Statistical Estimation Problems in Inventory Management

Alp Eren Akcay
Tepper School of Business, Carnegie Mellon University

April 30, 2013 10:00 am (324 GSIA, West Wing)

Most of the literature on inventory management assumes that demand distributions and the parameters that characterize these distributions are known with certainty. However, this is not the case in practice and the unknown parameters must be estimated using only a finite (and sometimes very limited) amount of historical demand data. The sequential process of first estimating the parameters and then optimizing the inventory based on these estimates does not perform well especially when there is limited amount of data for estimation. The discrepancy between the performance of an optimal inventory target and the performance of its estimate from a short demand history is a serious, but often ignored, operational problem.

The first study in this dissertation aims to solve this problem by considering a demand history with distributional characteristics that are hard to capture using standard distributions, and uses a flexible system of distributions that can capture a wide variety of distributional shapes with asymmetry, peakedness, and tail weight. The second study, on the other hand, considers an intermittent demand history which includes many zero values because demand does not arrive every inventory-review period. In both of these studies, the objective is to develop inventorytarget estimation methods that account for the operational costs of incorrectly estimating the unknown parameters in the demand model. In particular, we combine inventory management and parameter estimation into a single task to balance the costs of under- and overestimation of the optimal inventory target of a product. In the third study, we focus on finding a probability guarantee to the near-optimality of an inventory target estimator in the presence of temporally dependent demand data. Our findings shed light on how the autocorrelation and tail dependence in a demand process affect the number of demand observations required to achieve a performance arbitrarily close to the performance of the optimal inventory target, which has been only investigated for independent and identically distributed demand in the inventory management literature.

Thesis Committee: Bahar Biller, Sridhar Tayur, Alan Scheller-Wolf, and Fatma Kilinc-Karzan