Algorithms Of Democracy

Introduction:

There are few subjects in more politics more contested than the value of the Electoral College. It's easy to see why this is such a polarizing issue. In my adult lifetime, there has never been a Republican President who has made his way into the White House by winning the popular vote; the Electoral College has always been the system that delivers the presidency to a candidate whom the majority of Americans did not vote for. And, of course, for those people for whom the Electoral College delivers victories; they see those victories as being the intention of the framers of the Constitution who, in their wisdom, made sure that the voters in smaller states would receive enough electoral votes to remain relevant and to prevent the case where we become the United States of California and New York.

Regardless of their position on the Electoral College, it's been my experience that most people don't really have even a perfunctory understanding of how it operates. They know that a President needs 270 of its electoral votes to win, and they know that the allocation of electoral votes has something to do with the population as measured by the census, but past that it's workings remain largely a mystery. I resolved to do some research and understand exactly how this system works, why it seems to be biased the way it does, and to see if any justifications for that bias could be found in the legislation that controls it.

The Constitution:

It's well known that the Electoral College is enshrined in the constitution, and any arguments that we should do away with it have to contend with the fact that doing so requires something that is very politically difficult: either a constitutional convention or an amendment. I searched the Constitution for a section that contained some kind of math. I knew I wasn't likely to find an equation, but I expected some sort of plain-english definition of the algorithm which would be used to take data from the census and assign electors to each state, a process known as 'apportionment.' I was, needless to say, surprised to find that this was not in the text of the Constitution, nor any of its amendments. Digging deeper, I did, of course, find the information I was looking for about the systems we use to appropion votes based on census data; but the critical take away from this step is that this very critical piece of the Electoral College is *not* enshrined within the US Constitution. It's defined in lesser laws that can be, and have been, changed through much difficult to achieve legislative processes.

Apportionment Methods:
In order to actually aprotion votes, there needs to be some kind of well defined algorithm for doing so. While it wasn't in the constitution, the method we currently use is called Huntington-Hill, sometimes also referred to as the 'method of equal portions.' I assumed that this was the mechanism by which the smaller states are given some extra votes to help them resist being overwhelmed by the more populous ones. This was the mechanism I wanted to consider replacing in an effort to re-balance the Electoral College instead of trying to replace it completely.

Huntington-Hill Method:
This is the algorithm that we currently use to apportion votes. It puts all the states in a list, and then has a stack of electors to approtion. For each elector, it selects the top state from the list, approtions the elector to that state, and then re-calculates its place in the list based on the following coefficient:

$$\frac{Population}{Electors * (Electors + 1)}$$

Of course, this coefficient would be indeterminate if the number of electors in state was zero, so the first thing we do is give every state one elector. This also prevents a case where a state never gets any electoral votes.

Hamilton-Vinton Method:
Since one of the main criticisms against the Electoral College is that it doesn't give every US voter an equal vote, I implemented a legacy apportionment method that would (at least, as closely as possible) achieve this. This method simply assigned each state electoral votes based on their population as a percentage of the US population.

$$Electors_{state} = \frac{Population_{State}}{Population_{Country}} x\ Electors_{Total}$$

Of course, we cannot assign partial electoral votes, so some rounding was needed. This leads to a case where we have a remaining elector, and so that is assigned to the state that had the largest remainder in population as left by the rounding process. This was the way that votes were apportioned from 1850 until 1911.

Modeling:
In order to compare these two methods, I wrote some basic tools in Python that would run these algorithms to assign electors. I used the data from the 2010 census for population numbers. Those tools can be found on my GitHub page here:
https://github.com/notkevinjohn/ElectorAllocation

The apportionment of electors based on population isn't the entire story, of course. We also assign electors for a state's representation in the Senate, and that's much easier to do. Every state gets two senators, and every state gets two electors based on those senators. The District of Columbia also receives two of these electoral votes, despite its lack of any senators.

Democracy Quotient:
One of the most common criticisms of the Electoral College is that it doesn't give everyone the same amount of influence in electing the President. People in smaller, less populous states have more per-capita electoral votes than people living in larger, more populous states. I set out to quantify this difference by defining the following quotient as the ratio of per-capita electoral votes in the smallest state to per-capita electoral votes in the largest state:

$$DQ = \frac{Electors_{SmallestState} / Population_{SmallestState}}{Electors_{LargestState} / Population_{LargestState}}$$

A distribution method with DQ of exactly 1 would mean that everyone in the country's vote counted the same. And

higher values mean that there is a greater discrepancy between how much everyone's votes actually count for. The largest state remains California, and the smallest remains Wyoming.

Data:
So I put these two apportionment methods into my model, and I fully expected that the Hamilton-Vinton method would come up with a dramatically different apportionment of votes that would yield a Democracy Quotient far closer to 1, but to my surprise the apportionments were almost identical, you'll need to look closely to see the differences between the two, and the DQ's are absolutely identical.

