Reflecting Voter Preferences in U.S. Presidential Primaries Using Ranked-Choice Election Systems

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Honors Thesis

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Abstract

This paper assesses the effectiveness of various ranked-choice voting systems, as compared to the current plurality system, in reflecting aggregate voter preferences in United States presidential primary elections. Survey data, gathered in February 2020 by FairVote, elicited the ranked preferences of a random sample of likely Democratic primary voters for eight remaining candidates in the election at that point. I use these data to estimate a model of voter preferences and to simulate various election outcomes, including a simple plurality election and various types of ranked-choice elections. Voter preferences, which are analyzed using a multinomial logit choice model, inform the social welfare for the voting population that each candidate provides. Using these estimates of social welfare for each candidate, I assess how each ranked-choice election system compares to the current plurality system and which systems best reflect aggregate voter preferences. I also evaluate each system on the basis of various desirable criteria for practical application. I find that certain RCV mechanisms provide, in some instances, higher social utility for the voting population and that they meet desirable criteria better than does the simple plurality mechanism.

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support system, and I could not appreciate it more.

1 Introduction and Motivation

Electoral reform is a controversial topic in the United States, especially for presidential elections, as voters, politicians, and political scientists express frustration with the country's primary and general election voting systems. Electoral mechanisms, such as the electoral college and delegate allocation, were historically put in place to prevent a "tyranny of the majority" and to provide adequate political representation to smaller populations, but such mechanisms are increasingly viewed as skewing election outcomes (Goldberg, 2017). Calls for reform have increased with heightened polarization, and organizations have taken to analyzing the effect of "spoiler" candidates on election outcomes in existing voting systems ("Polarization", 2020). Though it is not clear how outcomes would have changed with the absence of Jill Stein from the 2016 presidential election, Ralph Nader from the 2000 presidential election, or Ross Perot from the 1992 presidential election, discourse by academics and reform organizations often considers the suggestion that ranked-choice voting (RCV) would have been able to correct for these "spoiler" candidates (Kambhampaty, 2019; "Ranked Choice Voting In Presidential Campaigns", 2020; Tabarrok, 2001; Foley, 2019). RCV allows voters to rank every candidate in one ballot in order of preference, in one trip to the polls or in one absentee form, rather than only having to choose one candidate per office as is required by current ballots.

Though RCV has most frequently been proposed in response to general election outcomes, this thesis is concerned with assessing the implications of RCV in U.S. presidential primary elections. RCV has been highly debated for the implications it has on vote allocation in a two-party system, as it provides more incentives for voters to select candidates whom they would not otherwise deem viable; similarly, RCV could also alter voting incentives in primary elections, especially since primaries provide more options for voters to choose from than do general elections. This thesis determines if RCV systems allow parties to nominate candidates who better reflect the preferences of all of their voters than does a plurality system, especially valuable as parties have an increasing number of candidates competing each cycle. The 2020 Democratic primary elections, conducted from February to August, saw a record number of candidates competing for the party nomination; twenty-nine candidates declared their intentions to run and, ultimately, eleven remained in the race by the start of the first primary events, the Iowa caucuses. Many candidates withdrew from the race as it became increasingly clear (through media and polling) that the election would come down to a two-person contest between Joe Biden and Bernie Sanders.

The other nine candidates who were still in the election at the start of primaries withdrew at various times from mid-February to mid-March after assessing their performance in early elections. Many voters in early elections expressed frustrations about having voted for a candidate who did not remain in the race much longer. For example, Pete Buttigieg had received tens of thousands of votes and over 20 pledged delegates during February primary elections, only to drop out of the race before Super Tuesday on March 3rd (Coltrain, 2020). Other voters had cast their ballots strategically to avoid voting for candidates whom they did not foresee remaining in the race. For example, some avoided voting for Michael Bloomberg or Elizabeth Warren, despite them both remaining in the race past Super Tuesday, because the winner, by that point, would likely be either Joe Biden or Bernie Sanders. Both of these trends skew election outcomes because they incentivize voters to misrepresent their preferences. RCV is touted for providing a potential solution to such concerns (Risch, 2020).

Rational primary voters cast their ballots in a manner which they think will lead them to the best possible president in office for their desired outcomes, whether that be descriptive representation or passage of favorable policies. This could entail voters selecting whichever candidate aligns most with their preferences, demographics, or stances, or they might select the candidate who they believe is best positioned for competition in the general election. Regardless of the different factors that determine voter preferences, voting systems are used to select the best outcome for the overall voting population using only voters' ballots as an input.

There are a few main questions considered in this thesis. Firstly, do the various election systems—simple plurality, similar to our current system, and ranked-choice methods—truly yield different outcomes? If they do yield differences in outcome, is this consequential for social utility? Additionally, do these various election systems otherwise differ, perhaps in their effects on voting procedure or in their practical applications? In economics, these questions are best considered in the context of previous game theory and social choice research. This thesis uses existing literature in these research areas to determine bases on which to evaluate the voting systems considered; my paper, however, stands unique in considering ranked preferences that are used to select a single candidate winner.

I use survey data to simulate outcomes of various voting systems on the 2020 U.S. Democratic Party presidential primary election. The voting systems considered include variations of runoff, Borda Count, and Condorcet mechanisms. Using a model of voter preferences based on ideology and other demographic characteristics, I estimate the overall utility provided by each candidate in the race. I use these utility measures to determine how each voting system impacts social utility for the voting population to contribute to my assessment of the benefits and drawbacks of each system. It would be highly consequential to our democracy to determine which system best reflects voter preferences and best incentivizes truthful revelation. This would not only encourage voter turnout, but would also encourage potential candidates to compete in elections, especially as increased trends of polarization require political parties to nominate the best candidate possible by thoroughly considering all possible options.

2 Background

The presidential primary nomination process is not set in the United States Constitution, so it is flexible and has evolved over the years. The current primary election system is, on its face, a simple plurality election where the candidate with the most votes wins; however, there are many complicated facets to the process, notably regarding the staggered timing and locations of elections and regarding convention delegates. Historically, party nominees were internally selected by party leadership, but nominee selection has since come to occur at a national convention, which is seen as more democratic and transparent. Reformers pushed to expand primary elections to state voters to measure public opinion of candidates, and primary elections currently play this same role in party nominations (Yglesias, 2016). In these primary elections or caucuses, voters either go to a polling place or to an event hosted by the state party to cast a ballot or otherwise express preference for one single candidate among the competing slate.

The varied timing of each state's primaries has stirred a lot of discussion over the years ("'Front-loading' the Primaries", 2004). Certain states whose primaries are held earlier in the cycle are significantly more influential in swaying election outcomes, especially as primary elections come to be decided more often before the end of the primary election season. New Hampshire had long held the title of "first-in-the-nation" to vote in primaries and, noticing the level of influence that they had, other states have tried to move up their primaries to have similar influence (Yglesias, 2016). In 2016, however, parties ruled that primaries cannot occur before February of election year, and that only Iowa, New Hampshire, Nevada, and South Carolina can have primaries in that month. Thus, candidates spend their time in early months campaigning in these critical states, a trend called "front-loading."

Critics note that front-loading is problematic as it gives incredible power to states with smaller populations since media and agency pollsters can quickly transmit information about how candidates are performing or are projected to be performing across states ("'Front-loading' the Primaries", 2004). They note that states with larger populations, and that are in considerably different geographic regions, have to vote last, often after the election is already decided (Yglesias, 2016). One notable example is California, which is among the last to vote, like other Western states, despite having a very large population. States have attempted to lean into the geographic clustering of elections by creating geographic blocs—like Super Tuesday, which started out as a bloc for Southern states—to encourage candidates to spend campaign time in certain regions (Yglesias, 2016). Timing of various elections is especially consequential as candidates drop out in between primaries if they are not signaling early strength; in later sections, I discuss how election systems vary in considering votes if candidates drop out mid-season.

Additionally, an often misunderstood aspect of U.S. presidential primary elections is the role of delegates. The party chooses how many delegates are allocated to each state. State parties choose to hold either primary elections, run by the state and local governments, or caucuses, run by the state party, to determine how delegates will vote at the party's national convention. Delegates are often "pledged" based on the proportion of votes received by each candidate in the state or district. It is notable that the candidate who is the plurality winner in the state, but might not be the majority winner, receives the pledges of the largest portion of that state's delegates. Additionally, each party also has some "unpledged" delegates who are not bound to vote in alignment with any election result. In the Democratic party, there are a significant number of these delegates, called "superdelegates," whose roles are hotly debated for the amount of influence they have on party nominee selection. Once the national convention begins, delegates cast their first round of votes and a candidate is selected only if they achieve an absolute majority of votes. If this does not happen, it is considered to be a "brokered convention" and delegates are "released." They are then allowed to reconsider their votes in subsequent rounds until one candidate finally attains an absolute majority of votes (Yglesias, 2016). I assess, through my evaluation of various RCV systems, how ranked ballots could help inform delegates in their voting process.

Both for presidential primaries and in other elections, some states have begun to implement ranked-choice voting systems. For the 2020 presidential primaries, Nevada, Alaska, Wyoming, Kansas, and Hawaii used forms of RCV (Risch, 2020). The latter four states had very late primaries, all in April to May, after every candidate except Joe Biden had already dropped out. Nevada held an early primary in February; however, the option of RCV was only available to early voters. All five states saw increases in voter turnout; though not necessarily caused by RCV, the new voting systems were not shown to have negatively impacted turnout. One state has gained national attention for its use of ranked-choice voting in other elections: Maine. Vote counts from a notable election in Maine are publicly available and I, in the later Data section of this thesis, explain why I chose not to use this data set. Despite this, RCV has had considerable impacts on election outcomes in Maine, and the state has been praised for its successful implementation ("Spotlight: Maine", 2020). RCV has otherwise been used in many local elections throughout the country, often to assess if and how it would work at higher levels ("Data on Ranked Choice Voting", 2020). The RCV election types implemented in these states are usually either instant-runoff elections or single-elimination runoff elections, where the least popular candidate is eliminated one at a time.

In addition to these two runoff mechanisms, this thesis also considers two commonly-discussed types of ranked-choice elections in game theory: Borda count and Condorcet elections. Both are explained in detail in further sections; but, in brief, Borda count assigns a number of points to each candidate based on their position in a voter's ranking, and Condorcet methods consider the outcomes of each possible head-to-head face-off between candidates. Borda count has been used in variations in many countries in Europe and has also been used at universities in the U.S. for student government and department officer elections. Its variations have also been used in multi-winner elections ("Ranked Choice Voting 101", 2020). The Condorcet method is not known to have been used in any government elections, but it has been used by some private organizations ("Ranked Choice Voting 101", 2020).

In a later section, I expand upon why these election types were selected for consideration, as well as on some of their costs and implications when applied in practice.

3 Literature Review

3.1 Desirable qualities of voting methods

Literature concerning social choice and aggregate voter preferences helps to determine which election systems are worth evaluating and what their benefits and drawbacks might be. Firstly, Kenneth Arrow's seminal work in social choice articulates criteria to be met for a satisfactory election system. Arrow (1950) attempts to address the question of finding a method, other than a well-known "paradox of voting," that aggregates individual tastes while implying rational behavior on the part of the community and while considering ordered preferences (that are complete and transitive), rather than cardinal ones. Arrow concludes if there are at least three candidates for members of society to choose from, then every social welfare function (a function mapping multiple individual orderings to one societal ordering) satisfying his conditions would yield a social ordering that violates one of two desirable properties: being "non-imposed" and being "non-dictatorial." This is to say that every global societal preference order would either not be achievable given the individual preference orders, making it imposed, or would merely follow the choice preferences of one individual while disregarding the preferences of all others, making it dictatorial. This paper and Arrow's other works have been greatly consequential in choice theory for articulating desirable properties to look for in various social choice mechanisms. While Arrow's argument is that a full societal ranking of candidates cannot be satisfactorily determined given individual rankings, this thesis explores if one can satisfactorily select a single most-preferred candidate from aggregate preferences (particularly in a way that is more reflective of voter preferences than our current method in the United States).

Similarly, Gibbard (1973) and Satterthwaite (1975) question the plausibility of "strategy-proofness" in various voting systems, where voters attempt to secure their desired outcome by misrepresenting their preferences. Gibbard set out to verify the conjecture that no non-dictatorial system of voting with at least three possible outcomes can preclude strategic voting. He proved that every such straightforward game with at least three possible outcomes violates the condition of non-dictatorship. Satterthwaite develops on Gibbard's paper, as Gibbard did not make a direct connection between strategy-proofing and Arrow's desirable properties; he questions whether a strategy-proof voting procedure can be constructed to remove incentives for committee members to use a sophisticated strategy. Satterthwaite finds a negative conclusion: if the committee is voting on at least three alternatives, every strategy-proof procedure is dictatorial, as it gives one committee member absolute power over the choice outcome. He also finds that a one-to-one correspondence exists between strategy-proof voting procedures and social welfare functions satisfying Arrow's four conditions. Together, this literature has formed the "Gibbard-Satterthwaite Theorem," suggesting that for all voting rules, the rule is either dictatorial, only limited to two possible outcomes, or subject to tactical voting. It is important to assess how each ranked-choice system simulated in my paper affects the incentives that voters face and how subject they are to tactical voting.

3.2 Using logit models to estimate voter preferences

My use of a multinomial logit model in estimating voter preferences is greatly informed by Dow and Endersby (2004). They present a theoretically appropriate model of voting behavior based on utility maximization that serves as a basis for this thesis in developing a model of voter preferences. Dow and Endersby differentiate the multinomial logit (MNL) from binary logit/probit, ordered logit/probit, and multinomial probit (MNP) models and characterize voter choice as a decision among unordered alternatives (parties or candidates) as a function of chooser (voter) and choice (party/candidate) attributes. They assert that the MNL model performs as well as or better than MNP, being simpler to optimize and more often converging at a global optimum, predicting similar percentages of the observations but finding more parameters to be statistically significant, and estimating parameters with smaller confidence bands. The MNL centers on the independence of irrelevant alternatives (IIA) property, which states that, when considering an individual's ranking for a subset of specific alternatives, changes in that individual's rankings of any "irrelevant" alternatives should not impact the relative ranking of the "relevant" subset of options. Though there exists a debate on whether this is too restrictive in the multinomial logit model, the authors state that IIA should not be viewed as too restrictive on voter preferences as it should be considered as a desirable logical property rather than as a statistical one. For these reasons, and since the model, according to the authors' assertions, works well with smaller data sample sizes than are needed for MNP, the multinomial logit model is promising for my data and for my research question.

Other academics, in fields from political science to econometrics, have used logit models to estimate voter preferences in papers that similarly inform this thesis. Kamakura, Mazzon, and De Bryun (2006) develop a model based on the classic spatial theory of voting where voters make choices based on their perceptions of the candidates' positions as compared to their own. They develop a nested logit factor model of voter choice to predict future outcomes in multi-stage elections. They conclude that candidate strategy before a second round of an election can be guided using demographic data and by identifying positioning of candidates on latent dimensions on which candidates compete. This thesis similarly assesses the effect of voters' demographic data and ideological positioning on preferences for candidates. This paper also considers cannibalization of votes among similar candidates in elections, which is often thought to be a large problem with our current majoritarian voting system that might be reduced with ranked-choice voting. My work is distinctive from this paper in that the authors are primarily concerned with multi-stage elections where voters must return to the ballot booth, whereas, in my model, all rankings are gathered at the same time, and the thesis considers single-stage ranked-ballot elections.

