Designing Mechanisms for Participatory Budgeting

Doctorial Consortium

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ABSTRACT

When seeking for suitable mechanisms for participatory budgeting (PB), one has to decide on which criteria to assess them. In this paper, I present several appealing criteria for PB mechanisms. I briefly introduce each of them and discuss their impact on the design of PB mechanisms.

KEYWORDS

Computational Social Choice; Participatory Budgeting; Voting

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1 INTRODUCTION

Modern democracies are built on the idea that important decisions should be made by taking into account citizens' opinions. While it is generally clear that this is a good idea, it is not always straightforward to decide how to incorporate the opinions of millions of individuals into the decision making process. To help making this decision, a formal study of voting scenarios has been developed in the field of social choice [2]: the study of how to aggregate individual opinions into a collective decision.

It can be argued that social choice theory was initiated by Kenneth Arrow's book *Social Choice and Individual Values* [1]. Arrow focused on classical social choice: scenarios where a single alternative has to be selected (such as presidential elections). In recent years, many other settings have been studied, and in particular that of multi-winner elections where several alternatives—e.g., members of a committee—are to be declared winners [17, 21]. Overall, more and more complex scenarios have been introduced in the literature, making it possible to study richer models that are closer to real-life processes. Interestingly, these new models made it possible to initiate the study of recent innovations in participatory democracy [6, 24]. Participatory budgeting (PB) may be the most stringent example, and will be the central theme of my thesis.

Behind participatory budgeting lies a set of democratic mechanisms through which citizens are asked to give their opinion on how to use public funds. The first PB process took place in 1989 in the Brazilian city of Porto Alegre. More than thirty years later, it has spread all around the world [12, 35]. Even though it has been extensively studied in political science over the past twenty years [8, 12, 32], PB was only recently introduced in the social choice literature [4, 5, 16, 19, 23].

PB processes are typical examples of social choice problems. They are usually formalized in the following way. A decision maker has to select from a set of projects the ones to fund. Each project is associated with a cost, and the decision maker can only use a limited amount of resources to fund the projects. This defines a budget limit, constraining the total cost of the selected projects. In order to make an informed decision, the decision maker will ask voters to submit their preferences about the projects.

Social choice scientists then study PB mechanisms, *i.e.*, mathematical functions taking as input the PB setting and the opinion of the agents, and returning a set of selected projects whose total cost does not exceed the budget limit. The goal of my thesis is to find the most suitable PB mechanisms (note the plural here), in the hope to provide recommendations for real-world PB processes.

It is always difficult to talk about "most suitable mechanisms" since there usually are no clear-cut answers as to which criteria they should satisfy. Moreover, social choice theory is grounded in results proving that no mechanism can have it both ways [1, 18, 31]. Most of the literature is actually devoted to understanding what makes a good mechanism and whether it is possible to find one. For my thesis, I have identified several criteria that have been introduced over the years and that would provide interesting insights about PB mechanisms. In the rest of this paper, I will introduce them and discuss how to design PB mechanisms satisfying them.

2 NORMATIVE REQUIREMENTS

In this section, we will briefly introduce several normative requirements—called *axioms* in the social choice literature [34]—that we deem should be satisfied by any sensible PB mechanism.

2.1 Representation of Diversity

Let us start with the idea that the outcome of a PB election should represent the diversity of the voters as much as possible. Indeed, since most of the time, several projects will be selected in the outcome of PB elections, one can better reflect the diversity of the society in the outcome, compared to a single-winner election for instance. It thus seems particularly important for a good mechanism to provide guarantees on the representation of the voters, a property usually referred to as *proportionality*.

Proportionality is one of the main ideas studied for multi-winner elections, a special case of PB without costs [3, 21]. Among the most prominent concepts are those related to *justified representation* [3], the idea that if x percent of the voters agree on some projects costing no more than x percent of the budget, then these voters deserve to be represented in the final outcome. Several axioms

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based on justified representation have already been imported in the PB setting and appealing mechanisms satisfying them have been proposed [4, 27], preparing the ground for further studies.

Based on the observation that almost all real-life PB processes actually are repeated over the years, we recently extended the concept of proportionality to a setting for long-term PB [20]. The main idea of that work is that mechanisms could ensure the outcome to be proportional, maybe not for a given year, but in the long run.

2.2 Incentive Compatibility

Another important requirement is incentive compatibility, also called *strategyproofness*. It states that no agent should have an incentive to adopt a strategic behavior during the PB process, *i.e.*, to submit other preferences than their true preferences.

