A Two Hundred-Year Statistical History of the Gerrymander*

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Abstract

In this paper we assess the geographic compactness of every congressional district used across U.S. history. Using the original gerrymander as a standard and a variety of compactness measures, we assess changes in geographic gerrymandering over time and analyze the effect of key voting rights laws and court cases on compactness. We find that approximately 20% of all districts are less compact than the original gerrymander. This pattern has been fairly steady over the past 200 years, but has worsened since the 1970s. We also show a strong relationship between non-compact districts and Democratic vote share in Congressional elections; Democratic districts tend to be less compact than Republican districts.

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1 Introduction

Geographic compactness of legislative districts has long served as a way to identify where map-makers have manipulated district boundaries to favor one interest, social group, or political party over others. Most states today have some form of compactness criterion, down to legislation of the use of specific formulas for assessing compactness. At the federal level, the Apportionment Act of 1911 states that congressional districts are to consist of "contiguous and compact territory," though that language was eventually dropped in the Apportionment Act of 1941. While compactness may itself be a desirable feature of districts (say because it minimizes travel time), significant deviations from compactness are taken as indicative of other forms of political manipulation of the election laws, such as favoring one of the political parties or interfering with the representation of one social group or interest.[1] How closely districts comport with this standard, then, is informative about the extent to which states comply with this broad districting principles and it is a key piece of evidence in detecting political manipulation of legislative boundaries.

This paper presents an historical assessment of the geographic compactness of all congressional districts from the 1st Congress to the present. We do so with an eye toward three specific questions regarding compactness as a stand-alone districting principle and as an indicator of other sorts of manipulations. First, how compact are districts compared with a standard of what constitutes a non-compact boundary? Second, is compactness indicative of racial gerrymanders? Third, is compactness indicative of partisan gerrymanders?

In offering this assessment, we introduce a standard for what constitutes a minimum acceptable level of compactness. Generally, there exists no accepted statistical or legal standard for measuring whether a district is non-compact (see Niemi et al. 1990). The legal literature on legislative districting has generally sought such a standard, but usually gets no farther than a subjective assessment of ugliness (see Polsby and Popper 1993). Pildes and Niemi (1993) offer a comparison of the compactness of every U.S. House district drawn during the 1991-1992 redistricting cycle. Their analysis offers an enlightening comparison of the compactness of various districts in that cycle of apportionment, but it offers no metric against which to measure whether a district was unusually

[1] For a general discussion of districting principles and practices see Butler and Cain (1992); also see Levitt (2010).

misshapen. How bad is bad? We invoke an historical standard which has become synonymous with political manipulation of legislative district boundaries: the shape of the 1812 Massachusetts Senate district, the Gerrymander. If there is a district whose shape defines a gerrymander, it is the original beast itself.

We compare the compactness of every congressional district in U.S. history against the shape of the original gerrymander. One in five Congressional Districts, 20 percent of all districts ever drawn, are less compact than the original gerrymander. That frequency of non-compact districts has increased somewhat since the mid-1960s. Twin federal actions dramatically altered the practice of districting. First, in 1964, the Supreme Court required extensive redrawing of districts to comply with the standard of one-person-one-vote. Second, beginning in 1970s, the federal Voting Rights Act compelled creation of minority districts. Both requirements are thought to have contributed to the growing distortion of legislative district boundaries (Pildes and Niemi 1993; Ansolabehere and Snyder Jr. 2008). It is difficult to say what one would expect if, say, districts were drawn arbitrarily (see Chen and Rodden 2013), however the high rate of non-compactness historically — 20 percent of all congressional districts — suggests that states typically do not comport with the most basic standards of compactness when drawing district boundaries. Other factors might have contributed to the increasing distortion of district boundaries, including the introduction of computerized districting and the increased partisan rancor in U. S. politics.

Interestingly, the compactness of the original gerrymander suggests a readily acceptable standard for measuring and assessing the compactness of legislative districts. Existing measures of district compactness have different scales and "ideal districts" that must be understood to interpret a particular compactness result. For example, with the Reock measure, a perfectly circular district would receive a score of "1", a perfect square a score of ".64", and less compact districts receive smaller scores. With the Schwartzberg perimeter measure, a perfect circle would receive a score of 1, and less compact districts receive higher scores. With other measures, such as the ratio of the district area to the perimeter, there is no "ideal" district shape to use as a benchmark; districts are only assessed relative to each other. Here, we propose that the original gerrymander be the standard for measuring district compactness for all measures. We adjust and scale every

measure such that the compactness score of the original gerrymander is always "1," higher scores are less compact, and lower scores are more compact.

This standardizing approach offers four distinct advantages. First, all measures, regardless of how they are calculated, are interpreted in the same way, and on the same scale. This makes it easier to understand what a compactness measure means relative to an established baseline. Second, we can more easily compare different measures of the same district. A district may be non-compact on one measure, but compact on another. The common scale allows for direct comparisons between these measures. Third, we have a clear reference district that is well-known and easy to visualize. When we say a district scores "1.25" on a given measure, we can interpret that as "this district is 25% worse than the original gerrymander." Fourth, we can use the score of the original gerrymander as a cutoff for identifying unambiguous gerrymanders. If a district is worse that the original gerrymander across some set of measures, we can classify it as a gerrymander as well.

Compactness itself may not be of great concern. Rather, non-compactness is usually a red flag. It indicates that something unusual happened to district boundaries, and suggests that districts may have been drawn to favor one social group or political party. Specifically, non-compactness is often taken as facial evidence that the districts were drawn so that one party might gain electoral advantages over others, as in the original gerrymander or in the 2012 Florida congressional districts,[2] or discriminating against racial groups, as in the first case of racial districting *Gomillion v. Lightfoot* (364 U. S. 399 (1960)).

