**Visualizing Gerrymandering:**

**Efficiency Gap Analysis of the 2016 House of Representatives Election Results**

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I590 – Data Visualization

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# Introduction

Gerrymandering is “a practice intended to establish a political advantage for a particular party or group by manipulating [district boundaries](https://en.wikipedia.org/wiki/Boundary_delimitation)”.[[1]](#footnote-1) An easy way to explain gerrymandering is illustrated in Figure 1 below.[[2]](#footnote-2)

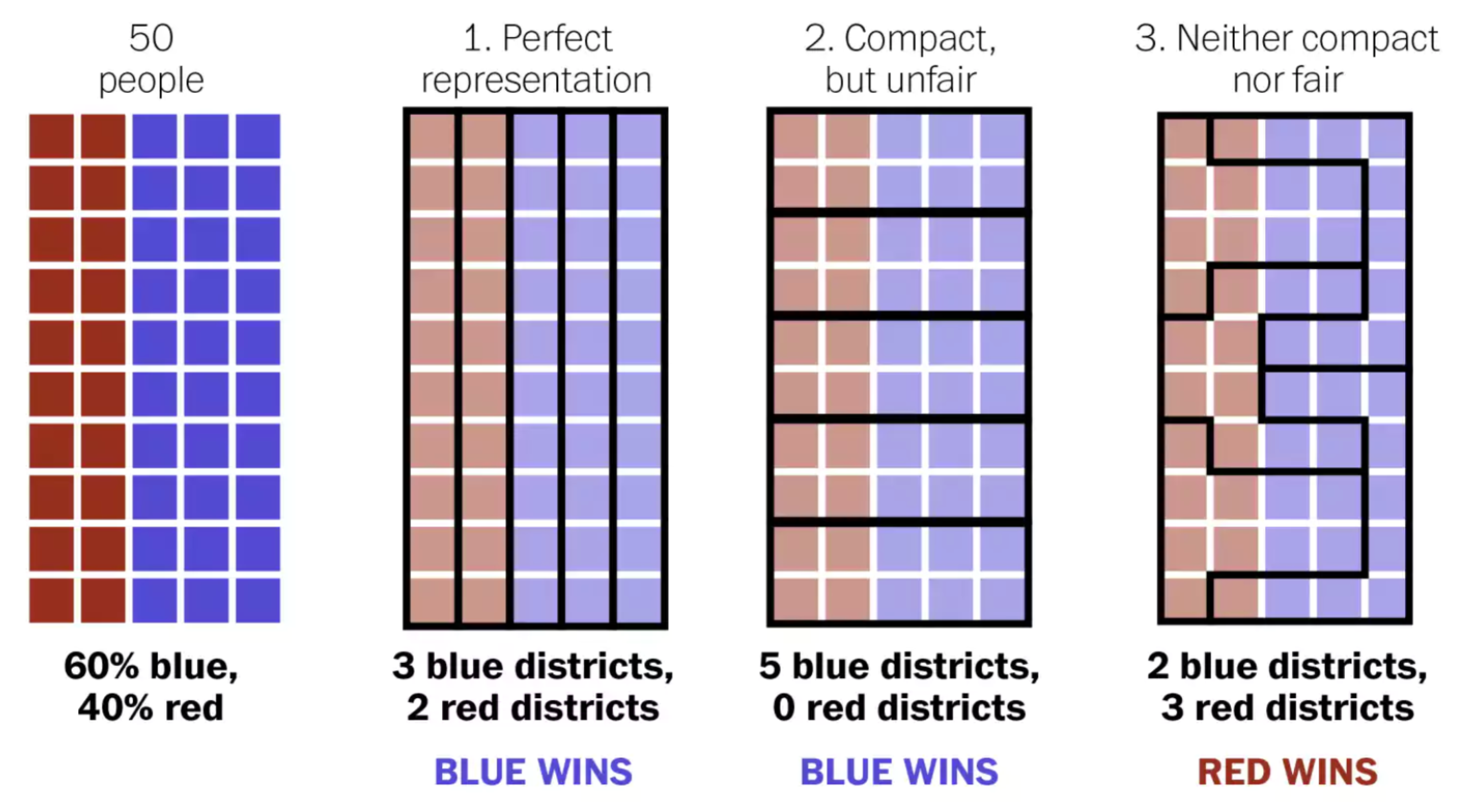


Figure 1 – The best explanation of gerrymandering you will ever see.2

The leftmost picture in Figure 1 represents a population of 50 people in a hypothetical rectangular state. Imagine this state can elect 5 representatives to the US House of Representatives, each representing 10 people. Since the proportion of red and blue voters is 2:3, a perfectly fair election would elect 2 representatives of the “red” party and 3 representatives of the “blue” party to the House of Representatives.

The grouping of voters by boundaries inside a state is called “districting”. Districts are redefined every 10 years based on census numbers, so that each district have the same population. Each electoral district in a congressional election will elect a single representative.[[3]](#footnote-3) On Figure 1, the second picture on the left shows district boundaries achieving ideal representation; the third and fourth show examples of districting that favor one or the other party, and are both unfair. The third illustration is unfair to “red” voters and the fourth is unfair to “blue” voters.

The primary motivation for our project is the identification of states where certain parties are blatantly under/over represented due to unfair districting. We will primarily use the concept of “efficiency gap” for our analysis. This concept was conceived for the specific purpose of assessing gerrymandering[[4]](#footnote-4),[[5]](#footnote-5) and is being used in the current Wisconsin gerrymandering case Gill v. Whitford.[[6]](#footnote-6),[[7]](#footnote-7)

Central to the “efficiency gap” metric is another concept called “wasted vote”. A “wasted vote” is a vote that does not contribute to win an election. So all votes for a losing candidate are “wasted” in that sense, and all votes for a winning candidate in excess of the number of votes needed to win the election are also “wasted”. The efficiency gap is calculated as “the difference between the two parties' wasted votes, divided by the total number of votes”.[[8]](#footnote-8) The metric therefore measures the percentage of votes that failed to contribute to place a party’s candidate on an electoral seat.

The issue of vote “efficiency” and “waste” can be well illustrated by the 2016 congressional election results shown in Figure 2. According to the Wikipedia infobox for the United States House of Representative Elections, 20169 Republicans received 49.1% of the popular votes while Democrats received 48%. Yet Republicans won 241 seats while Democrats only won 194; *the Republican Party was able to convert 1% more votes into 24% more seats in the congress.*

# 

Figure 2

Section from United States House of Representative Elections, 2016 Wikipedia info box[[9]](#footnote-9)

Our project delivers a visualization that provides insights into the connection between the imbalance portrayed in Figure 2 and gerrymandering, while using the efficiency gap metric as a tool to assess unfair districting. We spend considerable time contrasting efficiency gap numbers for different states. We hope that through impactful visualization that clearly highlights unfair representation in general, and gerrymandering in particular, we will raise awareness to existing districting issues, so that voters possibly become motivated to join by-partisan efforts to stop gerrymandering (such as FairVote[[10]](#footnote-10)) thus contributing to a more fair electoral system and a stronger democracy.

# Overview of Existing Work on Gerrymandering

We identified many visualizations that explain gerrymandering with play data,[[11]](#footnote-11),[[12]](#footnote-12) including the one included herein as Figure 1. There are many visualizations on the web showing maps of districts with highly irregular boundaries that clearly indicate gerrymandering, but do not include any data analysis.12,[[13]](#footnote-13),[[14]](#footnote-14) The online game “The Redistricting Game”[[15]](#footnote-15) is worth mentioning because it offers an excellent opportunity for players to understand how gerrymandering really works. In the game players engage in districting a fictitious state to achieve political advantage.

In addition to the issue of wasted votes and unfair representation that we explore on our project, there are at least two other relevant issues associated with gerrymandering. One of them is well explained in two videos featuring Governor Arnold Schwarzenegger.[[16]](#footnote-16),[[17]](#footnote-17) Governor Schwarzenegger outlines how politicians engage in gerrymandering to perpetuate themselves in the US House of Representatives, regardless of their performance. We found visualization that corroborates Mr. Schwarzenegger assertion. According to OpenSecrets.org the US House of Representatives re-election rate in the period of 1964-2016 was seldom less than 85%.[[18]](#footnote-18) Mr. Schwarzenegger created a “Crowdpac” to combat gerrymandering.[[19]](#footnote-19)

The second issue that motivated our project is related to the possible impact of gerrymandering in the perceived growing polarization of our political system.19,[[20]](#footnote-20),[[21]](#footnote-21) One possible way to approach the topic is the Cook Partisan Voting Index[[22]](#footnote-22),[[23]](#footnote-23) which measures “how strongly a United States [congressional district](https://en.wikipedia.org/wiki/Congressional_district) or [state](https://en.wikipedia.org/wiki/U.S._state) leans toward the [Democratic](https://en.wikipedia.org/wiki/Democratic_Party_%28United_States%29) or [Republican](https://en.wikipedia.org/wiki/Republican_Party_%28United_States%29) Party, compared to the nation as a whole”.22 We found one visualization that analyzes this data: The State of Gerrymandering, created by an organization called Silicon Valley Data Science.[[24]](#footnote-24) While we will not analyze polarization for this project we will likely use datasets used by the Silicon Valley Data Science in their study. This data is available in GitHub.[[25]](#footnote-25)

In addition to the above-mentioned study, three other works on gerrymandering offer great explanations of gerrymandering, and include visualizations with real data:

1. Princeton University website gerrymander.princeton.edu[[26]](#footnote-26) has many useful links, proposes a test to determine if a state has gerrymandering, and allows users to explore how gerrymandered their state is; it includes interactive visualizations; data is not available.
2. Duke University website Quantifying Gerrymandering @ Duke[[27]](#footnote-27) has many useful links, shows interactive visualization, and lists data sources.
3. Patrick Han’s block entry The Most Gerrymandered States Ranked by Efficiency Gap and Seat Advantage[[28]](#footnote-28) has many useful links and analyzes efficiency gap; data is not available.

# Project Unique Contribution

Unlike the visualizations we identified in our research, our project explores gerrymandering using a top down approach that starts from an analysis of election results at the national level, and drills down to states using number of votes needed to elect house representatives as the starting point of our analysis.

