A Nonparametric Approach with Marginals for Modeling Consumer Choice

Given data on the choices made by consumers for different offer sets, a key challenge is to develop parsimonious models that describe and predict consumer choice behavior while being amenable to prescriptive tasks such as pricing and assortment optimization. The marginal distribution model (MDM) is one such model, which requires only the specification of marginal distributions of the random utilities. This paper aims to establish necessary and sufficient conditions for given choice data to be consistent with the MDM hypothesis, inspired by the utility of similar characterizations for the random utility model (RUM). This endeavor leads to an exact characterization of the set of choice probabilities that the MDM can represent. Verifying the consistency of choice data with this characterization is equivalent to solving a polynomial-sized linear program. Since the analogous verification task for RUM is computationally intractable and neither of these models subsumes the other, MDM is helpful in striking a balance between tractability and representational power. The characterization is convenient to be used with robust optimization for making data-driven sales and revenue predictions for new unseen assortments. When the choice data lacks consistency with the MDM hypothesis, finding the best-fitting MDM choice probabilities reduces to solving a mixed integer convex program. The results extend naturally to the case where the alternatives can be grouped based on the similarity of the marginal distributions of the utilities. Numerical experiments show that MDM provides better representational power and prediction accuracy than multinominal logit and significantly better computational performance than RUM.