CS 109 Project: A Better Way to Reform the Electoral College

The Electoral College is a highly controversial system. According to a recent poll, 50% of Americans would replace it with a national popular vote, while only 36% would keep the college, with 14% of respondents being indifferent. Much of the debate about replacing the Electoral College centers around these two systems. The goal of this project is to introduce another alternative to the Electoral College.

For better or for worse, the Electoral College as it exists today is the measuring stick by which all options for reform will be measured. As a result, I will list some of the most salient aspects of the current system, both positive and negative:

Positive aspects of the Electoral College:

- **Favors small states, rural areas:** The current Electoral College gives a disproportionately large voice to smaller states, which are generally rural. For example, Wyoming has a population of 578,000 but casts 3 electoral votes, giving it an electoral vote for every 193,000 people. California, by contrast, has 55 electoral votes but 39,560,000 people, meaning that for every electoral vote cast by California there are 719,000 California residents. Many see this as positive, as otherwise candidates would find it more convenient to campaign only in large cities where large numbers of voters can be reached more efficiently
- **Compartmentalization:** While it is difficult to conclude that fraud has been absolutely decisive in any one election, there have been many accusations of wrongdoing and mismanagement in American presidential elections. Kennedy using the Chicago political machine to beat Nixon in Illinois, the Hanging Chad fiasco in Florida in 2000, Virginia Governor Terry McAuliffe's pardoning of 200,000 felons in 2016 and alleged Trump-Russia collusion in the same year are all high-profile examples. Notably, only the last example crossed state lines. If elections were conducted on a national popular vote basis, the entire election could swing on any one instance of cheating in any of the 50 states, creating both a greater incentive to do so and the potential for enormous controversy. In addition, each state's method of conducting elections, would become the concern of the other 49 states, more so than ever before. Issues such as voter ID laws and electronic ballots would likely demand federal legislation. Keeping the Electoral College system means that no matter how badly one state cheats or mismanages its Electoral College system, no other state's electoral votes are affected.

Negative aspects of the Electoral College:

- **Popular vote winner can lose the election:** The current method of selecting the president of the US does not always give the victory to the candidate who garners the plurality of votes. Even a candidate winning a majority of votes could still lose the election, although this has happened only once. Many find this undemocratic. The popular vote winner has lost the Electoral College twice in the past five presidential elections, making this particular issue a sticking point among many and a focus of reform efforts.
- **Competitive ('swing') states attract most of campaigning attention:** Because each state allocates its electors on a winner-take-all basis, presidential candidates focus their campaigning in states which they anticipate to be competitive. States with large

populations that are evenly split between Republicans and Democrats, like Ohio and Florida, get disproportionately large amounts of attention during the campaign and often decide the election. Meanwhile, solidly red or blue states like California and New York get relatively little attention despite the many electoral votes available.

My intention is to examine the feasibility of a system which addresses all of these concerns: statewide proportional allocation, specifically the Integral Proportional System (IPS) proposed by Vincy Fon. The general idea of statewide proportional allocation is as follows: instead of giving all of their electors to the candidate who wins a plurality in their state, states split up their electoral votes proportionally among the top candidates.

Fon's algorithm for allocating the votes of a given state is as follows: find the maximum number of votes received by any candidate, and call this number x1. This candidate receives e1 = ceiling(x1 / total votes * total electors) electoral votes. In other words, the candidate winning a plurality is allotted his fair share of electors, rounded up to the nearest integer elector. Next, find the number of votes received by the runner-up of the popular vote in the given state, and call this x2. Also let the number of votes not cast for the plurality winner equal rv1 (rv1 = total votes - x1). Let the number of electors remaining equal re1 (re1 = total electors – e1). The number of electoral votes the second candidate receives is e2 = ceiling(x2 / rv1 * re1)). This process of finding the proportion of remaining votes received and then rounding up for can be continued until all electoral votes have been distributed.

This algorithm is illustrated well with an example. Consider a state where 100 votes are cast and 10 electoral votes are available. Candidate one receives 57 votes, candidate two receives 33 votes, and candidate three receives 10 votes. The first candidate will receive ceiling(57/100 * 10) = 6 electoral votes. Because 4 electoral votes and 43 popular votes remain, candidate two will receive ceiling(33/43 * 4) = 4 electoral votes. After allocating votes to these two candidates, no electoral votes remain, and thus the third candidate receives no electoral votes. Note that in a perfectly proportional system, candidates one, two and three would have received 5.7, 3.3, and 1.0 electoral votes, respectively. However it is unclear whether the Constiution would allow decimal allocation of electors. In addition, the Fon system has the effect of those candidates who pluralities in given states a boost, which will likely help to ensure that at least one candidate wins the 270 electoral votes required to win the entire election.