We extrapolate the common notion of “power”, defined in the Merrian-Webster dictionary as “the ability to act or produce an effect” to mean the ability to successfully elect a candidate of one’s choice.[[29]](#footnote-29) We produce visualizations to show that power is not equitably distributed across the electorate, in the sense that electors from certain parties, in different states, are able to elect their representatives with fewer votes than their opponents. At the national level, we confirm the Wikipedia infobox from Figure 2; in the whole, in the 2016 House of Representative elections, Republican electors had more power than Democrat electors.

We believe our approach provides a context in which to analyze gerrymandering that is useful because it highlights how this practice contributes to a larger issue. In fact, if we agree with the Declaration of Independence that “all men are created equal”[[30]](#footnote-30) there is no reason we should accept that certain electors possess more power than others. (Power in the sense we discussed above). So, redistricting that risks creating an imbalance of electoral power is immoral, whether unlawful or not. We believe the flow of our visualizations provide new insights into the issues of electoral power and representation associated with gerrymandering.

# Data

Project data was scraped from the New York Times (NYT) House Election Results: G.O.P Keeps Control webpage,[[31]](#footnote-31) seen in Figure 3 below. Election results data at state district level is stored in a single variable in the html code, in JSON format, so it was relatively straightforward to parse the file to obtain election results data, and create the raw dataset for the project.

Pre-processing included many clean up steps and a large number of aggregations and summarizations to allow visualization programs to retrieve data directly with minimal to no need for additional data processing. The NYT data source did not contain vote counts for the many uncontested wins in the 2016 election.

An uncontested win is one in which one of the following scenarios happen:

1. Only the winning candidate receives all votes
2. The winning candidate has not opponents
3. Candidate(s) other than the winning candidate do not appear on the ballot (write-ins)

Votes for uncontested wins were imputed as the average number of votes per district for the given state of the winning candidate. We plan to find, and load real data for uncontested wins in a future release of the project, if time permits.

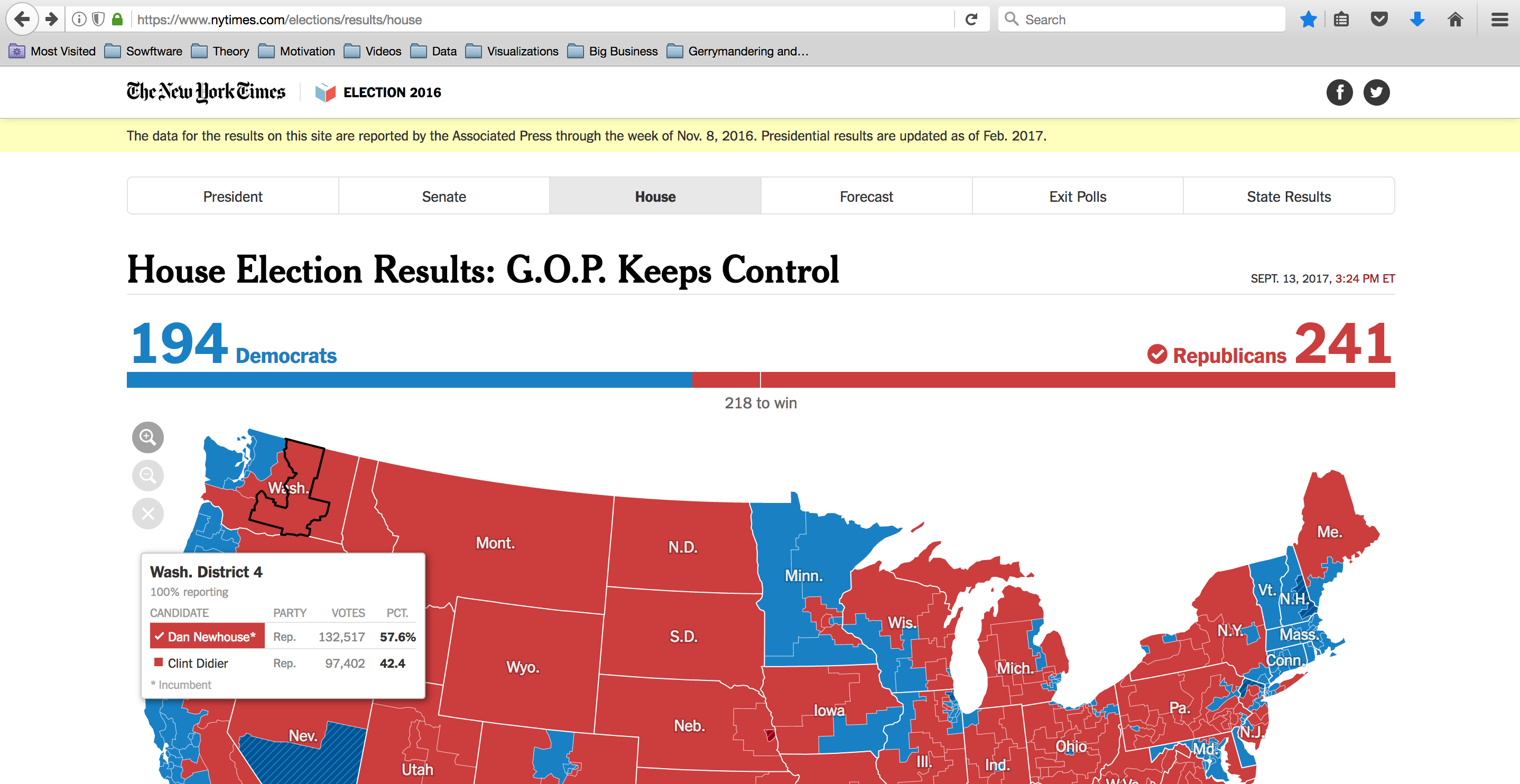


Figure 3

New York Times webpage “House Election Results: G.O.P. Keeps Control”31

# Methods: Ideas, Sketches, Prototypes

To illustrate initial visualization ideas for the project, we initially explored examples of efficiency gap on paper, using Figure 1 from the introduction. Below we show one example of such explorations. The calculations are based on Eric Petry’s explanation of the efficiency gap in the article How the Efficiency Gap Works.[[32]](#footnote-32)

Example: Heavy gerrymandering, high irregular district boundaries. From Figure 1, 3nd scenario; assumes districts are numbered top to bottom, left to right.

|  | **Red Votes** | **Blue Votes** | **Wasted Red** | **Wasted Blue** | **Net Wasted** |
| --- | --- | --- | --- | --- | --- |
| District 1 | 6 | 4 | 0 | 4 | 4 Blue |
| District 2 | 6 | 4 | 0 | 4 | 4 Blue |
| District 3 | 6 | 4 | 0 | 4 | 4 Blue |
| District 4 | 1 | 9 | 1 | 3 | 2 Blue |
| District 5 | 1 | 9 | 1 | 3 | 2 Blue |
| Totals | 20 | 30 | 2 | 18 | 16 Blue |

Net 16 blue votes wasted / 50 total votes = 32% efficiency gap favoring red voters

After creating the dataset for the project, we were naturally drawn to pursue a top down approach starting with issues of representation at the national level, as illustrated in Figure 2. Later, due to some unsuccessful visualizations we further realized that gerrymandering and the efficiency gap only make sense under certain circumstances; only when the proportion of votes for a party exceeds the proportion of seats won by a full whole numbers does it make sense to consider the efficiency gap. In other words, unless a party has enough votes in the state to elect at least one more candidate, redistricting to benefit the loosing part wouldn’t grant the party an extra seat anyway.

Analysis of wasted votes was another idea we pursued and abandoned. Figure 4 shows is a visualization we will not use in the final project because wasted votes need to be considered in context and we did not find a good context yet in which to present this metric.