Compactness can be immediately informative about individual districts. If a district's boundary is determined to be unusually distorted, a court or other analyst might then examine other characteristics of the district and neighboring districts, such as racial or partisan composition, to determine whether the non-compactness might have had the effect of diluting the vote of certain groups of individuals in the are affected by the district. One may also determine the relationship between the characteristics of suspect districts and the political orientation of the legislature that drew the district. For example, is a Democratically controlled legislature more likely to cre-

[2]See *Romo v. Detzner* decided July 10, 2014, in the Circuit Court of the Second Judicial Ciruit in and for Leon, County, Florida, 2012-CA-412 `http://www.floridaredistricting.org/documents/Romo_Final_Judgment_10-Jul-2014.pdf`.

ate misshapen Republican districts, say because of packing of the opposition party, or misshapen Democratic districts, say, to increase the number of potential Democratic districts. We examine the connection between the non-compactness of a district and the extent to which it tilts toward one of the parties, and whether that slant is a function of who drew the districts (a court, a commission, or a legislature. Throughout the extensive literature on districting and gerrymandering several factors are thought to contribute to the characteristics of districts and the structure of representation. The most prominent of these is: the number of districts (Young 1988; Gilligan and Matsusaka 2006), unified government (Cox and Katz 1999, 2002), population density (Chen and Rodden 2013), racial composition (Owen and Grofman 1988; Lublin 1997; Friedman and Holden 2008), and partisanship and incumbency protection (Ansolabehere and Snyder 2012; Rush 2000; Forgette and Platt 2005).

2 Measuring Compactness

A substantial literature considers the problem of measuring district compactness. Young (1988) and Niemi et al. (1990) examine a wide variety of methods to measure compactness. Here, we seek to build on Altman (1998), which analyzes the historical compactness of districts in the context of districting principles and voting rights challenges.

The literature generally divides methods into several categories, including dispersion, which assesses the general shape and area of the district, regularity of the perimeter, which penalizes districts for contorted borders, and population distribution, which takes populations concentration into account when evaluating the district's shape. As our goal here is an historical assessment of district compactness, we are unable to consider compactness measures of this third category due to data availability. Thus, we focus on the area and perimeter of congressional districts to assess compactness.

Our analysis below focuses on four key methods for measuring compactness.[3] First, we use two measures of dispersion, Reock and the convex hull ratio, to examine the shape of districts. Reock (1961) compares the area of the district to the area of the minimum bounding circle that encloses

[3]One future goal of this project is to calculate every feasible compactness measure for every district, including all measures listed in Young (1988) and Niemi et al. (1990).

the district. The "ideal" district is a circle, with a perfect score of 1; a square has a score of 0.63. The convex hull ratio uses a similar approach, but substitutes the minimum bounding circle for the minimum bounding convex polygon. With this measure, any convex polygon is equally ideal, but districts with significant protrusions or curves are non-compact. The top half of Figure 2 illustrates these measures.[4]

One of the drawbacks of these dispersion measures is that some states, due to borders or coastlines, are non-compact themselves, and as a result some districts within them will receive low compactness scores, regardless of how the district borders are drawn. This is a particularly important problem when we seek to compare district compactness across states, or when we use the average compactness of a state plan to compare states. As a result, we implement an adjusted version of Reock and the convex hull ratio that excludes areas outside of the state's borders from the area of the minimum bounding circle or convex polygon. For example, in Figure 2, the minimum bounding circle encloses the district, but also includes part of New Hampshire at the top, and the Atlantic ocean to the right of the district. The Reock measure includes these areas, but the adjusted Reock measure excludes them, and only includes the area of state within the circle, shaded in gray. This method of adjusting the minimum bounding geometry is used in some state compactness statutes, such as Michigan.[5]

The second set of measures examines the perimeter of the district. Schwartzberg (1965) and Polsby-Popper (1991) measure how effectively the perimeter of a district captures the area of a district. Districts with smooth perimeters are more compact than those with contorted borders, and the most compact possible district is a circle. Schwartzberg measures the ratio of the perimeter of the district to the perimeter of a circle with the same area. Polsby-Popper measures the ratio of the area of the district to the area of a circle with the same perimeter. These two measures are closely related. As Polsby and Popper (1991) point out when proposing their measure, they are mathematically equivalent.[6] However, they are often used as two separate measures of compactness. The bottom half of Figure 2 illustrates these two measures.

[4]Some districts are non-contiguous due to islands or other geographic features. For these districts, we draw separate bounding circles or convex polygons for each individual feature.

[5]Mich. Comp. L. §§3.63, 4.261, see `http://redistricting.lls.edu/states-MI.php#criteria`

[6]$Polsby\text{-}Popper = 1/(Schwartzberg^2)$ (see Polsby and Popper 1991, note 204).

Like the dispersion measures, perimeter-based measures are also particularly sensitive to state borders. In particular, the convoluted coastlines of states such as Maine, Maryland, Virginia, and Louisiana produce coastal districts with extraordinarily low Polsby-Popper and Schwartzberg scores. Furthermore, these scores are extremely sensitive to the resolution of the map. The more detailed the map, the greater the district perimeter. Unlike the dispersion measures, however, there is not an easy adjustment to correct for complex geography. As a result, we must be more careful when using perimeter-based compactness scores, to ensure that non-compactness is due to political rather than coastal geography.

