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Knowledge and Economic Development

The theme of the October 1990 ORSA/TIMS meeting was "Productivity and Global Competition." An address that Richard M. Cyert gave there, and which appears in the OR Forum, pursues this theme by emphasizing the importance of knowledge in contrast to natural resources as the critical ingredient in economic development in the future, and stresses the rapidity with which knowledge is transferred across national boundaries and the impossibility of restraining it. Cyert forecasts that the competition among nations will lead to a situation in which no nation dominates international trade the way the United States did from the end of World War II until the early 1970s. Rather, the leadership will change in a pattern in which one nation innovates and others begin to follow and erode the innovation. Thus, in the long run the critical ingredient will be the proportion of the GNP that a nation is willing to devote to research.

Contributions of Stella Dafermos

Equilibrium arises as a central concept in many diverse applications, such as user-optimized traffic networks, multicommodity trade, and oligopolistic markets. In "Equilibrium Modeling, Analysis, and Computation: The Contributions of Stella Dafermos," Anna Nagurney provides an intellectual history of one of the first female doctorates in operations research in the United States, highlighting her role in the development of methodologies, including variational inequalities, for the study of equilibrium systems.

Managing National Forests

The USDA Forest Service is responsible for the management of 123 national forests, which comprise approximately 191 million acres of land. Several laws have been passed, notably the National Forest Management Act of 1976, which requires that each forest develop a multiresource-based land management plan every 10 years. These plans must comply with regulations that require considerable analysis to address a number of matters, including economic efficiency and the scheduling of timber harvests for up to 150 years. In 1979, the agency decided that the linear programming system FORPLAN would be the central analysis tool for planning. In "National Resource Land Management Planning Using Large-Scale Linear Programs" Brian Kent, B. Bruce, Bare, Richard Field and Gordon Bradley describe the use of this system from 1980–1988. FORPLAN was used to develop management plans for all but two national forests; its use influenced many decisions on how to manage the forests, including those where today's controversial issues are being debated.

Offshore Lease Bidding at Gulf Oil

During the late 1970s and early 1980s when oil prices were high (as they are again), major oil companies spent hundreds of millions of dollars a year on leases for the right to drill offshore. Competition for leases was intense, the geologic and economic uncertainties were enormous, and decisions were made subject to the constraints on available capital. In "Development and Use of a Modeling System to Aid a Major Oil Company in Allocating Bidding Capital," Don Keefer, Beckley Smith and Harry Back describe a long-term effort to help Gulf Oil Corporation's management allocate bidding capital at lease sales. In addition to developing the "Strategy System," which synthesized techniques from decision analysis, statistics, and nonlinear optimization, the authors had to convince executives that analytical input could be useful. Eventually, the Strategy System became a routine part of bid preparation during a period in which Gulf's bids exceeded $1.5 billion.

The Line Segmentation Problem

Many U.S. manufacturers who have adopted just-in-time (JIT) systems report significant improvement in productivity, lead-time, and quality. Kanban systems control the flow of materials to achieve JIT operations. In printed circuit board assembly, boards go through dozens of production stages, each consisting of multiple machines. When three to six product families are produced per week, minilines are formed. Each miniline is dedicated to a product family and a kanban system is used within each line. In "The Line Segmentation Problem," Reza Ahmadi and Hirofumi Matsuo formalize the problem and develop an efficient algorithm to segment the production facility and to form minilines by assigning machines to each line. The objective is to achieve the highest productivity while maintaining a weekly product mix ratio.

Coordinating Production of Products

Scheduling products on shared production facilities is a classic problem of operations management and industrial

engineering. The Economic Lot Scheduling Problem (ELSP) is a model that focuses on certain key issues, specifically, the tradeoff between setups and inventories. While the ELSP has been studied by researchers for decades, it is only recently that simple, robust heuristic methods have been developed. Paul Zipkin's paper, "Computing Optimal Lot Sizes in the ELSP," shows how to streamline central parts of the calculation in this overall approach.