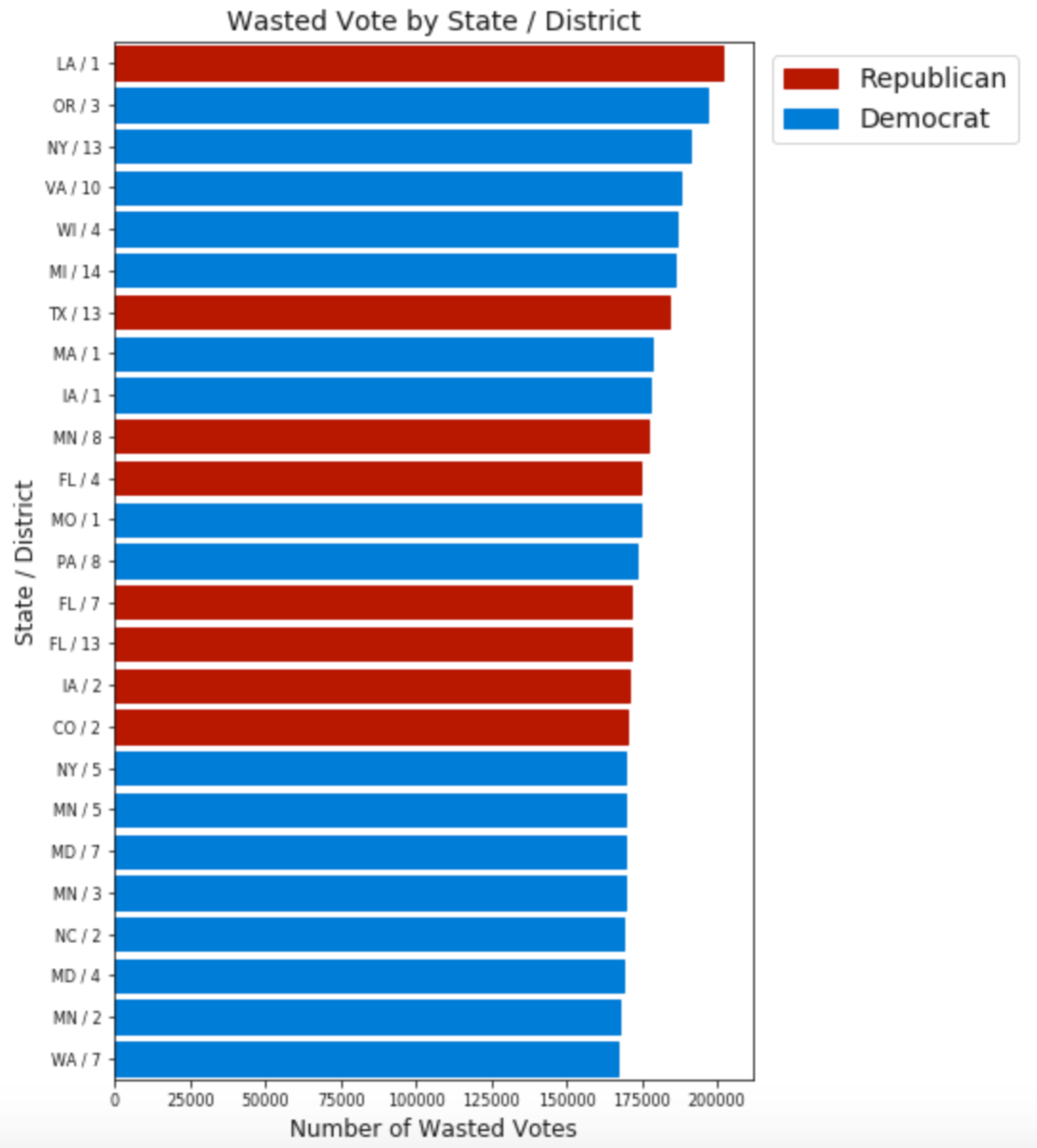


Figure 4 – Abandoned visualization showing wasted votes per state / district

These are initial plot ideas we considered. Some of them were selected.

1. Efficiency gap by state (bar chart or heat map with tabular data)
2. Districts with highest relative number of wasted votes (same as above)
3. Seats lost due to districting, by state (percentage of votes vs. percentage of seats)
4. Seats gained due to districting, by state (same as above)

These were ideas for iterative capabilities put forth at the beginning of the project:

1. Allow user to generate plot(s) by first selecting a state
2. Allow user to generate plot(s) by first select top/bottom states on a particular metric
3. Allow user to generate plot(s) that display total for entire country
4. Add links to the plots so user can jump to Congressperson’s webpage
5. Add links to organizations that are fighting gerrymandering
6. Add links to pages that educate on the subject

We are still considering implementing an interactive visualization, if time permits. In the results section of this document we will describe how we envision the interactive visualization could work.

The following research questions and working hypotheses were put forth at the onset of our project:

1. Are wasted votes a good indicator of gerrymandering?
2. Is the efficiency a gap good indicator of gerrymandering?

We expected that yes; both wasted votes and efficiency gaps would be good indicators of gerrymandering. At this point we believe neither is *per se* a good indicator of gerrymandering and we decided to not focus on wasted votes, since wasted votes are included in the formula to calculate gerrymandering. By contextualizing the efficiency gap properly we believe it is a good indicator of gerrymandering.

At the proposal phase of the project we planned to confirm our findings by analyzing the shape of the districts in the states where the efficiency gap suggests gerrymandering is occurring. This verification will be performed manually at this first phase of the project, i.e., by searching online for the state and district maps. In the results section of this document we describe our findings analyzing maps based on efficiency gap numbers.

# Methods: Visualization methods selection

We mostly analyze categorical data that primarily falls into 3 categories (the “parties”[[33]](#footnote-33)) and secondarily can be grouped by State (52 categories) or State and District (there were 435 districts at play in the 2016 election). We selected bar charts as the natural choice to compare numbers of votes across these categories.

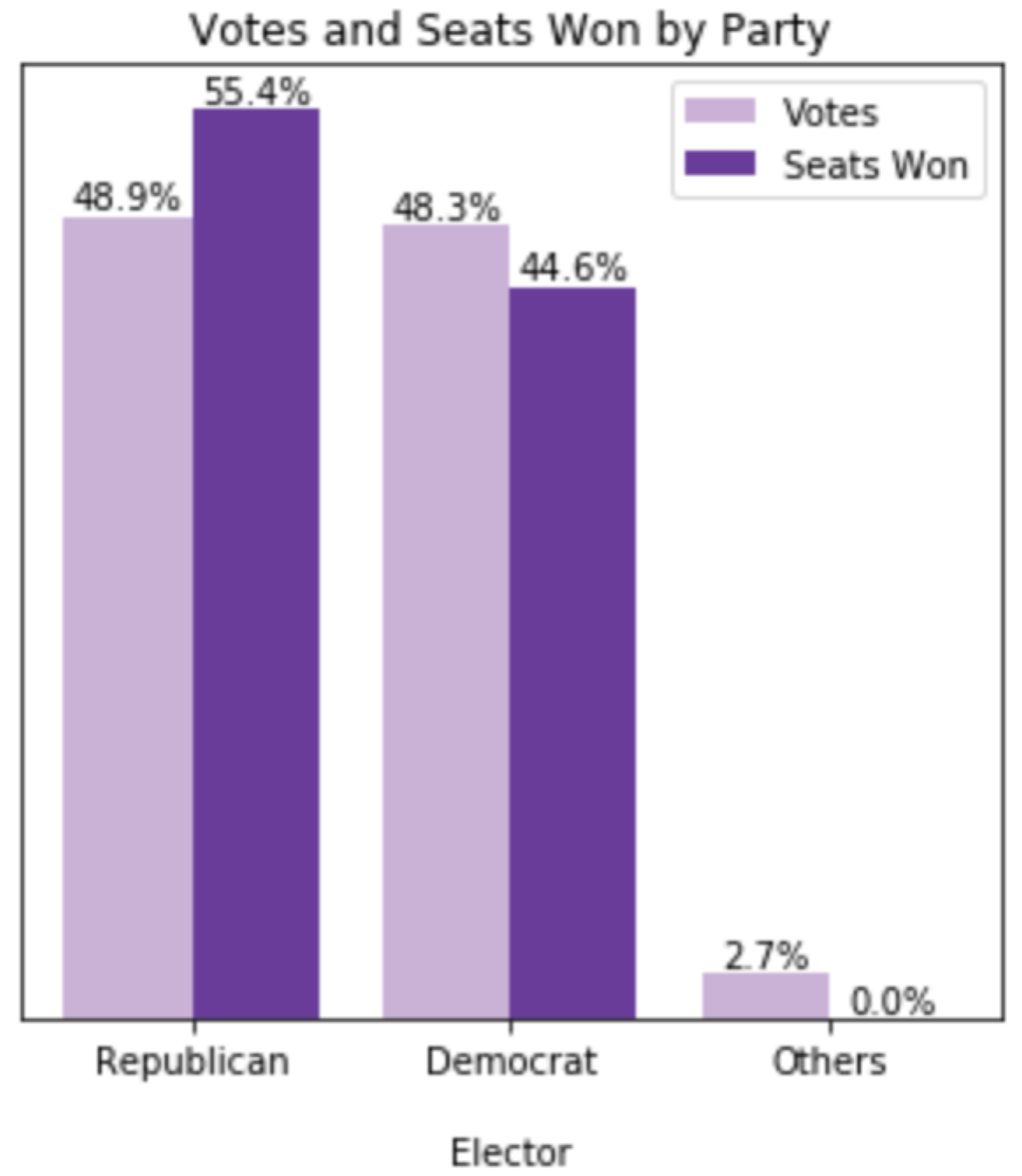
We selected a top-down approach to visualize gerrymandering, starting with US number of votes vs. seats won, and drilling down to states. We developed a series of questions to guide the visualization and tell a story that shows where gerrymandering is at play, where it is not, when the efficiency gap metric works well as measure of gerrymandering, and when it doesn’t. We summarize our findings in the conclusion of our report.

Based on our experience analyzing the election results data using Jupyter Notebook and interacting with the various visualization programs we developed, we can envision an interactive webpage that would allow users to explore issues of representation in general and gerrymandering in particular. In the conclusion section of the document we offer some details of a future interactive visualization.

# Results

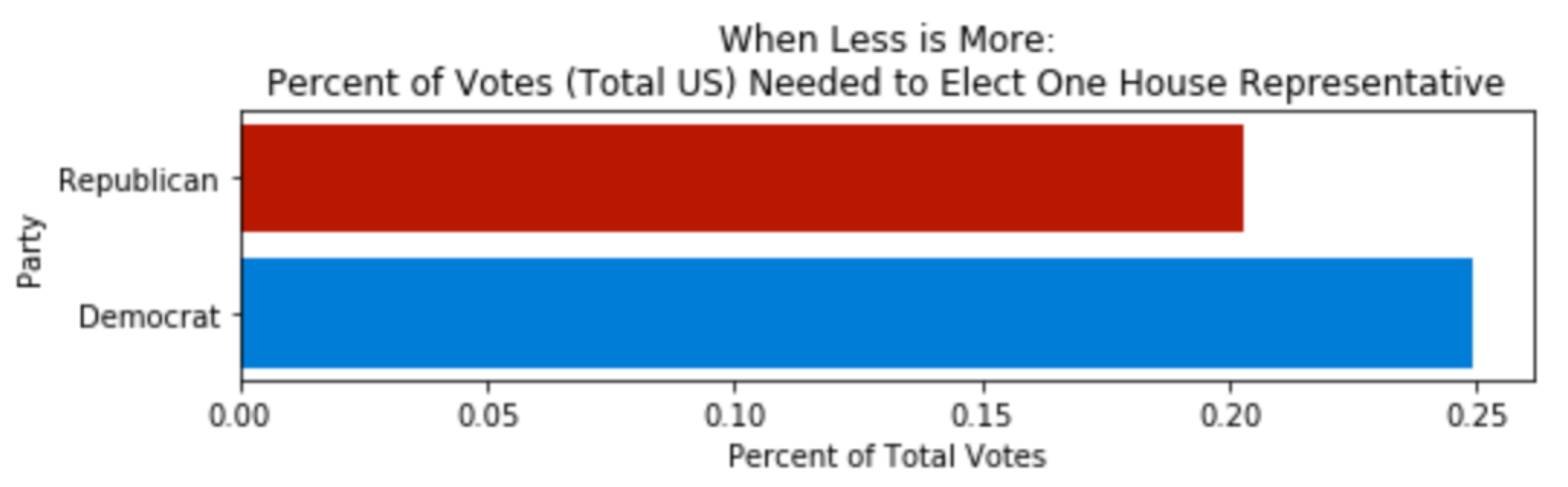
Questions 1 – Where did the votes go?