As discussed throughout the literature, no one measure of compactness is optimal. Each measure has its advantages in detecting certain forms of non-compactness, and its disadvantages in missing others. For example, a spiral shaped district will be relatively compact using both of the dispersion measures, but extremely non-compact on the perimeter measures (Young 1988). A triangle is perfectly compact using the convex hull ratio, but non-compact using Reock. As a result, multiple criteria are desirable for assessing non-compactness and gerrymandering (Edwards and Polsby 1991; Niemi et al. 1990).

2.1 Data

We use the United States Congressional District Shapefiles assembled by Lewis et al. (2013) to measure the compactness of every congressional district from the 1st Congress to the present. Lewis et al. (2013) provide separate shapefiles for each Congress, such that we can measure not only the districts produced following the decennial censuses, but districts created through mid-decade redistrictings and districts that change mid-decade due to legal challenges and court orders.

To measure the compactness of each district, we used ArcGIS and the Python module ArcPy to measure the area and perimeter for each district and calculate the minimum bounding circles and convex polygons (and the state-boundary-adjusted variants) used in our dispersion measures. These tools allow us to automate much of the work involved in calculating compactness measures, a substantial advantage over the more limited tools available in the 1980s and 1990s when the compactness literature was largely developed. Table 1 shows the distribution of each compactness

measure.

While most congressional districts now are defined every ten years, historically many districts persisted with the same boundaries for much longer periods, while others might only be used for one or two Congresses as a result of mid-cycle redistricting or voting rights litigation. From 1789 through 2013, 9,276 different districts have been used over a total of 34,996 district-Congresses.[7] However, of these 9,276 different districts, many are close variants of each other, as some districts changed minimally following redistricting. We use district-Congress as the unit of analysis. By using district-Congress instead of district, districts that are used for longer time periods are weighted more heavily than districts that are used for a single congress.[8]

Table 1: Distribution of Compactness Measures For All Congressional Districts

			Percentile				
Measure	Mean	SD	10%	25%	50%	75%	90%
Reock	0.405	0.110	0.260	0.326	0.408	0.481	0.547
Reock Adj.	0.526	0.147	0.340	0.424	0.518	0.622	0.719
Convex Hull Ratio	0.760	0.106	0.620	0.697	0.768	0.840	0.889
Convex Hull Ratio Adj.	0.809	0.107	0.664	0.746	0.822	0.888	0.935
Polsby-Popper	0.293	0.158	0.080	0.178	0.287	0.401	0.511
Schwartzberg	2.381	1.875	1.399	1.580	1.866	2.369	3.532

Statistics based on 34,996 observations. Each observation is a district-Congress. Excludes single-district states.

3 District-Level Results

We begin with the original gerrymander, our baseline for assessing district compactness. While the origin of the Gerrymander is well known, it is often incorrectly described as a congressional district instead of a state senate district. The original gerrymander, upon which the famous cartoon is based, was a Massachusetts Senate district. Figure 1 shows the infamous gerrymander cartoon, the

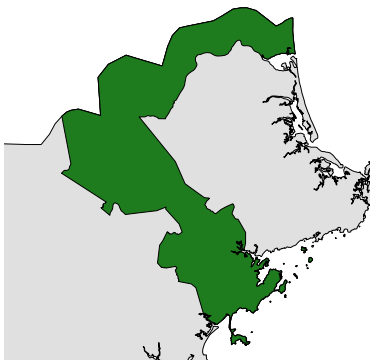
[7] These counts exclude at-large districts. Multi-member districts are counted as single districts.

[8] Additionally, using district as the observation would overrepresent districts that change very slightly over time, because each would appear as a separate observation. This choice also keeps the number of observations constant when we analyze the data by congress.The results are very similar when we use the district as the unit of observation instead.

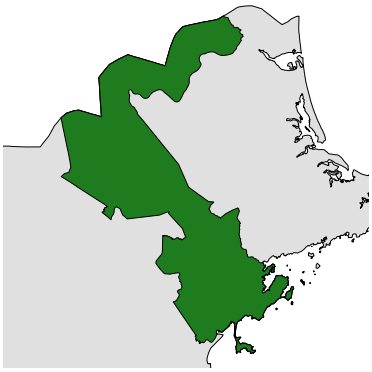
actual Massachusetts Senate District, and the 2nd Congressional District, which is often confused with the original gerrymander. The only difference between the original gerrymander and the congressional district is the town of Salisbury, the "head" of the gerrymander. While the original gerrymander is not a congressional district, we will use it, rather than the "headless" congressional district, as our baseline due to its well its identifiable shape and its recognition as an effective political gerrymander.[9]

Figure 1: The Original Gerrymander

"The Gerry-mander. A new species of of Monster, which appeared in Essex South District in January last." *Boston Sentinel*



Actual map of the original gerrymander, a Massachusetts State Senate district drawn in 1812.



Map of the Massachusetts 2nd Congressional District, 13th Congress.

