Investigating Similarities and Differences Across States in DVC Scores for Evaluating Redistricting Plans

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Abstract

There has been widespread concern about gerrymandering in the redistricting process, but applicable laws still leave room for partisan manipulation of redistricting. Viewing redistricting from a public official's perspective, avoiding reliance on data other than from the census, Belin, Fischer, and Zigler (2011 Statistics, Politics and Policy) introduced the idea of a "density-variation / compactness" (DVC) score as a one-number summary where plans with higher scores can be expected to have fewer "safe seats". Drawing on expanded accessibility of mapping software, we carried out analyses of the originally proposed DVC score, with an eye toward identifying similarities and differences in values across states. In particular, we were interested to investigate unusual values, which we noted arose in cases where there was a change in the apportionment of congressional seats to a state that led to consequences for district-specific population densities. We discuss the implications of these findings for the utility of the DVC score as an accessible measure that can be reported rapidly to facilitate public consideration of the merits of redistricting plans before plans are finalized.

1. Introduction

Politics in the United States has been polarized on many levels in recent years, a pattern that many observers have viewed as being fueled by partisan redistricting. Efforts to gain unfair advantages through the redistricting process are commonly described as "gerrymandering" with reference to an 1812 redistricting plan in Massachusetts supported by then-Governor Elbridge Gerry, whose party retained control of the state Senate despite losing the governorship and control of the state House of Representatives in the next election.

Requirements to engage in redistricting at the state level every ten years follows from the constitutional requirement to update information on the distribution of the population in the United States. After census counts are finalized, they are entered into a formula specified in federal law that determines the number of representatives apportioned to each state. Subsequently, a database is transmitted from the U.S. Census Bureau to each state containing counts at the census-block level with accompanying information on the representation of

racial/ethnic categories, which is relevant to the implementation of provisions of the Voting Rights Act. Procedures for developing redistricting plans differ across states.

Informally, one can view the redistricting process in a given locale as being governed by an implicit loss function relating census data and geography to redistricting-plan characteristics. The resulting districts can be viewed as encoding political values, which should be understood as encompassing considerations beyond just partisan preferences. Domains that might be considered in the redistricting process include geometric criteria (such as compactness of districts and contiguity of areas within a district), "policentric" criteria (such as avoiding crossing jurisdictional boundaries), "ethocentric" criteria (reflecting shared interests or "communities of interest", as might arise among people living along a sea coast or roadway), or ethnocentric criteria (such as the racial and/or ethnic composition of a district).

Using a hypothetical scenario as an illustration, Table 1 describes alternative redistricting plans with very different implications in a state that has overall balance in party affiliation between two dominant political parties (characterized here as the Orange party and the Purple party). With equal-sized districts, a party's statewide voter registration percentage would be the average of the district-specific voter registration percentages. Given that the both Plan A and Plan B yield a 50-50 statewide voter registration split, either assortment of district-specific voter-registration percentages would be conceivable results of a redistricting process. However, given the stability of both residence and partisan preference in the United States and empirical evidence regarding the difficulty of overcoming a deficit of 10 percent or more in voter registration in an election, the political implications of the two plans would appear to be very different. Under Plan A, there is no evidence of partisan bias in the initial voter-registration distribution, with each party appearing to have modest edges of differing degrees in three districts and one district being a toss-up. But under Plan B, voters favoring the Orange party appear to be "packed" into two districts where their candidate would be the prohibitive favorite to win election, while the other five districts feature a voter-registration split that, although not quite as extreme, still would make the Purple-party candidates prohibitive favorites to win election.

Table 1. Voter registration percentages for two hypothetical redistricting plans in a state with 7 districts and a 50-50 statewide voter registration split

		District						
Plan	Party	1	2	3	4	5	6	7
A	Orange	44	46	48	50	52	54	56
	Purple	56	54	52	50	48	46	44
B	Orange	42	42	42	42	42	70	70
	Purple	58	58	58	58	58	30	30

To the extent that none of the districts in Plan B have a close enough partisan split for a candidate in the minority party to have a realistic chance to get elected, the "safe seats" under Plan B would not only lack suspenseful elections but could be anticipated to reinforce polarization in governance. The reason why has to do with the interplay of redistricting with the dynamics of political primaries where parties select general-election candidates. Instead of competing for voters who sometimes favor the Purple party and sometimes favor the Orange party, candidates might be incentivized to compete for the most partisan voters in their respective parties to secure nomination for the general election. In a legislative context, such a structure at the district level can be anticipated to have the effect of electing fierce partisans with the downstream consequence of thwarting compromise in governance.