Republicans electors casted about 1% more votes than democrats in the 2016 House of Representatives election. Yet, they were able to elect about 24% more candidates than democrats.



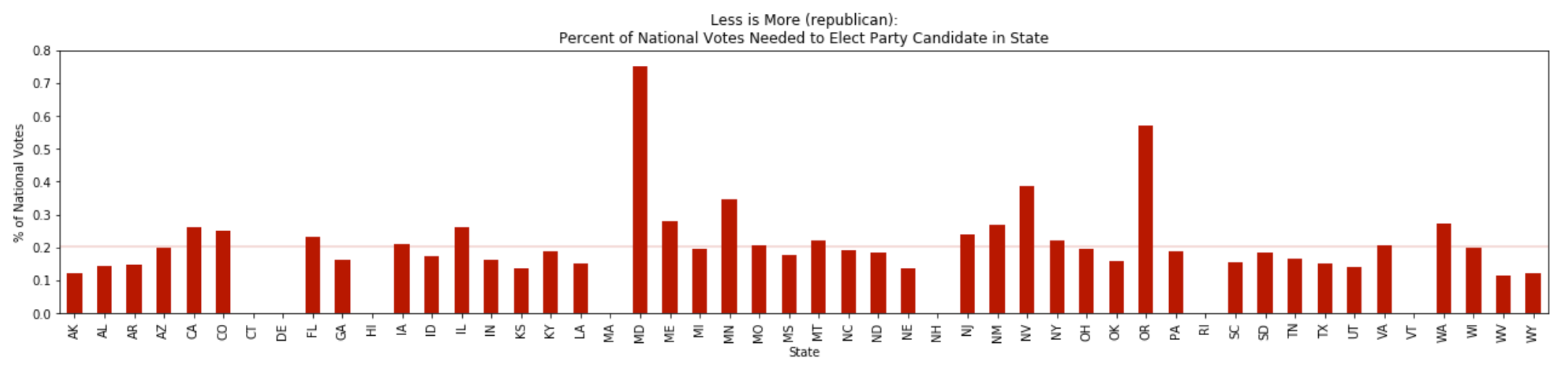
Question 2: Do republican electors have more power?

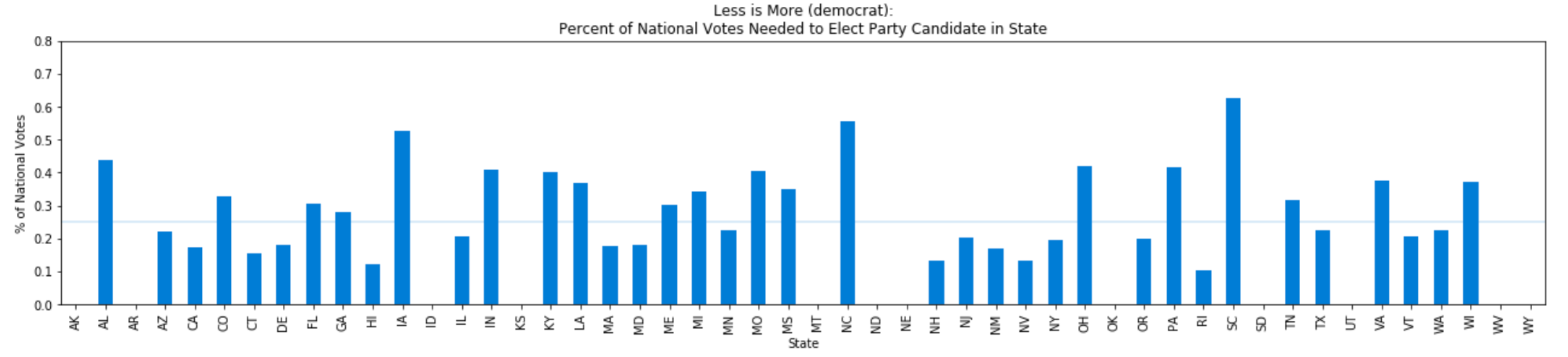
Power is defined by the Merriam-Webster as the "ability to act or produce an effect".29 On average, it took roughly 20% more Democrat electors to win a seat for a Democrat candidate, than it took Republican electors to elect a Republican candidate. In that sense, Republican electors had more power in the 2016 House of Representative elections. The next plot “More is less” shows that *more votes* to elect a candidate means *less power*.



Question 3: How do state and national numbers compare?

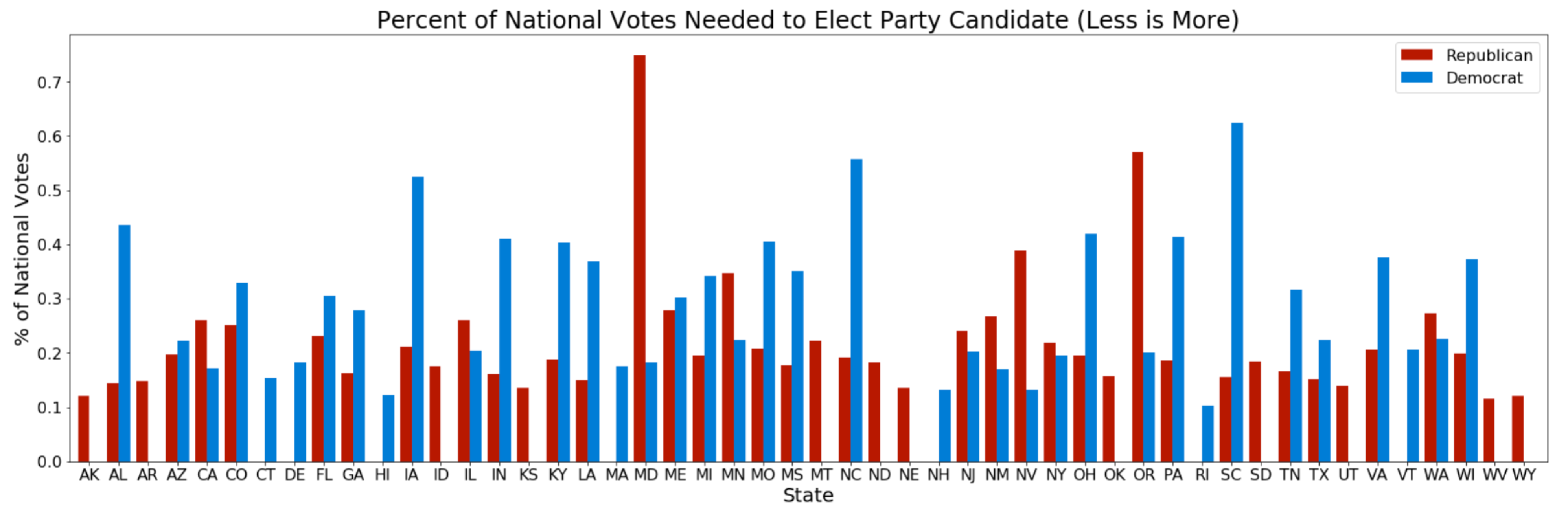
Numbers at the state level reveal even more strikingly that Democrat electors needed more votes on average to elect their representatives to the House of Representatives than did Republican electors. The horizontal lines on the graphs below show the national average votes needed to elect a candidate of each party.





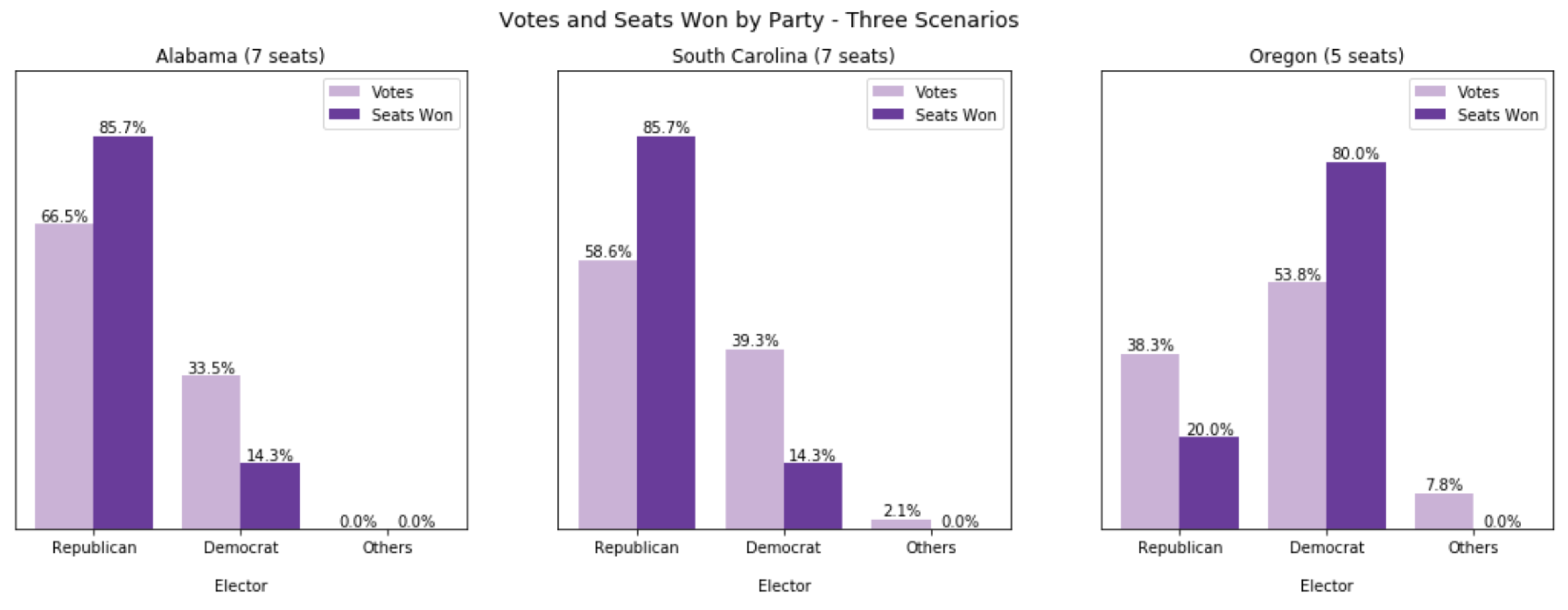
Question 4: How do party numbers compare at the state level?

