

Sean Higgins
Dr. Gregory Matthews
Modeling and Simulation
Due: 12/09/20

Maine Rank Choice Voting Systems

Introduction:

Maine has been a progressive leader in exploring alternative voting systems used in primary and federal elections. First used in 2018, rank choice voting enables voters to select a preference in candidates in which one candidate must receive a majority of the vote, and if no candidate has more than fifty-percent plus one of the votes, then the votes are tabulated in rounds with the lowest-ranked candidates eliminated each round until one candidate is declared the winner[1]. This is the first time in the United States voters will use rank choice voting to elect the next U.S. President, though Maine's rank choice voting was used in 2018 where it was significant in the victory of a Democratic Representative over the Republican incumbent[2]. Supporters of rank choice voting lobbied for its implementation in Maine after the state elected the Governor twice without the total votes surpassing a majority[2], however Maine's Supreme Court issued the unanimous advisory opinion concluding the state's constitution requires winners of general election of State Representatives, State Senators, and the Governor be decided by a plurality[1]. Opponents say rank choice voting is too confusing and violates the 'one person, one vote' principle; the Republican Party of Maine sued unsuccessfully to try and stop the use of rank choice voting in the U.S. Presidential election[2], and Susan Collins joined others in her party to criticize the voting method, saying, in her specific race, her opponent Sara Gideon would be at an advantage because another progressive candidate had the biggest share of independent support[3]. In 2020, the two races on Maine's ballot to use the rank choice voting method, U.S. Senate and U.S. President, resulted in all winning candidates receiving a majority of the votes: U.S. Sen. Susan Collins, President-Elect Joe Biden statewide and in 1st Congressional District and President Trump in the 2nd Congressional District, so there were no runoffs to analyze or change the results of those elections[3].

The rules of rank choice voting can differ, but Maine has tried to simplify their approach to make the transition easiest for voters. To briefly go through the rules: first voters rank the candidates for a given office by preference (allowing the voter to choose 1-n candidates) and does require voters to choose all candidates, second the votes are counted and either a candidate is declared the winner by receiving a majority of the vote or the election goes into a runoff, third if no candidates win outright then the candidate with the fewest votes is eliminated, fourth all first-preference votes for any eliminated candidates are replaced by the next highest preference if one exists, fifth the process jumps back to the second step and repeats until a winner is declared.

Following, I will analyze the results of experiments that focus on the margin of victory, number of runoffs, and number of times the favorite candidate wins when changing four different characteristics of the election: rank choice voting vs. common election, required preference vs. not required preference, variable number of candidates, and variable turnout percentage. Finally I run each of those four experiments twice, one with candidate polling weights that have a larger margin between top two candidates and one with the weights that have a smaller margin between the top two candidates, to analyze the effects on the closeness of the election.

Methods:

To simulate rank choice voting, first create a randomly weighted vote population to try and accurately reflect votes based on arbitrary polling percentages. Then with that full population, drop a random percentage of votes to represent voters that did not turnout to the polls. With this leftover pile of votes, count them and begin the rank choice voting rules. To do this, I have a rankChoice() function that takes the counted votes, determines if there is a winner, and then the runoff() function is called if no winner; the runoff() function gets the next candidate to be eliminated, updates and counts the votes, then calls the rankChoice() function to loop back through the rules until a winner is declared.

Next I ran eight experiments, each n=1000 times, and analyzed the results. For each experiment, I looped over n times and for each iteration created a RankChoice() instance based on the configuration parameters; out of the parameters(see appendix code), I only changed the random seed during each iteration. There is a results data frame that collects data from each iteration, primarily number of runoffs, margin of victory as the number of votes, margin of victory percentage as a percentage, and number of times the favorite candidate wins. Then after the loop, I do some calculations with the data from the results data frame and print out those results. Last, I plot margin of victory, margin of victory percentage, and number of runoffs to see the spread and distribution of each metric. To total eight experiments, I run the following experiments twice, each with different candidates polling weights, rank choice voting vs. common election, required preference vs. not required preference, variable number of candidates, and variable turnout percentage.

Results:

Rank Choice Voting vs. Common Election:

In this first experiment, I wanted to do a basic comparison between a common election, in which the winner simply receives a plurality, and a rank choice election. I initially ran this experiment with five candidates and a margin of about 20% between the favorite and second choice candidates. The first result of this was not surprising with 100% wins for the favorite candidate. Though when comparing the margin of victory, rank choice resulted in a larger margin of victory by 3%. In Figure 0, the distribution of the margin of victory for all four plots is relatively normal, this did not differ between the two types of elections. Figure 1 shows the overwhelming majority of elections went to three runoffs, but there were a small number of elections that only went to 1 runoff. In the second run of this experiment, there were four candidates and a margin of 2% between the favorite and the second choice. Here, the favorite won the common election 100% of the time, but the favorite won the rank choice elections 95% of the time losing 46 out of 1000 elections. In Figure 2, the distribution of the margin of victory for all four plots are similar and not exactly normal; these are right skewed with more margins of victory towards the smaller side. Figure 3 shows all these elections went to 3 runoffs, which is somewhat odd and unexplainable at this point. Overall, it appears rank choice elections more often result in a larger margin of victory. Also, only in rank choice elections does it become possible for the favorite candidate to lose the election.

