Operations Research

In This Issue

To cite this article:
(2004) In This Issue. Operations Research 52(6):ii-v. https://doi.org/10.1287/opre.1040.0160

Operations Research
Vol. 52, No. 6, November–December 2004, pp. ii–v
ISSN 0030-364X | EISSN 1526-5463 | 04 | 5206 | 00ii

DOI 10.1287/opre.1040.0160

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Distribution Management in the Retail Industry

Traditionally, retailing firms take a hierarchical approach to distribution management, first setting delivery schedules for stores, and then planning inventory, vehicle routes, and warehouse logistics subject to these schedules. Such an approach can produce a worse solution than if delivery schedules and routes were determined jointly. The quality of the solution to this problem can have substantial impact on the bottom line of the firm because it affects not only transportation costs but also inventory costs, labor costs, and warehousing and distribution capacity requirements. In "A Periodic Inventory Routing Problem at a Supermarket Chain," V. Gaur and M. L. Fisher describe a system to solve this problem at a supermarket chain. The system jointly determines delivery times, vehicle routes, and truck schedules to replenish stores from a central warehouse subject to constraints on fleet size, delivery time windows, delivery frequency, warehouse capacity, traffic jam delays, and several other parameters. The system not only yielded cost savings, but also provides strategic and tactical benefits to the firm, such as in measuring the cost impact of supply chain decisions. It has been rolled out in the supermarket chain serving thousands of stores from several warehouses and suppliers.

Analysis Procedures for Multiple Uncertain Targets

Consider a firm trying to develop a product that outperforms its competitors on quality, cost, convenience, and other dimensions. Hence competitive performance on these dimensions serves as the firm's targets. But since competitors will be simultaneously improving their products, these targets will be uncertain. Hence the firm is confronted with multiple uncertain targets. This formulation, with multiple uncertain targets, also describes many other resource allocation decisions. (In theory, all decisions could be modeled in this way.) In "Multiattribute Preference Analysis with Performance Targets," R. F. Bordley and C. W. Kirkwood develop new approaches to analyzing such decisions. The authors develop analysis procedures based on utility theory that can simplify the analysis relative to traditional methods. They show that, in some situations, this analysis is isomorphic to a reliability theory analysis. They also show that their approach is a generalization of common forms of goal programming.

Scheduling Flexible Servers with Overlapping Skills: Optimality and Robustness in Heavy Traffic

Problems of matching multiskilled servers with multitype customers are prevalent in computer, communication, manufacturing, and service systems. Such problems are acknowledged as difficult, and their importance is amplified in heavily loaded systems. In "Scheduling Flexible Servers with Convex Delay Costs: Heavy-Traffic Optimality of the Generalized $c\mu$-Rule," A. Mandelbaum and A. L. Stolyar show that, if there is sufficient overlap in servers skills, this problem still has a surprisingly simple robust solution. Specifically, each server operates autonomously and serves its constituency by myopically trying to maximize, at all times, the rate of decrease of the instantaneous delay costs (independently of any customer arrival characteristics.) The proof that such a rule is (asymptotically) optimal in heavy traffic is based on its fluid and diffusion approximations: it is shown that the system "self-organizes" so that both workload and cost-rates are simultaneously minimized.

Options on the Average Price

Asian-style options are an important family of financial contracts actively traded over-the-counter in currency, equity, interest rate, commodity, energy, and insurance markets. In contrast with standard option contracts that deliver payoffs based on the price of the underlying asset at one point in time, Asian-style or average price options deliver payoffs based on the average underlying price over a prespecified time period. Accurate pricing of Asian options is an important practical problem in financial engineering. This problem raises several interesting methodological issues related to the fact that these options are path dependent. In "Spectral Expansions for Asian (Average Price) Options," V. Linetsky applies spectral theory of diffusion processes to this problem and derives two new analytical formulas for the value of the Asian option when the underlying asset price follows geometric Brownian motion. The two formulas allow accurate computation of Asian option prices. In addition to financial engineering applications, this paper will be of interest to researchers applying diffusion processes in other areas, such as heavy traffic limits.