The problem we saw with Democratic electors needing to cast more votes to elect their candidates is exacerbated when we look at numbers at the state level. Clearly democrats were disadvantaged in more states, and often in a more significant way.



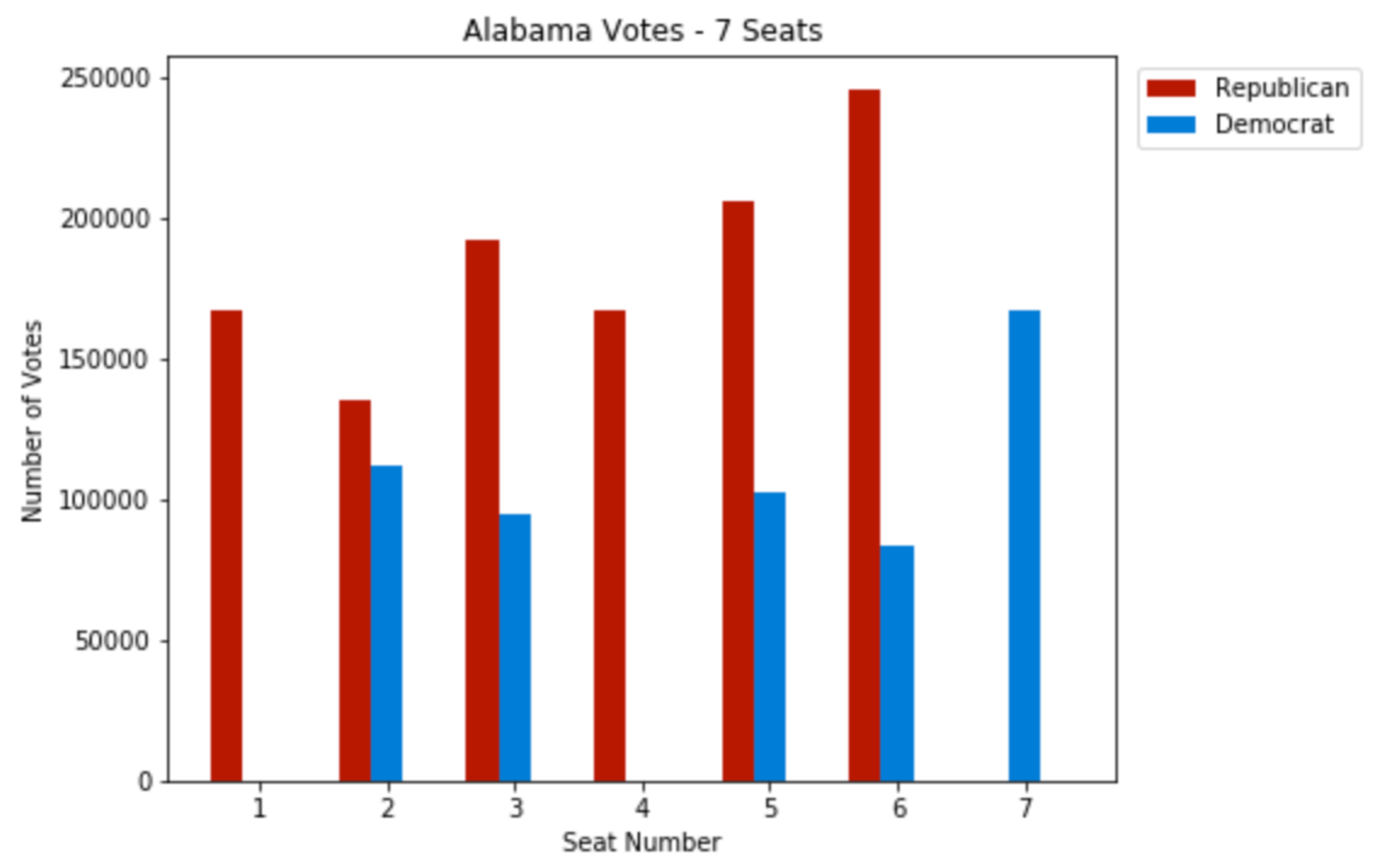
Question 5: How are votes cast on states where a party has extreme advantage?

By looking at the previous plot, we can identify many states where one of the two parties appears to have substantially more power. We now analyze 3 of them: Alabama, where Republicans have more power, and Maryland and Oregon, where Democrats have more power.



Alabama

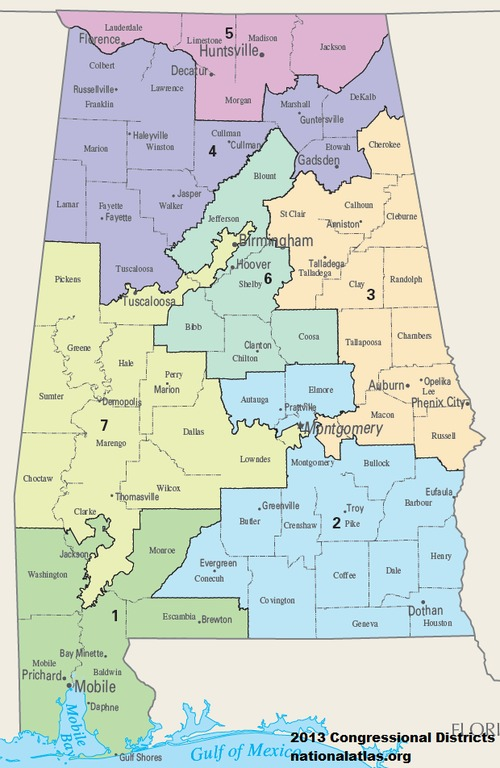
Below we show the election results for Alabama at the district level.



There are two strategies to gerrymander a state. The first one is to draw district lines to dilute the votes of one party across many districts, so the unfavoured party will win no seats or fewer seats – that is called “cracking”[[34]](#footnote-34). The second strategy is to concentrate votes of a party in a few districts, where that party will then win in a landslide, leaving other districts up for easy wins to the opposing party – that is called “packing”.

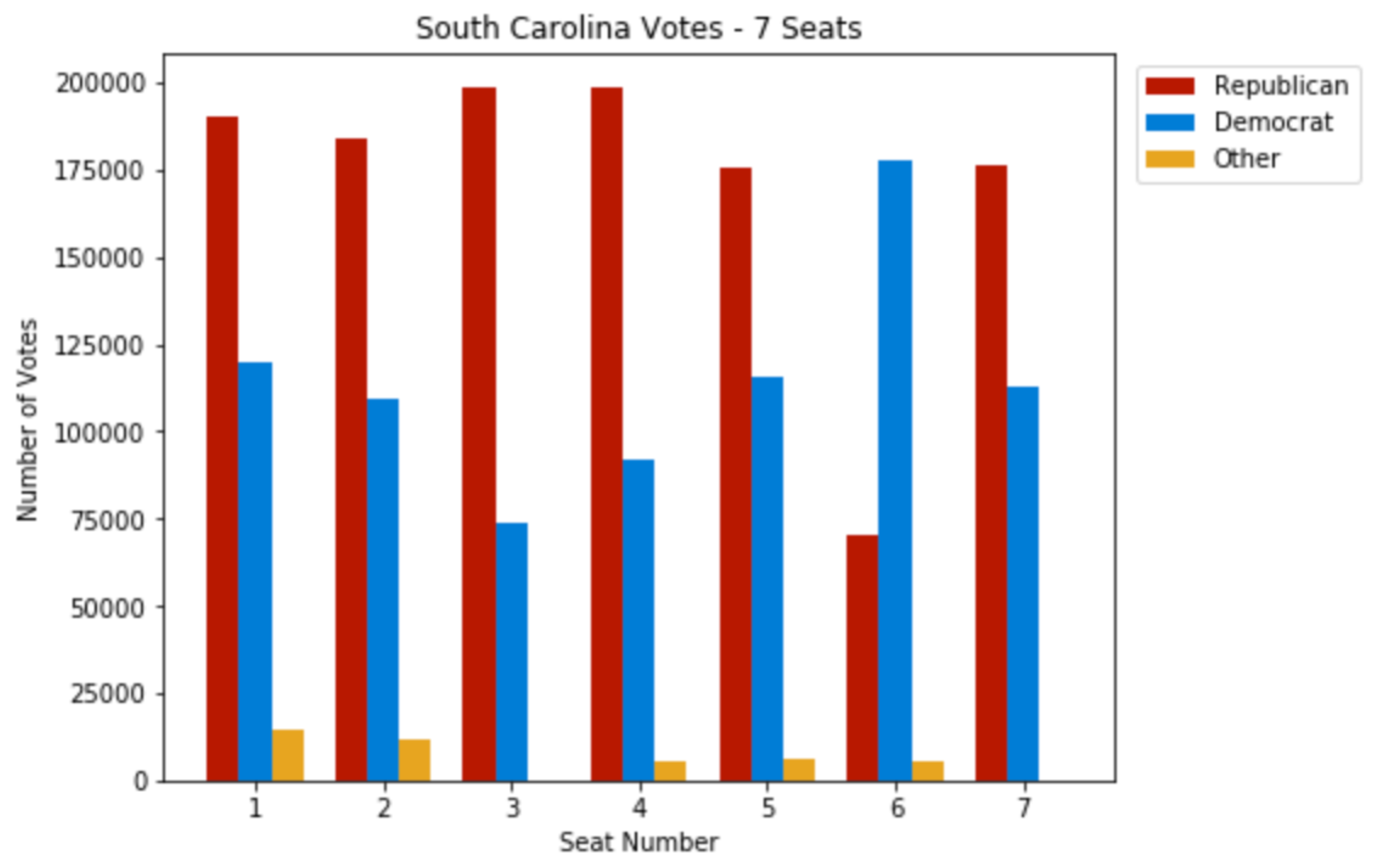
Both “cracking” and “packing” appear to be at play in Alabama. If districts 2 and 3 are adjacent, it is conceivable that district lines were intentionally drawn to split (“crack”) blue votes. If district 7 is close to district 5, it is conceivable that district lines were intentionally drawn to isolate blue votes in district 7, ensuring a red win in district 5 (“packing”).