Furthermore, although the term "gerrymandering" got its name through an association between an oddly shaped district and the profile of a salamander, Table 1 further illustrates that the political impact of redistricting flows from the composition of districts, not from their shapes. Drawing on experience from California, Cain, MacDonald, Hui (2006) noted that turnover of legislative seats from one party to the other has historically been more likely when voter-registration difference ranges from a 3% advantage for Republicans to a 10% advantage for Democrats. Yet in the wake of redistricting in 2002, California had no districts within that range of voter-registration differences, leading some observers to characterize the redistricting plan as an "incumbent gerrymander".

Indeed, among 865 elections governed by California's 2002 redistricting (encompassing 5 election cycles for 53 congressional seats, 40 state Senate seats, and 80 state Legislature seats), exactly one seat changed hands from one major party to the other, corresponding to a turnover rate of 1 / 865 = 0.12%. That decade was also marked by gridlock in state government following from California's rules governing taxation and spending, which required two-thirds majorities in both houses of the state legislature to pass a state budget. Were it not for a successful ballot referendum in 2008 that bypassed the legislature in authorizing the issuance of bonds favored by a majority of voters, the revenue-generation and spending priorities of a majority of the population could have been thwarted by a minority in the state legislature. Regardless of one's political preferences, polarization on this scale had the potential for implications such as damage to the credit-worthiness of the people of California and massive, abrupt disruption of public services.

Although there is no meaningful constraint on individuals outside government to develop districting plans with reference to voter registration data, voting data, or other markers of partisan preference, overt use of data on partisan preference by government officials responsible for redistricting could give rise to predictable criticism in public discourse. Some states have established commissions outside of state legislatures to develop redistricting plans, accompanied by guidance not to use certain types of data that might fuel perceptions of partisan bias. In other states, where the structure of redistricting plans has fueled predictable patterns of one party garnering legislative representation disproportionate to its share of state vote totals, it is not unusual for the processes that gave rise to proposed redistricting plans to lack transparency.

Recognizing both the mix of cross-cutting interests inherent in the redistricting process and the existence of patterns in American politics revealing associations between population density

and partisan preference, Belin, Fischer, and Zigler (2011) introduced the notion of a "density-variation / compactness" or DVC score as a one-number summary of a redistricting plan that could be calculated based only on census data and geography but that might be used to evaluate candidate redistricting plans. Conceptually, given evident correlation between population density and partisan preference, it was reasoned that less variation in population density across districts would give rise to more districts where the partisan advantage of one major party over another was within a range where competitive elections would be realistic, including in the years after redistricting where partisan swings from election cycle to election cycle could be anticipated.

In this framework, compactness played the role of a tuning parameter, encoding a political (though not partisan) value aligned with the tradition of election districts being associated with representation of local geographic areas. It was recognized that a narrow focus on competitive elections could be advanced by creating irregularly-shaped districts that mixed high-density and low-density areas, but placing no weight on the shapes of districts could be anticipated to sacrifice the tradition of local-area representation. A statistic that favored less variation in population density across districts as well as greater average geometric compactness would thus give consideration to two legitimate non-partisan goals, where limiting the density-variation measure would favor the inclusion of districts with a degree of partisan balance, and placing weight on compactness would favor local-area representation.

The original work of Belin, Fischer, and Zigler (2011) included development of a specific DVC score as a function of the average absolute deviation in population density across districts within a jurisdiction and the average compactness of those districts. The measure was developed using California data and was evaluated using Texas data. Expanded access to analyzable data in the current data environment has provided an opportunity to evaluate the Belin-Fischer-Zigler DVC score in other states, motivating the current investigation.

2. Methods

The DVC score of Belin, Fischer, and Zigler (2011) can be described as follows. Let the subscript p index candidate redistricting plans, let the subscript ref signify a reference plan, let v be a measure of variation in population density across districts, and let $\overline{c}$ summarize the average compactness across districts. The original version of a DVC score was defined as follows:

$$DVC_p = 15 \times \left[\left(\frac{V_{ref}}{V_p}\right) - 1\right] + 5 \times \left[\left(\frac{\overline{c}_p}{\overline{c}_{ref}}\right) - 1\right]$$

In this framework, to the extent that v_p is smaller than v_{ref}, the DVC score would be higher, thus favoring lower density variation in the current plan relative to the reference plan. Similarly, to the extent that $\overline{c}_p$ is larger than $\overline{c}_{ref}$, the DVC score would be higher, thus favoring larger average compactness for candidate plan relative to the reference plan.

