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Power and truth in liquid democracy

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SUMMARY

This dissertation provides methods for studying two questions of *liquid democracy*: (i) *how powerful is each voter in influencing the voting result*, and (ii) *how is the voting quality influenced when voters can split their delegations*. These two questions are studied with a mix of analytical and simulation techniques.

We work on a specific voting setting, where a set of voters is expected to select one out of two candidates. Only one of the two candidates is the ground truth, i.e., beneficial to all voters. However, voters are only aware of the correct candidate with noise. We assume that voters are informed, that is, they make decisions better than random. Then, by the mechanism of liquid democracy, voters may directly vote based on their own awareness of the voting issue or rely on other voters to make the decision, with interactions constrained by a social network. The voting result is finally decided by a quota voting rule (or a special case: the weighted majority rule), i.e., a given candidate is selected if a voter group whose size exceeds the quota chooses the candidate, otherwise the other candidate is chosen.

In the study of question (i), we formulate a voter's voting power as the probability that she can change the voting result by unilaterally changing her own vote. This concept is captured by voting power indices, like the Banzhaf index. However, in liquid democracy, each voter can vote for a specific candidate or delegate to other voters. We therefore study voting power in liquid democracy by addressing one of the key features of liquid democracy: voters are able to freely remand their delegations during the entire phase (the *instant recall feature*). In order to capture this feature, we generalize the *Banzhaf power index* to the complex voting strategy space of liquid democracy, and call it the *delegative Banzhaf index*.

Our theoretical analysis of the delegative Banzhaf index shows that voters' voting power strongly depends on the delegation structure. A voter sacrifices voting power by delegating to other voters, since her vote is then partially decided by others. This sacrifice becomes larger if the delegation is indirect. What fits the intuition is that a voter collecting more delegations from others tends to be more powerful, and this is not only applicable to voters who actually vote, but also to delegators. However, a voter's voting power in liquid democracy is not only determined by her collected number of delegations, but also by how she collects delegations: direct delegations better empower those who receive the delegations.

Then, applying methods from game theory, we find that power-sensitive voters tend to avoid delegating too indiscriminately, especially via indirect delegation, in order to maintain their influence on the voting issue. These results provide a more

positive perspective on the issue of so-called supervoters in liquid democracy, because power concentration does not appear to occur under our assumptions.

To address question (ii), we provide two weighted delegation models that represent how voters split their votes and delegate to multiple delegates: one is probabilistic and models such behavior as mixed strategies, i.e., distributions on the space of possible delegations; the other one models such behavior as a split of votes viewed as shares to different delegates. Compared to the pure delegation setting (i.e., each voter can only delegate to one delegatee), we demonstrate that it is possible to optimize the decision-making quality through the weighted delegation scheme. However, this requires centralized coordination.

We then investigate, both theoretically and empirically, voters' behavior in delegation games where weighted delegation is allowed. The results show that the Nash equilibria in weighted delegations, that is, delegation structures where no agent has an incentive to change their delegation, are always weakly better in terms of decision-making quality than those in pure delegation. However, this comes with a higher price of anarchy, i.e., the fraction between the optimal welfare and the welfare of the worst equilibrium. Empirically, our simulations show that when voters are boundedly rational, weighted delegation reaches a better decision-making quality than pure delegation.

Overall, in this dissertation, we study liquid democracy, this young collective-decision-making method, in terms of the above two questions. We contribute formal methods to analyze it, and show liquid democracy's potential to enhance the quality of collective decisions.