Required Preference vs. Not Required Preference:

In this experiment, the goal was to analyze whether changing the rank choice rules of requiring the voter to list all preferences versus not would affect the outcome of the election. In the first run of this experiment, I again used five candidates and a margin of about 20%. This resulted in the favorite candidate winning 100% of the time. The margin of victory was only 0.01% different between requiring and not requiring preference. Again, in Figure 4 (left two plots are

for required preference, and the right two are for not required), you can see the distribution of the margins of victory for all four plots was normal, and Figure 5 (same configuration as Figure 4), shows most elections went to three runoffs with very small number ending in the first runoff. In the second run of this experiment, I used the closer margin of 2% between the top two candidates, and this resulted in the favorite candidate winning about 95% of the elections. The results of the margin of victory between the two types of preference was about the same as the first run with a 0.002% difference. However there were some outliers in this experiment for the outcome of some elections that required preferences for all candidates, as you can see in Figure 6. You can also see that for the not required preference rule in the elections with a closer margin between the top two candidates there is another right skew in the data. Finally, in Figure 7, you can see the elections with required preference resulted in mostly two runoffs with a few going to three, but in the elections that do not require preference, all went to three runoffs. This suggests that making voters choose all candidates would result in fewer runoffs, however it would be considered highly unconstitutional if a voter only marked one candidate to then throw that vote out.

Variable Number of Candidates:

In this third set of experiments, I set out to analyze the results of outcomes with different number of candidates running. For the first run, I conducted four elections per iteration: 2 candidates, 3 candidates, 4 candidates, and 5 candidates. I also made the margin of the top two candidates fairly large to begin, and of course every election run, 4000 total, was won by the favorite candidate. The margin of victory seemed to shrink with the number of candidates, but this could have been my error in scaling the margin of weights accurately. Figure 8, showing candidate 1 in the top right 2 plots, candidate 2 in top left 2 plots, etc., shows all plots with relatively normal distributions. Figure 9, with same configuration as Figure 8 (top right to left), shows expected results with more runoffs as the number of candidates rises. The second run of this experiment involved the margin of the top two candidates being much closer, and it was setup same as the previous in terms of number of candidates per iteration. In this run, the margin of victory was stayed relatively the same across the number of candidates, but the number of elections the favorite candidate lost was the most with 3 candidates and the least with 5 candidates; 3 candidates was significantly more often to result in the favorite candidate losing compared to 2 candidates with 100 more wins. Looking at Figure 10, three of the election distributions, except the elections with 3 candidates, have outliers that distort the plot, but overall these plots look mostly normal and a bit skewed right. Figure 11 shows a similar picture as Figure 9, except for the elections with 3 candidates where all the runoffs went to 3 rounds. This suggests elections with closer margins of polling weights will result in more runoffs.

Variable Turnout Percentage:

In the last set of experiments, the goal was simply to look at the effects of changing the percentage voter turnout, or of votes dropped. First run, as the previous three, was setup with a 20% margin between the top two candidates and only two elections were run per iteration, one with 50% voter turnout and the other with 25% voter turnout. The first run resulted in nothing surprising; favorite candidate wins every race and the margin of victory between the two turnout percentages was 0.01%. In Figure 12, right two plots being 50% turnout, looks normal, and Figure 13 shows most elections went to 3 runoffs. The second run of this experiment was with candidates that have a small margin between the top two. This resulted in similar margins of victory, but the favorite candidate lost more elections with 50% turnout versus 25% turnout in a close election. This experiment did not result in any interesting results.

Conclusion:

Rank choice voting has many variations, and depending on which rules are used, the outcome to an election could change. Simply comparing the rank choice election approach to a common election approach resulted in 5% of elections. The margin of victory is also higher in rank choice elections giving voters a greater sense of relief that the chosen candidate was correctly chosen. Making voters list all candidates in the election may result in fewer runoffs, which in reality more runoffs is very bad, however the fact that votes not listing all candidates would be thrown out, outweighs the concern of more runoffs. The number of candidates running significantly affects the outcome of the election, with three candidates being the most likely for the favorite candidate to lose in a close election. In reality this would also have influence from both political parties running other candidates to steal votes from a competitor. The last experiment on voter turnout was not set up very well, and thus did not render interesting results. In the future, I would run more experiments for longer times to get a more accurate picture. In a scenario that I would not be limited by time, I would have built more complex methods that more accurately represent elections in the United States, such as representing political polarization and more accurate voter populations since most voters are towards the ends of the political spectrum with more extreme views.

Appendix:

Code: <https://github.com/sean-m-higgins/rank-choice-election-simulation>

Sources:

1. <https://www.maine.gov/sos/cec/elec/upcoming/rankedchoicefaq.html>
2. <https://apnews.com/article/election-2020-senate-elections-voting-maine-united-states-355f2859cf5dabf25bb0bb953f9c66bd>
3. <https://bangordailynews.com/2020/11/05/politics/daily-brief/maines-experiment-with-ranked-choice-voting-was-muted-in-2020/>
4. [https://ballotpedia.org/Ranked-choice voting \(RCV\)](https://ballotpedia.org/Ranked-choice_voting_(RCV))

Figure 0:

