Robust Stackelberg Equilibria

JIARUI GAN, University of Oxford, UK
MINBIAO HAN, University of Chicago, USA
JIBANG WU, University of Chicago, USA
HAIFENG XU, University of Chicago, USA

This paper provides a systematic study of the *robust Stackelberg equilibrium* (RSE), which naturally generalizes the widely adopted solution concept of the strong Stackelberg equilibrium (SSE). The RSE accounts for *any* possible up-to-δ suboptimal follower responses in Stackelberg games and is adopted to improve the robustness of the leader's strategy. While a few variants of robust Stackelberg equilibrium have been considered in previous literature, the RSE solution concept we consider is importantly different — in some sense, it relaxes previously studied robust Stackelberg strategies and is applicable to much broader sources of uncertainties.

We provide a thorough investigation of several fundamental properties of RSE, including its utility guarantees, algorithmics, and learnability. We first show that the RSE we defined always exists and thus is well-defined. Then we characterize how the leader's utility in RSE changes with the robustness level considered. On the algorithmic side, we show that, in sharp contrast to the tractability of computing an SSE, it is NP-hard to obtain a fully polynomial approximation scheme (FPTAS) for any constant robustness level. Nevertheless, we develop a quasi-polynomial approximation scheme (QPTAS) for RSE. Finally, we examine the learnability of the RSE in a natural learning scenario, where both players' utilities are not known in advance, and provide almost tight sample complexity results on learning the RSE. As a corollary of this result, we also obtain an algorithm for learning SSE, which strictly improves a key result of Bai et al. [2021] in terms of both utility guarantee and computational efficiency.

A full version of this paper can be found at https://arxiv.org/abs/2304.14990.

CCS Concepts: • **Theory of computation → Algorithmic game theory**; **Solution concepts in game theory**; **Exact and approximate computation of equilibria**; **Convergence and learning in games**.

Additional Key Words and Phrases: Stackelberg game, robust equilibrium[1]

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