Chapter 6 Conclusions and Future Directions

In this dissertation we have taken a comprehensive look at the effect that the type and amount of information can have on the bribery and manipulation problems. We have also surveyed a novel dataset that we are just starting to understand. The plethora of data present in the Netflix dataset will continue to support research in this area for several years.

In Chapter 3 we saw that relaxing the deterministic information assumption changes the reasoning complexity, with the problems generally becoming more difficult. However, this change in complexity is not uniform and we are left with several problem instances that are still computationally easy. This novel line of investigation has shown that, even in the face of uncertain information, many election rules are still susceptible to bribery and manipulation.

In Chapter 4 we saw the effect that structured information can have on the reasoning complexity of the bribery and manipulation problem. In the combinatorial domains with preferences modeled as CP-nets, many of the bribery problems are computationally tractable. In fact, for some cases of k-approval, the complexity of bribery actually became easier.

In Chapter 5 we identified and mined a novel set of data for use in empirically testing various voting rules and paradoxes. We saw that Condorcet's paradox is of little concern in our elections. Furthermore, we saw that in many cases voting rules return the same winner and are highly Condorcet efficient. We also saw that there is little to no support for existing statistical models of election data in the literature.

Though we present a significant body of research in this dissertation, we feel we have just begun to scratch the surface of some of these questions. The Netflix dataset, along with other publicly available datasets that we will mention, allow us unprecedented access to data with which we can empirically test and verify many of the assumptions about voting

rules in the ComSoc community. Additionally, despite some hard instances, we still have not hit truly computationally hard barriers for many of our models; many of them are either approximable to close factors or tractable in an FPT sense. These observations form the basis for much of the ongoing work.

For our theoretical work detailed in Chapter 3 and Chapter 4 we would like to complete our results. We were unable to provide lower bounds for some of the problems and we are continuing to work on these proofs. We would like to investigate heuristics and approximability results for the computationally hard bribery and manipulation problems. We are also interested in considering additional manipulation actions for our work with CP-nets: in the work presented in this dissertation, the manipulator can only delete dependencies, while we would like to investigate the complexity of the manipulation problem when the outside agent is also allowed to add dependencies within the CP-net. We would also like to verify some of our models using the vote histories from the US Congress from 1789-2000 from the University of California, Berkeley, *Vote World* project [133]. We can also obtain detailed records of the money received by candidates and lobbying performed by industries from the *Open Secrets* dataset [63]. Additionally, we would like to augment our models to use elements of inter-agent influence and look at the bribery and manipulation problem in the context of social-networks and other factors [60].

For the empirical work detailed in Chapter 5 we would like to empirically investigate voting rules and their potential as maximum likelihood estimators [31]. Additionally, we would like to expand our empirical evaluation of election cultures to include several new models of population distributions proposed by Tideman and Plassmann [124], and others. There has been extensive work in the computational social choice community on the probability that an election is computationally hard to manipulate based on the number of voters and candidates [129, 135]. Additional work has shown that voting rules are susceptible to small coalitions (relative to the total number of voters) for many voting rules [103] and protocol tweaks to decrease the probability that a small coalition will be able to manipu-

late an election [44]. We also plan to leverage the dataset to investigate manipulation in scenarios where voters do not express strict or complete orders [81, 139]. Additionally, we will be in a unique position to evaluate the effect of partial orders on election outcomes by classifying the sets of possible winners [80]. This plethora of data puts us in the position to empirically test many of the theoretical assumptions and/or predictions in the computational social choice literature.