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ALM: A Chronicle of Models and Modeling Choices

Asset-liability management (ALM) refers to the buying and selling of securities (assets) to meet current and future payments (liabilities) under uncertainty associated usually, at least in the banking industry, with interest-rate movements. Over time, operations researchers have modeled the problem using linear programming (LP) in a variety of ways. In "LP Modeling for Asset-Liability Management: A Survey of Choices and Simplifications," M. S. Sodhi takes us from the early simple "static" models to later "dynamic" or stochastic programming models with recourse. He presents these models as different ways that modelers chose to simplify from a plethora of modeling choices. But, not all choices are consistent with one another or with finance theory. As researchers realized that dynamic models are difficult to solve, they simplified the models for reasons of tractability. This paper shows how many different LP models are simplifications of the same basic model.

Dynamic Resource Allocation in Stochastic Processing Networks

A stochastic processing network provides high-fidelity stochastic models for many complex systems like semiconductor wafer fabrication facilities. How to efficiently allocate resources is an important issue for a complex stochastic processing network. In "Maximum Pressure Policies in Stochastic Processing Networks," J. G. Dai and W. Lin propose a family of maximum pressure policies for dynamically allocating resources in a stochastic processing network. Maximum pressure policies achieve maximum throughput for a large class of stochastic processing networks including semiconductor wafer fabrication facilities, networks of data switches, and queueing networks with dynamic routing. Maximum pressure policies are also attractive in that their implementation does not use arrival information.

Routing Military Convoys

Present-day military engagements emphasize the need for the high mobility of land forces. Thus, routing convoys so that they reach their destinations in the shortest time is important. However, in conflict situations, convoys may not be allowed to stop nor to meet one another en route. In "Solving a Time-Space Network Formulation for the Convoy Movement Problem," P. Chardaire, G. P. McKeown, S. A. Verity-Harrison, and S. B. Richardson are motivated by such considerations to specify a new problem, the convoy movement problem (CMP). They develop an integer programming model for the CMP based on the concept of a time-space network and, by applying Lagrangian relaxation to this model, obtain results for a number of test problem instances, derived mainly from real-world problems. Their implementation is based on a synthesis of ideas from mathematical programming, artificial intelligence, and computing science and leads to results that demonstrate the effectiveness of their approach.

Hydroelectric Power and Dynamic Pricing

With the extensive restructuring of power systems throughout the world, the analysis of strategic behavior in electricity markets has become an active area of research. Typically, this behavior has been examined in static models assessing "one-shot" equilibrium in quantities, prices, or supply functions. Nonetheless, dynamic strategies arise when hydroelectric (hydro) power is a significant source of production. This situation is the focus of the paper "Dynamic Pricing and Learning in Electricity Markets" by A. Garcia, E. Campos-Nañez, and J. Reitzes. While the concept of "opportunity cost" under centralized minimum-cost dispatch has been well understood by decision makers in hydroelectric systems, the estimation of "opportunity cost" under bid-based market dispatch is still the subject of debate. In this paper, the authors show the role of "indifference" prices, i.e., prices that equate the gains from releasing or storing water—in determining the market equilibrium. Moreover, since most of the time market participants rely on heuristic procedures to estimate indifference prices and/or they encounter difficulties in making reasonable forecasts of other players' behavior, a learning algorithm is shown to filter out estimation errors and converge to an equilibrium in which players bid their indifference prices.

Designing Differentiated Services

In many modern service operations, in particular in the emerging realm of information services, provisioning of service must often meet certain quality-of-service (QoS) requirements, necessitating multiple service levels. This also serves to segment the market of potential users according to their willingness to pay for various QoS levels. One of the central problems that arises in this context is to price these services so as to extract maximal revenues,

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and to determine congestion notification mechanisms by which users are informed of potential delays and service degradation. In "Pricing and Design of Differentiated Services: Approximate Analysis and Structural Insights," C. Maglaras and A. Zeevi study a specific instance of this problem, restricting attention to two classes of service: a high quality grade "guaranteed" class; and a lower quality grade "best effort" class. The paper develops a hierarchical approach where one first solves a deterministic relaxation of the original problem, and subsequently determines the performance of this solution in the original stochastic system and refines it to account for stochastic fluctuations. It is shown that in large-scale systems, pricing rules derived from the deterministic analysis are "almost" optimal, and a real-time congestion notification mechanism results in increased revenues.

Chain Store Location Strategies in a Duopoly

Large retail chains use different location strategies to create favorable conditions for themselves in the market. Sometimes they behave aggressively, opening many stores in order to contain the competition. Some other times, however, they are more accommodating. Motivated by their observations of coffee-shop competition in Montreal, Canada, A. Dasci and G. Laporte develop a game-theoretic model in "A Continuous Model for Multistore Competitive Location" to uncover some of the reasons that lead to those diverse strategies. The premise of their model is that firms defer precise site selection decisions because the sites they select may be unavailable for a number of reasons. Instead, firms formulate less precise strategies at first, such as the approximate number and location of their stores. The authors show that competition under this premise is usually more relaxed, leading to higher profits and coexistence with a competitor. The paper provides managers with a viable approach to formulate their location strategies. It will, hopefully, also motivate researchers to explore new applications of this methodology.