State	Huntington Hill	Hamilton Vinton
Alabama	9	9
Alaska	3	3
Arizona	11	11
Arkansas	6	6
California	55	55
Colorado	9	9
Connecticut	7	7
Delaware	3	3
Florida	29	29
Georgia	16	16
Hawaii	4	4
Idaho	4	4
Illinois	20	20
Indiana	11	11
Iowa	6	6
Kansas	6	6
Kentucky	8	8
Louisiana	8	8
Maine	4	4
Maryland	10	10
Massachusetts	11	11
Michigan	16	16

Minnesota	10	9
Mississippi	6	6
Missouri	10	10
Montana	3	3
Nebraska	5	5
Nevada	6	6
New Hampshire	4	4
New Jersey	14	14
New Mexico	5	5
New York	29	29
North Carolina	15	15
North Dakota	3	3
Ohio	18	18
Oklahoma	7	7
Oregon	7	7
Pennsylvania	20	20
Rhode Island	4	3
South Carolina	9	9
South Dakota	3	3
Tennessee	11	11
Texas	38	38
Utah	6	6
Vermont	3	3
Virginia	13	13
Washington	12	14
West Virginia	5	5
Wisconsin	10	10
Wyoming	3	3
District of Columbia	3	3

DQ	**3.605**	**3.605**

The conclusion we can draw from this is that the effect the apportionment methods have on the democraticness of our elections is completely dwarfed by the apportionment of votes based on the senators. That apportionment is, of course, part of the Electoral College that is defined in the constitution. However, the number of electors in the house is *not* set in the constitution. As such, the ratio of what percentage of electors are apportioned through a democratic, population based approach to the number that are apportioned through a non-democractic senator based approach is not controlled by the Constitution.

Apportionment Act of 1911:
This is the law that capped the number of house seats at 435, and as such fixed the ratio of democratic to non-democratic electors at 435:100. But it's of course worth noting that this is just a regular law. It could be replaced with a new law without any special criteria like those required for a constitutional amendment. So I asked a question, could we get closer to a democratic election if we allowed for seats in the house that were in line with the level of representation people had in 1911? To do this, I considered the population in 1911 of around 93 million. That's less than 1/3rd of what the population is today, so if we multiply the total number of electors by 3, we should get an idea of how many electoral votes we might have in the system were it not for the apportionment act. Of course, this number isn't terribly significant, in theory this ration could be whatever legislators wanted to set it to. So I ran the analysis with 1407 electors instead of 538, which is 435*3 electors for population and 102 electors for senators (plus DC).

State	Huntington Hill	Hamilton Vinton
Alabama	22	22
Alaska	5	5
Arizona	29	29
Arkansas	14	14
California	160	159
Colorado	23	23
Connecticut	17	17
Delaware	6	6
Florida	81	82
Georgia	43	43
Hawaii	8	8
Idaho	9	9
Illinois	56	56
Indiana	29	29

Iowa	15	15
Kansas	14	14
Kentucky	20	20
Louisiana	21	21
Maine	8	8
Maryland	26	26
Massachusetts	30	30
Michigan	44	44
Minnesota	24	24
Mississippi	15	15
Missouri	27	27
Montana	6	6
Nebraska	10	10
Nevada	13	13
New Hampshire	8	8
New Jersey	39	39
New Mexico	11	11
New York	84	84
North Carolina	42	42
North Dakota	5	5
Ohio	51	51
Oklahoma	18	18
Oregon	18	18
Pennsylvania	56	56
Rhode Island	6	6
South Carolina	22	22
South Dakota	5	5
Tennessee	29	29
Texas	108	108

Utah	14	14
Vermont	5	5
Virginia	36	36
Washington	30	30
West Virginia	10	10
Wisconsin	26	26
Wyoming	4	4
District of Columbia	5	5
DQ	**1.663**	**1.663**

Once again, you'll need to look very closely to see the differences between these two apportionment methods, but what is very clear is that as we increase the number of electors in the system, the DQ gets closer to 1. What this means is that, if we so chose, we could modify the electoral college to remove, or at least reduce, the problem of votes not counting the same from state to state.

2016 Election Results:
Equipped with this knowledge, I assumed that in a system where votes were more evenly distributed that elections would tend to have results that more closely approximated those of the popular vote. This was intuitive, but wrong. I extended my modeling software to use the results of the 2016 election and re-calculate them based on different methods of apportioning electors and (as I would come to learn much more importantly) allocating those electors based on the two models: winner-take-all and proportional. It's important to note that at no time did I change a single person's vote in this revisionist history exercise; and as you'll see, the winner of that election will change based on how electors are allocated. For the proportional model, I only allocated votes between the two major parties, so votes that went to third party candidates were not considered in this analysis.

I chose 2016 as the election to re-analyze since it was the most recent one, and also because it was one of the more prevalent cases where the winner of the Electoral College vote was not the winner of the Popular Vote. This, of course, also happened in 2000, but I thought it would be more salient to show that 2016, which wasn't considered a particularly close election, could have flipped its result based on the procedures. I should note that in my modeling, I did not make exceptions for Maine and Nebrasksa, both of which do not currently have winner-take-all elections. So while the Huntington-Hill, Winner-Take-All model is considered to be what we have now, the actual results are slightly different then the real-world results.

Data:
The following results show how many electors are allocated to the Republican and Democratic candidates for the 2016 election while changing both the apportionment method and allocations methods as indicated.

	Huntington Hill (538)		Hamilton Vinton (538)		Huntington Hill (1407)		Hamilton Vinton (1407)	
Winner-Take-All	**305**	233	**305**	233	**794**	613	**795**	612
Proportional	268	**270**	267	**271**	689	**718**	690	**717**

From these data the result is very clear. The only thing that should really matter to people who are upset that the outcome of the Electoral College doesn't match the outcome of the popular vote is Winner-Take-All elections. If these were to go away, the Electoral College could become a benign pass-through system that would almost never produce a result that differed from the popular vote.