0.022)	(0.023)
Compactness*Nested Districts β7	0.0232	0.0341	-0.0211	-0.0508
	(0.021)	(0.028)	(0.037)	(0.036)
Natural Geography β8	0.101**	0.142**	-0.127	-0.225**
	(0.026)	(0.034)	(0.076)	(0.081)
Communities of Interest β9	-0.121**	-0.0895**	-0.0508	0.0116
	(0.020)	(0.026)	(0.029)	(0.030)
(Effective counties per district * County Lines)^0.5 β10	0.433*	0.793**	-1.725**	-2.044**
	(0.177)	(0.231)	(0.169)	(0.182)
(Effective counties per district * County Lines) β11	-0.288	-0.685*	2.573**	2.819**
	(0.219)	(0.287)	(0.285)	(0.309)
Requiring VRA pre-clearance β12	-0.0825*	-0.162**	-0.0853**	-0.118**
	(0.034)	(0.044)	(0.029)	(0.031)
Preserve Core of District β13	0.0911**	0.134**	.	.
	(0.025)	(0.034)	.	.
Observations	2,047	2047	1,527	1,527

Robust standard errors in parentheses: ** p<0.01, * p<0.05

Table 2c: Effect of Population Growth and Neighbors in Non-partisan and Bi-partisan Maps

Control of map	non-partisan control by independent commission or court		bipartisan control by legislature or politician commission	
Sample	full	full	full	full
Estimation method	OLS w/spatial correlation	Quantile reg. w/spatial correlation: median	OLS w/spatial correlation	Quantile reg. w/spatial correlation: median
	[6]	[7]	[8]	[9]
Population Misalignment β14	-0.169**	-0.195**	-0.177**	-0.241**
	(0.048)	(0.066)	(0.063)	(0.075)
spatial lag: seniority	-0.00508*	-0.00605	-0.00263	-0.00421
	(0.003)	(0.003)	(0.003)	(0.003)
spatial lag: vote margin	-0.424**	-0.441**	-0.377**	-0.258*
	(0.103)	(0.139)	(0.103)	(0.119)
spatial lag: error	0.206**		0.284**	
	(0.056)		(0.061)	
Constant β0	0.713**	0.752**	0.832**	0.884**
	(0.022)	(0.029)	(0.030)	(0.032)
Observations	2,047	2047	1,527	1,527
Robust standard errors in parentheses: ** p<0.01, * p<0.05				

Table 3: Summary of effects of TDPs

Control of the Map	Unified Partisan	Bipartisan	Politically Independent
Compactness	+	-	0
County Lines	0	+	0
Communities of Interest	+	0	-
Natural Geography	0	0	+
Preserve Core	+		+
Preclearance under VRA	+	-	-

An entry of +(-) indicates a positive (negative) and significant coefficient while 0 indicates a coefficient that is not statistically different from 0. We are missing one coefficient due to lack of variation in the sample.