We use this original gerrymander as a standard by which we assess all other districts. Rather than compare districts to some ideal geometry, whether a circle, square, or other desirable shape, we compare districts to this gerrymandered (by definition) shape. By standardizing our compactness measurements relative to the original gerrymander, we are able to analyze different measures using a common scale and shared interpretation. While any district (or shape) could be selected as a standard, we believe that the original gerrymander is an extremely effective choice. As a deliberate, unambiguous, and successful political gerrymander (Griffith 1907), the original gerrymander offers

[9]As discussed in Griffith (1907), the original gerrymander is not in fact the first political gerrymander in the United States. Several congressional and state legislative districts were drawn prior to the original gerrymander that we would consider to be gerrymanders, and even some colonial districts were gerrymandered as well.

a useful and interpretable standard: any district worse than the original gerrymander across some set of compactness measures should be considered gerrymandered as well. The use of the phrase "some set of compactness measures'; reflects that multiple criteria are desirable for assessing district compactness. Districts that are bad on one measure may be good on others. However, compactness measures generally correlate, and a district that scores poorly on a number of different measures is a likely gerrymander. Figure 2 illustrates the compactness of the original gerrymander using the Reock, convex hull ratio (and their adjusted variants), Polsby-Popper, and Schwartzberg measures. Table 2 reports the raw scores for the original gerrymander for each measure.

Table 2: Compactness Score for the Original Gerrymander

Measure	Score
Reock	0.289
Reock Adjusted	0.396
Convex Hull Ratio	0.494
Convex Hull Ratio Adjusted	0.539
Polsby-Popper	0.095
Schwartzberg	3.247

Using the compactness results for the original gerrymander, we standardize the results for all other districts by dividing the district's result by the compactness score of the original gerrymander.[10] The higher the score, the less compact (the more non-compact) the district. A score less than one means that the district is more compact than the original gerrymander on that measure, while scores greater than 1 mean the district is less compact. Table 3 reports the standardized distributions for each measure. This allows for better interpretability between measures than in Table 1. For example, the average district is 16% better than the original gerrymander using Reock, but 52% better using the convex hull ratio. All of the subsequent analyses of compactness use these standardized measures.

[10]For measures such as Schwartzberg, where higher scores indicate lower compactness, we divide the score of the original gerrymander by the district's score.

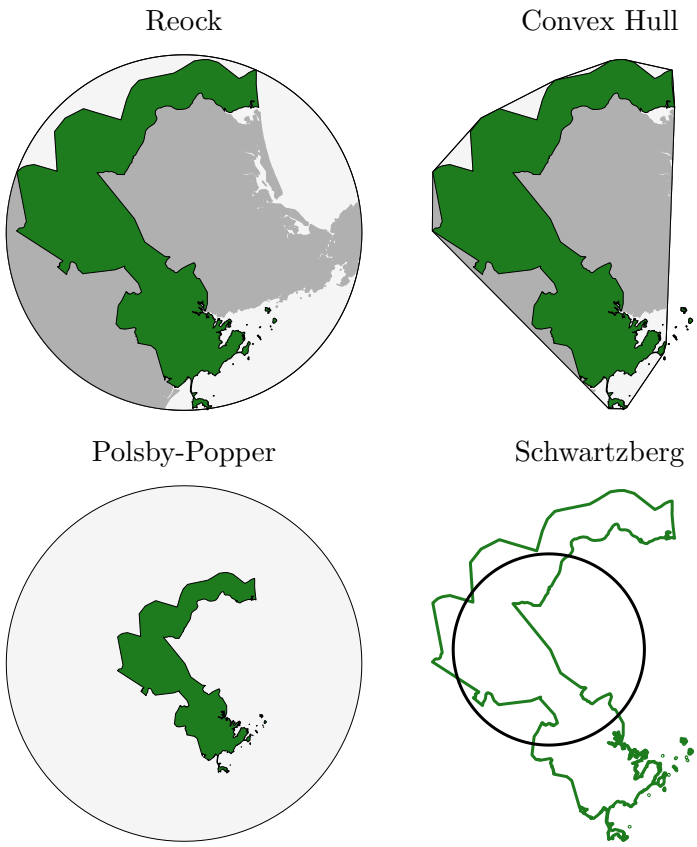


Figure 2: Illustrations of Compactness Measures using the Original Gerrymander

The top two maps illustrate measures of dispersion: Reock and convex hull ratio. They are defined as the ratio of the area of the district to the area of the bounding geometry. The circle/polygon outline define this geometry. The light gray area within these outlines defines the area of the bounding geometry that is within the borders of the state. This area is used in the adjusted measures. The bottom two maps illustrate measures of perimeter. Polsby-Popper is the ratio of the district area to the area of a circle with the same perimeter. Schwartzberg is the ratio of the perimeter of the district to the perimeter of a circle with the same area.

Table 3: Distribution of Compactness Measures For All Congressional Districts, Standardized Measures

			Percentile				
Measure	Mean	SD	10%	25%	50%	75%	90%
Reock	0.838	0.155	0.638	0.730	0.833	0.948	1.042
Reock Adj.	0.785	0.244	0.466	0.626	0.798	0.954	1.092
Convex Hull Ratio	0.474	0.210	0.219	0.317	0.458	0.598	0.751
Convex Hull Ratio Adj.	0.414	0.231	0.141	0.242	0.386	0.550	0.730
Polsby-Popper	0.781	0.175	0.540	0.662	0.788	0.908	1.016
Schwartzberg	0.699	0.237	0.412	0.531	0.671	0.835	1.036

Statistics based on 34,996 observations. Each observation is a district-Congress. Excludes single-district states. Measures are standardized such that the original gerrymander receives a score of 1 on each measure. For all measures, a higher score corresponds to lower compactness (higher non-compactness).

3.1 Historical Trends in Compactness

District compactness has changed significantly over the history of Congress. Before *Baker v. Carr*, congressional districts rarely had equal populations, and boundaries were often drawn using town or county lines (Altman 1998). However, as the original gerrymander illustrates, even districts drawn using town and county lines can be significantly non-compact. Figure 3 plots the distribution of district compactness by Congress using the Reock adjusted, convex hull ratio adjusted, and Polsby-Popper measures. In both dispersion-based measures, non-compactness is increasing over time. These plots reveal an interesting pattern. While the bad districts continue to get worse, the entire distribution is changing as well. The entire distribution, not just the top percentiles, is becoming less compact than in the past.