So how does this method of allocating electors compare to the Electoral College? Addressing the first concern of favoring small states and rural electors, this system preserves the number of electoral votes each state gets to cast. As a result, small and rural states maintain their louder voice. In addition, each state still allocates their electoral votes independent of all the others, maintaining compartmentalization.

Does the Integral Proportional System ensure that the popular vote winner also wins the Electoral College? There certainly is no guarantee. However, in the simulations I ran (details on which will follow), allocating electors on a winner-take-all basis as we do today resulted in roughly 5 times as many elections in which the candidate winning a plurality of votes lost the Electoral College than did an IPS system. Finally, does the IPS system mean that attention will be more evenly distributed among swing states and solidly red and blue ones? While I did not directly analyze this, it follows from intuition that if swinging the popular vote by a few points in a solidly red state can earn candidates an electoral vote there, then they will pay more attention to the state. Similarly, if swinging the percentage in Florida from 49 to 51 earns one only one or two electoral more electoral votes, one is less likely to prioritize campaigning in Florida.

So why does the IPS system attract so little attention nationally? The answer is that entirely overhauling the Electoral College requires enormous political will. To do so through Constitutional amendment, one needs ratification by 38 states. This is a big ask when there are so many small states who stand to benefit from keeping the current system. The National Popular Vote Compact represents an attempt to circumvent this. Each state can allocate its own electoral vote as it wishes, so if states representing 270 electors sign on then these states will give their electoral votes to the national popular vote winner. These 270 votes will be enough to ensure victory for the popular vote winner. The National Popular Vote Compact has states representing less than 200 electoral votes signed on at present, however, and seems to have stalled.

Crucially, each state can adopt the IPS system and use it to allocate its electors unilaterally. States like California and Wyoming that are ignored because of the overwhelming majority that one party possesses would instantly become battleground states. No state is likely to do this, however, because it would further diminish the length that their electoral votes go. Consider California again: adopting IPS for the 2016 election would have gifted Donald Trump 18 additional electoral votes. The IPS system would benefit Republicans as long as a plurality of Californians vote for Democrats, meaning that the Democratic state legislature would never choose to shoot their own party in the foot by adopting IPS. The same goes for a state like Texas: adopting IPS would have gifted Hillary Clinton 17 votes in 2016, a non-starter for a Republican state government.

But what if Texas and California adopted the IPS system co-laterally? Each state would become more competitive and receive more attention from presidential candidates. For 2016 at least, the end result would be relatively fair: Donald Trump would have received only one more electoral vote as a result of the switch.

Would it be fair for Texas and California to make this deal permanent? If one party can expect to consistently win more electoral votes as a result of this trade, then it is unlikely that both state legislatures will agree to adopt IPS. By my simulations, because California is so much larger than Texas, and Texas is much more likely to have a Democrat win a plurality of votes, Democrats can expect 34 fewer electoral votes by California adopting an IPS system, while Republicans will only lose 12 on average if Texas adopts IPS.

There is a solution to this issue too. If Texas uses a pure Integral Proportional System, but California only uses IPS for 20 of its electors and allocates the remaining 35 using the old-fashioned winner-take-all method[1], the net result would be nothing: Texas would expect to hand 12 votes to Democrats, who would have them taken right back and handed to Republicans in California.

My proposed method for reforming the Electoral College is as follows: each state that currently suffers from a lack of presidential campaigning because it is solidly red or blue should broker a deal with one or many other states so that the states involved agree to adopt an Integral Proportional System, in whole or part.

These pacts need to be permanent, as the makeup of states' electorate is likely to change. In addition, the number of electoral votes themselves changes. A realistic time frame would see states adopt pacts after data from the 2020 census is released and in time for the 2024 election, so

[1] To make this work, California would simply imagine it only had 18 electoral votes and distribute these using IPS. It would then grant the remaining 37 in lump sum to the candidate winning a plurality in California.

that the models predicting what is fair can be as accurate as possible. States can then renegotiate after the 2030 census and in time for the 2032 election.

This is admittedly somewhat of a beggar-thy-neighbor strategy: If California and Texas agree to adopt this system, they will join Florida and other swing states in having an outsized impact on the election and will thus attract even more campaigning. Other solidly red and blue states will become even more irrelevant: maybe New York and Alabama will adopt a similar pact in frustration. If more and more states adopt IPS, a large and well-balanced pool means that few states will be stuck with adopting a mixed system in order to maintain parity between Democrats and Republicans.