Koop and Poirier (1994) also use a multimonial logit framework and specifically consider rank-ordered elections. They conduct a Bayesian investigation of multinominal logit models on rank-ordered elections, to further develop on their previous research of first-preference elections, and they test to see if these rank-ordered elections meet the independence of irrelevant alternatives assumption. Koop and Poirier conclude that voter preferences are determined in part by an individual's demographic, work-related, income, and socioeconomic characteristics. In my analysis, I also consider the effect of such characteristics on voter preferences. This research presents an applied example of how a MNL framework can be developed to reflect voter preferences based on demographic characteristics in, specifically, rank-ordered elections, as is directly relevant to this thesis.

Finally, Scarpa and Thiene (2005) use a multinomial logit model and a latent-class approach to estimate preferences for various rock-climbing destinations in the Italian Alps based on demographic characteristics of surveyed rock-climbers. They use the observed choices of individual rock-climbers to derive conditional estimates of welfare measures for the overall population. This helps extend my multinomial logit model to look at change in consumer surplus, helping determine the social welfare of electing certain candidates over others.

This thesis draws upon existing literature to develop my model of voter preferences, to determine how to estimate social welfare of various candidates based on these preferences, and to determine various properties that a desirable voting system should meet. My paper stands unique among existing literature as it specifically focuses on ranked, ordered voter preferences to select one single most-preferred candidate in single-stage elections.

4 Theoretical Model

This section explores the factors influencing a person's decision to vote for a candidate, whether that be casting a single ballot for them as their most-preferred choice or ranking them in a choice profile among other candidates. I clarify who might vote in a primary election; identify factors that influence a voter's utility for each competing candidate; and elaborate on how voters might embrace different frameworks to maximize their utilities before casting ballots, depending on how they view candidate ideologies. Finally, I explain how voters might attempt to strategically vote based off their perceptions of other voters' actions. This theoretical model allows us to develop an empirical model in later sections that determines the overall utilities of each candidate for a population of voters.

4.1 Setting

In the United States, citizens who are eligible to vote make the decision of whether or not to participate in elections based on their "political efficacy." This entails their internal efficacy, the belief that one has enough understanding of politics and policy to participate, and their external efficacy, the belief that one can influence government by their actions ("Perceptions of the public's voice," 2015). If an eligible person's political efficacy is sufficiently high, their marginal benefits of voting (i.e. possible positive outcomes of their votes) outweigh their marginal costs of doing so (i.e. time spent researching candidates and casting a ballot), and the person will register to vote and possibly affiliate with a political party. Partisan affiliation can be determined by numerous environmental influences (family, religious affiliations, etc.) and might often vary from a person's individual ideological identification. Since voters have various levels of attachment to a certain party, the choice to officially register with a partisan affiliation might be determined by the primary election regulations that exist in a voter's home state.

In closed-primary states (nine of them), party primaries are only open to voters who have registered with that party. In open-primary states (fifteen of them), any voter may vote in a party's primary without choosing to affiliate with them, enabling voters to cross party lines. Nine states hold primaries as being open-to-unaffiliated-voters, where unaffiliated voters can choose to participate in any party's primary, and the remainder of the states fall in between these open and closed regulations dependent on the wishes of state party leaders ("State Primary Election Types", 2021).

Enabled by the complexity of primary registrations, there are instances where a voter might want to vote in the primary opposite from their own party to elect a candidate that will be easily defeated in the general election. For the purposes of this thesis, let us assume that a voter in a party primary is not voting to set the party up for weakness. In other words, I am assuming that voters participating in the party primary intend to vote for whichever candidate they select in the party primary in the general election, if that candidate becomes the party nominee. Though I am imposing this assumption, it still leaves room for unaffiliated or oppositely-affiliated voters to participate in party primaries.

Once a voter has made the decision to participate in a party primary, there are numerous factors that can influence a voter's favor for a candidate. There are demographic characteristics D_V which people use to describe or identify themselves, including gender, age, race, sexuality, socioeconomic status, or regional location. These characteristics could also include choices such as career, union affiliation, and veteran/military status. Similarly, each candidate has the aforementioned demographic characteristics D_C that are either explicitly stated or implicitly perceived by voters. There are also desired traits T that a voter might want a candidate to have: years and type of previous experience, appearance, oration, and the often-debated "electability" trait. Additionally, many people vote based on key-issue topics K including, but not limited to, climate change, abortion, or gun legislation. Finally, a voter's favor for a candidate can depend on the ideology of the voter themselves I_V, and that of the candidate I_C.

Upon identifying these characteristics that affect voter preferences, we can suggest that utility of a candidate for a voter is dependent on demographic characteristics, D; candidate traits, T; key-issue topics, K; and ideology I. Note that costs of voting (i.e. time spent researching candidates and casting ballots) are not included in the following equation since these costs are the same across candidates, and since voters are assessing candidate utilities separately than they are assessing the decision of whether or not to participate in an election. The utility of candidate C for voter V is

$$U_{C,V} = f(D_V, D_C, T, K, I_C, I_V).$$

Once a voter assesses their utility for each candidate, they vote for the candidate who provides them the most utility or, if they are able to rank candidates, do so in the order of the utility each candidate provides. To each individual voter, each independent variable holds a weight, β_V, which can be either positive or negative based on the numerous values these variables can have. For example, candidate traits, T, could include a candidate being highly experienced. Voters could view ample previous experience as being a positive or negative thing, and this quality could either be very important in selecting a candidate or barely a point of consideration. Including these independent variable weights, we can consider the utility of candidate C for voter V as

$$U_{C,V} = \beta_{1V}(D_V) + \beta_{2V}(D_C) + \beta_{3V}(T) + \beta_{4V}(K) + \beta_{5V}(I_C) + \beta_{6V}(I_V).$$

Since the role of ideology in voter utility is of particular interest to this thesis, I expand further on how it can be factored into primary voters' decisions. There are two different ways voters might take the ideology of each candidate into consideration: they might examine it in proximity to the voter's own ideology or consider the candidate's ideology by itself.

4.2 Ideology as a determinant of voter preferences

To ideologically characterize candidates and voters, one of two commonly discussed frameworks of ideology are used in the United States. Most commonly, people are described as existing at a point on a left-right continuum, introduced by Downs (1957), where "the left" favor more state-planned economies and "the right" favor more deregulated ones. However, this axis has come to encompass American social thought as well, and "the left" are considered to be more liberal overall, and "the right" are considered to be more conservative overall. The second framework considers the left-right continuum to be a non-nuanced view of ideology and instead views ideology as being on a political compass that considers two-dimensions: an economic axis (left-right) and a social axis (authoritarian-libertarian).

Voters might assess the distance of each candidate's ideology from their own. We could consider that a voter has higher utility for a candidate when they are "closer" in distance to that voter's ideology. Thus, they will attempt to minimize the distance $|I_C - I_V|$. This is similar to how Black (1948) examined voter behavior in the median voter theorem, in which he assumed that each voter would rank candidates in order of preference corresponding to how "close" they are to the voter. This would suggest that a voter is more likely to first-prefer a candidate who is ideologically similar to them.

However, voters might, instead, take a different strategy in weighing a candidate's ideology. Given that the purpose of primary elections is to select candidates who will compete against the opposing party's nominee, a voter might put large stock into which candidate will perform best in the general election if they perceive the quality of the presumptive nominee of the opposing party to be particularly low. Large debate exists about the "electability" of various candidates, as the term is ill-defined and simply reflects various predictions about what will fare best. In this theoretical model, this notion of "electability" could be included in the desirable traits of candidates, T. Voters who are more concerned about a potential party nominee performing better in the general election (due to unique hatred for the presumptive nominee of the opposing party or for other reasons) might have a stronger weight for this term T.

Additionally, political science and public choice theory have noted that it is prudent for candidates to play to the extreme of their parties during primary elections to secure the nomination, and then move toward the center of the political axis during the general election to form a majority coalition and win over moderate voters. However, polling shows that when voters are asked who they would want to make president with a "magic wand," their preferences for a candidate vary significantly compared to who they are likely to vote for in the current electoral system, often actually voting for more moderate candidates than they would truly prefer (White, 2020). Since this differs from what political science has observed in the past, this might imply that "electability" is swaying how primary voters consider candidate ideology as a factor. For instance, an extreme voter (who would have made an extreme candidate president with a "magic wand") might, in reality, vote for a more moderate candidate (despite a large ideology distance) because they think they will fare better in the general election. Voters might, thus, have varying utilities for different candidate ideologies independent of their own ideologies or the distance between the two, based, rather, on which candidate's ideology they believe will help defeat a general election opponent. Voters like this do not necessarily attempt to minimize the distance $|I_C - I_V|$ and, rather, ideological distance might be less determinant of candidate utility for such voters than I_C itself.

4.3 Strategies: predicting other voters' votes

As is evident in the previous subsections, many of the considerations voters take in determining their candidate preferences involve predicting how other voters will vote. Voters have to predict who primary voters in the opposing party will elect and, then, depending on the candidates other primary voters are most likely to select, choose between them to have an impactful vote. Especially in a large field of candidates, voters rely heavily on pre-election and mid-election polling to assess which candidates are most popular.

Media and political polling have large influences on voter strategy in U.S. presidential primary elections. If there are more than two candidates competing in a primary election, polling, which is easily and widely available to voters, elucidates the top two candidates in the race before many have cast their ballots. This greatly reduces the incentive for voters to cast single-choice ballots for any candidate other than these top two, out of fear of a "wasted ballot." Thus, after polling and early voting results, voters strategically make their votes matter by preemptively narrowing the competition and choosing among the most likely to win the primary, or the most "electable", still taking into consideration all of the traits and demographics as they otherwise would. In a ranked-choice ballot, this one consideration is eliminated, dependent on which voting regime is used to tally votes, as the full ballot is considered even if the voter's top preference is not one of the "top two" candidates. Voters can rank candidates how they would like and, if they happen to first-prefer a candidate who is not viable or who ends up dropping out of the race, the method would instruct ballot-counters to move further down the voter's list of preferences.

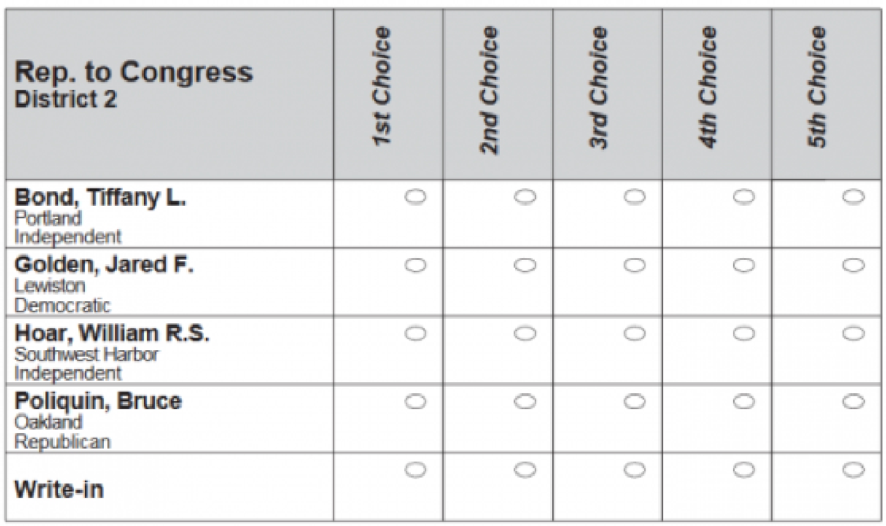
As typical of strategies in non-cooperative game theory, voters are considering other voters' behavior, as well as their own preferences, before making a move. For example, in plurality systems where voters can only select one candidate, voters might strategically select between the two most popular candidates at the time. Taking other voter behaviors into consideration impacts not the voter's own preferences for each candidate but, rather, how they will act upon their preferences when casting ballots. Further in this thesis, when considering the merits of each election system as related to certain desirable criteria, I explore strategies voters can or need not pursue in each different systems.

5 Data

Survey Data This thesis uses survey data both to simulate various election outcomes and to develop the model estimating voter preferences. The organization FairVote, a nonpartisan organization dedicated to electoral reform and a proponent of ranked-choice voting, commissioned a survey in February 2020 through SurveyUSA. This poll took a random sample of voters throughout the United States. The electronic survey determined if each voter was likely to vote in the upcoming Democratic party primaries through the initial questions. Then, it gave all "likely Democratic primary voters" (LDPVs) the option to rank their preferences of the eight remaining 2020 Democratic presidential primary candidates at the time: Joe Biden, Michael Bloomberg, Pete Buttigieg, Tulsi Gabbard, Amy Klobuchar, Bernie Sanders, Tom Steyer, and Elizabeth Warren. LDPVs ranked one choice at a time, with the options being the eight aforementioned candidates, minus any candidate selected in a previous choice, plus an "undecided" option. Once a respondent selected "undecided" or ranked seven preferences, the survey redirected to demographic questions before completing the survey. All respondents, including those who were not LDPVs, answered the demographic questions. This survey was set up in such a way that no respondent could indicate preference for any candidate multiple times (thereby disabling circular preferences), but still allowed them the freedom to not submit a complete choice profile.

Maine 2018 Election Data I also considered real votes from implemented ranked-choice elections to determine which type of data is most suitable my research questions. Maine implemented ranked-choice voting in the 2018 election for their 2nd Congressional District, and vote counts are readily available through the Maine Secretary of State. In this ranked-choice election, Democrat Jared Golden defeated Republican incumbent Bruce Poliquin in the instant runoff, though Poliquin had been leading when votes were still being allocated to two Independent Party candidates. This contest is a great example of how ranked-choice systems can change election outcomes. However, though the FairVote data is survey data rather than real votes, it, unlike the Maine data, provides the opportunity to explore the effects of RCV on elections with a large number of candidates and also includes demographic data that directly correspond to each rank profile. Additionally, the Maine ballots were set up in such a way that many voters indicated circular preferences and attempted to strategically vote for candidates multiple times. The ballot is pictured in Figure 1, and it shows a table where all four candidates plus a "write-in" option were listed down the rows and 1st-5th choices were listed across the columns. Voters simply had to fill in the bubbles corresponding to their preferences. Out of the 300,287 voters who participated in this election, 26,964 voters ($\sim$9% of total number of participants) have errors in their ballots; 12,625 voters ranked the same candidate in multiple slots, creating either cyclical or otherwise erroneous preferences; and 14,575 voters skipped slots in their rankings, also possibly indicating erroneous preferences (though this can be remedied by simply moving later preferences up to fill the skipped rank). This data teaches us a lot about voter behavior in ranked-choice ballots; if RCV is to be implemented, election officials would benefit from attempting to set up ballots in a manner that reflects how SurveyUSA conducted the FairVote survey, where repeated or skipped preferences are avoided since voters can only vote for each candidate once. Given that the FairVote survey prevented such erroneous votes and also acquired demographic data, it is better suited to the empirical model of voter preferences in this thesis than is the Maine election data.