The district map for Alabama is shown next (source wikipedia[[35]](#footnote-35)). Note the wiggly shape of the district lines.

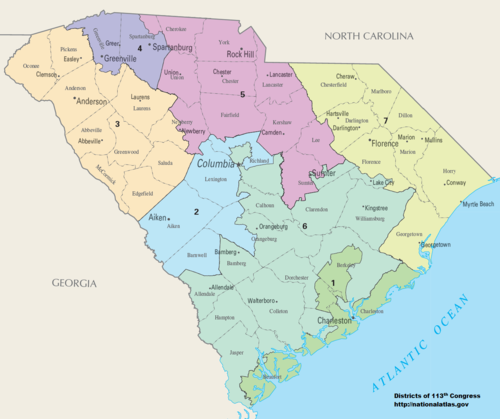


South Carolina

Below we show the election results for South Carolina at the district level.

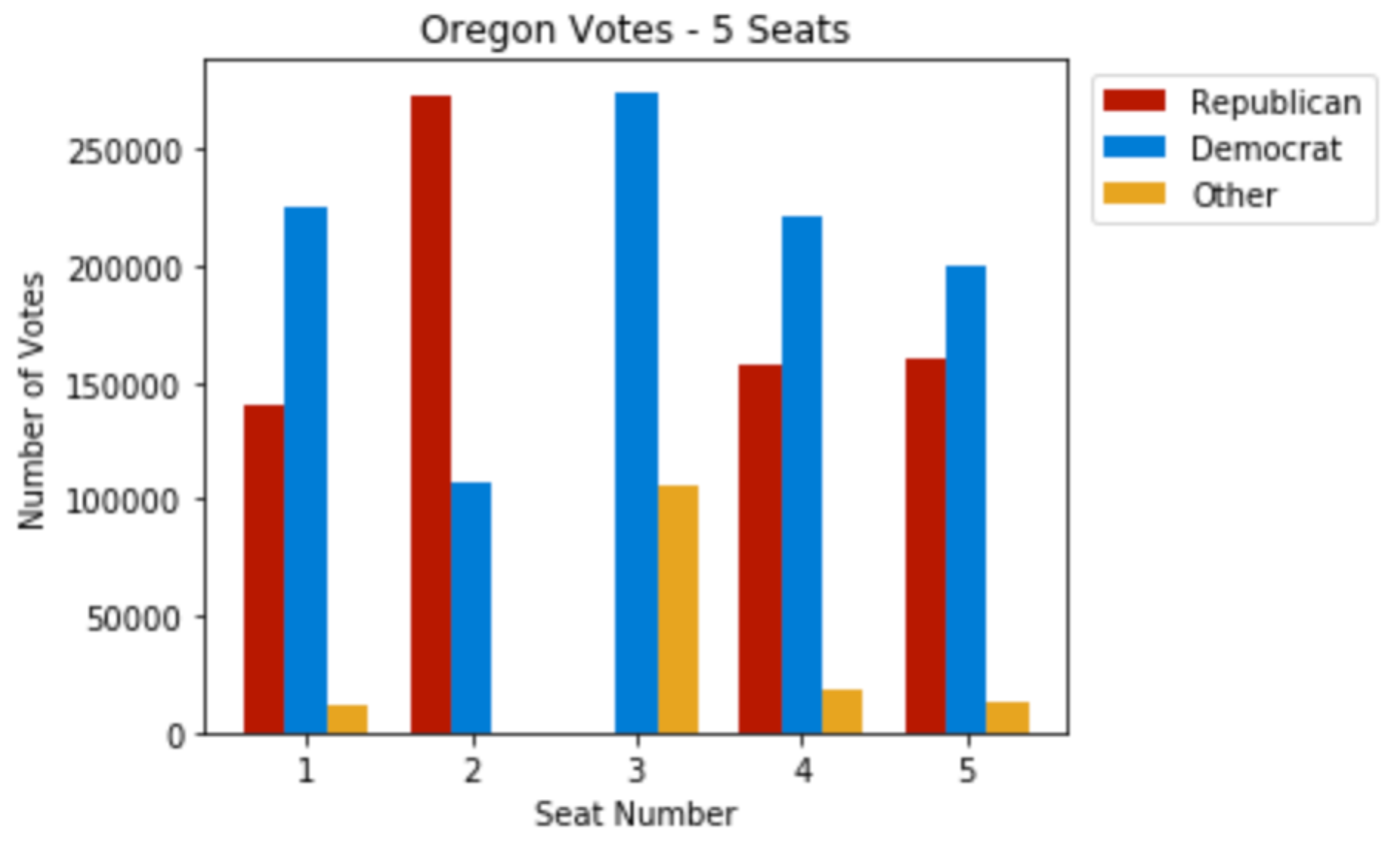


Gerrymandering appears to be happening in South Carolina, specifically “cracking”, since many blue votes we see on the plot are spread across several districts that are likely adjacent. The district map for the state below35 confirms what the plot suggests for districts 5 and 7. Packing of blue votes in district 6 favors red win in district 1. Note the wiggly shape of district lines delineating districts 1, 2 and 6.

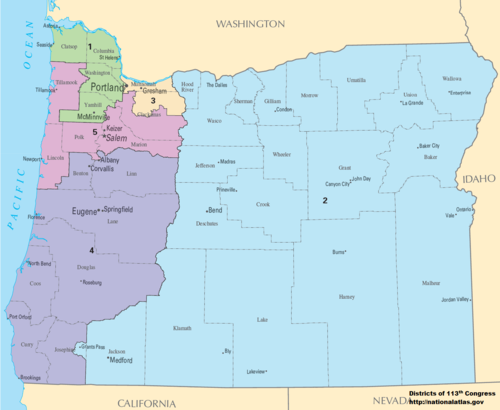


Oregon

Below we show the election results for Oregon at the district level.



Unlike Alabama and South Carolina, Oregon shows a strong presence of a third party. The presence of a third party exacerbates the imbalance of power between red and blue voters that we see in the plot from question 3. Still, red votes are diluted across districts 1, 4 and 5, which are adjacent per the Oregon district map below.35



Would it be fair to move district boundaries for districts 1, 4 and 5 to make red votes more competitive? We don’t think so. An operating assumption that drives the motivation to eliminate gerrymandering is the realization that election results are unfair. But if we look at Oregon election numbers, the proportion of seats won by Republicans and Democrats was 1:4. Even though red votes are diluted across districts 1, 4 and 5, and even though red votes appear to be concentrated in district 2, together their proportion to blue votes is less than 2:3. Therefore the election results in Oregon can be deemed fair.

Question 6: Can the efficiency gap help identify gerrymandering?

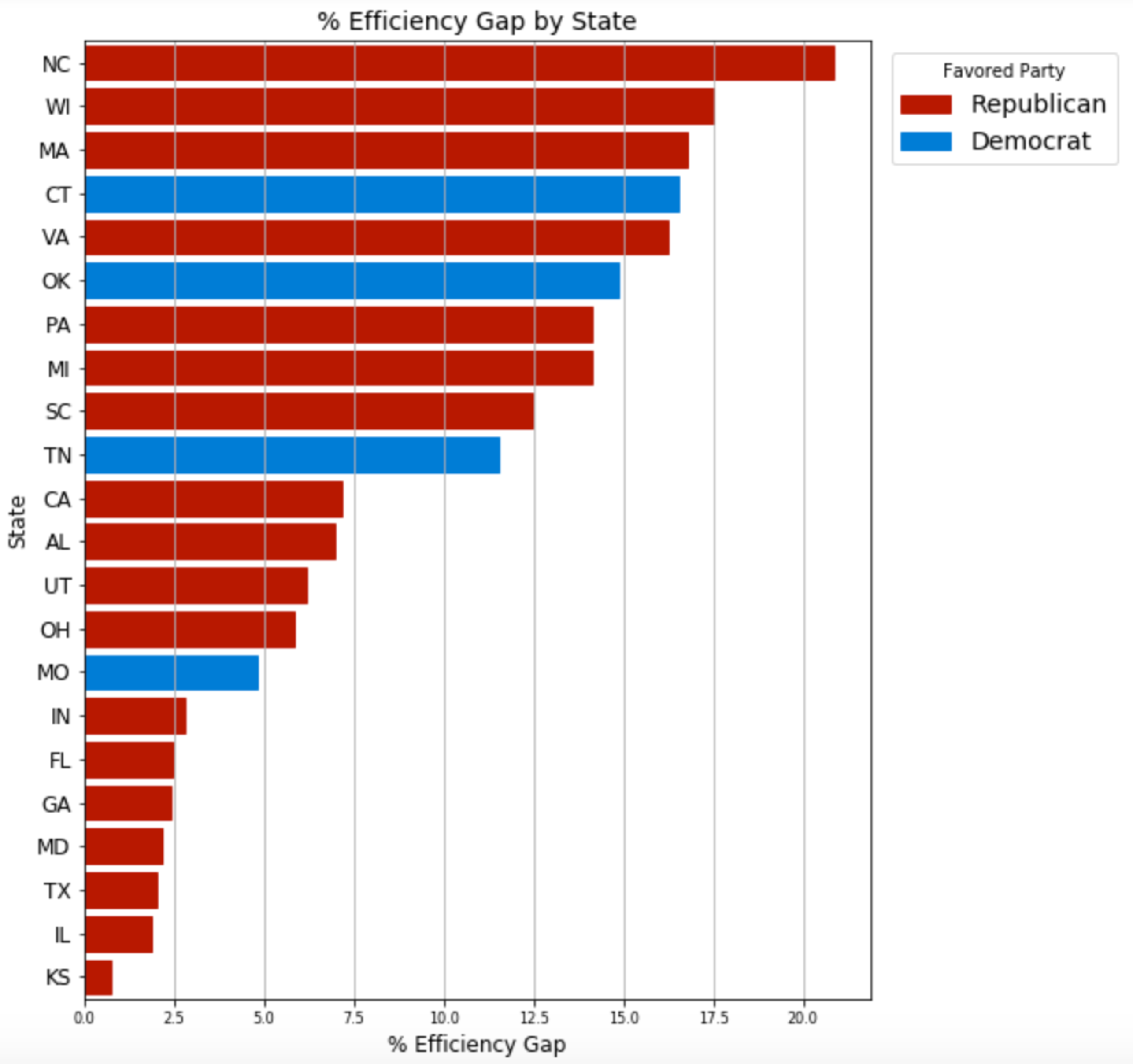
The efficiency gag is calculated as the “the difference between the two parties' wasted votes, divided by the total number of votes”.[[36]](#footnote-36) The calculation of wasted votes is not straightforward if there are more than 2 parties participating in the election. This is how we calculated wasted votes on this project:

* For districts with one uncontested candidate
  + All votes from winner beyond simple majority are considered wasted votes.
* For districts with two candidates:
  + All votes from losing candidate are considered wasted votes.
  + All votes from winner beyond simple majority are considered wasted votes.
* For districts with more than two candidates:
  + All votes from losing candidates are considered wasted votes.
  + All votes from winner beyond second most voted candidate plus 1, are considered wasted votes.