The plot of Polsby-Popper scores over time tells a different story. The 90th percentile of districts were worse in the earliest Congresses than they are in the present. Furthermore, there is slight a general trend in first fifty years towards increasing compactness. This is driven not by substantive changes in how districts are drawn, but by changes in the composition of the country. As the nation expanded westward, the new states themselves were generally more compact than the original colonies and earliest additional states because they lacked complex coastlines. Additionally,

as the number of districts increased, the effect of coastal districts in Massachusetts/Maine, Virginia, Maryland, and elsewhere on average compactness diminished. Within the last fifty years, however, a similar trend is evident on this measure as in the others — there is an increase in non-compactness throughout most of the distribution. This shift, however, is largest among the bottom of the distribution. This is likely due to the fact that the very worst districts — the aforementioned coastal districts — remain relatively constant across the entire time period. However, as with the other two measures, even the best districts are getting less compact.

While the trend generally persists across the entire time period, it is strongest in recent decades. Table 4 reports averages for each standardized measure for three time periods: 1941–1970 (districts drawn before *Wesberry v. Sanders* took effect), 1971–2000 (districts drawn before *Shaw v. Reno* took effect), and 2001–2013 (district drawn after *Shaw v. Reno*). Across all measures, non-compactness has increased, and the differences between these averages are highly significant for all time periods and measures.

Table 4: Compactness by Era

Time Period	Reock	Convex Hull	Polsby-Popper
1942–1971	0.773	0.386	0.763
$n = 6356$	(0.003)	(0.003)	(0.002)
1972–2001	0.823	0.502	0.834
$n = 6430$	(0.003)	(0.003)	(0.002)
2002–2013	0.887	0.593	0.859
$n = 2568$	(0.005)	(0.006)	(0.002)

Mean and standard distribution of standardized Reock, convex hull ratio, and Polsby-Popper scores for congressional districts by time period. From each time period to the next, the difference in means for each measure are significant at $p < .01$.

3.2 Using the Standard to Identify Gerrymandered Districts

In this section we use the standard of the original gerrymander to identify potentially gerrymandered districts. Rather than use the compactness measurements of the original gerrymander to