Figure 1: Sample of Maine's 2018 Ranked-Choice Ballot for ME-02 Congressional Race



Rep. to Congress District 2	1st Choice	2nd Choice	3rd Choice	4th Choice	5th Choice
Bond, Tiffany L. Portland Independent	○	○	○	○	○
Golden, Jared F. Lewiston Democratic	○	○	○	○	○
Hoar, William R.S. Southwest Harbor Independent	○	○	○	○	○
Poliquin, Bruce Oakland Republican	○	○	○	○	○
Write-in	○	○	○	○	○

Information Gathered from FairVote Data FairVote gave me their raw data of all respondents' full choice profiles. Respondents provided information about the following demographics: gender, age, race, ideology, party affiliation, 2016 presidential vote, educational attainment, income, marital status, child status, religious affiliation, regional description, evangelism, union membership, military affiliation, LGBTQ household, and zip code. Respondents indicated qualitative demographics by selecting one of the provided options; for example, respondents categorized their ideological beliefs as being very conservative, conservative, moderate, liberal, very liberal, or stated that they were not sure. There were 2,868 total respondents to the survey, and we do not have information about how many people were contacted to participate. Of this total, only the LDPVs were shown the questions to rank candidates; there were 954 voters who denoted a preference for at least one candidate. Key summary statistics of demographic compositions of survey respondents are presented in Table 1. SurveyUSA also assigned each respondent a demographic weight.

Of the 954 LDPVs who were able to rank preferences, the first-choice preferences were as follows: 291 votes for Bernie Sanders, 191 for Joe Biden, 177 for Michael Bloomberg, 89 for Pete Buttigieg, 86 for Elizabeth Warren, 45 for Amy Klobuchar, 16 for Tulsi Gabbard, 19 for Tom Steyer, and 40 people were undecided. The number of votes for each candidate in each other preference slot are shown in Table 2.

Thus, in the FairVote data, the percentage of voters first-preferring each candidate are the following: Bernie Sanders, 31%; Joe Biden, 20%; Michael Bloomberg, 19%; Pete Buttigieg, 9%; Elizabeth Warren, 9%; Amy Klobuchar, 5%; Tom Steyer, 2%; Tulsi Gabbard, 2%; and Undecided, 4%. SurveyUSA also conducted a separate poll of United States voters around the same dates—February 13th, 2020 through February 17th, 2020— to assess who people were most likely to vote for. The results stand as follows: Bernie Sanders, 29%; Michael Bloomberg, 18%; Joe Biden, 18%; Pete Buttigieg, 12%; Elizabeth Warren, 10%; Amy Klobuchar, 4%; and Tom Steyer, 2% (Rakich, 2020). The SurveyUSA poll finding similar first-choice results to the one commissioned for FairVote allows us to validate the data set being used for this thesis as being reflective of popular opinion around the time.

Table 1: Demographic Summary Statistics of FairVote Survey Respondents

Demographic	All Respondents			LDPVs		
Gender	Male	1,380	(48.12%)	Male	457	(47.90%)
	Female	1,488	(51.88%)	Female	497	(52.10%)
Race	White	2,002	(69.80%)	White	609	(63.84%)
	Black	295	(10.29%)	Black	153	(16.04%)
	Hispanic	385	(13.42%)	Hispanic	140	(14.68%)

	Asian	114	(3.97%)	Asian	35	(3.67%)
	Multiracial	27	(0.94%)	Multiracial	11	(1.15%)
	Other	45	(1.57%)	Other	6	(0.63%)
Party Affiliation	Republican	912	(31.80%)	Republican	33	(3.46%)
	Democrat	1,108	(38.63%)	Democrat	777	(81.45%)
	Independent	669	(23.33%)	Independent	138	(14.47%)
	Not Sure	179	(6.24%)	Not Sure	6	(0.63%)
Ideology	Very Conservative	352	(12.27%)	Very Conservative	30	(3.14%)
	Conservative	566	(19.74%)	Conservative	86	(9.01%)
	Moderate	1,016	(35.43%)	Moderate	334	(35.01%)
	Liberal	498	(17.36%)	Liberal	316	(33.12%)
	Very Liberal	229	(7.98%)	Very Liberal	173	(18.13%)
	Not Sure	207	(7.22%)	Not Sure	15	(1.57%)
Household Annual Income	Under $40k	1,100	(38.35%)	Under $40k	321	(33.65%)
	$40k-80k	1,063	(37.06%)	$40k-80k	380	(39.83%)
	Over $80k	705	(24.58%)	Over $80k	253	(26.52%)
Education	High School	763	(26.60%)	High School	195	(20.44%)
	Some College	1,092	(38.08%)	Some College	344	(36.06%)
	4-Year College Degree	1,013	(35.32%)	4-Year College Degree	415	(43.50%)

Table 2: Breakdown of Votes for Each Candidate in Each Preference Slot

Selection	Pref. 1	Pref. 2	Pref. 3	Pref. 4	Pref. 5	Pref. 6	Pref. 7
Biden	191	204	163	91	57	28	27
Bloomberg	177	117	106	87	64	53	55
Buttigieg	89	102	114	128	109	74	34
Gabbard	16	20	20	23	46	61	112
Klobuchar	45	47	77	84	130	127	75
Sanders	291	187	118	56	46	30	32
Steyer	19	31	49	68	79	120	136
Warren	86	159	137	141	78	62	34
Undecided	40	47	83	106	69	54	50
Total Voters	954	914	867	784	678	609	555
Total Undecided Votes	914	867	784	678	609	555	505

Note: This table is counting from the original data. To simulate elections in later sections, I was able to fill in the eighth preference with the last remaining candidate, as long as all seven previous preferences were made.

6 Empirical Model

6.1 Voter ideology and utility of a candidate for a voter

We can consider the following model of voter preferences.

There are voters ($i = 1, \ldots, n$) selecting among candidates ($j = 1, \ldots, p$) in an election. Ballots are structured in a way such that voters only have strict preferences among candidates and they cannot indicate circular preferences, nor select one candidate more than once.

Individual preferences are determined based on a voter i's utility for candidate j. Voter i ranks candidates A, B, and C in the order A>B>C if

$$U_{iA} > U_{iB} > U_{iC}.$$

Voters can choose to rank as many of the p candidates they choose. Ranks only reflect an order of preference, rather than a magnitude of preference. We can assume that a voter prefers any ranked candidate over any candidate whom he/she does not rank.

A voter i's utility for candidate j is modeled by

$$U_{ij} = \sum_{x \in X} I_{ix}\beta_{jx} + \varepsilon_{ij},$$

where I_{ix} is the indicator for whether voter i has ideology x, and β_{jx} is the quality of candidate j for a voter with ideology x. The β vectors for each ideology group x contain p entries, each corresponding to a "value" V of each candidate for a voter in that ideology group. ε_{ij} is a random component of utility, assumed to be independently and identically distributed across candidates and voters. There are X ideology descriptors and I seek to estimate that number of ideology β vectors using the multinomial logit model previously used to model voter choice behavior (Dow and Endersby, 2004).

Other demographic characteristics would be considered by adding $\sum_{y \in Y} D_{iy}\alpha_{jy}$ to the utility function. Here, D_{iy} is the indicator for whether voter i has demographic y, and α_{jy} is the quality of candidate j for a voter with demographic y. That being said, given the limitations in this data set (which are further explained in the following subsection), to consider the impact of various demographic characteristics on voter preferences, we would instead amend the previous equation to consider $\sum_{y \in Y} D_{iy}\alpha_{jy}$ for demographic characteristics, rather than $\sum_{x \in X} I_{ix}\beta_{jx}$ for voter ideology.

Each voter is a utility maximizer. The probability of voter i casting a ballot for candidate 1 is given by the following:

$$P_{i1} = \Pr[U_{i1} > U_{i2}, U_{i1} > U_{i3}, \ldots, U_{i1} > U_{ip}].$$

For any m in the set of 1,. . ., p candidates,

$$P(m) = \Pr[\varepsilon_{im} - \varepsilon_{ij} < (\sum_{x \in X} I_{ix}\beta_{jx}) - (\sum_{x \in X} I_{ix}\beta_{mx}), j \neq m],$$

where j is any candidate other than m and where ε is distributed type-I extreme value.

The probability that a voter i votes for candidate j, conditional upon him/her casting a ballot, is given by

$$\Pr(\text{vote} = j | \beta_{jx}, \sum_{x \in X} I_{ix}) = \frac{e^{\sum_{x \in X} I_{ix}\beta_{jx}}}{\sum_{k=1}^{p} e^{\sum_{x \in X} I_{ix}\beta_{kx}}}.$$

A voter i's (who has the ideology x) utility for candidate j can also be considered as

$$U_{ij} = V_{jx} + \varepsilon_{ij},$$

where V_{jx} is a numerical candidate "value" for any voter in ideology group x—contained in the β vector for ideology x, solved for using the above maximum likelihood estimation framework, inputting individual voter ranked preferences for various candidates—and where ε_{ij} is an error term that is i.i.d among candidates and voters. To determine the overall utility of a candidate j for the population of voters, expressed as U_j, we can sum V_{jx} across each voter and weight each voter according to demographic weights provided in the data.

6.2 Data limitations as applied to the empirical model

Much of previous literature working toward building a model of voter preferences has considered the role that various demographic characteristics, both of individual voters and of different candidates, play in voter decisions to cast a ballot for a party or candidate, similar to my theoretical model. For the purposes of this thesis, the following empirical model explores the role of ideology as the main determinant of preferences for candidates for a few reasons. Primarily, the data is fairly limited in candidate preference variation among various demographics, so it is difficult to consider the interplay of multiple demographics. Any one variable can be considered on its own but cannot be considered along with another variable (ex. a regression focusing solely on race or on ideological descriptor but not both). Having to focus on only one variable, this model chooses to consider ideology, as it is often theorized as being a main determinant of voter preferences in seminal location models of voting (Downs, 1957). Additionally, an ideological descriptor might capture political leanings that are caused by voters' other identities, such as race or gender. Further, demographics complicate voter preferences by introducing implicit biases, making it difficult to simply control for demographics as being a factor in preference. For example, a white man with implicit biases might require a male candidate of color or a female candidate to be closer to him ideologically to provide him the same utility that a white male candidate would. This could be accounted for using dummy variables for each of a voter's demographic characteristics and interaction terms among them; however, as previously stated, there is not enough variation in the data to consider multiple variables in this way. Additionally, since demographic weights are provided in the data, they can be included in the regressions to account for variation in other demographics among ideology groups. Finally, we are also limited by the data in the types of information collected. FairVote only collected information about voter demographics and ideology descriptors. We do not have information on each voter's perception of candidate traits T or stances on key issues K, nor do we have clear metrics of candidate demographics D_C or candidate ideology I_C.

Thus, this model helps evaluate the acquired survey data to two ends. Firstly, it assesses how a voter's ideology affects their utilities for various candidates. Spatial models of voter preference often consider the distance between a voter's ideology and that of each candidate; though I might consider distance if there were clear ideology descriptors for each candidate, this model allows us to evaluate the impact of voter ideology on candidate preferences more generally. Additionally, the model enables us to estimate, for the given data set of ranked-choice ballots, which candidate provides the most utility for the overall population of voters.

6.3 Evaluating different voting systems

I use the ranked-choice ballots in the obtained survey data to simulate outcomes of various election systems. Each simulation outputs one single candidate (rather than an aggregate ranking for the population) after votes are counted. Voting methods are differentiated by the steps used to "count the votes" and, in practical application, by their ballot structures. The null hypothesis is that each voting method simulated yields the same output. The alternative hypothesis is that the voting methods yield more than one output across simulations.

In the event that the null hypothesis is rejected, the empirical model described above can be used to evaluate the output of each voting system. For the selected candidate j from each simulation, the overall utility for that candidate, U_j, corresponds to the social utility of that candidate and of that voting system. Another test will be conducted where the null hypothesis is that the multiple yielded candidates have indistinguishable overall utility. That is to say, if candidates A, B, and C are selected as outputs, their overall utilities are equal: $U_A = U_B = U_C$. The alternative hypothesis is that the candidates have significantly different overall utility. If this null hypothesis also rejected, the voting system (or systems) that yield a candidate with the highest overall utility is determined to provide the highest social utility for the aggregate voting population.

7 Results

This section first presents both the results of the simulated election outcomes and of the logit maximum likelihood estimation on the FairVote survey data. Then, I use a likelihood-ratio test to test the hypotheses presented in the model and present simulations using new data, randomized based on the MLE results, to validate the election outcomes. Additionally, I consider other regressions to answer lingering questions about the estimation results.

7.1 Simulated election results

In the FairVote data, there were 954 voters determined to be LDPVs. For the purposes of these simulated election outcomes, I counted these 954 voters' ranked preferences as ballots, and each ballot was weighted based on the voter's assigned demographic weight to properly reflect the population of concern, the U.S. Democratic primary electorate. The following paragraphs explain how ranked-choice ballots are counted in each different system. In a later section, I further explain why these systems were selected for consideration, as well as their merits and drawbacks. Note that the simple plurality method is the only one that does not require a ranked ballot to have been cast; thus, the remaining systems are considered to be applications of ranked-choice voting.

Simple Plurality First-choice votes are counted for each candidate. The winner is the candidate who receives the most first-choice votes.

Instant Runoff This is a two-stage election. In the first stage, first-choice votes are counted for each candidate and the two candidates with the most first-choice votes proceed to the second stage. Then, full-choice profiles of each voter are used to see which of these two candidates each voter preferred; the most-preferred candidate after the second round is determined to be the winner.

Single-Elimination Runoff Since there are eight candidates to select from, there are seven stages in this election. In the first round, first-choice votes are counted, and the candidate who receives the fewest first-choice votes is eliminated. In the second round, full-choice profiles are used to determine which of the remaining candidates is highest-ranked in each voter's ballot. This process continues as the candidate with the fewest votes is eliminated each round and only the remaining candidates are considered on each voter's ballot. The winner is determined by who receives the most votes in the two-candidate face-off in the final round.

Borda Count Points are awarded to each candidate based on where they fall in each voter's ranking. Since there are eight candidates, each voter's first choice is given eight points, their second choice is given seven points, and so on until their eighth and final choice is given one point. Any unranked candidate receives zero points from that voter's choice profile. The winner is the candidate who has the most points once all ballots are counted.

In this data set, however, voters only had the option to rank seven candidates. Though we could infer each voter's eighth preference, we cannot assume that the voter would have ranked the candidate over leaving the slot blank. Thus, no candidates are given only one point from a ballot in the aforementioned method of counting. Therefore, I present an additional, modified version of this system in the results where each voter's first choice is given seven points, their second is given six points, and so on until their seventh final choice receives one point, while any unranked candidate receives zero points. This should theoretically yield equivalent results to the first method of Borda count.