In the original version of a DVC score offered by Belin, Fischer, and Zigler (2011), a state's redistricting plan in the year 2000 was used as a reference plan. The measure of density-variation that was used was average absolute deviation, which was anticipated to be

understandable to lay audiences without requiring familiarity with a notion such as the standard deviation. The compactness measure that was used was Reock compactness, calculated as [district area] / [area of minimal encompassing circle]. The multipliers 15 and 5 were *ad hoc* choices that gave density variation three times the weight of compactness in the resulting measure.

Here, we implement the same measure across all states with more than one congressional district. We calculate DVC scores for 2010 (which can be traced to redistricting in 2002 after the 2000 census) and for 2012 (associated with the redistricting after the 2010 census). Seeking to understand the operating characteristics of this version of the DVC score in practice, we present a range of descriptive summaries from exploratory analyses.

3. Results

Figure 1 displays a scatterplot of 2012 versus 2010 DVC scores for states where both scores were in the range [-10, 10]. The positive correlation is suggestive of similarities in plans across election cycles.

Figure 1. Scatterplot of 2012 versus 2010 DVC scores for scores in the range [-10, 10]

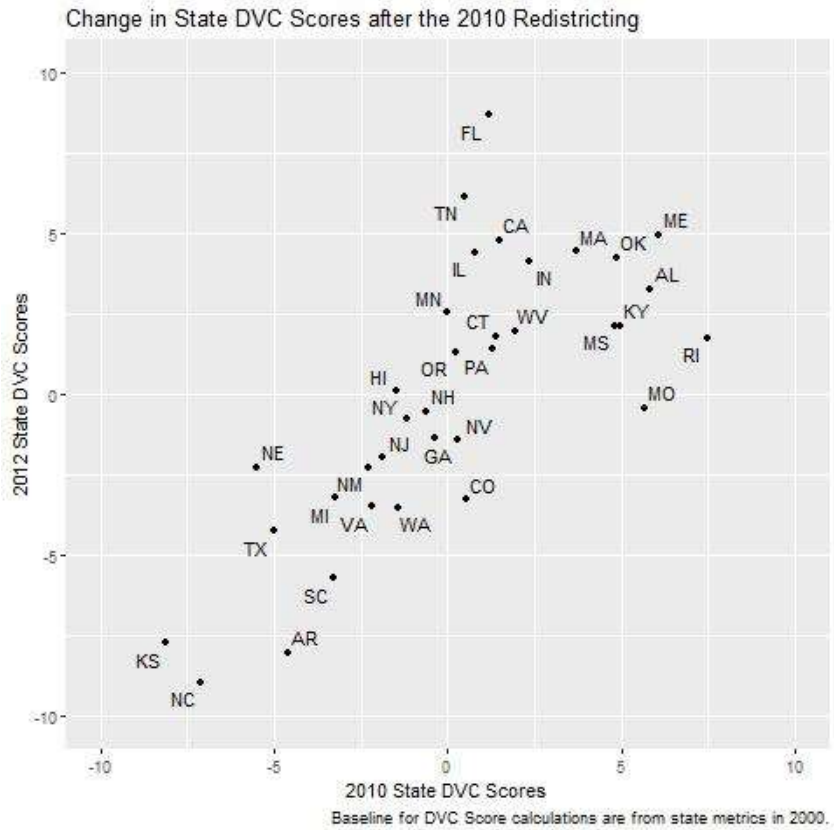


Table 2 calls attention to a degree of stability in DVC scores by highlighting the four states with the smallest change in DVC score between 2010 and 2012.

Table 2. Four states with the greatest stability in DVC scores from 2010 to 2012						
State	Year	V_{ref}	V_p	$\overline{c}_{ref}$	$\overline{c}_p$	DVC_p
New Hampshire	2010	70.54	72.88	0.3379	0.3336	-0.5447
	2012	70.54	72.12	0.3379	0.3343	-0.3814
New Jersey	2010	2494.3	2863.0	0.3140	0.3201	-1.8346
	2012	2494.3	2920.1	0.3140	0.3395	-1.7823
New Mexico	2010	50.92	60.71	0.4198	0.4082	-2.5575
	2012	50.92	60.71	0.4198	0.3877	-2.8019
Pennsylvania	2010	2285.4	2049.3	0.3685	0.3100	0.9339
	2012	2285.4	2006.7	0.3685	0.2776	0.8506

However, there were outlying values that emerged in our exploration. Table 3 calls attention to instability in DVC scores by highlighting the four states with the largest changes between 2010 and 2012. A noteworthy reality is that three of the states featured changes in the number of congressional seats apportioned to the state between redistricting cycles.