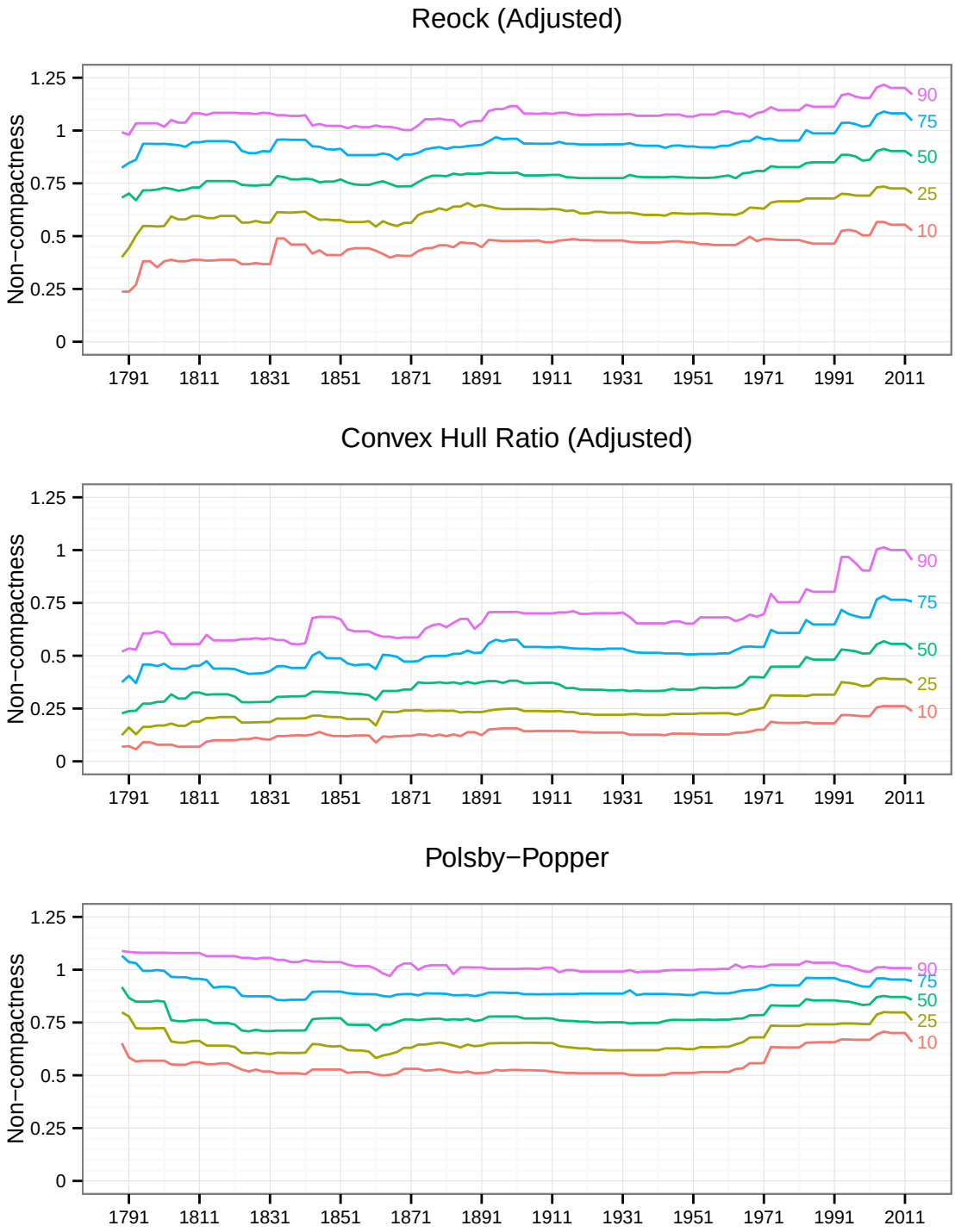


Figure 3: Historical Trends in District Compactness

These graphs plot the distribution of each compactness measure by Congress. Each line shows how the specified percentile changes over time. Higher scores correspond to less compact districts. In the last 50 years, districts are significantly less compact than in the past.

standardize the measurements for all other districts, we use the original gerrymander's compactness scores as cutoff. Figure 4 plots the percentage of districts in each congress with worse scores than the original gerrymander for Reock (adjusted), the convex hull ratio (adjusted), and Polsby-Popper. All three measures generally correlate, with the exception of Polsby-Popper in the first fifty year (see discussion in §3.1). In the last fifty years, we see a substantial increase in the percentage of districts worse than the original gerrymander under all three measures.

Table 5 reports the number and percentage of all congressional districts that are worse than the original gerrymander. Overall, 28% of all congressional districts are less compact than the original gerrymander on at least one of our three measures, but only 1% are worse on all three of the compactness measures used in this paper. This highlights the importance of using multiple criteria to assess non-compactness: of the districts that are worse on one measure, only 11% are worse on a second measure.

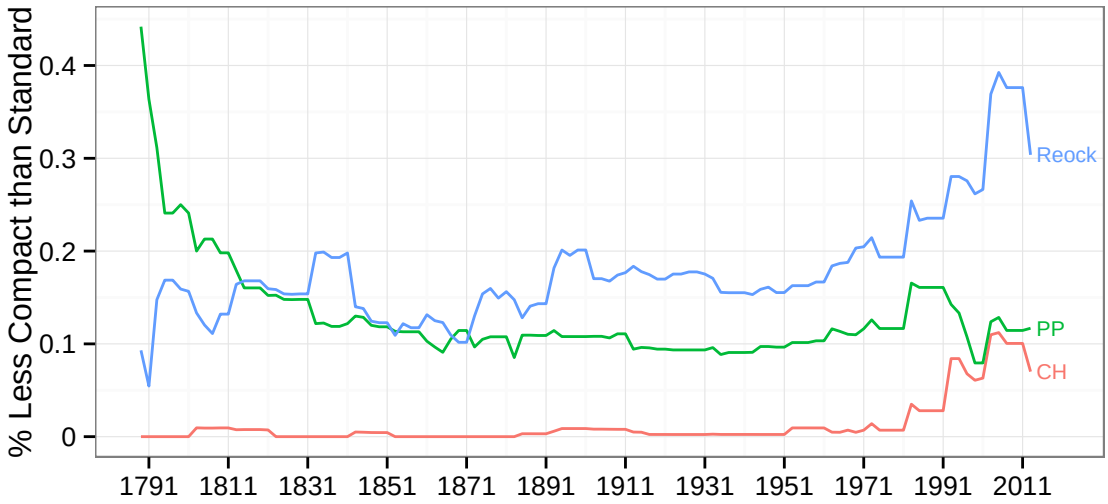


Figure 4: Districts Less Compact Than the Standard

Each line plots the percentage of districts in each congress that are worse than the original gerrymander (standardized score greater than 1) for the specified measure. *CH*=Convex hull ratio; *PP*=Polsby-Popper.

Table 6 divides the non-compactness results in Table 5 by measure. The second column gives the number and percentage of districts that are worse than the original gerrymander on each of the three measures. The set of columns on the right then show the percentage of these districts that

Table 5: Noncompact Districts by Number of Measures Noncompact

All Districts, 1789–2013

Number of Measures	N	%	Number of Measures	N	%
All measures (3)	300	0.009	All measures (3)	300	0.009
2 or more	1097	0.031	Exactly 2	797	0.023
1 or more	9923	0.284	Exactly 1	8826	0.252

1973–2013

Number of Measures	N	%	Number of Measures	N	%
All measures (3)	276	0.031	All measures (3)	276	0.031
2 or more	687	0.076	Exactly 2	411	0.046
1 or more	3123	0.347	Exactly 1	2436	0.271

Each observation is a unique district-Congress.
1789–2013: $n = 34,996$; 1973–2013: $n = 8,998$.

are also worse on the other measures. For example, 19% of all districts are worse than the original gerrymander using Reock, but of these districts only 9% are also worse using the convex hull ratio.

While a substantial percentage of districts are worse than the original gerrymander under Reock (19%) and Polsby-Popper (12%), only 2% of districts are worse using the convex hull ratio. The original gerrymander is relatively non-compact on all three measures, but it is extremely non-compact using the convex hull ratio due to the sharp angle of the "neck" of the gerrymander. The original gerrymander also surrounds an extremely compact district, such that the state-boundary adjustment does little to improve its convex hull ratio. Thus, the original gerrymander is a hard standard to exceed using convex hull ration. As Figure 4 shows, most (and sometimes all) districts were more compact on this measure than the original gerrymander through the 1950s. Since then, there is a significant rise of non-compactness on this measure. Modern district shapes increasingly deviate from convex polygons compared to the past.