Technical Explanation

With my real-world analysis complete, I will now move to a technical explanation of the questions to be answered using statistics and simulation, and the tools required to do so. I admit that I did not succeed in answering all the questions I attempt to with satisfactory accuracy, however I will still pose the questions here so that another more capable statistician and programmer (potentially future me!) can answer them.

Questions to be answered:

- If each state adopted an Integral Proportional System, would the winner of the national popular vote be more likely to win the Electoral College and by how much? If a given consortium of states adopted IPS, would the winner of the national popular vote be more likely to win the Electoral College and by how much?
- If two or more states wish to adopt the IPS system co-laterally, how can this be implemented without giving either Republicans or Democrats an advantage?

Data

To answer these questions, I looked at US presidential elections going back to 1976. For state-by-state popular vote counts, I sourced from the MIT Election Data + Science Lab. I downloaded state-by-state electoral vote counts from Dave Leip's Atlas of U.S. Presidential Elections.

Simulating a presidential election

Simulating a presidential election is a much harder task than I imagined at the outset. I modeled election by simulating an election in each state. Each state was assumed to have a portion of its population voting for democrats and a portion voting for republicans, with both distributions being normally distributed with some covariance. Furthermore, each state was assumed to be independent of all other states and the District of Columbia. That being said, the limitations of this approach are as follows:

- **Votes for Democrats and Republicans and not normally distributed:** For starters, neither can exceed the population in the state or fall below zero. More generally, I expect that vote distributions have thinner tails than the normal distribution does. I could not find a way to simulate a normal or multivariate distribution with kurtosis, however.
- **States are not independent:** A particularly compelling candidate is likely to change the distribution in all 50 states, however my model does not account for this.
- **Adopting IPS could change the underlying distribution:** My simulations attempt to model the results of an IPS election using data from winner-take-all elections. It is highly

probable that adopting an IPS system will change the behavior of voters, however. For example, turnout would likely increase in newly competitive states.

- **States change over time:** States experience migration and population growth and decline, and as a result the number of electoral votes they can allocate changes. In addition, populations can age or grow younger based on the birth rate, which affects political affiliations. There is a treasure trove of demographic data out there which might suggest a different distribution than the one this project creates.

My Model

With all these caveats taken into account, I will detail how I attempted to simulate presidential elections. Because I envision the process of states adopting IPS to be conducted on a decennial, post-census basis, I did the same with my own models. I had three periods in my data: the elections of 1992, 1996, and 2000 (between the 1990 and 2000 censuses), the elections of 2004 and 2008 (between the 2000 and 2010 censuses), and the elections of 2012 and 2016 (between the 2010 and 2020 censuses: this period is missing the 2020 election). I attempted to model elections using only data conducted in a prior census-period.

First, I needed to create an expectation for the proportion of votes for Democrats and for Republicans in each state. I attempted to do this in three ways. The first method was simply predicting that the proportions from the most recent election would continue. The second was to take an average of the previous three elections. The third was to linearly regress the previous three elections in order to account for whether the state was shifting towards one party or the other.

Surprisingly, the best predictor of elections in the next census period was, by a sizable margin, the first method. This is admittedly unsatisfying. In future I intend to create a better which incorporates census data, accounts for the underlying divisions in statewide populations regarding party affiliation, removes the assumption that all states are independent, and accounts for incumbent advantage.

In order to simulate each state, I also needed an estimate for how much my guess was off by. I calculated this result empirically. I generated a estimated proportion for each party in each state in each election in all four periods, and then found the difference between my guess for the proportion of democratic/republican votes and the actual result.

Using bootstrapping, I found that my estimates were not significantly worse for any one state when guessing both Democratic and Republican vote proportions. I did find, however, that my estimates were worse for Republican vote proportion than Democratic ones. Not one of my 100,000 bootstraps replicated the same difference in average error between the two parties.

Because the average guess was not biased to be an over or under estimate, I used the standard deviation of all the errors of my guess for Democratic and Republican distributions as the standard deviation of the Democratic and Republican distributions themselves when simulating elections.

Finally, I needed to calculate a covariance for Democratic and Republican proportions. Again using bootstrapping, I determined that no state had a covariance significantly greater or less than any other. As a result, I used the covariance of my errors across all states for my simulation. Unfortunately, I had to artificially increase this covariance: otherwise a large portion of elections would have Democratic and Republican proportions adding up to greater than 1.

Conclusions

Using this model, I attempted simulate the 2020 election. M most interesting conclusions and tools are as follows:

Fair state pairing tool:
I created a tool which, when given two states, will find a fair number of electors for each state to allocate using IPS. For example, if given New York and Texas, it will recommend that New York put 22 electors under IPS and Texas put all 38. If given Massachusetts and Alabama, it will recommend that Alabama allocate all 9 electors using IPS, and Massachusetts allocate 9 of its 11.