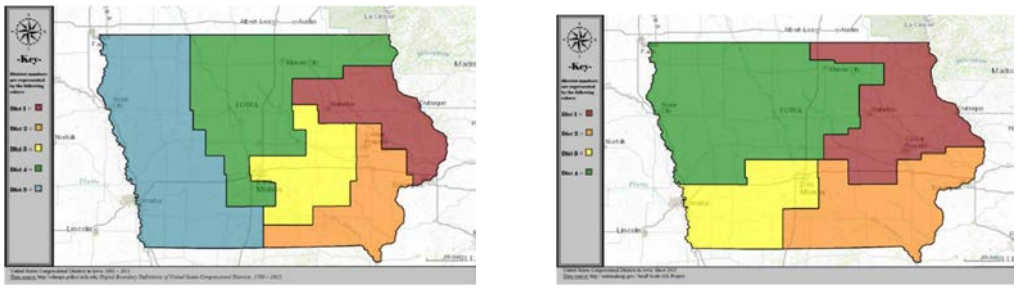
Table 3. Four states with the greatest instability in DVC scores from 2010 to 2012						
State	Year	V_{ref}	V_p	$\overline{c}_{ref}$	$\overline{c}_p$	DVC_p
Iowa	2010	33.01	23.87	0.3736	0.3633	5.6073
(5 seats to 4 seats)	2012	33.01	13.77	0.3736	0.3476	20.6104
Louisiana	2010	263.41	242.73	0.4146	0.4043	1.1536
(7 seats to 6 seats)	2012	263.41	122.05	0.4146	0.3331	16.3896
Utah	2010	659.03	13.55	0.4871	0.4038	713.4621
(3 seats to 4 seats)	2012	659.03	85.63	0.4871	0.3699	99.2360
Wisconsin	2010	1008.3	1254.5	0.3755	0.3871	-2.7896
	2012	1008.3	163.00	0.3755	0.3801	77.8505

Additional insight into the changes in the structure of the redistricting plans between redistricting cycles in these four states is provided in Figure 2. Specifically, Figure 2(a) shows maps of the 2010 and 2012 redistricting plans in Iowa, Figure 2(b) shows the respective 2010 and 2012 plans for Louisiana, Figure 2(c) shows the respective 2010 and 2012 plans for Utah, and Figure 2(d) shows the respective 2010 and 2012 plans for Wisconsin. Dissimilarities in the shapes of districts within states from one redistricting plan to the next, which have been adapted to accommodate population shifts, also can incorporate different mixes of partisan preference in ways that can have implications for elections.

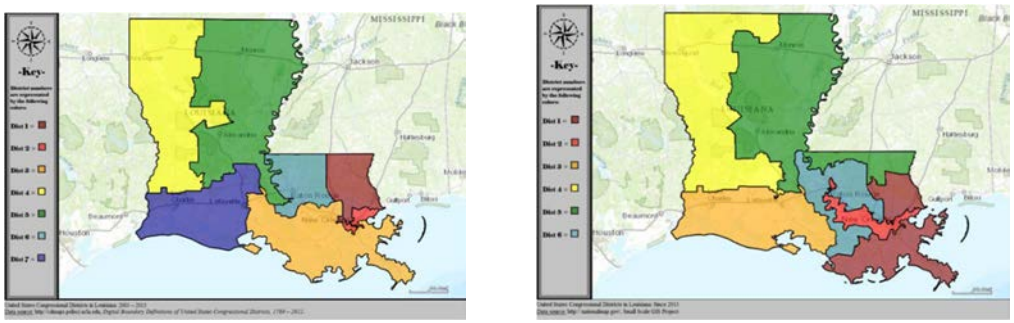
Because population shifts can be expected to occur incrementally, there is reason to believe that DVC scores from one redistricting plan to the next within a state would be comparable so long as the number of districts remains the same and the shapes of the districts are similar. But if the number of legislative seats changes, necessary alterations in the shapes of the districts are apt to change the density variation measure in the DVC score, as reflected in the DVC components summarized in Table 3.