3.3 The Most Gerrymandered Districts in U.S. History

Using our three compactness measures together, we define the most gerrymandered districts as those that are worse than the original gerrymander on all three measures. There are 300 such

Table 6: Percentage of Congressional Districts Worse than Original Gerrymander, by Compactness Measure

Measure	Worse than Gerrymander	Within-group Reock	Within-group CH	Within-group PP
Reock Adj.	0.191	—	0.087	0.122
	(6671)		(581)	(812)
Convex Hull Ratio Adj.	0.017	0.983	—	0.514
	(591)	(581)		(304)
Polsby-Popper	0.116	0.200	0.075	—
	(4058)	(812)	(304)	
Worse on Any Measure	0.284	0.672	0.060	0.409
	(9923)	(6671)	(591)	(4058)

The second column gives the percentages and numbers (below) of congressional districts less compact than the original gerrymander by the measure listed in the first column. The three columns on the right gives the percentages and numbers (below) of districts less compact than the original gerrymander by compactness measure within the group that are less compact by the measure in the first column. Each observation is a unique district-Congress, $n = 34,996$.

district-Congresses, representing 109 unique districts. Figure 5 displays some of these districts. The set of the most gerrymandered districts includes some well-known examples of gerrymandering, such as the Illinois 4th "earmuffs" and the Maryland 3rd "pinwheel," but also includes some less recognized gerrymanders including the MA 9th district. Most of the 109 districts that are worse than the original gerrymander on all three measures are recent; only 16 of the districts were drawn before the 103rd Congress. New York (18), Florida (14), California (13), and Texas (12) appear on the list the most times, and Florida has the highest percentage of district-Congresses on the list; 6% of all district-Congresses in Florida are less compact on all three measures than the original gerrymander.

3.4 Compactness and Competition

The incidence of highly non-compact congressional districts has increased over the past 50 years. That trend may be worrisome in and of itself, but it might also be indicative of deeper changes in our politics. Geographic non-compactness of districts has long been thought to signal political

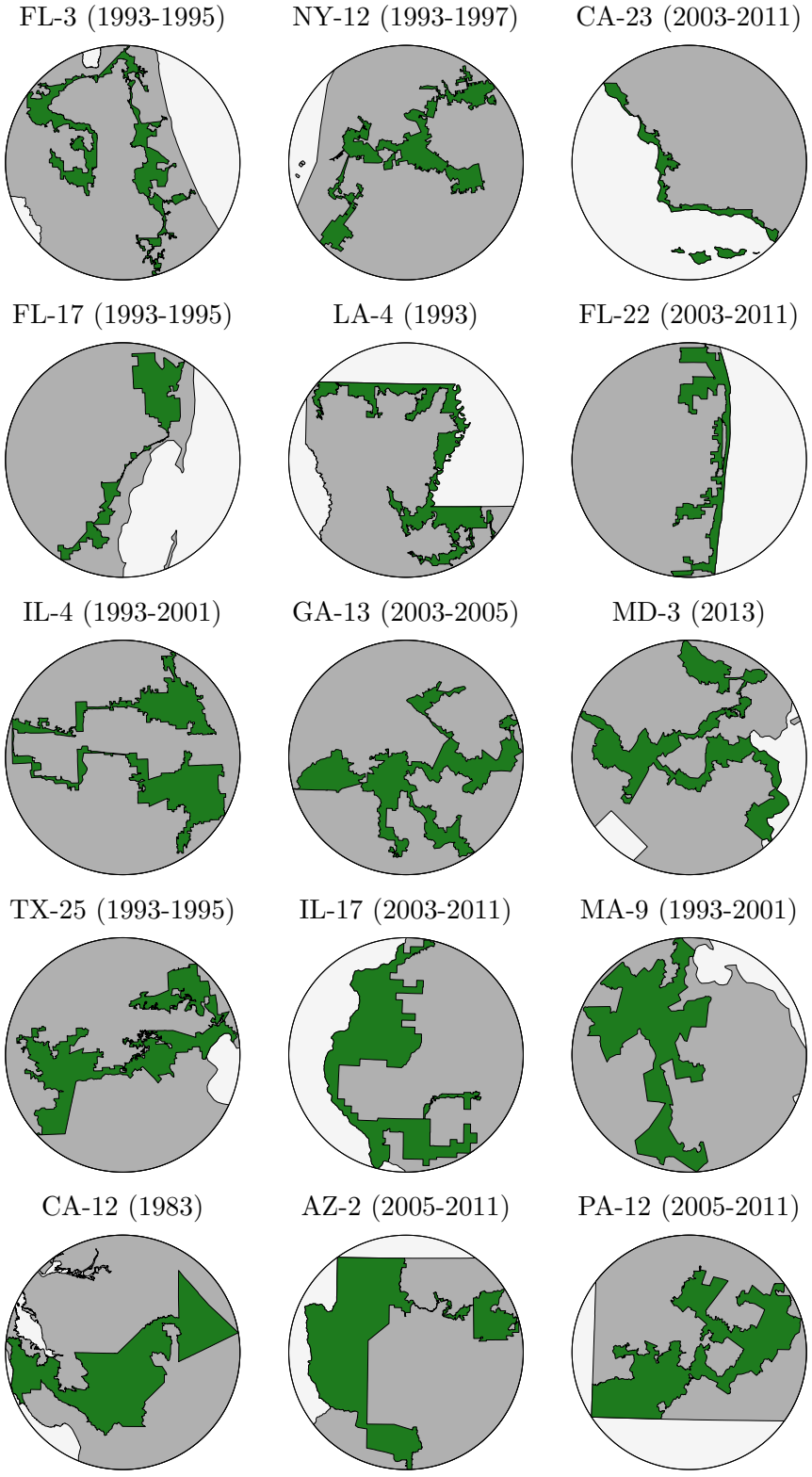


Figure 5: Examples of Highly-Gerrymandered Districts

manipulation to favor one party over another, for example. Certainly that is the story of Elbridge Gerry's handiwork in 1811. In this section we present a first look at the connection between non-compactness and partisanship using the measures developed here.