Strategyproofness has been extensively studied in social choice and has brought some of the most famous impossibility results [18, 31]. PB is no exception to that, and it has been shown that simple proportionality requirements cannot be satisfied together with strategyproofness [25, 26]. What this means for us is that it is impossible to design a mechanism that is incentive compatible and proportional at the same time. This is one of the many compromises one has to decide on when looking for suitable PB mechanisms.

In a recent paper we investigated the problem of incentive compatibility in a generalized two-stage model for PB [30]. The idea was to develop a model capturing more closely real-life PB processes where voters first submit suggestions for projects, and in a second stage vote over the shortlisted suggestions. We showed that it is almost impossible to define mechanisms for both stages of the process that would prevent voters from misreporting their suggestions in order to manipulate the final outcome.

2.3 Monotonicity Requirements

Monotonicity axioms have also been introduced for PB [33]. Those are axioms postulating the way a mechanism should behave in a dynamic environment. One axiom for instance requires that if a projects was selected in the outcome and that project becomes cheaper, everything else being the same, then this project should still be selected. These axioms provide additional criteria to further distinguish between mechanisms.

3 TRUTH-TRACKING ABILITY

Mechanisms can be compared based on the normative requirements they satisfy, but also based on their epistemic, or *truth-tracking*, ability. This line of work is based on the assumption of the existence of a ground truth defining the objectively best outcome of an aggregation scenario, and that the voters are just noisy estimators of that ground-truth [13]. A mechanism can then be seen as a procedure that aggregates noisy information in order to recover the ground truth. In that view, the best mechanisms are those that are more likely to recover the ground truth.

This approach has been successfully applied in many frameworks, from single-winner elections [10, 11, 36], to judgment aggregation [7], and multi-winner voting [9, 28]. It would be interesting to analyse PB mechanism through that lens.

The existence of a ground truth in the context of PB might not always be straightforward. An example could be the mechanism behind the game `EteRNA` [15]. It has already been argued to be a multi-winner voting scenario with a ground truth [28]. It is very natural to imagine that alternatives (protein foldings to synthesize) actually have different cost, making it a PB scenario.

4 ALGORITHMIC EFFICIENCY

The ultimate goal of my thesis is to identify suitable mechanisms for PB that can be used in real-life instances. For the mechanisms to be used in practice, they have to be implementable efficiently on a computing device. That is where the algorithmic analysis comes into play: a good mechanism should be implementable using algorithms that are efficient even with a large number of ballots.

Algorithmic efficiency induces yet another need for compromises in the design of PB mechanisms. For instance, some of the stronger proportionality requirements cannot be satisfied by a mechanism running in polynomial time (unless `P = NP`) [4].

5 ADAPTABILITY TO THE SCENARIO

As we explained in the introduction, participatory budgeting actually is a loosely defined term that encompasses many different scenarios. When investigating real-life PB processes, one can notice a lot of small variations of the basic model. In some cases, there are quotas on categories of projects, in other cases the process is repeated over the years, *etc.* To avoid having to develop specific mechanisms for each of these cases, we seek to design mechanisms that can easily be adapted to reflect small changes of the setting.

In that spirit, we embedded participatory budgeting into judgment aggregation [29], a more general aggregation framework [14]. This allowed us to provide general definitions for PB mechanisms that would apply similarly even when adding new constraints to the settings (quotas over projects or dependencies between projects). Grounding PB mechanisms in a more general setting is one way to enforce the adaptability of our mechanisms.

6 CONCLUSION AND FUTURE WORK

Throughout this paper, we have discussed many different ways to assess the quality of a mechanism for PB. To answer our initial question, a good mechanism is one that provides a nice compromise on all of the requirements we introduced. It is still not clear whether such a mechanism exists and some future work is needed to be able to identify suitable ones.

Among the different criteria that we discussed, it is important to note that no work has been done on the epistemic approach for PB. This research direction is one I would like to pursue.

There is still a lot of work to be done on the proportionality side of PB, especially since it is not clear what the best way of measuring the satisfaction of an agent is. The concept of *share* that we recently introduced [20] might provide new insights on that question and deserves more attention.

In a more conceptual approach, to fully understand how to design mechanisms for PB, one should also try to understand what is specific about PB. It would then be interesting to see how to adapt the axiomatic characterizations of multi-winner voting mechanisms [22] to PB. Doing so should allow us to pinpoint the main conceptual differences between the two settings and thus to deepen our understanding of PB.

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