Online Appendix

In this appendix, we present fast and approximate solutions to the planner's optimization problem in both partisan and non-partisan cases.

A. Nonpartisan Case: the Knapsack Problem

We first show how to approximate the solution to the non-partisan planner's optimization problem defined in Section 3.2. The key is to notice that the above linear optimization problem is identical to the canonical *knapsack problem*, in which one maximizes the total value of objects to be placed in a knapsack of fixed sized, with each object having its own value and size. The analogous case for the nonpartisan planner is maximizing the number of voters given a budget constraint where each individual-treatment pairing may be thought of as an object.

Following Dantzig (1957), we approximate the exact solution of this linear programming problem by ordering the individual pairs by their maximum vote per dollar ratio and treat the individuals with the highest such ratio first until the budget is exhausted. If the ratio is non-positive (i.e., the best non-control treatment for an individual does not outperform the control), this individual is not treated. In most cases, this approximation yields solutions very close to the optimal result because the ratio of the per-use cost of the most expensive treatment (e.g., \$15 for a canvassing shift) is tiny compared to the overall budget (usually at least \$10,000). Thus, when the addition of an expensive and efficient treatment runs just over budget and a cheaper yet less efficient tactic should be used in its place, inefficiencies at the edge of the problem are of little importance.

B. Partisan Case: the Stochastic Knapsack Problem

To derive a fast and approximate solution to the partisan's optimization problem defined in Section 4.3, the key is to notice that this optimization problem is identical to the *stochastic Knapsack problem*, in which one maximizes the probability that the total value of items in the knapsack equals or exceeds a target value where each object has a random value and a known size. As in the non-partisan case, each individual-treatment pair can be treated as an item.

As an approximate solution to this problem, we use the algorithm that is based on Geoffrion (1967) where subgroups are ordered by the weighted combination of the mean and standard error of their posterior vote choice profile, $\pi(\rho)$. Optimization is performed over the weight parameter, which can take values between 1 (i.e., only mean of the posterior matter) and 0 (i.e., only the standard error matter). For a discussion of when this approximation fails to yield the optimal result, see Henig (1990). The intuition behind this algorithm can be developed by considering the following scenarios. Campaigns with a natural advantage (i.e., would garner a majority of the vote without treatment) could further increase their probability of winning by contacting voters who are highly responsive on average and have a low variance of their treatment response. On the other hand, campaigns who are behind aim to treat segments of the population who are *both* highly responsive and who have high variance. Thus, unlike in the nonpartisan case, the optimal subgroups to treat change depending on the outcome under the control. The algorithm finds an approximate solution by limiting its search to the subspace defined by the weight parameter, which makes optimization feasible when the dimension of δ is large.

References

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