Simple Condorcet Condorcet elections consider all possible head-to-head scenarios between candidates; for these eight candidates, there are twenty-eight head-to-head face-offs. Using a simple Condorcet method, the winner is the candidate who wins the most number of head-to-head matchups.

Marginal Condorcet (using win percentages) Slightly different from the previous method, in each head-to-head matchup, we observe the percentage by which the victorious candidate wins. For example, if the outcome is 65% of votes for Candidate A to 35% for candidate B, the "win percentage" is 30%; candidate A has 30 added to their win percentage tally from this matchup, and candidate B does not have any points added to their tally. Using this marginal Condorcet method, the winner is the candidate who has the highest tally of win percentages after all of the head-to-head matchups.

Marginal Condorcet (using total percentages) This method also considers the percentage of votes received by candidates in each Condorcet matchup; however, each candidate receives a tally corresponding to the total vote percentage they received in each matchup. For example, if the outcome is 65% of votes for Candidate A to 35% of votes for Candidate B, candidate A has 65 added to their total percentage tally from this matchup, and candidate B has 35 added to their tally.

Upon simulating the election outcomes using Python, Bernie Sanders was found to be the winner for all election types. The outcomes of each election are presented in detail with their procedure in Table 3. Since we do not see variation in the outputs of each voting method in the different simulations, we fail to reject the first null hypothesis.

It is surprising that Sanders won every single election type, mostly considering that he did not win the presidential primary in reality. That none of the election systems yielded a different candidate than the others could suggest that the ballots from this sample are either overwhelmingly in favor of Sanders or are highly polarized. I still proceed with the other steps to see how the nature of the data led to these outcomes.

Table 3: Simulated Election Outcomes Using All Likely Democratic Primary Voters

Election Type	Procedure	Winner
Simple Plurality	Biden— 174 first-choice votes Bloomberg— 173 first-choice votes Buttigieg— 73 first-choice votes Gabbard— 12 first-choice votes Klobuchar— 34 first-choice votes Sanders— 233 first-choice votes Steyer— 16 first-choice votes Warren— 69 first-choice votes Undecided— 37 voters	Bernie Sanders
Instant Runoff	First-round votes reflect Simple Plurality totals. Second round: Biden— 367 votes Sanders— 387 votes	Bernie Sanders
Single-Elimination Runoff	Round 1: Gabbard is eliminated Round 2: Steyer is eliminated Round 3: Klobuchar is eliminated Round 4: Warren is eliminated Round 5: Buttigieg is eliminated Round 6: Bloomberg is eliminated Round 7: Biden— 367 votes Sanders— 387 votes	Bernie Sanders

Borda Count	Biden— 4197 points Bloomberg— 3429 points Buttigieg— 3002 points Gabbard— 923 points Klobuchar— 2235 points Sanders— 4275 points Steyer— 1768 points Warren— 3383 points	Bernie Sanders
Borda Count (allocating 7 points to first-preference)	Biden— 3529 points Bloomberg— 2846 points Buttigieg— 2440 points Gabbard— 666 points Klobuchar— 1723 points Sanders— 3615 points Steyer— 1316 points Warren— 2771 points	Bernie Sanders
Simple Condorcet	Biden— won 6 matchups Bloomberg— won 5 matchups Buttigieg— won 3 matchups Gabbard— won 0 matchups Klobuchar— won 2 matchups Sanders— won 7 matchups Steyer— won 1 matchup Warren— won 4 matchups	Bernie Sanders

Marginal Condorcet (by win percentage)	From all matchups: Biden— won by 247.15 % Bloomberg— won by 138.90 % Buttigieg— won by 110.20 % Gabbard— won by 0.00 % Klobuchar— won by 57.62 % Sanders— won by 259.95 % Steyer— won by 28.57 % Warren— won by 150.30 %	Bernie Sanders
Marginal Condorcet (by total percentage)	In all matchups: Biden— had 427.62 % of votes Bloomberg— had 344.90 % of votes Buttigieg— had 295.67 % of votes Gabbard— had 80.74 % of votes Klobuchar— had 208.77 % of votes Sanders— had 438.00 % of votes Steyer— had 159.46 % of votes Warren— had 335.80 % of votes	Bernie Sanders

7.1.1 Election results from bootstrapped samples

One might reconcile Sanders' success in the previous simulations with his loss in the 2020 primaries by attributing the difference to his popularity with the electorate shifting after the survey data was collected. To see how sensitive election outcomes are to changes in preferences of the electorate, we can look at election results from bootstrapped samples. I bootstrapped results to select 10,000 random samples of 500 voters (while accounting for the probability of selecting each voter based on their demographic weights) on which to run each of the election types. The summarized results of these bootstrapped elections are seen in Table 4.

We see more variation in the outcomes of these elections than the elections counting all 954 voters at once. In each ranked-choice election, Joe Biden won in 3.5% to 9.83% of the samples while Bernie Sanders won those elections in the remainder of the samples. It is interesting to note that, despite this trend in the ranked-choice elections, Sanders won all 10,000 simple plurality simulations. Of the 4,364 total elections that Biden won, all were versions of ranked-choice elections, and, in each of these instances, the corresponding simple plurality election for the sample elected Sanders instead. We should also note that, based on the election win counts, no two systems are always electing the same candidate. Since these bootstrapped results show more variation in election outcomes by yielding two different candidates as winners, we can look to the empirical results to compare the social utilities provided by Joe Biden and Bernie Sanders for the overall voting population.

Table 4: Numbers of Election Wins Per Candidate Using Bootstrapped FairVote Data

Election Type	Biden	Sanders
Simple Plurality	0	10,000
Instant Runoff	350	9,650
Single-Elimination Runoff	393	9,607
Borda Count	983	9,017
Borda Count (using 7→1 points)	657	9,343
Simple Condorcet	470	9,530
Marginal Condorcet (Win %age)	857	9,143
Marginal Condorcet (Total %age)	654	9,346

Note: Candidates other than Biden and Sanders were omitted from this table, as they did not win any of the bootstrapped elections.

7.2 Empirical results

Table 5, shows the results for the ideology β vectors from the maximum likelihood estimation in the empirical model. Each row corresponds to the β vector for the ideology, and each number in the row is considered to be the value of that candidate, V_j, for a voter with that ideology. For example, the candidate value of Biden, V_{Biden}, for a very conservative voter is 1.0435.

Using these β vectors, the total number of sampled voters that identify with each ideology, and their demographic weights, I calculate the average overall utility of each candidate j for this population of voters, expressed as U_j. These utilities are given in the "average" row of Table 5. Figure 2 presents these β terms from Table 5 as a graph, where larger width corresponds to higher utility of that candidate for that ideology group.

After assessing the utilities provided by each candidate to a member of each ideology category and by weighing these individuals' utilities by their demographic weights, we can see an overall ranking of candidates for the voting population. Candidates are ranked as such in the ideology estimation: Biden, Warren, Sanders, Buttigieg, Bloomberg, Klobuchar, Steyer, Gabbard.

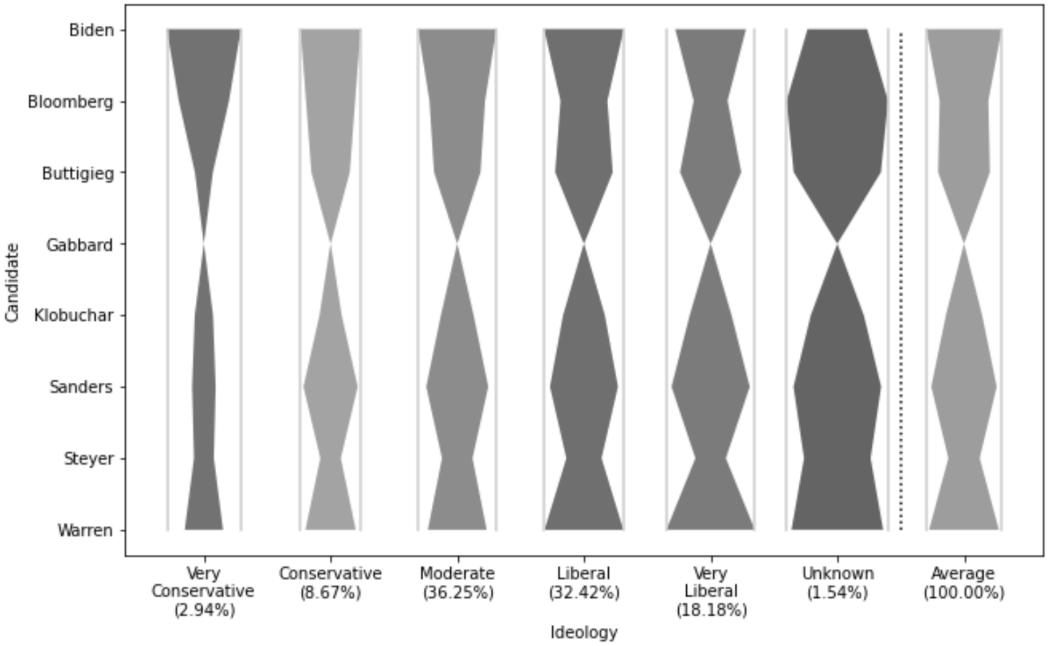
Surprisingly, Bernie Sanders, who won each simulated election using all ballots, is ranked only third in this population ranking, with Joe Biden and Elizabeth Warren above him. It would seem that if Biden provides the most utility for the voting population (when considering each candidate's value for each voter's ideology group), then he should be elected using at least one of the simulated mechanisms. Before attempting to resolve this seeming discrepancy, I confirm that the social utilities found in the empirical results are truly statistically significant with a likelihood-ratio test.

Table 5: Effects, β, of Ideology on Utility for Candidate

		Biden	Bloomberg	Buttigieg	Gabbard	Klobuchar	Sanders	Steyer	Warren
Very Conservative	(2.94%)	1.0435	0.349	-0.591	-1.114	-0.585	-0.432	-0.538	0.000
Conservative	(8.67%)	0.288	-0.0342	-0.344	-1.460	-0.820	0.115	-0.870	0.000
Moderate	(36.25%)	0.571	-0.0925	-0.359	-1.710	-0.762	0.0936	-0.826	0.000
Liberal	(32.42%)	0.0283	-0.928	-0.618	-2.286	-1.078	-0.312	-1.270	0.000
Very Liberal	(18.18%)	-0.513	-1.586	-0.790	-2.574	-1.357	-0.295	-1.687	0.000
Not Sure	(1.54%)	-0.935	0.283	-0.131	-2.672	-1.128	-0.117	-0.731	0.000
Average	(100.00%)	0.164	-0.611	-0.523	-2.029	-0.978	-0.125	-1.120	0.000

Note: Elizabeth Warren is used as the benchmark candidate. Additionally, the percentage of LDPVs in each group varies slightly from Table 1 because these estimations do not include LDPVs who selected “Undecided” as their only ranking.

Figure 2: Candidates' Quality, V_j, for Each Ideology Group and on Average



Note: Tulsi Gabbard is used as the benchmark candidate, since she had the lowest quality in each group of voters.

7.2.1 Likelihood-ratio test

This likelihood-ratio test is evaluating which candidate, Biden or Sanders, provides the highest overall utility for the voting population of the eight candidates. I am testing only these candidates because the simulated voting outcomes and the maximum likelihood estimation yielded two different outcomes, with Biden leading in overall utility for the population and Sanders winning all of the election simulations.

The overall parameter space is given by Θ and, in this instance, would be the true "highest quality" candidate. I test the null hypothesis that the parameter θ is in a specified subset, Θ_0, of Θ. The alternative hypothesis is that the parameter θ exists in the complement of Θ_0, expressed as Θ_0^C.

The test statistic for a likelihood-ratio test is given by

$$\lambda_{LR} = -2 \ln \frac{\sup_{\theta \in \Theta_0} \mathcal{L}(\theta)}{\sup_{\theta \in \Theta} \mathcal{L}(\theta)}$$

but can be rewritten to be expressed as a difference in log-likelihoods,

$$\lambda_{LR} = -2[\ell(\theta_0) - \ell(\theta)] \text{ where } \ell(\theta) \equiv \ln[\sup_{\theta \in \Theta} \mathcal{L}(\theta)]$$

For our purposes, the constrained parameter, θ, or the null hypothesis, is that Sanders provides the most utility out of the slate of eight candidates. The unconstrained parameter, θ_0, or the alternative hypothesis, is that Biden provides the most utility out of the slate, since he was the one deemed to have done so by the MLE results.

Since the test statistic λ_{LR} is multiplied by -2, it converges asymptotically to the χ^2-distribution. I use two degrees of freedom in this calculation as there are two differences in dimensionality between the parameters θ and θ_0: in θ, $U_{\text{Sanders}} > U_{\text{Biden}}$ and $U_{\text{Sanders}} > U_{\text{Warren}}$, while the opposite hold in θ_0. The critical value for the χ^2-distribution at the 95% confidence level with df=2 is 5.991.

Using the previously estimated β parameters, the maximum log likelihood of the data with the unconstrained parameter, θ_0, is 5094.35 and the maximum log likelihood of the data with the constrained parameter, θ, is 5101.33. The test statistic is, thus, estimated to be $\lambda_{LR} = -2[5094.35 - 5101.33] = 13.96$.

At the 95% confidence level, since the χ^2 value of $\lambda_{LR} = 13.96$ is larger than the critical value of 5.991, we reject the null hypothesis in this likelihood-ratio test and can reasonably conclude that the constrained parameter, that Sanders provides the most utility out of the slate of candidates, is not a good fit for the data.

We can consider the second set of hypotheses presented in the empirical model (whether to reject or fail to reject the null hypothesis that multiple yielded candidates have indistinguishable overall utility) in the context of the outcomes of the bootstrapped simulations, which did yield multiple candidate outputs. Based on the likelihood-ratio test, we can now reject this second null hypothesis and say that that the multiple yielded candidates, Joe Biden and Bernie Sanders, do have distinguishable overall utility, and Joe Biden does provide the highest overall utility for the voting population. Recall that Biden was only elected by ranked-choice mechanisms and, in every instance where he was elected, the corresponding simple plurality simulation for the sample elected Sanders. As stated in the empirical model, the overall utility of the candidate for the voting population also corresponds to the overall utility of any election mechanism that elected that candidate. This means that any time that the simple plurality outcome differed from the ranked-choice mechanisms, the ranked-choice mechanism provided a higher utility for the voting population.

7.2.2 Simulating election outcomes using MNL estimates

Having confirmed the statistical significance of the the empirical results using a likelihood-ratio test, I also validate the election simulation mechanisms I am using in this thesis. To this end, I simulated random samples of 100 voters, with ideologies that are proportionally representative of the overall population of Democratic primary voters. Each voter, based on their ideology, has a randomly generated ranked-choice profile in alignment with the vote probabilities determined by the ideology β vectors in Table 5. 100 voters were randomly simulated ten times, and, with each new set of voters, the election types we have been evaluating were simulated. The results of these simulated elections are shown in Table 6. Note that each column corresponds to one set of randomly simulated voters, so any variation among candidate outputs in each column is due only to a difference in election mechanism.