Figure 2. Redistricting plan maps from 2010 and 2012

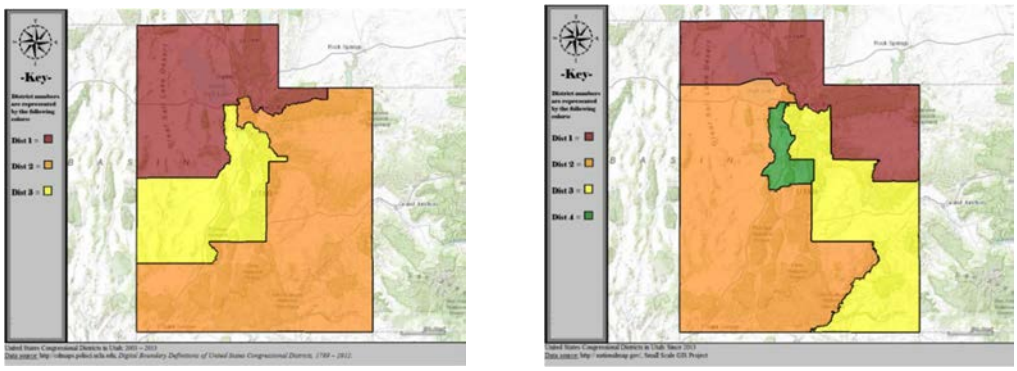
(a) Iowa



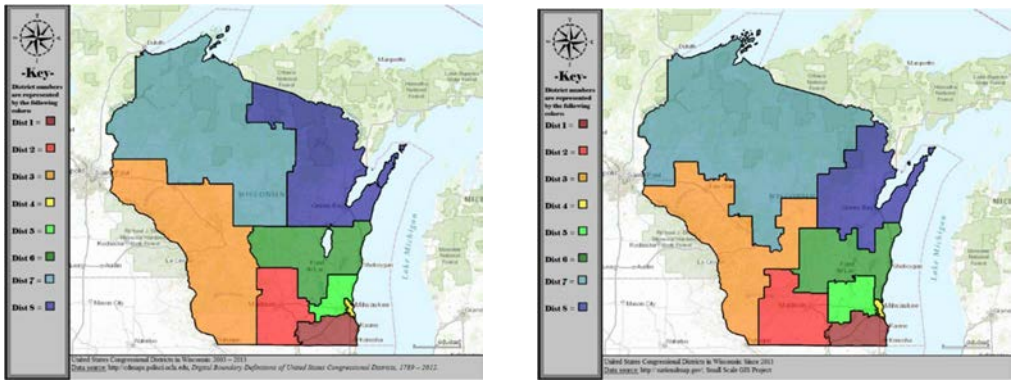
(b) Louisiana



(c) Utah



(d) Wisconsin



4. Discussion

The findings of this empirical investigation suggest that the 2011 version of the DVC score is sometimes stable and sometimes unstable. More generally, DVC scores appear to be sensitive to changes in a plan's conceptual framework. For example, in Utah, should there be a district encompassing as much of Salt Lake City as possible, or should portions of Salt Lake City be in multiple districts? Flexibility in the conception of districting plans presents challenges to representing the public interest in having a sizable proportion of districts where election outcomes are not effectively predetermined, which might then be expected to translate into less polarization in governance.

Drawing on evidence emerging from this analysis, DVC scores are also seen to be meaningfully impacted by differences in state geography. The goal of obtaining a DVC score that would be comparable across states or other jurisdictions remains elusive and arguably should not be viewed as essential.

It would be possible to develop an alternative DVC statistic, such as by using a different density variation measure (e.g., using standard deviation instead of average absolute deviation), using a different compactness measure (e.g., convex-hull compactness instead of Reock compactness), placing different weight on either the density-variation measure or compactness measure, or considering a different function of density variation and compactness. Investigations into alternative DVC measures seem indicated, in part because ratios in the original 2011 description of a DVC statistic was seen in some instances to give rise to numerical instability.

Another ingredient in the original DVC specification that deserves attention is the ad hoc choice of the applicable plan in the year 2000 as a reference plan. This choice has the potential to induce artifacts and can be anticipated to lose relevance as time goes on.

Meanwhile, it is noteworthy that the 2011 DVC statistic was not responsive to factors that led to criticism of the Wisconsin 2012 plan as a highly partisan gerrymander. Local reporting indicated that before this plan went into effect, 56 of 99 state legislative districts had a Republican voter-registration advantage, while after the plan went into effect, 64 of 99 districts had a Republican voter-registration advantage. Yet a Democratic governor was elected in 2018, and Democrats won 53% of the vote across all state legislative districts (including uncontested districts), but Republicans won 63 of 99 state legislative seats. Such a discrepancy between seats and votes is a hallmark of gerrymandering, yet the 2012 DVC score for Wisconsin let to it being a highly positive outlier.

The appeal of a DVC score is that there is reason to believe that population density would be a politically palatable proxy for partisan preference when responsible officials are engaging in redistricting planning with attention to the public interest in effective governance. While this empirical investigation points to gaps that the originally proposed DVC statistic does not address, the investigation also provides helpful insights regarding how a framework incorporating DVC scores might be modified. We look forward to pursuing further research in this area, as the field is still open for alternative DVC-score statistics and alternative strategies for developing state-specific reference plans.

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