We examine the relationship between partisanship and non-compactness at the individual district level. Using U. S. House election data from 1972 to 2008, we find that Democratic vote share is highly correlated with district non-compactness. We focus on the post 1970 period to set aside the problem of unequal population. Table 7 presents results from regressions of Democratic vote share in congressional elections on our measures of compactness. There is a strong relationship between the performance of Democratic candidates and the non-compactness of the district. The more Democratic the district, the less compact the district.

There are many possible explanations for this regularity. The geographic distribution of partisans is one possibility. Chen and Rodden (2013) argue that there is a natural tendency for Democrats to have less compact districts because they are more heavily concentrated in urban areas. This can produce a partisan bias at the state level in favor of Republicans. The creation of majority-minority districts under the Voting Rights Act is another possibility (Pildes and Niemi 1993). The method of redistricting (state legislature, commission, or courts) may also play a role in the creation of non-compact Democratic districts (Carson, Crespin, and Williamson 2014). Non-compact districts may be the product of Democratic gerrymanders, where Democratic state legislatures have drawn convoluted lines to benefit themselves. In other cases, non-compact Democratic districts may be drawn in Republican gerrymanders, where Democrats are packed into serpentine districts to reduce their electoral influence in neighboring districts.

Explaining the origins of this relationship awaits further investigation. Whatever the causes of the correlation between Democratic vote share and non-compactness of districts, the existence of such a relationship reveals that non-compactness can be indicative of political concerns and electoral outcomes. As a legal criterion, then, insistence on compactness may have important implications for the political fairness of legislative districts, individually and whole plans.

Table 7: Regressions of Democratic Vote Share on Compactness

	(1) Reock	(2) Convex Hull	(3) Poslby-Popper	(4) Reock	(5) Convex Hull	(6) Polsby-Popper
Dem. vote %	0.122***	0.121***	0.0624***	0.195***	0.209***	0.108***
	(0.012)	(0.010)	(0.006)	(0.0169)	(0.015)	(0.009)
Observations	7,981	7,981	7,981	6,912	6,912	6,912
R-squared	0.252	0.243	0.343	0.267	0.259	0.361
Uncontested Elections	Yes	Yes	Yes	No	No	No
State-Congress FE	Yes	Yes	Yes	Yes	Yes	Yes

This table displays OLS results from regressing Democratic vote share in congressional elections on standardized measures of district compactness, using state-congress fixed effects. Includes U.S. House general election results for from 1972–2008. The first three models include all elections; the last three exclude uncontested races. At-large elections are excluded.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4 Conclusion

The geographic configuration of legislative districts is one of the most immediate tests of the integrity of the districting process: we know a gerrymander when we see it. Even though people commonly conjecture such a casual standard, it is evident that state legislators, courts, and others involved in the districting process have struggled to establish clear guidelines for the geographic compactness of districts. We have proposed one such standard, the configuration of the original gerrymander. The everyday meaning of the term gerrymander and the manipulations that lie behind it are embodied in the geographic features of the map itself. By measuring those features and applying them to the history of all congressional districts, much can be learned about the integrity of the districting process in the United States and how it has changed.

We do not intend this as a bright line standard that any court or legislature could adopt. Rather it serves as a guide post, a marker that should raise concerns. There maybe other lower or higher thresholds, perhaps derived from other districts that have been accepted in a legal setting or in common parlance as examples of districting gone awry. Our purpose has been to lay down one such

marker – to our thinking the most obvious one – and to see where it leads.

Importantly, it appears that the geographic integrity of congressional districts has worsened in the United States since the 1960s. This certainly fits the common perception and much popular writing on the matter. But it is a social scientific question as to why that worsening has occurred. Was it the one-person, one-vote rule? The Voting Rights Act? The increased involvement of the courts? It is also an open question as to what the increasing non-compactness of congressional districts indicates. Is this a sign that representation is getting worse because there is increased manipulation of districts to favor one party over another? Has the creation of majority minority districts contributed to non-compactness, and if so, in what respects has that improved or distorted representation? These are important, unanswered questions, and certainly the next step in the quest to understand how the structure of representation has changed in the United States over the course of its history.

Whatever the answer to these questions, though, maintaining geographic compactness of districts has long been embraced as a traditional districting principle. Over the arc of U.S. history there was a steady state in the distribution of compactness and non-compactness, but that steady state was disrupted in the 1960s. The political process today is engaged in a protracted struggle to find a new balance among the various principles that guide districting, including geographic integrity. The patterns found here indicate a steady move away from geographic compactness as such a principle. There may be a reassertion of this criterion, as has been seen in states like Florida and in some recent federal court cases (such as *Page v. Virginia Board of Elections*), or the nation may shift toward a different conception of representation in which compactness, although a standard, is valued little. The historical trajectory certainly suggests that we are on the latter path. It is up to the legislatures and the courts in the United States to determine whether geography will remain a meaningful basis for representation, and if so what will be the criterion for representation of geographic areas in the United States.

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