Flexible and Fast Resource Management Using the Distributed Decision-Making Technology

Dispatch centers send off ambulances to emergency calls, computing environments allocate computation capacity to tasks, freight carriers dispatch trucks to serve loads. A common ingredient of all these dynamic resource management problems is a set of resources changing their status over time, as they are assigned to randomly arriving tasks using certain decision rules. In general, coming up with good decision rules can be computationally demanding, and these decision rules should be executed quickly when the response time is an issue. In "A Distributed Decision-Making Structure for Dynamic Resource Allocation Using Nonlinear Functional Approximations," H. Topaloglu and W. B. Powell propose a distributed resource management method that assigns the control of different resources to different decision agents. Their approach uses functional approximations to assess the impact of the decisions made by a certain agent on the other agents and thereby builds an interagent coordination mechanism. Using their distributed method, good decision rules can be found and executed very quickly, and each agent makes its decisions using only locally available information. This research will have immediate impact on the freight transportation industry, where the decision-making structure is characterized by multiple independent dispatchers responsible for the vehicle allocation decisions at different terminals.

Calibrating a Simulation

Monte Carlo simulation is widely used in the financial industry. Proper calibration of a simulation is of particular concern in finance, where simulation is often used to price one asset relative to the market prices of other assets. Assigning weights to simulated paths provides a mechanism for calibration. In "Large Sample Properties of Weighted Monte Carlo Estimators," P. Glasserman and B. Yu analyze what happens through such a calibration procedure as the number of simulated paths grow. They distinguish two cases depending on whether or not the simulated model is consistent with the prices to which it is calibrated. Their results show how the calibration strategy affects the value obtained through simulation.

Scheduling Two Hoists in No-Wait Electroplating Lines

The problem of scheduling material-handling hoists in electroplating lines for cyclic production is practically important. Once a feasible schedule is obtained, it can be easily coded into the programmable logic controller to control the line operation. However, the problem is difficult to solve optimally. The general problem is NP-hard even for the single-hoist case, and most previous studies are on the single-hoist problems. Problems with more than one hoist involve further difficulties because the hoists are restricted on the same track and cannot cross each other. In "An Efficient Optimal Solution to the Two-Hoist No-Wait Cyclic Scheduling Problem," J. Liu and Y. Jiang study the two-hoist problem in no-wait lines where the processing time requirements are extremely rigid. They show that this version of the problem is solvable by giving a polynomial optimal algorithm based on analysis of the problem structure.

Using Outsourcing to Hedge Against Limited In-House Capacity

Manufacturing firms are confined in capacity by design. Their capacity levels also vary unpredictably in time due to machine breakdowns, material shortages, and other causes.

To deal with this along with uncertain demands, firms often resort to outsourcing to avoid exorbitant operational costs and penalties. In "A Production-Inventory System with Markovian Capacity and Outsourcing Option," J. Yang, X. Qi, and Y. Xia study the optimal production-outsourcing control policy for a firm facing Markovian capacity levels and random but time-independent demands. Through dynamic programming formulations, the authors find the optimal policy forms for various problem settings. They also derive many managerial insights and guidelines for the problem from computational studies.

Systems for Reverse Logistics

Managers and scholars have begun the important but challenging task of extending logistics systems to encompass return flows. This concern with reverse logistics is driven partly by environmental issues but also by economics—a return option provides real value to customers, and the recovered products provide real value to the firm. In "A Series System with Returns: Stationary Analysis," G. DeCroix, J. Song, and P. Zipkin explore the implications for inventory management of returns in a serial system. It turns out that the form of the optimal policy is the same as in a system without returns. The methods needed to estimate the performance of such a policy and to determine a good one, however, are considerably more difficult in the returns case.

Optimal Routes Through Some Fixed Links and Vertices of a Mixed Graph

In some real problems, vehicles should visit some specified nodes and traverse some given links of a network consisting both of directed and undirected edges in such a way that the total traveling cost is minimum. The study of this problem and the design of an optimal method for its resolution is what A. Corberán, G. Mejía, and J. M. Sanchis propose in "New Results on the Mixed General Routing Problem." Besides its practical applications, this problem generalizes many of the most known arc routing problems, such as the Chinese and the rural postman problems, as well as other well-known node routing problems such as the graphical traveling salesman problem.

Comparisons of Yield-Rate Distributions

Effective yield management is crucial to the financial success of manufacturers, particularly in industries such as semiconductor manufacturing. Yield management activities include efforts to alter the distribution of the yield through product- or process-improvement initiatives. It is, therefore, important to ask: What are the desirable properties of a yield distribution, and is "higher yield" always better? In "Stochastic Comparisons in Production Yield Management," D. Gupta and W. L. Cooper address these questions. They demonstrate that some apparent improvements in the yield distribution can, in fact, reduce expected net profit, even when lot sizes are chosen optimally. Using the theory of stochastic orders, they subsequently describe methods that allow a manufacturer to identify when one yield distribution leads to higher expected net profit than another, without actually having to compute optimal lot sizes or optimal expected profits. Their results help formalize the notion that less-variable yield is better. They also provide easily verifiable conditions under which a stochastically larger yield is better.