Capturing Choice Overload via Generalized Markov Chain Model

Motivation and Introduction
- Purchase probability may decrease when the number of offered items increases
- Has been observed empirically: Iyengar and Lepper (2000)¹
- Called “Choice Overload”

Markov Chain Choice Model
- Each product is a node in the Markov Chain
- Customers do a random walk on this graph
- When they reach an offered product, they simply buy the product

Generalized Markov Chain Model
- Transition matrix has rank 1
- Transition probability
- Offer Set (Absorbing States)
- π(i, S) Probability of buying i when S is offered

Theorem: The Markov Chain choice model can approximate any RUM ²

Hence, it cannot capture choice overload!

Generalized Markov Chain Model
- Key idea: An offered product is not necessarily absorbing anymore!
- For each i ∈ S, if a customer reaches state i, then they
  - either stop at i with a probability µ(i, S), depending on set of offered products
  - or keep transitioning

Figure 2. 4 products, S = {3, 4}

Figure 1. Can’t decide what to watch!

• No Random Utility based choice model can capture choice overload
• For any RUM, probability of no purchase decreases with increasing offer set size

Generalized Multinomial Logit (GMNL) Model
- Transition matrix has rank 1
- Transition probability
- Offer Set (Absorbing States)
- π(i, S) Probability of buying i when S is offered

Assortment Optimization Problem
\[
\max_{S \subseteq \mathcal{N}} \sum_{i \in S} \pi(i, S)r_i = \max_{S \subseteq \mathcal{N}} \sum_{i \in S} \frac{\sigma_i v_i r_i}{v_0 e^{\alpha \sum_{j \in S} v_j} + \sum_{j \in S} v_j}
\]

Theorem 1: The assortment optimization problem under the Generalized Multinomial Logit model is NP-hard.

Theorem 2: There is a near-optimal algorithm to the assortment optimization problem under the GMNL model.

Lemma:
\[
\pi(i, S) = \frac{v_i}{v_0 e^{\alpha \sum_{j \in S} v_j} + \sum_{j \in S} v_j}
\]

Hardness ☹

FPTAS ☺

References