Of the 70 outcomes, Biden won 58 times, Warren won nine times, and Sanders won three times; the number of candidate win outcomes follows the overall social utilities provided by each candidate, shown in the "Average" row of Table 5. In the samples where different mechanisms yield different candidates, at least one ranked-choice mechanism provides an overall utility for the voting population that is equal to or higher than that of the simple plurality mechanism. Sample 5 elects Warren with simple plurality, but elects Biden with the marginal Condorcet (by win percentage) mechanism. Sample 6 elects Biden not only with the simple plurality mechanism, but also with the Borda count and marginal Condorcet (by total percentage) mechanisms. Sample 10 elects Sanders with the simple plurality system, but elects Biden or Warren using every ranked-choice mechanism.

Looking at the outcomes of different elections clarifies for us which mechanisms yield different results from others using the same sample of voter ballots. Even though it might appear, from this table, that the two runoff systems always yield the same result as simple Condorcet and that Borda count and marginal Condorcet (by total percentage) always yield the same result, these are not always the case, as we can see from the number of election win counts in Table 4. Rather, I simply use these results to find confidence in the mechanisms I use to simulate various election structures and to contribute to my evaluations of each voting system in a later section.

Being confident in the election simulation mechanisms used and in the empirical results, the question remains of why the simulated election outcomes which used the FairVote data as an input all yielded the same candidate, Bernie Sanders, despite the finding that he did not have the highest overall utility among the candidates for the population. This could imply that the multinomial logit regression using ideology fails to accurately model these voters' preferences, so, in order to address these discrepancies in the results, I consider other possible determinants of voter preferences, demographics, instead.

Table 6: Winners of Elections Simulated Using Ideology, β, Vectors

Sample Number	1	2	3	4	5	6	7	8	9	10
Simple Plurality	Biden	Biden	Biden	Biden	Warren	Biden	Biden	Biden	Biden	Sanders
Instant Runoff	Biden	Biden	Biden	Biden	Warren	Warren	Biden	Biden	Biden	Biden
Single-Elimination Runoff	Biden	Biden	Biden	Biden	Warren	Warren	Biden	Biden	Biden	Biden
Borda Count	Biden	Biden	Biden	Biden	Sanders	Biden	Biden	Biden	Biden	Warren
Simple Condorcet	Biden	Biden	Biden	Biden	Warren	Warren	Biden	Biden	Biden	Biden
Marginal Condorcet (Win %age)	Biden	Biden	Biden	Biden	Biden	Biden	Biden	Biden	Biden	Biden
Marginal Condorcet (Total %age)	Biden	Biden	Biden	Biden	Sanders	Biden	Biden	Biden	Biden	Warren

7.2.3 Other demographics

In an attempt to address the discrepancy between the full simulated election outcomes and the ideology estimations, it is helpful to consider demographics other than ideology. It might be the case that Biden provides the highest utility for the voting population only when considering candidates' utilities for each ideology group. To see if candidates' social utility rankings changed when considering other demographics, I ran separate regressions considering the following identifiers: race, gender, political party, income, and educational attainment.

The effects of each demographic on utility for candidate are shown in Tables 7 through 11 and the candidates' qualities, V_j, for each demographic group are depicted in Figures 4 through 8, where larger width corresponds to higher utility of that candidate for that ideology group. Candidates' average social utilities were ranked in the same order when considering all of the other demographics—race, gender, party, income, and education—as they were in the ideology estimations: Biden, Warren, Sanders, Buttigieg, Bloomberg, Klobuchar, Steyer, Gabbard.

Still, none of the rankings deemed Sanders as providing the highest utility for the voting population. Perhaps it is the case that Sanders' election success is explained by him performing particularly well with a certain demographic group that is well-represented in the electorate. To address this inquiry, we can note which groups he, and other candidates, performed best with.

Sanders performed surprisingly well with conservative and moderate voters (though still behind Biden in both groups), while Warren performed well with liberal (though behind Biden) and very liberal voters. Sanders performed well with Black (though still behind Biden) and Asian voters; Biden performed highest among Hispanic, Black, White, Multiracial, and Other voters. Biden performed best with both men and women, though men tended to prefer Sanders in the second spot, while women tended to prefer Warren in the second spot. Sanders was most preferred by Democrats (though behind Biden and Warren). Unsure voters favored Warren over other candidates, while Republican, Democrat, and Independent voters preferred Biden the most. Biden led among all income groups; Sanders provided the second highest utility for the group of voters making between $40k and $80k a year, while Warren came in second for the other two income groups. Finally, Biden led among voters whose maximum educational attainment was high school (with Warren close behind) and those who completed some college (with Sanders close behind), while Warren led among voters who obtained their four-year college degrees (with Biden close behind).

There are no identifiable demographic groups that Sanders performs well enough with to explain his overwhelming success in the election simulations. When considering all candidates, the MNL regressions yield that Biden provides the highest utility, regardless of which demographic is considered as the main determinant of voter preferences. To explain the discrepancy between these results and the simulated election outcomes where Sanders wins all election types, we might consider the MNL outcomes when only considering two candidates: Biden and Sanders. This can help us determine if Sanders is overwhelmingly preferred when the slate of candidates is limited.

Table 7: Effects, β, of Race on Utility for Candidate

		Biden	Bloomberg	Buttigieg	Gabbard	Klobuchar	Sanders	Steyer	Warren
Hispanic	(16.29%)	0.189	-0.768	-0.497	-2.038	-1.272	-0.264	-0.951	0.000
Black	(19.23%)	0.790	-0.250	-0.990	-2.373	-1.237	0.688	-1.313	0.000
White	(58.04%)	0.0201	-0.724	-0.322	-1.949	-0.805	-0.409	-1.175	0.000
Asian	(4.97%)	0.391	-0.508	-0.609	-1.675	-0.794	0.810	-0.465	0.000
Multiracial	(0.86%)	0.375	-0.640	-0.968	-2.179	-0.749	-0.259	-0.0673	0.000
Other	(0.61%)	1.424	1.222	-0.617	-13.451	-0.385	-0.124	-2.307	0.000
Average	(100.00%)	0.226	-0.617	-0.501	-2.103	-0.961	-0.111	-1.127	0.000

Note: Elizabeth Warren is used as the benchmark candidate. Additionally, the percentage of LDPVs in each group varies slightly from Table 1 because these estimations do not include LDPVs who selected “Undecided” as their

Table 8: Effects, β, of Gender on Utility for Candidate

		Biden	Bloomberg	Buttigieg	Gabbard	Klobuchar	Sanders	Steyer	Warren
Male	(48.54%)	0.320	-0.494	-0.469	-1.748	-0.884	0.0396	-0.933	0.000
Female	(51.46%)	0.00787	-0.748	-0.578	-2.288	-1.039	-0.330	-1.284	0.000
Average	(100.00%)	0.159	-0.625	-0.526	-2.026	-0.964	-0.151	-1.114	0.000

Note: Elizabeth Warren is used as the benchmark candidate. Additionally, the percentage of LDPVs in each group varies slightly from Table 1 because these estimations do not include LDPVs who selected "Undecided" as their

Table 9: Effects, β, of Party Identification on Utility for Candidate

		Biden	Bloomberg	Buttigieg	Gabbard	Klobuchar	Sanders	Steyer	Warren
Republican	(3.25%)	0.575	0.346	0.287	-0.784	-0.285	-0.140	-0.431	0.000
Democrat	(83.20%)	0.139	-0.714	-0.622	-2.155	-1.0781	-0.0464	-1.197	0.000
Independent	(13.11%)	0.338	-0.213	-0.0149	-1.359	-0.309	-0.576	-0.654	0.000
Not Sure	(0.44%)	-0.596	-1.864	-0.551	-2.131	-1.336	-1.122	-1.107	0.000
Average	(100.00%)	0.176	-0.619	-0.513	-2.006	-0.953	-0.124	-1.100	0.000

Note: Elizabeth Warren is used as the benchmark candidate. Additionally, the percentage of LDPVs in each group varies slightly from Table 1 because these estimations do not include LDPVs who selected “Undecided” as their

Table 10: Effects, β, of Total Annual Family Income on Utility for Candidate

		Biden	Bloomberg	Buttigieg	Gabbard	Klobuchar	Sanders	Steyer	Warren
Under \$40k	(34.25%)	0.190	-0.566	-0.521	-2.084	-0.915	-0.0610	-0.920	0.000
\$40k to \$80k	(40.25%)	0.177	-0.604	-0.493	-1.867	-0.974	0.0188	-1.150	0.000
Over \$80k	(25.49%)	0.154	-0.666	-0.530	-2.111	-0.954	-0.445	-1.194	0.000
Average	(100.00%)	0.176	-0.607	-0.512	-2.003	-0.948	-0.127	-1.082	0.000

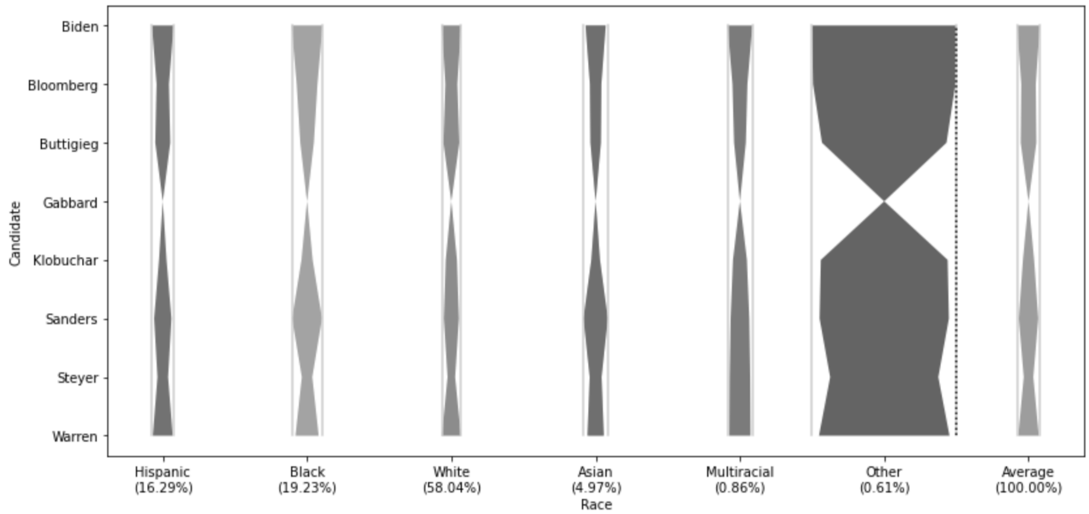
Note: Elizabeth Warren is used as the benchmark candidate. Additionally, the percentage of LDPVs in each group varies slightly from Table 1 because these estimations do not include LDPVs who selected "Undecided" as their

Table 11: Effects, β, of Highest Educational Attainment on Utility for Candidate

		Biden	Bloomberg	Buttigieg	Gabbard	Klobuchar	Sanders	Steyer	Warren
High School	(20.88%)	0.184	-0.481	-0.595	-1.906	-1.002	-0.0246	-1.053	0.000
Some College	(35.52%)	0.426	-0.606	-0.504	-2.030	-1.029	0.0296	-0.938	0.000
Four-Year Degree	(43.61%)	-.00922	-0.673	-0.490	-2.026	-0.870	-0.317	-1.221	0.000
Average	(100.00%)	0.186	-0.609	-0.517	-2.002	-0.954	-0.133	-1.085	0.000

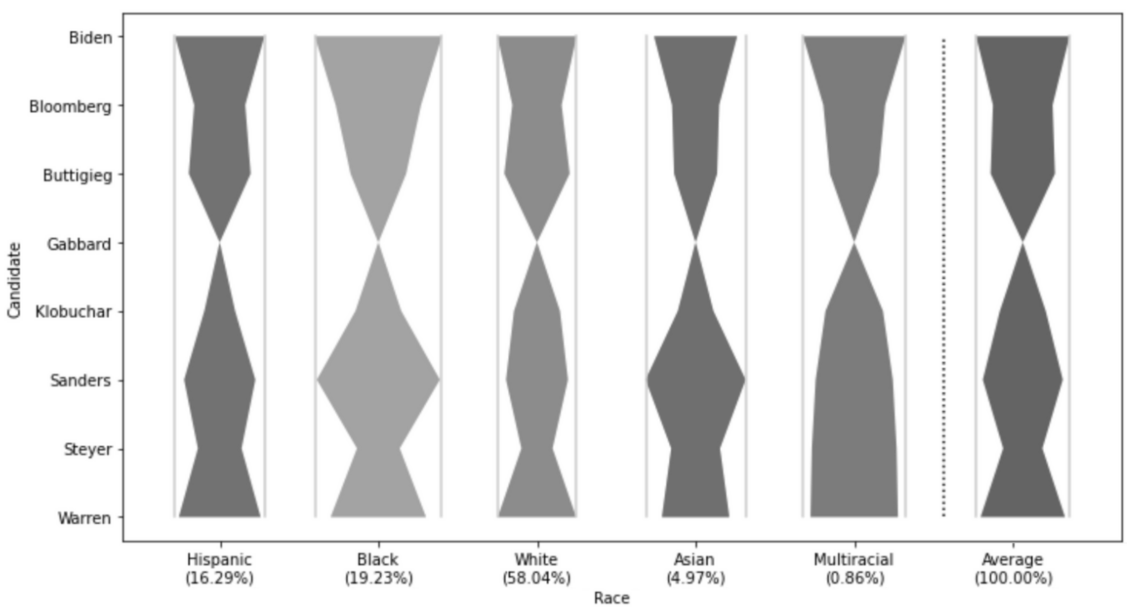
Note: Elizabeth Warren is used as the benchmark candidate. Additionally, the percentage of LDPVs in each group varies slightly from Table 1 because these estimations do not include LDPVs who selected “Undecided” as their

Figure 3: Candidates' Quality, V_j, for Each Racial Group and on Average



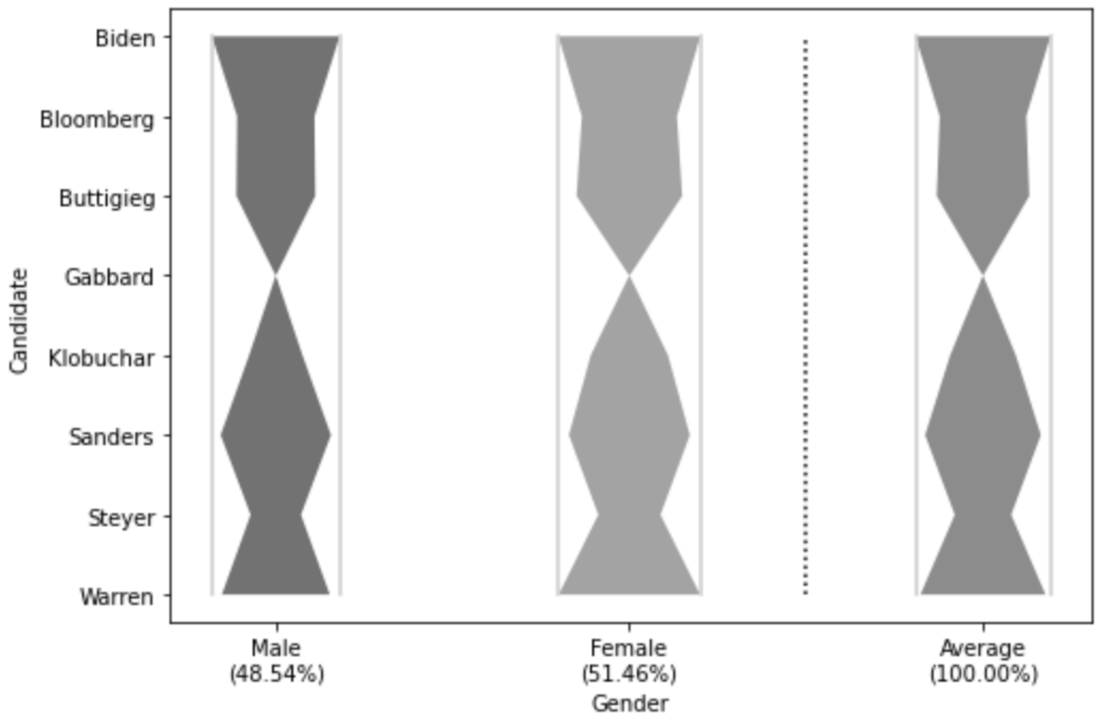
Note: Tulsi Gabbard is used as the benchmark candidate, since she had the lowest quality in each group of voters.

