

Dynamic programming decomposition for choice-based revenue management with flexible products

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Abstract

We reconsider the stochastic dynamic program of revenue management with flexible products and customer choice behavior as proposed by Gallego et al. [Gallego G, Iyengar G, Phillips RL, Dubey A (2004) Managing flexible products on a network. Working paper, Columbia University, New York]. In the scientific literature on revenue management, as well as in practice, the prevailing strategy to operationalize dynamic programs is to decompose the network by resources and solve the resulting one-dimensional problems. However, to date, these dynamic programming decomposition approaches have not been applicable to problems with flexible products, because sold flexible products must be included in the dynamic program's state space and do not correspond directly to resources.

In this paper, we contribute to the existing research by presenting a general approach to operationalizing revenue management with flexible products and customer choice in a dynamic programming environment. In particular, we reformulate the original dynamic program by means of Fourier-Motzkin elimination to obtain an equivalent dynamic program with a standard resource-based state space. This reformulation allows the application of dynamic programming decomposition approaches. Numerical experiments show that the new approach has a superior revenue performance and that its average revenues are close to the upper bound on the optimal expected revenue from the choice-based deterministic linear program (CDLP). Moreover, our reformulation improves the revenues by up to 8% compared to an extended variant of a standard choice-based approach that immediately assigns flexible products after their sale.

Keywords: Revenue Management, Flexible Products, Dynamic Programming Decomposition, Customer Choice, Fourier-Motzkin Elimination