Probability of popular vote winner losing Electoral College:
I simulated one million elections occurring in the next census cycle to determine the probability that a popular vote winner would lose the Electoral College as it arranged now, and the probability that a popular vote lose the Electoral College if all votes were allocated in IPS fashion. According to these simulations, a popular vote loser would win the normal Electoral College 30% of the time, and an IPS Electoral College 7% of the time. 53% of the time, no one would win the Electoral College under the IPS system, however, whereas this would happen only 1% of the time under the current system. This is likely a result of the extreme closeness of the 2016 election, however, which was used as the expectation of the proportions for each state. Using the less closely-contested election of 1984 instead, I find that the IPS system produces no candidate with 270 electoral votes only 236 times out of a million. In addition, one would expect that the psychology of expecting that one's vote will be more meaningful will result in less people voting for third party candidates, which should cut down on undecided elections in practice.

Expected Difference in Net Electoral Votes:
Finally, below is a list of expected net change in electoral votes when adopting the Integral Proportional System for all 50 states and the District of Columbia, from the perspective of Democrats. I say 'net' electoral votes because, in addition to having electors swap from Republican to Democrat, IPS also sends a significant number of electors to third parties. Net electoral votes is a measure of the change in margin between Democrats and Republicans. Electors sent from one major party to the other are twice as significant as those sent to third parties: if Democrats send one electoral vote to Republicans, their margin decreases by 2. As a result, each number represents roughly, but slightly less than, double the amount of electoral votes Democrats expect to gain by the given state adopting IPS, and roughly, but slightly less than, double the amount of votes Republicans expect to lose. It is better thought of as the expected change in margin.

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state: Alabama. Expected Diff: 5.549600000000001
state: Alaska. Expected Diff: 1.3940000000000001
state: Arizona. Expected Diff: 1.6870999999999992
state: Arkansas. Expected Diff: 3.472400000000001
state: California. Expected Diff: -36.5228
state: Colorado. Expected Diff: -2.054
state: Connecticut. Expected Diff: -3.4869
state: Delaware. Expected Diff: -1.1016000000000004
state: District of Columbia. Expected Diff: 1.3979
state: Florida. Expected Diff: 1.426399999999999
state: Georgia. Expected Diff: 3.4785000000000004
state: Hawaii. Expected Diff: -1.965
state: Idaho. Expected Diff: 2.1142000000000003
state: Illinois. Expected Diff: -12.062199999999997
state: Indiana. Expected Diff: 6.7646999999999995
state: Iowa. Expected Diff: 2.0063999999999997
state: Kansas. Expected Diff: 3.3470000000000004
state: Kentucky. Expected Diff: 4.7638
state: Louisiana. Expected Diff: 4.571400000000001
state: Maine. Expected Diff: -0.5225000000000003
state: Maryland. Expected Diff: -6.3914
state: Massachusetts. Expected Diff: -7.235099999999998
state: Michigan. Expected Diff: -0.3308000000000013
state: Minnesota. Expected Diff: -0.9693999999999994
state: Mississippi. Expected Diff: 3.2337000000000007
state: Missouri. Expected Diff: 5.9324
state: Montana. Expected Diff: 1.5306000000000002
state: Nebraska. Expected Diff: 2.8141999999999996
state: Nevada. Expected Diff: -0.5929000000000004
state: New Hampshire. Expected Diff: -0.16130000000000017
state: New Jersey. Expected Diff: -7.392299999999999
state: New Mexico. Expected Diff: -1.7076999999999996
state: New York. Expected Diff: -19.525200000000005
state: North Carolina. Expected Diff: 2.371000000000001
state: North Dakota. Expected Diff: 1.3362
state: Ohio. Expected Diff: 6.235799999999998
state: Oklahoma. Expected Diff: 3.8145
state: Oregon. Expected Diff: -3.1634
state: Pennsylvania. Expected Diff: 0.756599999999999
state: Rhode Island. Expected Diff: -1.5299000000000003
state: South Carolina. Expected Diff: 4.4585
state: South Dakota. Expected Diff: 1.4284
state: Tennessee. Expected Diff: 7.106200000000001
state: Texas. Expected Diff: 14.778900000000004
state: Utah. Expected Diff: 3.5744
state: Vermont. Expected Diff: -1.8205999999999996
state: Virginia. Expected Diff: -3.134999999999999
state: Washington. Expected Diff: -6.585899999999999
state: West Virginia. Expected Diff: 2.1203000000000003
state: Wisconsin. Expected Diff: 0.24070000000000052
state: Wyoming. Expected Diff: 0.9249999999999994
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Works (and data) Cited

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