Figure 4: Candidates' Quality, V_j, for Each Racial Group and on Average, Not Including "Other" Race



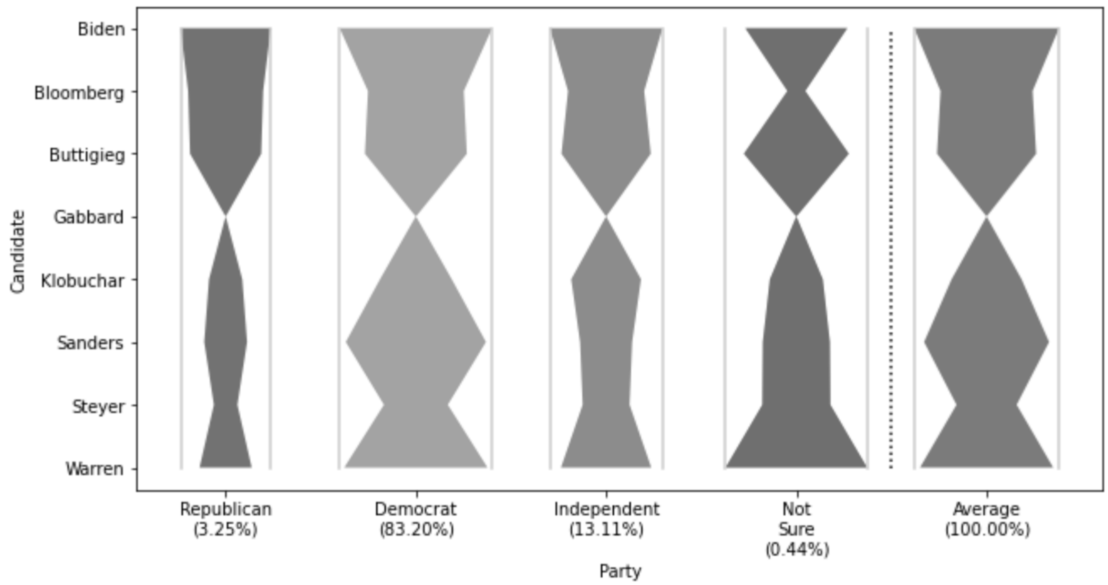
Note: Tulsi Gabbard is used as the benchmark candidate, since she had the lowest quality in each group of voters.

Figure 5: Candidates' Quality, V_j, for Each Gender Group and on Average



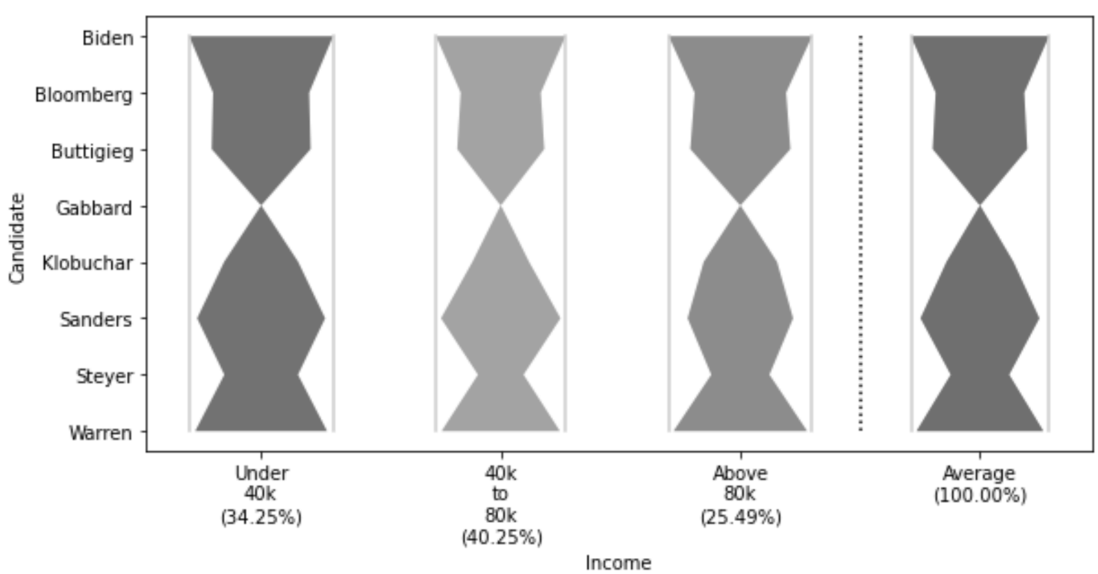
Note: Tulsi Gabbard is used as the benchmark candidate, since she had the lowest quality in each group of voters.

Figure 6: Candidates' Quality, V_j, for Each Party Group and on Average



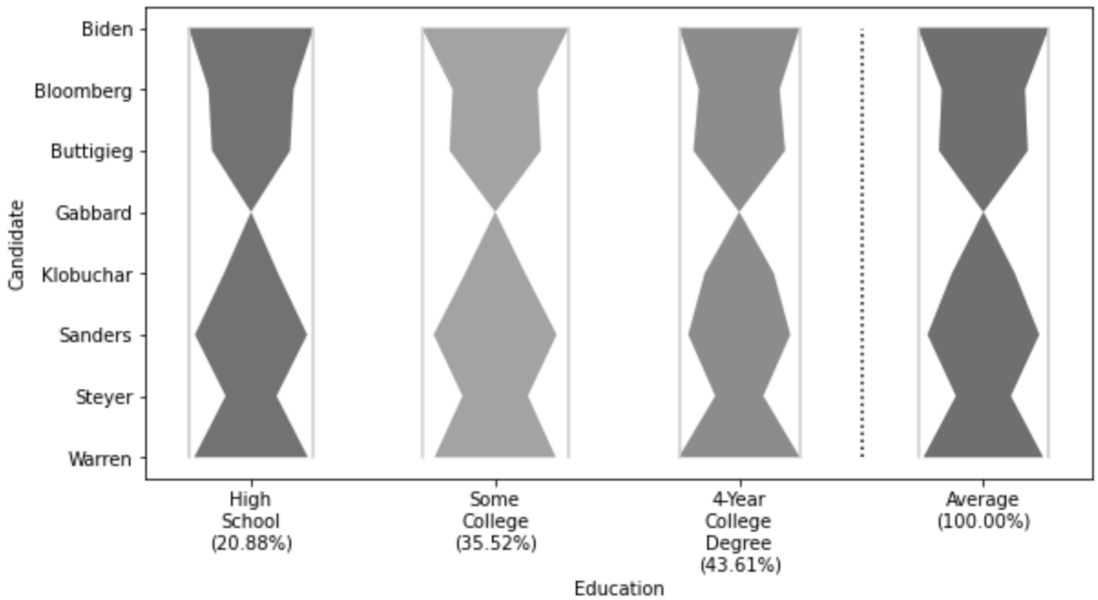
Note: Tulsi Gabbard is used as the benchmark candidate, since she had the lowest quality in each group of voters.

Figure 7: Candidates' Quality, V_j, for Each Income Group and on Average



Note: Tulsi Gabbard is used as the benchmark candidate, since she had the lowest quality in each group of voters.

Figure 8: Candidates' Quality, V_j, for Each Education Group and on Average



Note: Tulsi Gabbard is used as the benchmark candidate, since she had the lowest quality in each group of voters.

7.2.4 Bernie or Joe?

We can look at an regression comparing Sanders to Biden to see how the two measure up against each other. There were 873 voters of the 954 LDPVs who ranked either Bernie Sanders or Joe Biden or both. If a voter ranked only one of the two, we can infer that the ranked candidate is preferred to the other, thereby giving us a full ranking when considering only those two candidates.

This data is used to determine β values for those two candidates. These values are -0.100 for Joe Biden and 0.000 for Bernie Sanders. This tells us that, in this voting population, each person was 10% less likely to vote for Joe Biden over Bernie Sanders (in other words, there is a 47.5% likelihood of voting for Biden and a 52.5% likelihood of voting for Bernie Sanders). Given this information, we can better conceptualize that Bernie Sanders won every simulated election outcome using the full data set; despite Biden providing the highest social utility to voters, a majority of voters do prefer Sanders over Biden when the election is narrowed to the two of them.

Biden has the highest social utility of all candidates when the entire slate is included, but Sanders is deemed to have the highest utility over Biden in the pairwise comparison; this seems to violate the independence of irrelevant alternatives criterion at the aggregate level because the presence of "irrelevant" candidates changes the relative order of Biden and Sanders. This is perhaps because, in the empirical model used in this thesis, each ideology or demographic group (ex. Very Liberal voters, Asian voters, etc.) was treated as an individual; since each "individual" had multiple varying ballots attributed to them, IIA was violated at the individual level and each group itself did not have consistent preferences. Though the multinomial logit model violates IIA in this instance, IIA is a logical property rather than a statistical one, and we can still be confident in the validity of the empirical results. I further evaluate each voting system itself per the IIA criterion in the next section, but we can remain confident in the yielded β values.

After looking at the various results, how might one explain the discrepancy between the overall estimations and the Biden-Sanders estimation? Since Sanders had the highest utility in the latter estimation, why was he not determined to provide the highest social utility when all candidates were considered? The results could mirror some interpretations of real life outcomes: Sanders had fervent primary support, but did not reach as broad a coalition of voters as did Biden. Though the highest number of voters preferred Sanders—both when other candidates were competing and when only he and Biden were competing—Biden performed better within and across ideology and demographic groups. We can consider the level of social utility each candidate has to be a measure of the breadth of their support. It can be difficult for election mechanisms to take this into consideration, but, as seen in the election simulations on bootstrapped data and on the data generated using the MLE β values, ranked-choice mechanisms often select candidates with a wider appeal and higher utility than do the simple plurality mechanisms.

To even better understand the unique nature of the FairVote data, I also consider, in the next section, features of each of the election mechanisms considered in this thesis, how they might yield different outcomes, and how they might change voter incentives and strategies.

8 Evaluating Voting Systems

Given that Bernie Sanders was elected by every voting system when all voter ballots were considered, I supplement our understanding of these systems by evaluating them on their own merits, separate from evaluating their candidate output.

8.1 Criteria

To identify strengths and weaknesses of various voting methods, one should identify desirable traits of a voting system. It is important to note that, ultimately, the satisfaction of these criteria for each election system varies from theory to practical application in U.S. presidential primary elections. This section discusses why each system was chosen for consideration, the practical considerations of each mechanism's use in the United States, and each one's adherence to the following criteria.

Fairness

Arrow (1950) identifies four fairness criteria to be applied to ordinal voting systems: unrestricted domain, non-dictatorship, Pareto efficiency, and independence of irrelevant alternatives. Unrestricted domain says that voting must account for all possible individual preferences. Non-dictatorship means that the results of the election cannot reflect that of any one person's votes without consideration of other voters' choices (i.e. the election outcome should not be determined by one specific person's vote). Pareto efficiency is a state where no change can be made to the system's outcome that would lead to improved utility for one agent without decreasing some other agent's utility; practically, this means that if every voter prefers one candidate to another, the latter candidate should not fare better than the first in the election system outcomes. Finally, independence of irrelevant alternatives means that, when considering an individual's ranking for a subset of specific alternatives, changes in that individual's rankings of any "irrelevant" alternatives should not impact the relative ranking of the "relevant" subset of options.

Low Level of Cannibalization

Cannibalization refers to when similar candidates pull votes from each other. This term was used to discuss the trends among voters in the more radical wing of the Democratic party, but cannibalization can theoretically happen to any similar candidates appealing to a specific bloc of voters.

Consideration of All Votes Cast

In this democracy, anyone who has the right to vote and casts a ballot has the right to have their ballot counted. However, in practice, sometimes ballots are effectively "wasted." There is disagreement on what constitutes a ballot being "wasted," and some would argue that contingent preferences need not be taken into account as long as each ballot is counted in the first round of voting. This thesis, instead, assesses whether the election systems consider each voter's ballot in the event that their most-preferred candidate is not elected or that their most-preferred candidate drops out of the race.

Low Subjectivity to Tactical Voting

I assess how sensitive each election type is to "strategic" voting. There are different methods that fall under the umbrella of tactical voting, and the definition of tactical voting varies across literature. For the purposes of this thesis, I define tactical voting as when voters can use methods to deliberately misrepresent their preferences in order to push forward their most desired outcome. I also address how different voting systems impact a voter's incentives for truthful revelation or, conversely, to prioritize a "useful" vote when ranking their preferences, even if this misrepresentation does not ultimately push forward their most desired outcome.

8.2 Voting systems

Unrestricted Domain: Before assessing what differs among the various election systems, we must note that all of the elections are operating under an unrestricted domain. Some people would disagree, categorizing political preferences as being restricted because they are single-peaked. This suggests that if we can rank candidates on an ideological spectrum in the party and if we know a voter's ideology, then we can determine that voter's ranking of all candidates, as in the traditional one-dimensional spatial model. However, there exist no commonly agreed-upon locations of each candidate on the political spectrum. Additionally, there are identifiable rankings in the data set that would suggest that preferences are not single-peaked. For example, there were 91 LDPVs who ranked both Michael Bloomberg and Bernie Sanders in their top two spots, and all but two of these voters ranked more preferences than those two candidates. These two candidates are commonly considered to be on opposite ends of the party's political spectrum, so we can consider these 89 voters to be concrete examples of voter preferences not being single-peaked and of the domain not being restricted.

Non-Dictatorship: Additionally, all elections considered in this thesis are also non-dictatorial in that their outcomes do not reflect the votes of one specific person. Though plurality elections can be, in some instances, decided by one-vote, this is merely a close election rather than a dictatorial one as just over half the voters cast the deciding vote, rather than just one person who knows they have that control. In this thesis, all considered elections are non-dictatorial in that if there are two candidates and every voter except one selects candidate B while one person selects candidate A, candidate B still wins.

