DISSERTATION DEFENSE

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Essays on Operations Management

This dissertation focuses on the perishable inventory theory with health-care applications, the multi-variate input modeling for stochastic simulations, and temporal and bivariate dependence modeling for interarrival and service times of the queueing systems. This dissertation contributes to the perishable inventory theory by introducing the critical level policy for the first time with application from the blood platelet inventory management. Moreover, this dissertation introduces the Vector-Auto-Regressive-to-Anything (VARTA) method as an advanced simulation input modeling to analyze the impact of temporal and bivariate dependent interarrival and service times in the queueing systems. A synopsis of the three chapters of the dissertation follows.

Chapter 1: Blood Platelet Inventory Management with Protection Levels and Substitution

We consider a discrete-time inventory system for a perishable product that has distinct demand streams for product of different ages; an example of such a system is blood platelets. In addition to inventory holding, outdating and shortage costs, our model includes substitution costs when a demand for a certain-aged item is satisfied by a different-aged item. Our objective is to minimize the expected cost over an infinite time horizon. We introduce the critical level policy to the perishable inventory literature, protecting the newest items against excessive Downward substitution, borrowing an approach from the spare parts literature. This reserves these newest items for future demand for procedures needing younger items (i.e. fresher blood platelets). We model the problem as a Markov Decision Process (MDP) and evaluate the costs of a common heuristic replenishment policy (with and without a protection level) against extant "near optimal" policies in the literature. We show that the protection level policy may outperform other policies, particularly if supplies are capacitated.

Chapter2: Failure Probability of VARTA in Higher Dimensions

Vector-Autoregressive-To-Anything (VARTA) is a highly flexible model for driving large-scale stochastic simulations by generating samples of stationary multivariate time series with arbitrary marginal distributions. The construction of this model relies on a stable vector autoregressive process with a positive definite autocorrelation matrix. We show that there exist multivariate time-series input processes for which the conditions of stability and positive definiteness are violated. We investigate the likelihood of this event with increasing number of component time-series processes and order of

dependence by extending the onion method, which is used for sampling positive definite correlation matrices for random vectors, to sample positive definite autocorrelation matrices for multivariate time series. We find that the failure probability of VARTA reaches one with increasing number of component time series and order of dependence, but at a rate very much dependent on the rate of decay in temporal dependencies. We conclude with a discussion on an approximation of VARTA that might enable the simulation practitioner to avoid the failure of VARTA in high-dimensional settings.

Chapter 3: The Impact of Dependence in Queueing Systems

In this study, we use advanced simulation input modeling to study the impact of bivariate and temporal dependencies among interarrival and service times on the performance of a single-server queue. The distinguishing feature of our study from those in the literature is to consider a wide variety of distributional shapes for the probability density functions of the interarrival and service times, and the patterns that arise in the temporal dependencies of the interarrival and service times. We generate dependent interarrival and service times via using the Vector-Auto-Regressive-to-Anything method, which has never before been used in queueing systems. We investigate the impact of dependent interarrival and service times on the average waiting time of M/M/1, M/G/1 and G/M/1 systems. We show that high variance and positive skewed nonexponential distributions decrease the performance of the single-server system. We also compare impact of temporal dependencies in interarrival and service times for M/M/k systems ($k \geq 2$) with the M/M/1 system, and conclude that the effect of dependence decreases in multi-server systems. Our main contribution is to combine this advanced input modeling method with queueing theory for investigating the impacts of dependent interarrival and service times on the average waiting time.