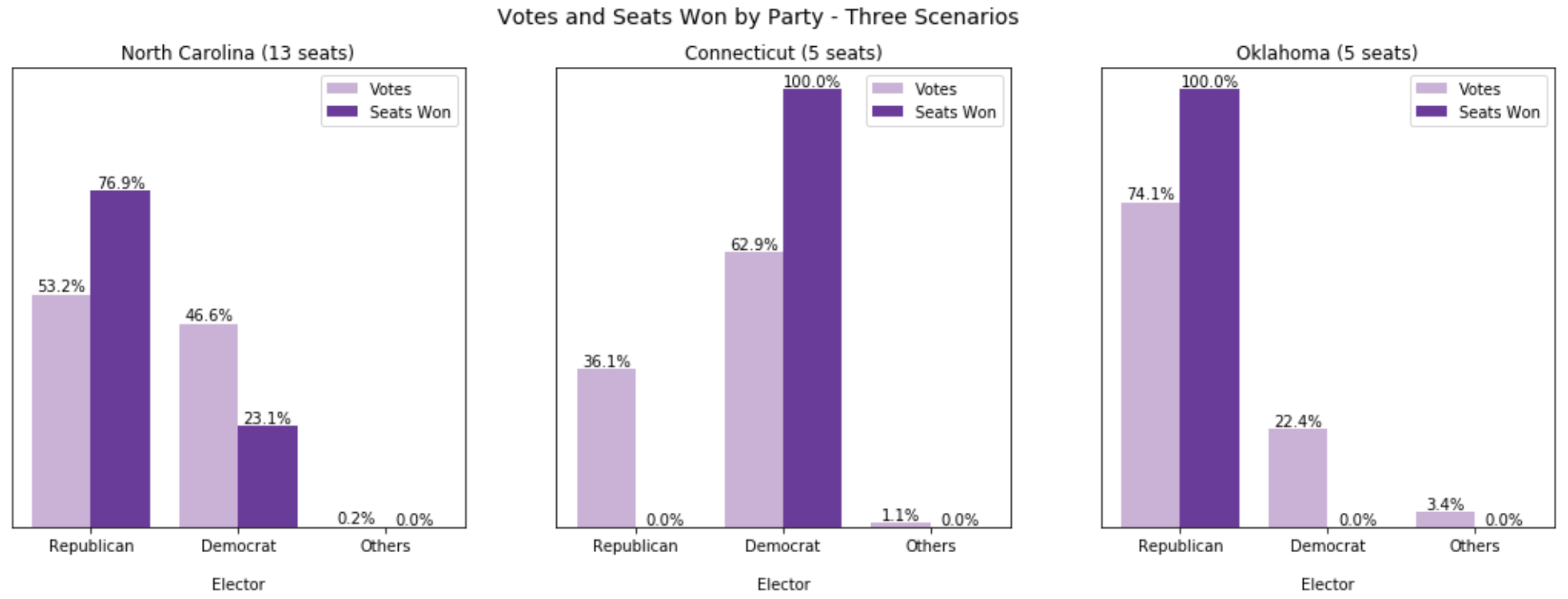
Note that many states are naturally not included in the gerrymandering analysis. All states with a single district are excluded, since gerrymandering doesn't apply when a state only has one seat to fill. Additionally, all states that have a proportion of red vs. blue votes that is not large enough to justify an additional seat are excluded as well. That was the Oregon case we discussed in the previous question.

Below is the plot showing the efficiency gap, by state, for the 2016 US House of Representatives election. As expected, Alabama appears on the list with value close to 7.5%. So does South Carolina, with a much higher efficiency gap of 12.5%. We will analyze a few different states to confirm the efficiency gap is an effective tool to assess gerrymandering.

Efficiency Gap by State

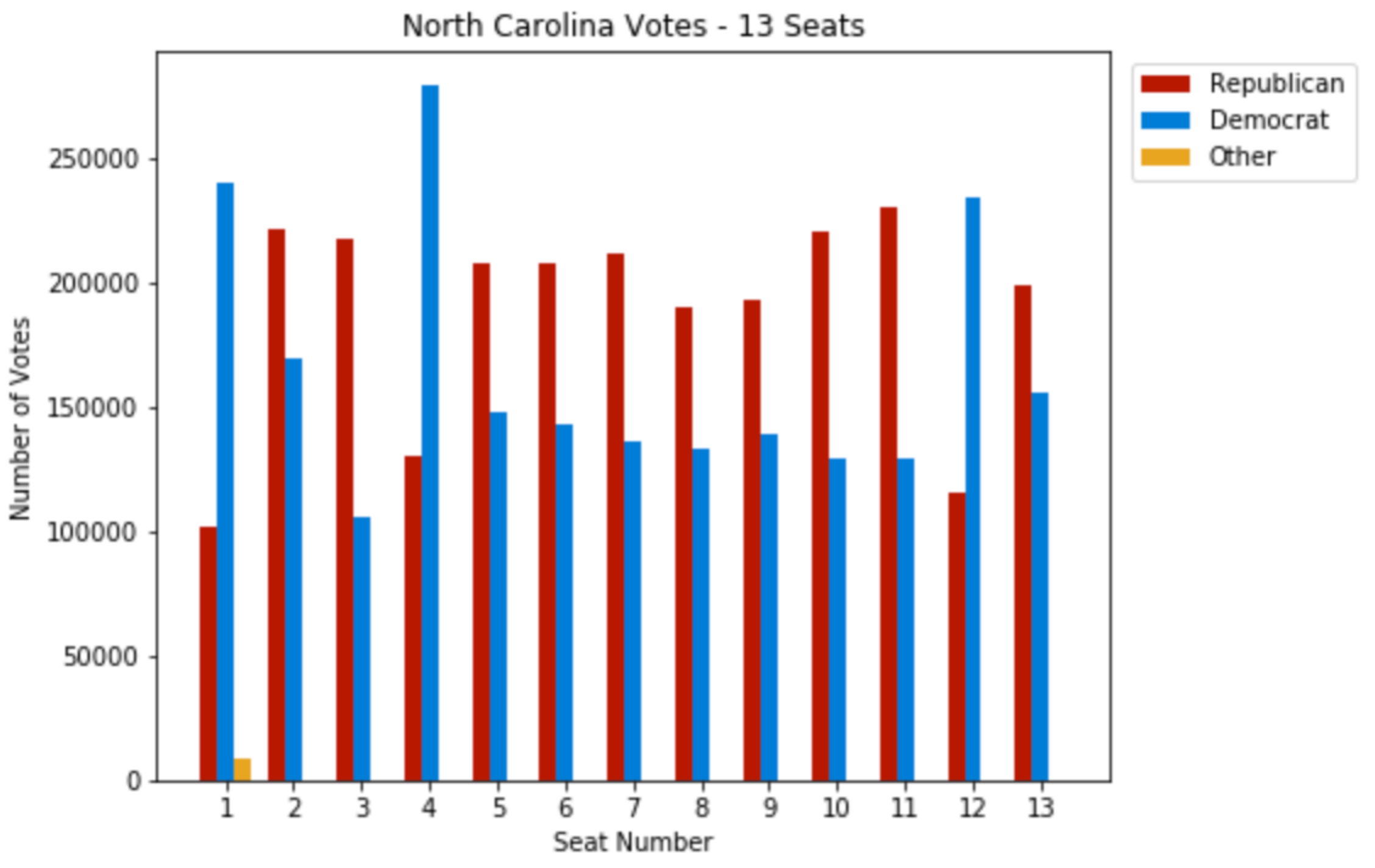


We will analyze North Carolina, Connecticut and Oklahoma.



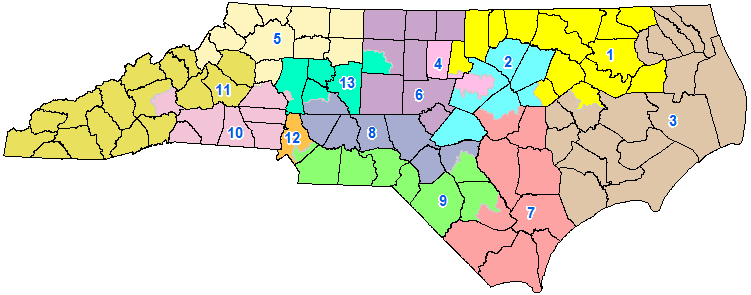
North Carolina:

Below we show the election results for North Carolina at the district level.