A General Equilibrium Model for Industries with Price and Service Competition

Blockbuster revolutionizes the video rental industry with a novel revenue sharing scheme to enable significantly larger inventory fill rates. It proceeds to advertise these in its advertising campaigns under the slogan "Go home happy" and backs up its availability promises with a free rental guarantee under the heading "I'll be there." Domino's has offered a 30-minute delivery guarantee. In many B2B settings, vendors routinely specify delivery windows, backed up with charge-backs, in case these service targets are violated. These examples illustrate how, in more and more industries, companies differentiate themselves on the basis of inventory service level guarantees along with standard competitive instruments such as prices. In "A General Equilibrium Model for Industries with Price and Service Competition," F. Bernstein and A. Federgruen characterize the equilibrium behavior of infinite horizon models for oligopolies in which the firms face this type of generalized competition, under demand processes whose distributions depend on all firms' prices and all firms' service levels. The authors compare the equilibria that arise when service levels and prices are chosen sequentially with those under simultaneous selections.

Optimal Inventory and Pricing Strategies with Random Demand and Fixed Ordering Cost

In recent years, scores of retail and manufacturing companies have started exploring innovative pricing strategies in an effort to improve their operations and ultimately the bottom line. Firms are employing methods such as dynamically adjusting price over time based on inventory levels or production schedules as well as segmenting customers based on their sensitivity to price and lead time. In "Coordinating Inventory Control and Pricing Strategies with Random Demand and Fixed Ordering Cost: The Finite Horizon Case," X. Chen and D. Simchi-Levi characterize the optimal inventory and pricing strategies in situations in which ordering costs exhibit economies of scale; an open problem raised more than three decades ago. The paper shows that when demand is additive, traditional inventory control policies are still optimal. On the other hand, for general demand function, e.g., multiplicative demand, the paper demonstrates that traditional inventory policies may fail to be optimal and characterizes the structure of the optimal policy.

Zone Tariffs: A Fair and Simple Way to Pay for Public Transportation

In many parts of the world, efforts are made to improve quality and user friendliness of public transportation systems while maintaining their economic efficiency. One of the means to achieve this goal is the introduction of tariff systems that are simple to understand and considered to be fair from the points of view of a customer and a public transportation company. In "Design of Zone Tariff Systems in Public Transportation," H. W. Hamacher and A. Schöbel investigate such a system. Three different models are proposed to measure the fairness of zone tariffs compared with classical distance-oriented tariffs (or other reference systems). Closed-form solutions are derived to determine for each of these objectives an optimal solution with respect to given zones. For the zone design problem, which is shown to be NP-hard, various heuristics are developed. The approach has been successfully applied to transportation systems involving several different transportation companies. The paper includes a case study reporting on the outcome of a tariff redesign based on the methods of the authors.

Supply Chain Stability

Supply chain managers and academicians have long known that production is more variable than demand, and that the variability of the order stream in a decentralized supply chain is greater for suppliers far removed from the final customer than for those nearby. This phenomenon is called the bullwhip effect. It is so prevalent in practice that an unstructured "beer game" is used in classrooms to illustrate it. In "On the Stability of Supply Chains," C. F. Daganzo explains this ubiquity. It first shows that the ratio of the maximum order size placed to the maximum order size received by a supplier is either amplified or damped by a policy independently of the customer demand. Amplifying policies suffer the bullwhip effect for all demand processes while damping policies never do. The paper also shows that policies that increase inventories during extended periods of high demand are amplifying if they do not use future order commitments. This explains the prevalence of the bullwhip effect—since it is always in the economic interest of suppliers to operate with higher inventories when the demand is high. The paper also introduces a commitment-based family of efficient damping policies and other ideas that can lead to improved business contracts.

What Erlang Left for Us to Think About

Thanks to Agner Krarup Erlang, we have long known how to analyze the multiserver queue with finite waiting room when the arrival process is Poisson and the service-time distribution is exponential, i.e., the $M/M/s/n/m$ model. However, the multiserver queue is notoriously difficult to analyze when these probabilistic assumptions are dropped. Since telephone call centers and other multiserver-queue applications often exhibit nonexponential service times, there is interest in developing approximations to describe the performance with other probabilistic assumptions. In "A Diffusion Approximation for the $G/GI/n/m$ Queue," W. Whitt attacks this problem.

Solving Large-Scale Concave Minimization Problems with Special Features

In many practical optimization problems a linear mathematical model provides a good approximation, e.g., for the transportation problem. However, when, for instance, economies of scale have to be taken explicitly into consideration, the linear transportation problem becomes a concave minimization problem, a special type of global optimization problem. In general, only small concave minimization problems with up to 10 to 20 variables can be solved in a reasonable amount of time. However, sometimes it is possible to exploit special structures or features of the problem. In "Cutting Planes for Low-Rank-Like Concave Minimization Problems," M. Porembski considers concave minimization problems where only a small number of variables, termed high impact variables, is responsible for the largest part of the objective value of a global optimal solution. By exploiting this he solves test problems with up to 110 variables with a pure cutting plane algorithm.