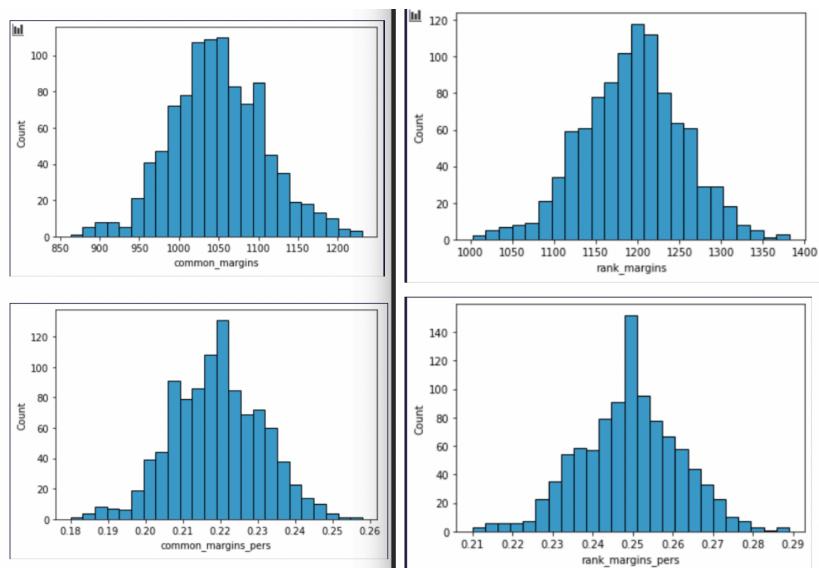


Figure 2:

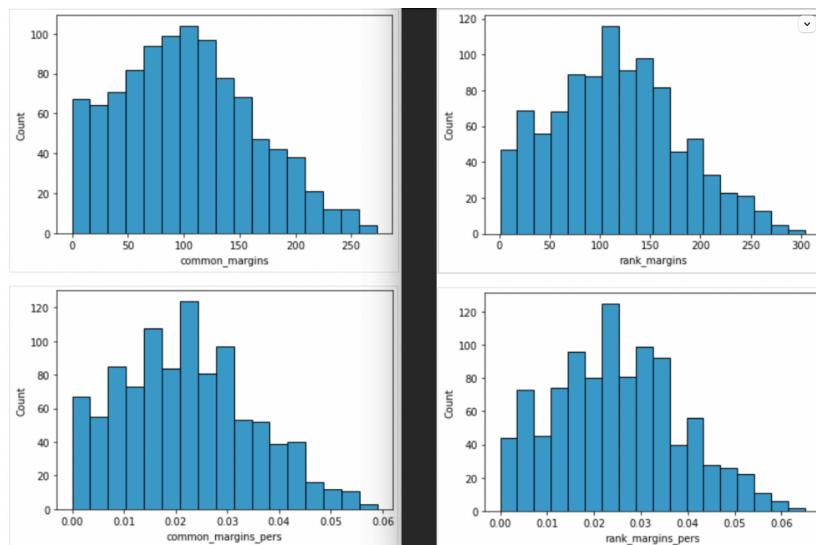


Figure 1:

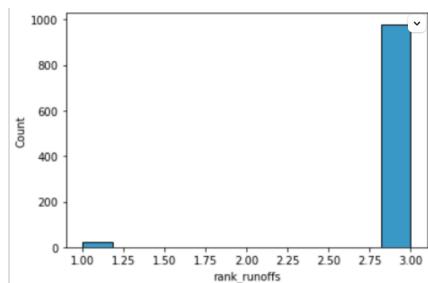


Figure 3:

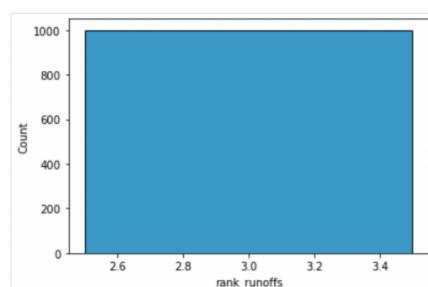


Figure 4:

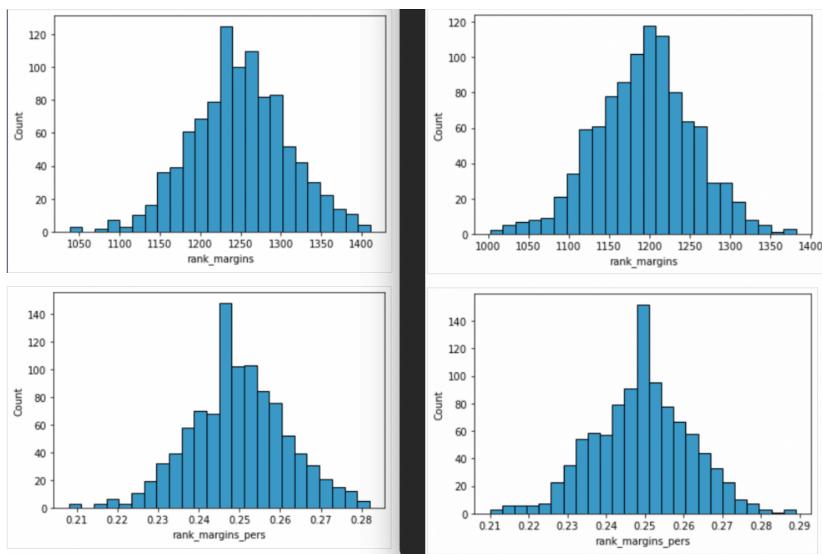


Figure 5:

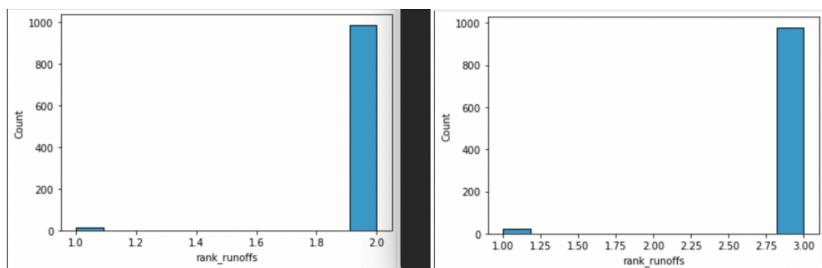


Figure 6:

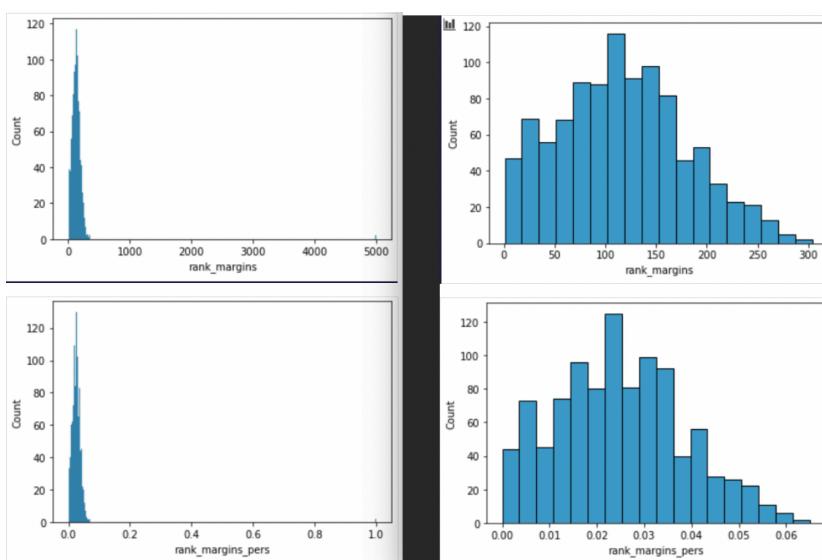


Figure 7:

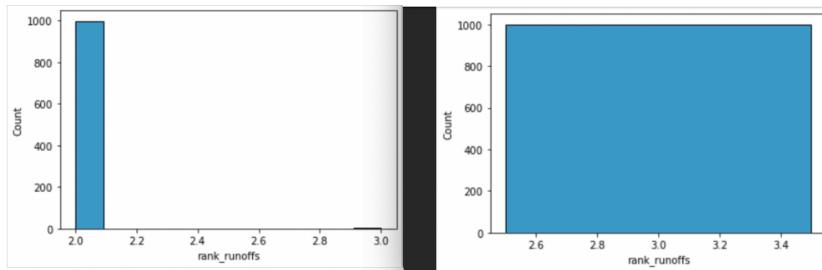


Figure 8:

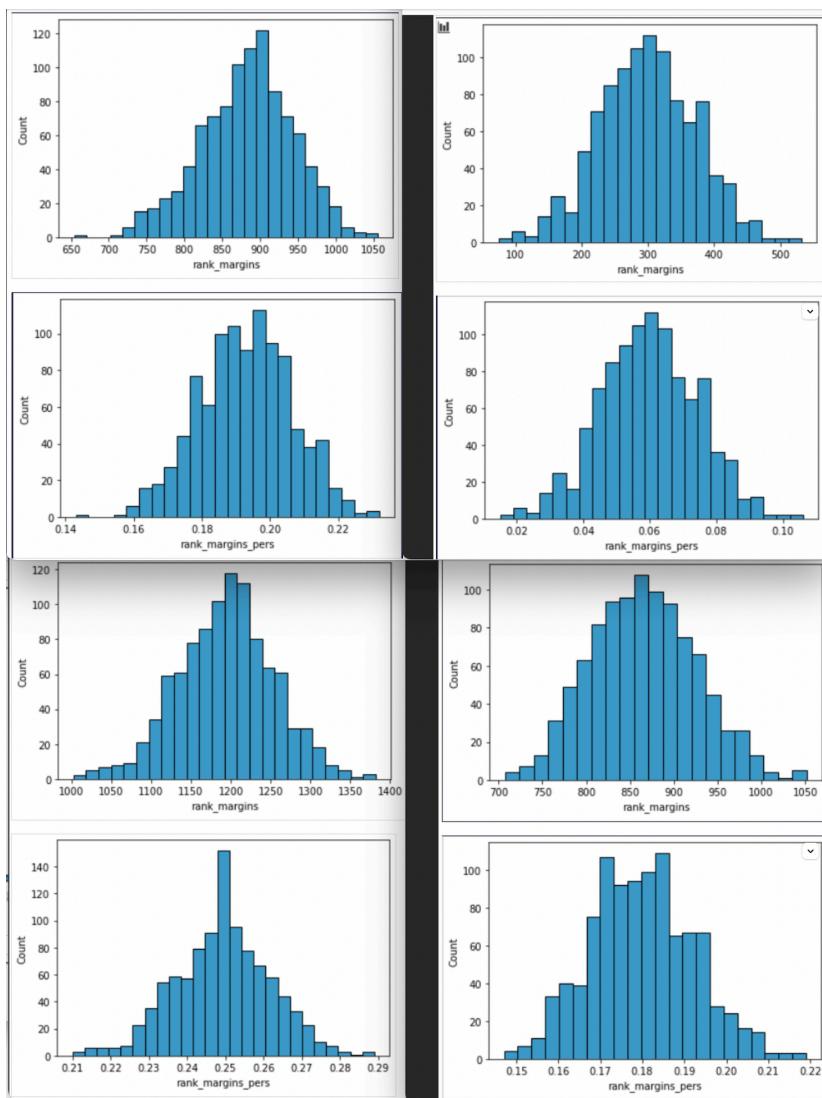


Figure 9:

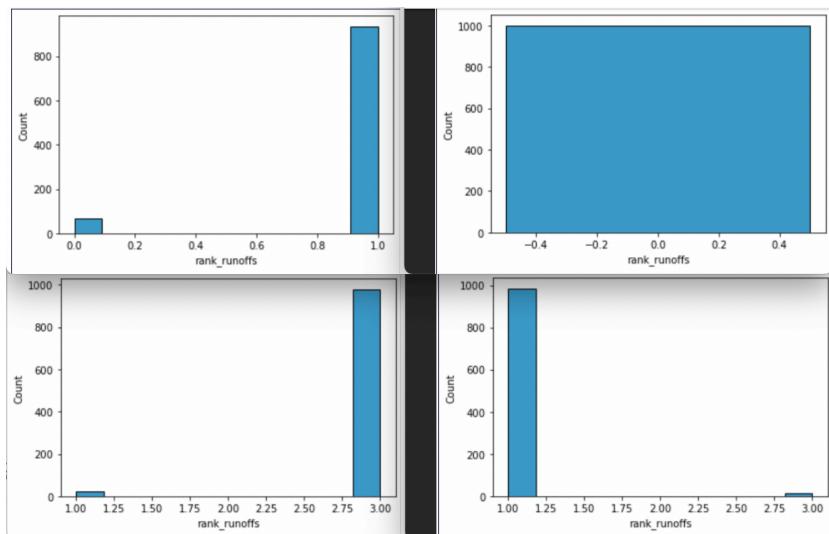


Figure 10:

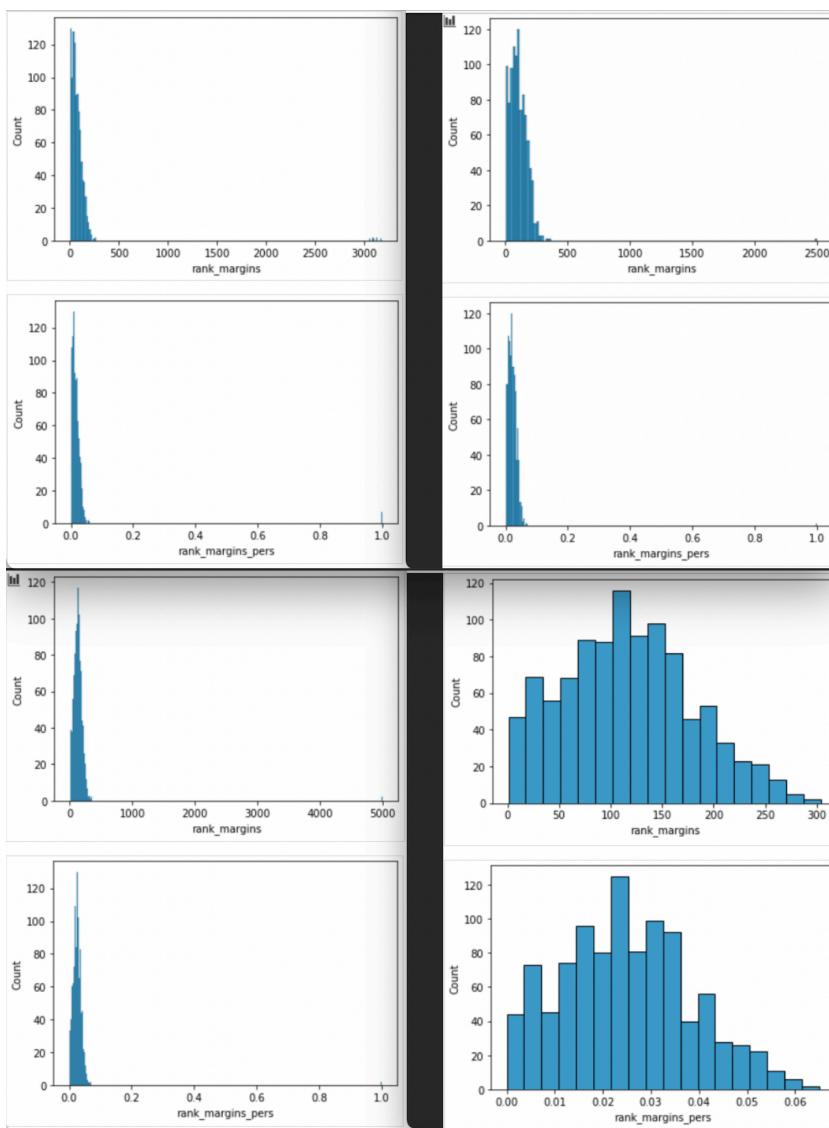


Figure 11:

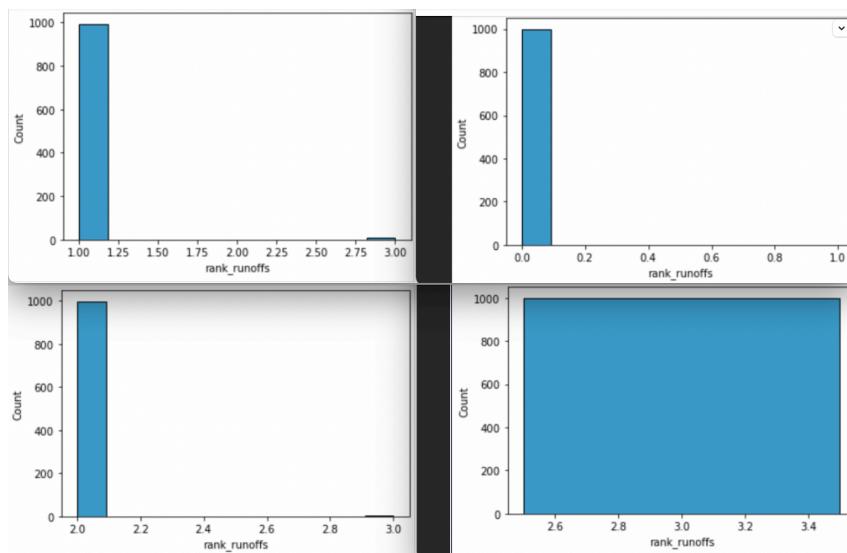


Figure 12:

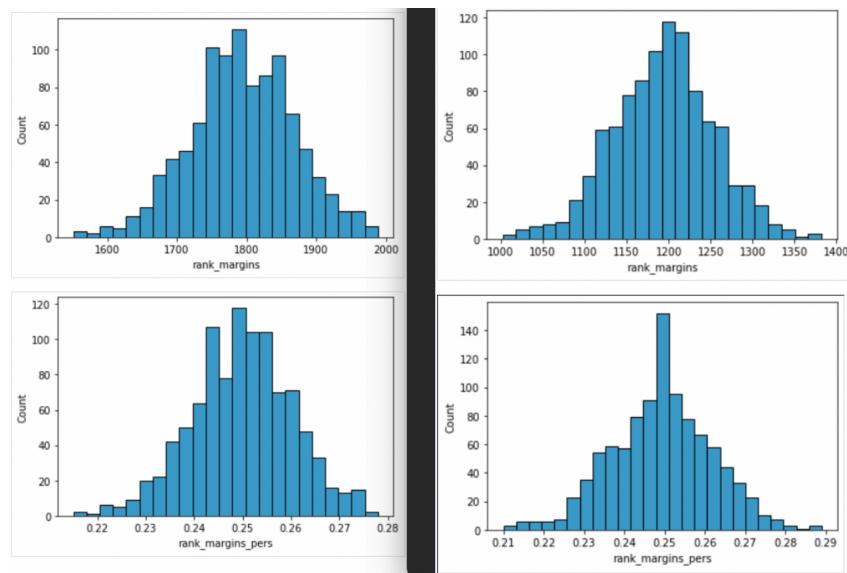


Figure 13:

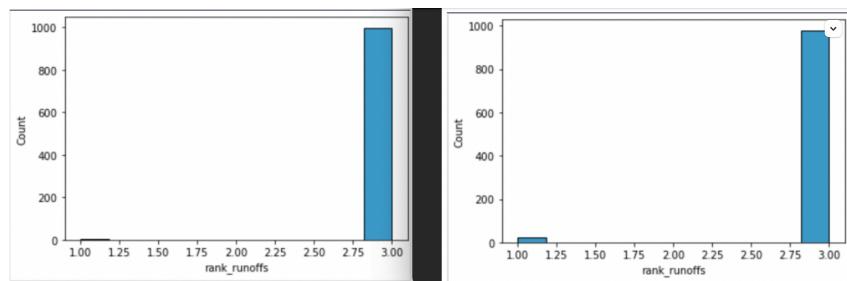


Figure 14:

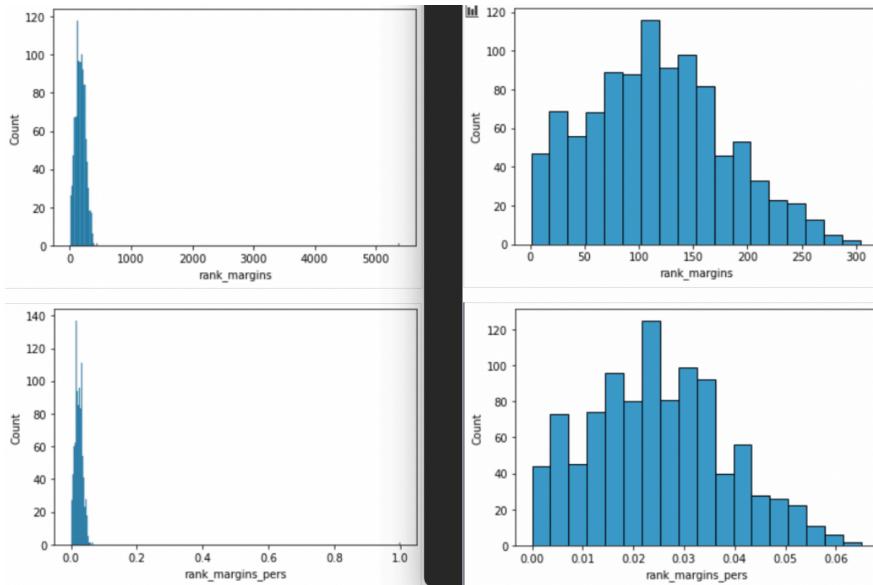
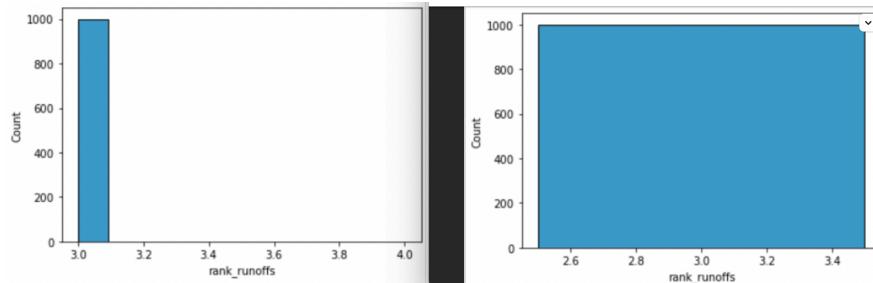


