Two-Stage Stochastic Programming under Multivariate Risk Constraints with an Application to Humanitarian Relief Network Design

Simge Kucukyavuz, Northwestern University

In this study, we consider two classes of multicriteria two-stage stochastic programs in finite probability spaces with multivariate risk constraints. The first-stage problem features multivariate stochastic benchmarking constraints based on a vector-valued random variable representing multiple and possibly conflicting stochastic performance measures associated with the second-stage decisions. In particular, the aim is to ensure that the decision-based random outcome vector of interest is preferable to a specified benchmark with respect to the multivariate polyhedral conditional value-at-risk (CVaR) or a multivariate stochastic order relation. In this case, the classical decomposition methods cannot be used directly due to the complicating multivariate stochastic benchmarking constraints. We propose an exact unified decomposition framework for solving these two classes of optimization problems and show its finite convergence. We apply the proposed approach to a stochastic network design problem in the context of pre-disaster humanitarian logistics and conduct a computational study concerning the threat of hurricanes in the Southeastern part of the United States. The numerical results provide practical insights about our modeling approach and show that the proposed algorithm is computationally scalable.