The Firm's Resource Investment Decision When the Firm Has Pricing Power

The ability to effectively match supply and demand greatly affects a firm's profitability. The amount of production capacity a firm invests in plays an important role in matching supply and demand. However, firms typically need to make these investment decisions long before production starts, when demand forecasts are highly uncertain. Investing in flexible resources, which are able to produce more than one product, can be an attractive strategy to hedge against demand uncertainty. Unfortunately, flexible resources have a higher investment cost than dedicated resources. Pricing is another strategy a firm can use to match supply and demand. When both pricing and flexible production resources are an option, practitioners need to understand how they affect the firm's optimal resource investment decision. In their paper, "Optimal Investment Strategies for Flexible Resources, Considering Pricing and Correlated Demands," E. K. Bish and Q. Wang address this issue. This paper provides practitioners with insights and principles on the firm's resource investment decision.

Optimal Scheduling for PCB Manufacturing

Price competition is keen in electronics manufacturing; therefore, improving throughput and reducing production costs are key strategies for survival for printed-circuit-board (PCB) manufacturers. In PCB production, panels are immersed in a sequence of processing tanks. Typical production lines have dozens of processing tanks and several material-handling hoists, and finding a schedule that avoids collision of the hoists and meets the processing requirements of the panels is not easy. By optimizing the schedule of the hoists, the production cycle can be minimized and hence the throughput can be maximized. In "Optimal Cyclic Multi-Hoist Scheduling: A Mixed Integer Programming Approach," J. M. Y. Leung, G. Zhang, X. Yang, R. Mak, and K. Lam present the first mixed integer programming formulation of the scheduling problem for multiple hoists. In the current competitive environment, PCB production has to react to fluctuating demand patterns, small lot-sizes, and changing varieties. The hoist schedule has to be rearranged frequently; thus, a tractable model to handle this situation is badly needed. The automation of the generation of optimal hoist schedules will greatly improve the efficiency and cost-effectiveness for production planning.

The Benefits of Stochastic Information for Improving Customer Service in Online Vehicle Routing

Most optimization models deployed in practice are deterministic, although their input data is, in general, subject to considerable uncertainties. However, historic data and/or stochastic models are often available to predict the future. In their paper, "Scenario-Based Planning for Partially Dynamic Vehicle Routing with Stochastic Customers," R. W. Bent and P. Van Hentenryck explore how stochastic information can be exploited to improve customer service in stochastic dynamic/online vehicle routing. They propose a multiple scenario approach that maintains multiple routing plans to accommodate more customer requests. These routing plans are generated using both known and future requests by continuously sampling the stochastic model. In addition, a consensus table is used to select a distinguished plan most similar to other plans in order to keep a diversified set of routing plans. Their experimental results show significant improvements in serving customer requests compared to earlier approaches on problems motivated by online courier and taxi services among others.

Dell's "Intelligent Fulfillment" Strategy and Inventory Control

Capital investments in information technology have provided production and inventory managers with more timely and better quality data than ever before. Dell's recent online initiative, "Intelligent Fulfillment," is one of many strategies to obtain advance demand information. Dell allows for four different levels of response time to customers: Standard (conventional: five-day promised order lead time), Value Delivery (slower: lower shipping cost), Premium Delivery (faster: next-day delivery) and Precision Delivery (specific date). A portfolio of Dell customers with different required response times gives Dell what the authors refer to as advance demand information. There is a growing consensus that this information can enable better capacity utilization, in particular for seasonal/cyclic demand environments. In "Inventory Control with Limited Capacity and Advance Demand Information," Ö. Özer and W. Wei show how best to use advance demand information for a periodic-review, capacitated, nonstationary stochastic production system. They establish optimal production policies and characterize their behavior. A numerical study and structural results provide insight into the joint role and value of advance demand information and additional capacity.

Optimal Policy for Full-Capacity Orders

While the uncapacitated single-item, periodic-review inventory control problem with fixed plus linear ordering costs was solved in the seminal paper of Scarf (1960), the capacitated version has not been fully characterized to date. In "All-or-Nothing Ordering Under a Capacity Constraint," G. Gallego and L. B. Toktay consider a special case of the capacitated problem where all orders are full-capacity orders. They prove that, for a class that includes convex cost-to-go functions, the optimal policy is a threshold policy with respect to the inventory position and that the results extend to the case of forecast updates.