Figure 15:



Parameters and Output:

Rank Choice Voting vs. Common Election

(Figure 0) — right side — rank choice election, left side — common election
 (Figure 1) — rank choice runoffs

```
next_config = {
    "pop_size": 10000,
    "print_on": False,
    "turnout_per": 0.5,
    "require_all_pref": False,
    "r_seed": i,
    "candidates": {
        0: ["Elizabeth II", 0.46],
        1: ["Genghis Khan", 0.25],
```

```

        2: ["Alexander the Great", 0.13],
        3: ["Mahatma Gandhi", 0.11],
        4: ["Augustus Caesar", 0.05]
    }
}

```

100% (1000 of 1000) |#####| Elapsed Time: 0:20:41 Time: 0:20:41
Rank Choice Election Fav. Wins Sum: 1000/1000
Common Election Fav. Wins Sum: 1000/1000
Rank Choice Election Win Margin: 1193.637
Rank Choice Election Win Margin Percentage: 0.249%
Common Election Win Margin: 1048.726
Common Election Win Margin Percentage: 0.219%

#=====

(Figure 2) — right side — rank choice election, left side — common election
(Figure 3) — rank choice runoffs

```

next_config = {
    "pop_size": 10000,
    "print_on": False,
    "turnout_per": 0.5,
    "require_all_pref": False,
    "r_seed": i,
    "candidates": {
        0: ["Elizabeth II", 0.42],
        1: ["Genghis Khan", 0.40],
        2: ["Alexander the Great", 0.13],
        3: ["Mahatma Gandhi", 0.05],
    }
}

```

100% (1000 of 1000) |#####| Elapsed Time: 0:22:09 Time: 0:22:09
Rank Choice Election Fav. Wins Sum: 954/1000
Common Election Fav. Wins Sum: 1000/1000
Rank Choice Election Win Margin: 116.544
Rank Choice Election Win Margin Percentage: 0.025%
Common Election Win Margin: 103.19
Common Election Win Margin Percentage: 0.022%

Required Preference vs. Not Required Preference

(Figure 4) — left side = Required Preference, right side = Not Required Preference
(Figure 5) — same ^

100% (1000 of 1000) |#####| Elapsed Time: 0:40:56 Time: 0:40:56
Not Required Preference Rank Choice Election Fav. Wins Sum: 1000/1000
Not Required Preference Rank Choice Election Win Margin: 1193.637
Not Required Preference Rank Choice Election Win Margin Percentage: 0.249%
Required Preference Rank Choice Election Fav. Wins Sum: 1000/1000

Required Preference Rank Choice Election Win Margin: 1248.181
Required Preference Rank Choice Election Win Margin Percentage: 0.25%

```
next_config = {
    "pop_size": 10000,
    "print_on": False,
    "turnout_per": 0.5,
    "require_all_pref": False, / True
    "r_seed": i,
    "candidates": {
        0: ["Elizabeth II", 0.46],
        1: ["Genghis Khan", 0.25],
        2: ["Alexander the Great", 0.13],
        3: ["Mahatma Gandhi", 0.11],
        4: ["Augustus Caesar", 0.05]
    }
}
```

#=====

(Figure 6) — left side = Required Preference, right side = Not Required Preference
(Figure 7) — same ^

```
100% (1000 of 1000) |#####| Elapsed Time: 0:42:23 Time: 0:42:23
Not Required Preference Rank Choice Election Fav. Wins Sum: 954/1000
Not Required Preference Rank Choice Election Win Margin: 116.544
Not Required Preference Rank Choice Election Win Margin Percentage: 0.025%
Required Preference Rank Choice Election Fav. Wins Sum: 963/1000
Required Preference Rank Choice Election Win Margin: 134.238
Required Preference Rank Choice Election Win Margin Percentage: 0.027%
```

```
next_config = {
    "pop_size": 10000,
    "print_on": False,
    "turnout_per": 0.5,
    "require_all_pref": False, / True
    "r_seed": i,
    "candidates": {
        0: ["Elizabeth II", 0.42],
        1: ["Genghis Khan", 0.40],
        2: ["Alexander the Great", 0.13],
        3: ["Mahatma Gandhi", 0.05],
    }
}
```

Variable Number of Candidates

(Figure 8) — top right 2 — 2 candidates, top left 2 — 3 candidates, bottom right 2 — 4 candidates, bottom left 2 — 5 candidates.
(Figure 9) — top right — 2 candidates, top left — 3 candidates, bottom right — 4 candidates, bottom left — 5 candidates.

100% (1000 of 1000) |#####| Elapsed Time: 1:03:29 Time: 1:03:29
 1 Candidate Rank Choice Election Fav. Wins Sum: 1000/1000
 1 Candidate Rank Choice Election Win Margin: 298.702
 1 Candidate Rank Choice Election Win Margin Percentage: 0.06%
 2 Candidates Rank Choice Election Fav. Wins Sum: 1000/1000
 2 Candidates Rank Choice Election Win Margin: 882.349
 2 Candidates Rank Choice Election Win Margin Percentage: 0.193%
 3 Candidates Rank Choice Election Fav. Wins Sum: 1000/1000
 3 Candidates Rank Choice Election Win Margin: 865.337
 3 Candidates Rank Choice Election Win Margin Percentage: 0.18%
 4 Candidates Rank Choice Election Fav. Wins Sum: 1000/1000
 4 Candidates Rank Choice Election Win Margin: 1193.637
 4 Candidates Rank Choice Election Win Margin Percentage: 0.249%

```

next_config = {
    "pop_size": 10000,
    "print_on": False,
    "turnout_per": 0.5,
    "require_all_pref": False,
    "r_seed": i,
    "candidates": {
        0: ["Elizabeth II", 0.53],
        1: ["Genghis Khan", 0.47]
    }
}

"candidates": {
    0: ["Elizabeth II", 0.49],
    1: ["Genghis Khan", 0.33],
    2: ["Alexander the Great", 0.18]
}

"candidates": {
    0: ["Elizabeth II", 0.46],
    1: ["Genghis Khan", 0.30],
    2: ["Alexander the Great", 0.13],
    3: ["Mahatma Gandhi", 0.11]
}

"candidates": {
    0: ["Elizabeth II", 0.46],
    1: ["Genghis Khan", 0.25],
    2: ["Alexander the Great", 0.13],
    3: ["Mahatma Gandhi", 0.11],
    4: ["Augustus Caesar", 0.05]
}

