

# AN ADAPTIVE AND VERIFIABLY PROPORTIONAL METHOD FOR PARTICIPATORY BUDGETING

EDITH ELKIND

Participatory Budgeting (PB) is a form of participatory democracy in which citizens select a set of projects to be implemented, subject to a budget constraint. The Method of Equal Shares (MES) is a simple iterative method for this task which runs in polynomial time and satisfies a demanding proportionality axiom (Extended Justified Representation) in the setting of approval utilities. However, a downside of MES is that it is non-exhaustive: given an MES outcome, it may be possible to expand it by adding new projects without violating the budget constraint. To complete the outcome, the approach currently used in practice is as follows: given an instance with budget  $b$ , one searches for a budget  $b' \geq b$  such that when MES is executed with budget  $b'$ , it produces a maximal feasible solution for  $b$ . The search is greedy, i.e., one has to execute MES from scratch for each value of  $b'$ . To avoid redundant computation, we introduce a variant of MES, which we call Adaptive Method of Equal Shares (AMES). Our method is budget-adaptive, in the sense that, given an outcome  $W$  for a budget  $b$  and a new budget  $b' > b$ , it can compute the outcome  $W'$  for budget  $b'$  by leveraging similarities between  $W$  and  $W'$ . This eliminates the need to recompute solutions from scratch when increasing virtual budgets. Furthermore, AMES satisfies EJR in a certifiable way: given the output of our method, one can check in time  $O(n \log n + mn)$  that it provides EJR (here,  $n$  is the number of voters and  $m$  is the number of projects). We evaluate the potential of AMES on real-world PB data, showing that small increases in budget typically require only minor modifications of the outcome.