Pareto Efficiency: Furthermore, all elections being considered in this thesis are Pareto efficient; based on the information provided in ballots, once the winning candidate is selected, the winner cannot be changed without making at least one other voter worse off. It is important, however, to note that if plurality elections are occurring without voters' truly revealed first-preferences, we cannot know if there are possible Pareto improvements. The same can be said of ranked-choice elections if people do misrepresent their preferences, but there are fewer incentives for voters to do so, and these ballots collect more information about the range of voter preferences with which systems can determine a Pareto efficient outcome. Pairwise votes are shown in Table 12, and we can see that none of the pairwise matchups have all voters preferring one candidate over the other. Since no candidates are universally preferred over any other, any outcome reached by the election systems is Pareto efficient.

Independence of Irrelevant Alternatives: We can look to the full FairVote elections to see if there are any instances where IIA is violated in the empirical data. Since Bernie Sanders won each election type, we would assume that a violation of IIA would occur if some "moderate" spoiler candidates were removed from the election to divert more votes toward Joe Biden. Removing votes for only Michael Bloomberg and reallocating his voters' preferences in the simple plurality election did not swing the election in favor of Joe Biden. However, considering an election only between Joe Biden, Bernie Sanders, and Elizabeth Warren did swing the simple plurality election (still accounting for demographic weights) in favor of Joe Biden, where Biden received 323 votes, Sanders receives 321 votes, and Warren received 125 votes. Sanders still wins all of the ranked-choice elections. Seeing this trend might also explain why Sanders lost to Biden in the actual primary despite performing so well in this data set and in polling from around the same time. It could be that voters preemptively narrowed the election not just to Biden and Sanders but also to Warren, and she acted as a "spoiler" candidate in the election since her voters' ballots could not be reallocated as they could have been in a ranked-choice election. Though we do not see any IIA violations in the ranked-choice elections from this data set, the ranked-choice mechanisms considered in this thesis are still susceptible to them in other situations; therefore, I still evaluate each system's adherence to the IIA criteria in the following subsections.

The first three previously discussed criteria—unrestricted domain, non-dictatorship, and Pareto efficiency—apply in the same ways to all voting systems considered. The remaining criteria, however,—independence of irrelevant alternatives, cannibalization levels, consideration of all votes cast, and subjectivity to tactical voting—differ between systems, so are considered separately for each election mechanism as follows.

Table 12: Number of Voters Preferring Candidates in Head-to-Head Matchups

(x, y)	Biden	Bloomberg	Buttigieg	Gabbard	Klobuchar	Sanders	Steyer	Warren
Biden	—	491	539	717	633	406	682	526
Bloomberg	329	—	436	609	496	325	556	421
Buttigieg	286	349	—	588	473	261	527	342
Gabbard	85	129	109	—	128	73	179	93
Klobuchar	179	270	243	506	—	193	431	215
Sanders	467	531	581	732	641	—	681	570
Steyer	121	187	180	422	227	134	—	178
Warren	318	400	446	649	541	261	582	—

Note: Each cell shows the number of voters who preferred candidate x over candidate y.

8.2.1 Majoritarian

Simple Plurality U.S. Democratic presidential primaries are majoritarian in that, after voters cast their ballots to pledge delegates to certain candidates, delegates must reach a majority at the national convention for a nominee to be selected. However, if no candidate reaches a majority from primary elections, it is up to the delegates, rather than voters, how to reallocate votes to yield a majority. Because I do not want to assume delegate actions, I instead simulated simple plurality elections to contrast with the ranked-choice voting systems. Additionally, when three or more candidates are competing in an election, the election is a plurality one rather than a majoritarian one unless there are subsequent rounds (or circumstances like how delegates can reallocate votes) or ranked-choice voting is used; this is the reality for many elections in the United States and plurality elections are widely used in this country.

Acknowledging that the simple plurality mechanism is meant to contrast with the ranked-choice elections, and since I contend that single-choice elections can be susceptible to tactical voting (as is later explained), I could have instead simulated this election by considering each voter's strategic preference among the two most "likely" candidates, Biden and Sanders. If I had done this, we would still see Sanders winning, but this was not the mechanism I used because we cannot assume that every single voter will feel pressured in a single-choice system to vote strategically among two candidates. This is why I counted plurality totals using only the first-choice preferences of each voter as provided in the ranked-choice ballot. When evaluating the merits of the simple plurality system, however, I consider elections where voters can indicate only a single candidate preference rather than being able to rank a full choice profile.

When an election system only has to consider one preference of voters, this is the least time-consuming of the possible systems for vote tabulators and county voting precincts. A simple plurality system for counting votes can, however, be used even if voters do indicate their ranked preferences on the ballot, but this would take more time at the polls or when filling out an absentee ballot while not reaping the benefits of collecting the additional information on voter preferences. Simple plurality elections are also the most transparent of the election systems and are easiest for the electorate to follow along with vote counts.

Independence of Irrelevant Alternatives: Simple plurality elections violate the independence of irrelevant alternatives condition. Suppose there are three candidates A, B, and C and seven voters; three voters have the preferences A>B>C, two voters have the preferences B>A>C, and two voters have the preferences C>B>A. In a plurality election between only candidates A and B, candidate A receives three votes and B receives four; thus, candidate B is the winner. However, once candidate C is introduced, candidate A receives three votes, candidate B receives two votes, and candidate C receives two votes; thus, candidate A is the winner. Since the winner of the election changes to another "relevant" candidate with the introduction of an irrelevant alternative, plurality elections violate the IIA property. This is a similar example to what we witnessed in the FairVote data set, where the introduction of Warren changed the relative ordering of Biden and Sanders.

Cannibalization: Let's modify the example above. Suppose that, now, there are two additional voters have the preferences C>B>A. Despite the fact that a sum of five voters prefer either candidate A or candidate B to candidate C, candidate C wins the plurality election with four votes, while A and B receive three and two votes each, respectively. In simple plurality elections, there is a significant possibility that candidates who are similar (in this example, we could consider A and B to be these similar candidates) will cannibalize support for the other, dependent, of course, on the other candidates competing in the election. If a voter ideologically aligns with two or more candidates, but they need to cast a single preference, they can at most select only one of these options in a simple plurality elections, thereby pulling support from the others. Note that this is also similar to the IIA violation we witnessed in the FairVote data; Bernie Sanders and Elizabeth Warren, who are widely considered to be similar candidates, seem to have cannibalized each other in swinging the election toward Joe Biden.

Consideration of All Votes: Simple plurality elections are also weak in that, in application in U.S. presidential primaries, early voting and staggered elections can lead to many wasted votes. Early voting for a state's election can occur up to a month before the state's primary Election Day, and several other states can hold primaries within that time. If a candidate notices that their performance has been low and decides to drop out of a race before other states' primary elections, voters who have already cast early votes for those candidates do not have a chance to reconsider or reallocate their votes. Early voters, registered voters who did attempt to participate in the election, are no longer having their votes "count" in the ultimate selection, despite likely being part of a strong voting bloc having chosen to vote early.

Subjectivity to Tactical Voting: The significant differences between a majoritarian/plurality system and ranked-choice election systems lie not so much in the method used to count votes, but in the incentive structures for voters to represent their true first-choice. There is an incentive to misrepresent preferences in simple plurality elections (i.e. assessing which two of the slate of candidates is strongest and indicating one's preference from only those two choices). For example, if a voter strongly likes candidate A and strongly dislikes candidate C, but views the election as a true competition between candidates B and C, they will cast their one ballot for candidate B rather than "wasting" their vote on candidate A. While this is a clearly misrepresented preference, this does not count as tactical voting under my previously-established definition because there is no way that a voter can misrepresent their preference to increase the likelihood of their true preference, or most-preferred candidate, winning. In this example, the voter choosing to vote for candidate B does not increase the likelihood of candidate A winning (it, in reality, decreases the likelihood of this). The only way to increase the likelihood of candidate A winning is to vote for candidate A, which would just be a truthful revelation of their preferences. Strategically voting for candidates who will perform well in the general, though considered by many to be an example of tactical voting, is considered in my model as simply one factor that might affect voter's preferences. However, voters should not forced into making this choice, as they often are in simple plurality elections.

8.2.2 Ranked-choice

Overall When voters are asked to submit ranked-choice preferences, it can cause lengthy ballots, potentially increasing production costs. It might also be more time-consuming for county precincts and vote tabulators to count votes; however, computer technology can help make this faster. Additionally, use of a ranked-choice system that does not merely count first-preference votes can be viewed as less transparent, since it is not as simple for citizens to follow the math behind vote tabulations. However, in applicable situations, having voters rank their choices in one ballot prevents the massive costs of holding separate runoff election timelines with lower participation rates—up to a million dollars just in some metropolitan counties ("7 Georgia Counties", 2020)—where voters must come back to the polls or submit new absentee ballots to express preference for one candidate.

In all ranked-choice ballots, voters do not have as large an incentive to misrepresent their preferences as is present when they can only choose one candidate. Especially in later primaries, voters often feel as though the competition has come down to two most likely candidates; thus, they only choose to cast their vote for one of those two. In ranked-choice ballots, however, voters can account for this by indicating their true preferences while ensuring to rank either one or both of these two "most likely" candidates somewhere in their ballots to participate if the election does come down to them. Relatedly, we see that there should be theoretically less cannibalization, as is discussed further. I evaluate the individual ranked-choice election types for the desired criteria—independence of irrelevant alternatives, low cannibalization levels, consideration of all votes cast, and low subjectivity to tactical voting—by grouping them into runoff, Borda count, and Condorcet mechanisms.

Runoff Mechanisms This category includes instant runoff and single-elimination runoff mechanisms. Instant-runoff voting (IRV) was included in this thesis for consideration because it is an often implemented RCV method in the United States, especially as many elections that use RCV only have at most three legitimate/feasible candidates. When there are only three candidates, a two-stage IRV method is all that is needed. This is also the system most comparable to multi-stage runoffs, such as what we recently saw in the 2020 Georgia elections for U.S. Senate. David Perdue and Jon Ossoff went to a runoff election in January 2021 after winning the two highest vote totals in the first round in November 2020. In this real-world example, Perdue would have won if the election merely ended with the plurality winner after the first round; however, after inviting voters to cast new ballots, Ossoff was declared winner after the second round. IRV explores how RCV can account for situations like this in one step, rather than having to host two elections. Single-elimination runoff was included as I predicted it might yield different results from IRV in some instances when more than three candidates are present and because it is the election system that the state of Maine uses for its ranked-choice ballots.

Consideration of All Votes: We noticed interesting results concerning if there were any differences in outcome between IRV and single-elimination, given that more than three candidates are options in the FairVote data set. If the two candidates in the last round of the single-elimination runoff are the same as the two candidates in the second/final round of instant runoff, then the vote counts in that last round are the same regardless of which system is used, and the winner remains the same. However, there were instances in the bootstrapped elections that the two yielded different outcomes (these elections are summarized in Table 4 and we can see that the number of wins per candidate do not equal each other for these two election types). Different candidates are elected by the two mechanisms only when there are different candidates in the second IRV round from the last single-elimination round; there are also times that the last round candidates differ between election types even when the two yield the same winner. We often saw this occur when Bernie Sanders and Michael Bloomberg proceeded to the second round of IRV but Bernie Sanders and Joe Biden made it to the final round of single-elimination. This suggests that Joe Biden had the third-most amount of people who preferred him first, but when votes could be reallocated, he and Sanders came out above Bloomberg, who had more people first-preferring him but fewer people preferring him as an alternate choice. For reasons such as these, when people are able to reallocate their votes even if their first-preferred candidate is no longer being considered, the runoff systems meet the "consideration of all votes" criterion. There are also no "wasted" votes because, even if a candidate drops out of the election after votes have already been cast, the tabulators can simply consider each voter's next-preferred choice.

Independence of Irrelevant Alternatives: Let's look back at the example considered where I determined that simple plurality elections violate Arrow's IIA condition, where there are three voters preferring A>B>C, two voters preferring B>A>C, and two voters preferring C>B>A. The plurality election considering only candidates A and B yielded B as the winner; however, once candidate C was introduced, A was deemed the winner. Runoff elections correct the IIA violation for this example, yielding B as the winner when all three candidates are participating (three votes for A, two for B, and two for C $\rightarrow$B is deemed more popular than C, so C is eliminated $\rightarrow$B wins against A in the final round) and when only A and B are participating (four votes for B and three for A).

However, this does not mean that runoff elections always meet the IIA criterion. Consider the following voter preferences: four voters prefer C>A>B, three voters prefer B>C>A, and two voters prefer A>B>C. In an election involving candidates A and B, A receives six votes and B receives three votes, making A the winner. When candidate C joins the race, C receives four votes, B receives three votes, and A receives two votes. When B and C go to a runoff, C receives four votes while B receives five, making B the runoff election winner. Since the introduction of candidate C in the race made B the winner when A would have otherwise won, IIA is violated. This example shows the impact of a popular but perhaps divisive candidate entering the race, diverting favor from well-liked but non-exciting candidates.

This IIA violation could also be an instance of cannibalization in the event that candidates A and C are similar.

Cannibalization: To further assess how runoff elections impact cannibalization, let's consider the second example discussed when assessing plurality voting, where the population had the following candidate preferences: three voters prefer A>B>C, two voters prefer B>A>C, and four voters prefer C>B>A. In the simple plurality election, candidate C wins because candidates A and B are cannibalizing each other. In either of the runoffs, the second and final round would be a runoff between candidates A and C, which would result in five votes for A and four votes for C, making A the winner. Here, we see that ranked-choice voting was able to correct for the cannibalization of similar candidates. Many hope that runoffs would correct for cannibalization in many such situations, and, while runoff elections can prevent IIA violations and cannibalization in many instances, neither are completely avoided.

Subjectivity to Tactical Voting: It is thought that tactical voting can be prevalent in runoff elections where there are multiple rounds of voting (i.e. deliberately voting for a weak candidate in the first round to set your truly preferred candidate up for success in the second round, or compromising in the first round to make sure you have a desirable candidate in the second round). However, this instance of tactical voting can be largely prevented by requiring voters to submit a ballot where they rank all their preferences at once. For this reason, IRV, and even more so single-elimination, is thought to be highly resistant to tactical voting (Bartholdi and Orlin, 1991). In ranked-choice runoff elections, voters express their preferences for candidates for every contingency of candidate matchups that might occur in later rounds, preventing compromising. This also prevents deliberately misrepresenting in the first round because voters must express preferences the same way for all rounds of voting, as they are only able to submit one ballot for the entire election. Since voters' rankings for each candidate are only considered if their more-highly-preferred candidates are no longer being considered, voters have incentives to rank all of the candidates competing in runoff elections, including ones they dislike or are indifferent to, simply to participate in the election in every contingency.