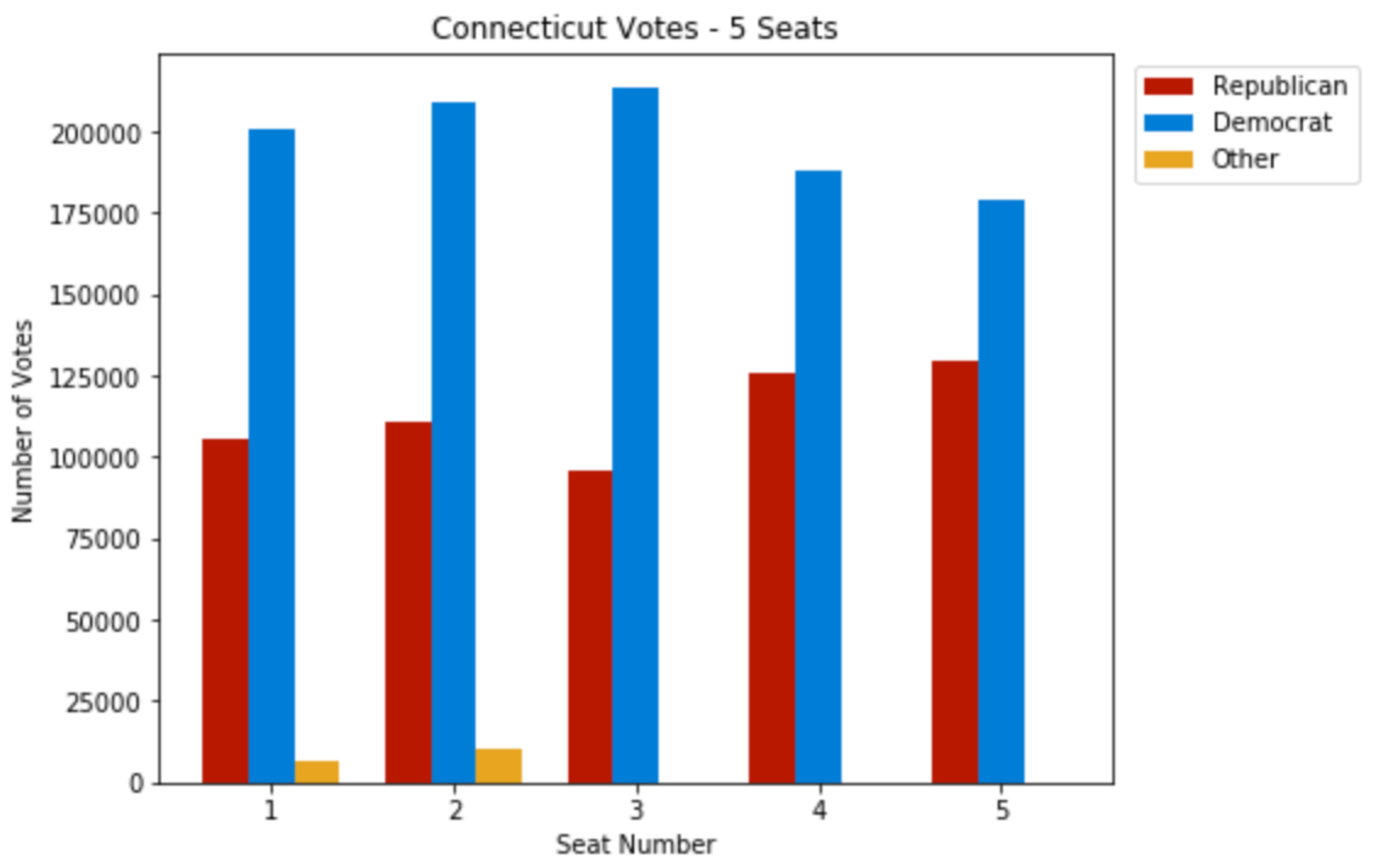
We see three relatively easy blue wins for districts 1, 4 and 12, and several relatively close blue losses across several districts, indicating possible gerrymandering through both cracking and packing. The district map in the next page allow for further analysis.

North Carolina district map:



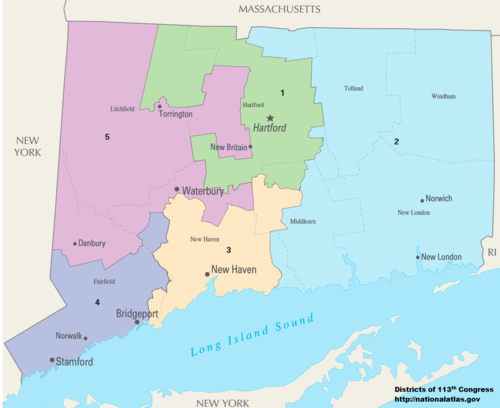
Connecticut:

Below we show the election results for Connecticut at the district level.



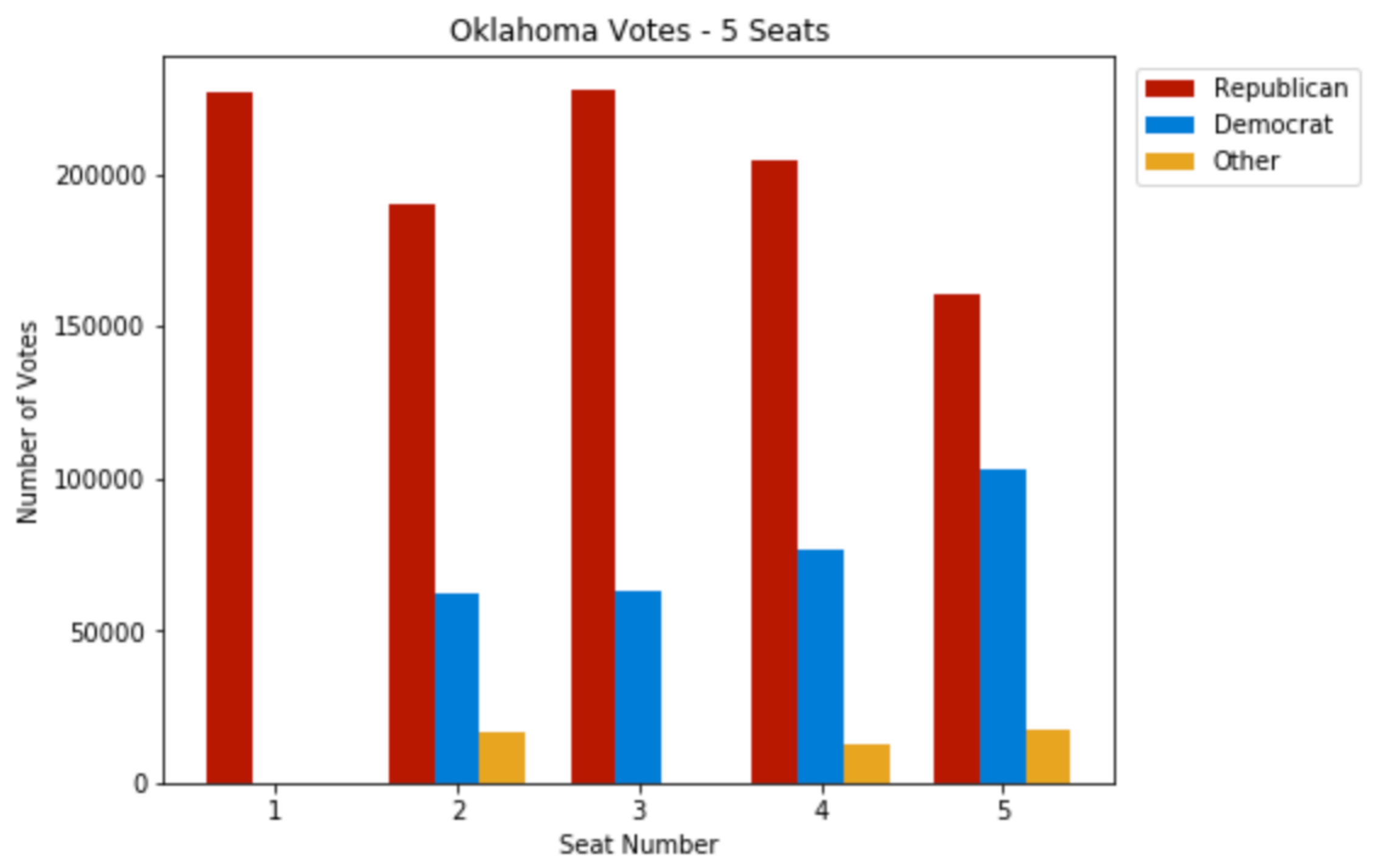
Clearly, red vote dispersion indicates the possibility of gerrymandering. The district map for the state is show next. District 5 encroaching boundaries appear suspicious.

Connecticut district map:



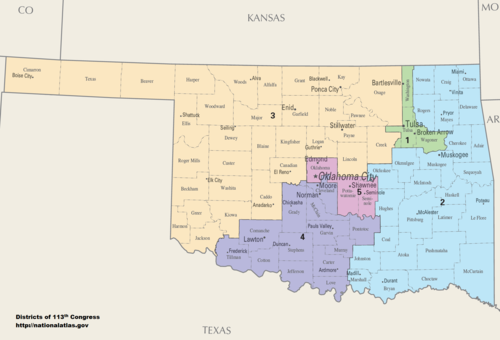
Oklahoma:

Below we show the election results for Oklahoma at the district level.



This state demonstrates the limitations of the efficiency gap metric. Note that the efficiency gap shows the Democratic Party as favored but Democrats did not win a single seat, so it couldn’t have benefited from gerrymandering. It does appear that blue votes were diverted from district 5 to facilitate a red win in that district. However, the number of red wasted votes was higher than the number of blue votes overall, so the efficiency gap calculation show democrats as benefiting from gerrymandering.

Oklahoma district map:



Conclusions

TODO – EXPAND

Gerrymandering is one of the factors causing representation imbalances in the US House of Representatives.

When comparing balance of power between republican and democrat electors, it is important to consider whether a third party is involved (Oregon case)

The efficiency gap is not always an effective way to assess gerrymandering (Oklahoma case)

What is happening in Maryland? We need to explore further why Maryland shows such a huge imbalance of power in Question 3 and yet doesn’t appear in the efficiency gap plot. Is that due to another limitation of the efficiency gap, and if so what?

Our top-down approach reveals a workable design for an interactive visualization: 2 fixed plots (plots from questions 1 and 2). A “menu” plot (question 4 plot) that will invite to users to click on any state to see 1) the “purple” plot for the state, showing votes vs seats won 2) the election results at district level plot and 3) the district map for the state. Possible additions: explanatory text for each state (52 explanatory texts) and highlights on wiggly district boundaries (that seems hard!)

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