```

#=====

(Figure 10) — top right 2 — 2 candidates, top left 2 — 3 candidates, bottom right 2 — 4 candidates, bottom left 2 — 5 candidates.

(Figure 11) — top right — 2 candidates, top left — 3 candidates, bottom right — 4 candidates, bottom left — 5 candidates.

100% (1000 of 1000) |#####| Elapsed Time: 1:13:46 Time: 1:13:46
 1 Candidate Rank Choice Election Fav. Wins Sum: 919/1000
 1 Candidate Rank Choice Election Win Margin: 107.192
 1 Candidate Rank Choice Election Win Margin Percentage: 0.022%
 2 Candidates Rank Choice Election Fav. Wins Sum: 804/1000
 2 Candidates Rank Choice Election Win Margin: 90.358
 2 Candidates Rank Choice Election Win Margin Percentage: 0.022%
 3 Candidates Rank Choice Election Fav. Wins Sum: 954/1000
 3 Candidates Rank Choice Election Win Margin: 116.544
 3 Candidates Rank Choice Election Win Margin Percentage: 0.025%
 4 Candidates Rank Choice Election Fav. Wins Sum: 969/1000
 4 Candidates Rank Choice Election Win Margin: 122.738
 4 Candidates Rank Choice Election Win Margin Percentage: 0.026%

```
next_config = {
    "pop_size": 10000,
    "print_on": False,
    "turnout_per": 0.5,
    "require_all_pref": False,
    "r_seed": i,
    "candidates": {
        0: ["Elizabeth II", 0.51],
        1: ["Genghis Khan", 0.49]
    }
}

"candidates": {
    0: ["Elizabeth II", 0.43],
    1: ["Genghis Khan", 0.42],
    2: ["Alexander the Great", 0.15]
}

"candidates": {
    0: ["Elizabeth II", 0.42],
    1: ["Genghis Khan", 0.40],
    2: ["Alexander the Great", 0.13],
    3: ["Mahatma Gandhi", 0.05]
}

"candidates": {
    0: ["Elizabeth II", 0.40],
    1: ["Genghis Khan", 0.38],
    2: ["Alexander the Great", 0.12],
    3: ["Mahatma Gandhi", 0.05],
    4: ["Augustus Caesar", 0.05]
}
```

Variable Turnout Percentage

(Figure 12) — right = 0.5 turnout, left = 0.25
 (Figure 13) — same ^

```

100% (1000 of 1000) |#####
Elapsed Time: 0:44:47 Time: 0:44:47
0.5 Turnout Percentage Rank Choice Election Fav. Wins Sum: 1000/1000
0.5 Turnout Percentage Rank Choice Election Win Margin: 1193.637
0.5 Turnout Percentage Election Win Margin Percentage: 0.249%
0.25 Turnout Percentage Rank Choice Election Fav. Wins Sum: 1000/1000
0.25 Turnout Percentage Rank Choice Election Win Margin: 1793.915
0.25 Turnout Percentage Rank Choice Election Win Margin Percentage: 0.25%

```

```

next_config = {
    "pop_size": 10000,
    "print_on": False,
    "turnout_per": 0.5, / 0.25
    "require_all_pref": False,
    "r_seed": i,
    "candidates": {
        0: ["Elizabeth II", 0.46],
        1: ["Genghis Khan", 0.25],
        2: ["Alexander the Great", 0.13],
        3: ["Mahatma Gandhi", 0.11],
        4: ["Augustus Caesar", 0.05]
    }
}

```

#=====

(Figure 14) — left = 0.5 turnout, right = 0.25

(Figure 15) — same ^

```

100% (1000 of 1000) |#####
Elapsed Time: 0:48:43 Time: 0:48:43
0.5 Turnout Percentage Rank Choice Election Fav. Wins Sum: 954/1000
0.5 Turnout Percentage Rank Choice Election Win Margin: 116.544
0.5 Turnout Percentage Election Win Margin Percentage: 0.025%
0.25 Turnout Percentage Rank Choice Election Fav. Wins Sum: 979/1000
0.25 Turnout Percentage Rank Choice Election Win Margin: 177.448
0.25 Turnout Percentage Rank Choice Election Win Margin Percentage: 0.026%

```

```

next_config = {
    "pop_size": 10000,
    "print_on": False,
    "turnout_per": 0.5, / 0.25
    "require_all_pref": False,
    "r_seed": i,
    "candidates": {
        0: ["Elizabeth II", 0.42],
        1: ["Genghis Khan", 0.40],
        2: ["Alexander the Great", 0.13],
        3: ["Mahatma Gandhi", 0.05]
    }
}

```