Borda Count Mechanisms Borda count has been posited as a potential voting system because it attempts to take into consideration the nuanced degrees of preference voters have for each candidate from the very first round, rather than only if necessary. Approval voting, where voters simply mark yes on any candidate of whom they would approve, is an instance of Borda count. Approval voting was not considered in this thesis as it is deemed to be easily manipulable, but Borda count is a more nuanced way to give candidates some "credit" for being placed somewhere in a voter's choice profile.

Independence of Irrelevant Alternatives: Borda count elections are often criticized for not meeting the IIA criterion. Assume there are three candidates A, B, and C. Voters have the following preferences: two voters prefer A>C>B and three voters prefer B>A>C. When only candidates A and B are competing, we use a 2-1 scoring system, and A receives 7 points while B receives 8 points, meaning B wins. When all three candidates are competing, we use a 3-2-1 scoring system. In this event, A receives 12 points, B receives 11 points, and C receives 7 points, meaning A wins. The introduction of candidate C made A the winner when B would have otherwise won, so IIA is violated. We often discuss IIA in the context of cannibalization. Here, it does not seem that candidate C is cannibalizing candidate B but, rather, that the Borda count mechanism is highlighting that candidate A is preferred over candidate C by every voter.

Cannibalization: Borda count does help to account for cannibalization of votes since candidates who are similar to each other, as long as they are ranked close to each other, receive a similar amount of points from each voter. Though the slight point differentials might impact which one of them wins, Borda count voters can still express preferences for any number of similar candidates over any other candidates that they strongly do not prefer.

Consideration of All Votes: Because the winner of a Borda count election is determined at one step, all ballots cast should are counted and there are no "wasted" votes. If, after a voter casts a ranked ballot in a Borda count election, a candidate drops out mid-election, the negative impacts that would be present in a single-choice election are mitigated since voters did still rank multiple candidates and allocate points to them.

Subjectivity to Tactical Voting: There are tactical voting concerns that arise with Borda count. Since unranked candidates receive zero points, even a ballot that does not allow for repeated or cyclical preferences can enable misrepresentation that benefits a voter's true first-preference. Assume candidates A, B, C, D, and E are competing, and there is a voter who would approve of any of them in the order E>B>C>D>A. While their true preferences would be expressed by ranking the candidates in that order, they have a tactical incentive to only rank candidate E in slot one and not rank any of the rest of the candidates, thereby awarding candidate E five points, while the rest receive zero. This occurs so long as voters are aware of how the ranked choices will be counted, especially since voters should not be required to rank full choice profiles if they do not want to, but it is a matter of democratic transparency that voters should have this information.

Additional Concerns: The previous criteria were evaluated using theoretical examples, but there are also some additional problems with Borda count that we can visualize in the FairVote data set. As was standard for the simulations in this thesis, voters ranked preferences one through seven; candidates received eight points per first-preference, seven-points for second-preference, and so on until receiving two points for seventh-preference. Realizing that I should not infer that a voter who chose all seven preferences would necessarily have ranked the one remaining candidate as eighth-preference if given the option to, I decided to see what would happen if I shifted the points over by one. Then, when candidates received seven points per first-preference, six points for second-preference, and so on until receiving one point for seventh-preference, we notice changes in the differences in points between candidates. As seen in Table 3, the point differential between Bernie Sanders and Joe Biden changes, from 78 to 86, denoting a 10% increase, dependent on the point totals being used. While we might have anticipated that the two different methods of allocating points would yield the same results (as they did in this instance), the magnitude of the win changed as Biden lost more points after shifting the scale than did Sanders. This suggests that Biden was receiving more points from being higher up in voters' rankings, rather than from simply being included in the ballots, than was the case for Sanders. We also see that the two Borda count mechanisms elected different candidates at times from the bootstrapped elections in Table 4 and the simulations using the β vectors in Table 6. It is a weakness of the Borda count method that something so arbitrary as the number of points allocated to each rank could have consequential effects on closer races. The point allocation and Borda count as a whole are weak to the criticism that assigning points to candidates based on how they were ranked by voters assumes magnitudes of difference in preferences that voters never explicitly stated.

Condorcet Mechanisms Simple Condorcet was selected for consideration because, in considering each possible two-candidate matchup from the slate of candidates, it acknowledges candidates who have appeal over all other candidates. Considering the number of head-to-head matchups that candidates win, however, ignores the margins by which they win and also always yielded 7-6-5-4-3-2-1-0 outcomes in the simulations. So, I also considered a marginal Condorcet method that adds up candidates' win percentages. Finally, realizing that even this might not provide a perfect picture, since matchups can have the same win percentage even if they do not have the same amount of voters participating, I also decided to add a marginal Condorcet method adding up total percentages of votes received per candidate.

It was very interesting to note, as seen in Table 6 that, the marginal Condorcet method with total percentages yielded a different outcome than the other two Condorcet methods in two elections. We also notice a different in win counts per candidate from these various Condorcet types in Table 4. We can possibly attribute these differences in outcome to the participation in vote ballots. For example, the Steyer-Gabbard matchups had fewer voters participating because they are not frequently ranked candidates, while the Biden-Sanders matchups have more voters because they are both frequently ranked candidates. Since the marginal Condorcet method by total percentage accounted for these differences in matchups, we see that it sometimes yields a different outcome. In elections with enforced ranking, where voters would have to rank all competing candidates, we should not see differences in these numbers; however, if voters should be able to rank only the candidates they want to, then we should expect to see some differences in outcome between these systems.

Independence of Irrelevant Alternatives: Adherence to the desired IIA criterion varies between the different Condorcet types. IIA does hold when using the simple Condorcet method. By nature, simple Condorcet considers pairwise elections; therefore, when a new candidate is introduced, they do not affect the existing matchups. The introduction of a new candidate only changes the winner of the election if they, themselves, are the new winner. However, IIA is violated in certain occasions with both marginal Condorcet elections. Let's consider a scenario where there are candidates A and B, and 51 voters prefer A>B while 49 voters prefer B>A. Candidate A wins simple Condorcet (having one pairwise win while B has zero), marginal Condorcet by win percentage (having a win percentage tally of 2% while B has 0%), and marginal Condorcet by total percentage (having a total percentage tally of 51% while B has 49%). Now, suppose that when candidate C is added, 51 voters prefer A>B>C and 49 prefer B>C>A. The A-B matchup has 51% of voters preferring A and 49% preferring B; the A-C matchup has 51% preferring A and 49% preferring C; and the B-C matchup has 100% preferring B and 0% preferring C. Candidate A remains the simple Condorcet winner, since A has two pairwise wins while B and C have zero each. However, now, candidate B wins both the marginal Condorcet by win percentage (percentage tallies are 4% for A, 100% for B, and 0% for C) and marginal Condorcet by total percentage (percentage tallies are 102% for A, 149% for B, and 49% for C). Therefore, IIA is violated in this instance for both marginal Condorcet methods.

Cannibalization & Consideration of All Votes: Similar to the other RCV systems, there is a slimmer likelihood for cannibalization in the Condorcet methods than in a plurality system. Voters can indicate that they prefer any number of similar candidates over other types of candidates without a problem. Additionally, by nature of the Condorcet voting systems considering all ballots in their entirety in a single round of ballot counting, all ballots cast are counted. If, after a voter casts a ranked ballot in a Condorcet election, a candidate drops out mid-election, the Condorcet ballots can still be counted while simply ignoring matchups that included that candidate.

Subjectivity to Tactical Voting: Since Condorcet elections consider head-to-head matchups, all voters have an incentive to rank every single candidate to have their opinions heard in all of the matchups. They do not have a tactical incentive to only rank one or a few candidates unless they are completely indifferent between any candidates who they leave unranked. Voters also have the incentive to rank all candidates if there is a candidate they particularly dislike, making sure to rank them in last or near-last place. Voters can, however, tactically misrepresent their preferences to set their preferred candidates up for more success. For example, if a voter prefers candidates in the order A>B>C>D>E but thinks that the competition will come down to being between candidates A and B, they can rank their preferences as A>C>D>E>B to try and set candidate B up for failure in all of their head-to-head matchups because this would benefit candidate A in all Condorcet types. Notice that this scenario reflects the aforementioned example showing an IIA violation: voters in marginal Condorcet elections can tactically rank less relevant candidates (candidate C in that example) higher than their preferred candidate's strongest competition (candidate A) to benefit their most preferred candidate (candidate B).

9 Discussion

Before discussing the implications of the previous two sections on presidential primaries, it is important to note some limitations. The empirical results are limited in that we cannot assume that the "first-choice" preferences that were indicated in the RCV ballots would have been the same as voters' single-choices if they were each only allowed to select one candidate. The difference in incentive structures created for voters by single-choice and ranked-choice ballots were discussed in length in the previous section, and using simple plurality as a proxy for a single-choice election is inherently flawed for these reasons. Additionally, though the survey data seemed to reflect popular polling at the time of collection, and though Bernie Sanders won every election simulated from votes in the data set, Joe Biden swept the remainder of the primary races and clinched a victory. There remain unknown reasons (perhaps further differences in incentive structures or a notion similar to that of "spoiler" candidates mentioned in the previous section) that surveys and polling around this time did not predict or reflect the eventual winner of the 2020 U.S. Democratic presidential primary election.

Looking at traits of various election systems, some fare better than others when considering certain criteria. All election systems met Arrow's criteria of unrestricted domain, non-dictatorship, and Pareto efficiency. The only system which was found to not violate the IIA principle was simple Condorcet. Though the simple plurality election is easiest and least costly to implement in the United States, it suffers by "wasting" votes, by leading to cannibalization of similar candidates, and by creating incentives for voters to misrepresent their preferences. All of the ranked-choice elections considered help to limit "wasted" votes and cannibalization and help reduce incentives for voters to misrepresent their preferences. However, Borda count and Condorcet elections can yield variable results based on the exact system used and they are more subject to tactical voting, whereas simple plurality and the runoff elections are not as susceptible to strategic voting. Joe Biden was deemed by my estimations to provide the highest social utility for the voting population and, though he was elected in real life by a system we've simplified to consider as a plurality one, this thesis has exposed weaknesses of simple plurality systems and has shown how sensitive voting systems can be to changes in voter preferences and incentives.

The two runoff systems—instant runoff and single-elimination runoff—though imperfect, provide many benefits compared to a simple plurality or majority election considering only single-choice ballots. Additionally, asking voters to cast ranked-choice preferences in regular elections would elicit benefits in participation and truthful revelation. Areas in the United States that have implemented RCV have seen success and popular support for its continued implementation ("Data on Ranked Choice Voting", 2020). Even if results were to suggest that neither of these runoff systems would yield different candidate outcomes than single-choice elections, collecting ranked-choice ballots would still provide ample additional data with which to further study voter preferences than currently exists. However, per my empirical results, ranked-choice outcomes that did differ from plurality outcomes always provided equal or higher social utility to the voting population than did the simple plurality result.

Assessing the impact of RCV on primary elections is notable and unique from impacts on other elections for two reasons. Firstly, it is increasingly common to see large slates of candidates in presidential primaries, and RCV is only triggered or consequential when there are more than three candidates competing. RCV has rarely been studied with well over four candidates (and rarely outside of general elections), and, as primary elections will surely continue to invite many candidates to compete, primaries provide unique territory in which to study the impact of ranked ballots on such large fields. Secondly, since candidates in presidential primaries are, by nature, all members of the same party, there are not two automatic front runners leading the race. In general elections, contests can easily be narrowed to two established, party-backed candidates. By contrast, presidential primary elections can be unpredictable in outcome, dependent only on voter mobilization and eager participation. Since voter preferences are less likely to be clustered around two candidates in primaries than they are in general elections, collecting ranked-choice data and surveys on future primaries would be uniquely informative.

As it currently stands in presidential primaries, nominee selection is warped for many reasons. Election timings highly complicate voter preferences and create anxiety on how to allocate limited votes. Delegates wield immense power since any brokered convention is left to their sole discretion and no longer to that of voters. It is likely that these delegate structures are a matter of agenda control by parties to elect their preferred candidates (Levine & Plott, 1977), under the notion that the party's preferred candidates will appeal to the overall electorate. That being said, it is understandable that the party establishment would hope to select a candidate who appeals to a majority of the voting base in order to form a strong coalition going into the general election; however, there is a way to gather information about how candidates truly appeal to the party base, rather than merely having delegates change their votes based on their preferences. Ranked-choice ballots would provide parties with more information than they are currently gathering, and parties can use these ballots to build broad, majority coalitions of voters rather than of delegates. Ranked-choice ballots, by informing parties about voters' true preferences, better inform everyone about how voters are ideologically dispersed throughout the voting population and help parties better understand their voters to help future candidate and party elections. Ranked-choice ballots also open the door to future research on how RCV can make some candidates more viable and perhaps impact their decisions on whether to remain in/drop out of elections or on where and how to strategically campaign. Ranked-choice ballots and voting systems are far better prepared to handle large slates of candidates than are our current systems. Furthermore, they are prepared to foster competition, ever important since parties that embrace fair, tough competition in their primary elections can set themselves up for more success in general and future elections.

10 Conclusion

This thesis addressed the question: do various election systems, both single- and ranked-choice, differ in their social welfare for a voting population, in their effects on voting procedure, or in their practical applications?

By building upon a theoretical model considering the role of demographics and ideology on voter preferences and by applying a multinomial logit model of voter choice from previous literature in economics and political science, this thesis determined a unique way to assess the favorability of various election systems in alignment with overall social welfare. The MLE results determining social utility of each candidate for the voting population also informed us about candidate preference trends among various ideology and demographic groups. Though the initial simulated election results using the ballots of LDPVs from the FairVote survey data did not show variation in candidates elected, we did see more variation in election system results by bootstrapping the data and when simulating voter ballots using the MLE results themselves. Observing that Bernie Sanders was overwhelmingly favored by most election mechanisms while Joe Biden was favored on average by most ideology and demographic groups helped elucidate the complexity and strength of voter preferences in an election with such fierce competition. When considering voter preferences for Biden vs. Sanders when only these two candidates were preferred, Sanders was considerably favored over Biden, helping to clarify Sanders' strength in the full election simulations.

Ultimately, the results were used to evaluate the single-choice plurality election method against all of the various ranked-choice election methods, assessing Arrow's fairness criteria, incentive structures, subjectivity to tactical voting, and practical application. If applied to U.S. presidential primary elections, ranked-choice systems would offer a potential remedy to the challenges voters face in navigating timing their ballots and would provide delegates with more information to cast representative ballots at national conventions.

There is also a potential for future research in considering the impacts of ranked-choice voting on candidate strategy, as changes in election mechanisms might affect the existing desires candidates have to distinguish themselves from their competition and to signal strength in early primaries. Information, such as that gathered from the empirical results, on how demographics and ideological characteristics impact voter preferences, could also be helpful for candidates looking to strategically campaign to voters in certain demographics, regional locations, or other affiliation groups needed to win the nomination. To this end, more data with larger sample sizes can be collected on ranked-choice voting, both from surveys and from implementation in elections. Further information, especially from elections with numerous competing candidates, would enable future models of voter preference and would teach us more about strategies, of both voters and candidates, and outcomes in ranked-choice elections.

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