Scheduling in the Real World

Weighted tardiness most accurately models concerns that drive real-world scheduling decisions, even though it is a difficult measure to deal with computationally and theoretically. The authors observed manufacturing systems in which simple, earliest-due-date (EDD) schedules were used to minimize weighted tardiness with excellent results. This contrasts strongly with tests in which EDD schedules perform poorly. In "Weighted-Tardiness Scheduling On Parallel Machines With Proportional Weights" Esther Arkin and Robin Roundy analyze EDD schedules for single and parallel machines. They conclude that EDD schedules perform well in either of two situations. If the weights of the jobs are approximately proportional to their processing times, the schedules work extremely well. This would be the case if the weights and the processing times of the jobs were approximately proportional to the dollar value of the goods being produced.

Railroad Productivity and Quality

Railroads in North America face increasing pressure from other modes of freight transportation, and the changing inventory policies of manufacturers to improve the quality of their service (on-time reliability) and reduce costs. At the heart of a railroad lies the dispatcher —the front line of the management of quality and productivity. Recent developments in satellite-tracking technology provide an opportunity to greatly enhance the tools available to the dispatcher to perform the job efficiently and effectively. In "Optimal Pacing of Trains in Freight Railroads," D. Kraay, P. Harker and B. Chen describe a new optimization approach for real-time dispatching of a rail line which treats the costs and the need for on-time arrivals. Preliminary results suggest that significant gains may be achieved on both dimensions.

Transportation Network Reliability

In a single commodity transportation network the nodes randomly become demand and supply nodes due to random variations of local demand values and random failure of some capacities. The transportation problem, which is supposed to tell us how the supply nodes assist the demand nodes to meet total system demand, may not be solvable because either the total supply is not enough, or it is enough but the system is not capable of a feasible transmission. In "On the Existence of a Feasible Flow in a Stochastic Transportation Network" E. Boros and A. Prékopa offer a new and powerful method to characterize the existence of a feasible flow in terms of a relatively few algebraic inequalities, and to compute efficient lower and upper bounds. The algorithms are simple, and, in many cases, good approximations may be obtained for system reliability. The results can be applied when designing hydrological and power networks.

Finite Dominating Sets

A class project in which a student wanted to know how to locate a toilet on a beach led to Eric Chen's dissertation on locating obnoxious facilities. For some problems, he could describe in advance a small set of locations, called a "finite dominating set," within which optimal locations must lie. Identifying such sets is an old theme of network location theory because it is easier to find optimal locations within a small set of candidates. A few years later, John Hooker's dissertation on facility location led him, Chen, and Robert Garfinkel to realize that strategies used to derive some of these sets could be generalized to subsume most results as special cases. In the absence of general results, a finite dominating set is often hard to find and verify. It may therefore be worth checking whether this paper, "Finite Dominating Sets for Network Location Problems," implies its existence.

Structured Partitioning Problems

In many combinatorial optimization problems (e.g., bin packing, allocating customers to queueing facilities, vehicle routing, multi-item inventory replenishment and routing/inventory control), an optimal partition into groups of limited capacity needs to be determined for a finite collection of objects, each of which is characterized by a single attribute. The cost is often separable in groups and the group cost may depend on the cardinality and some aggregate measure of the attributes, such as the sum or the maximum element. In "Structured Partitioning Problems," Shoshana Anily and Awi Federgruen identify easily verifiable, analytical properties of the group cost function under which an optimal partition may be computed with increasingly simple solution methods. They also discuss various applications.

Three-Index Assignment Problems

Three-index assignment generalizes the well known assignment problem to cover cases where three sets of resources must be optimally matched, such as: baseball players, fielding and batting positions; capital invest-

ments, locations and time periods; teachers, courses and classrooms; or ingots, soaking pits and time slots. In "An Algorithm for the Three-Index Assignment Problem," Egon Balas and Matthew Saltzman apply a range of algorithmic techniques to solve instances with more than 17,500 variables. Primal constructive and local search heuristics provide an ingredient that is of interest, as it can find near-optimal solutions to larger problems in a shorter time. Facet defining inequalities provide improved lower bounds. Lagrangian relaxations are compared, and the one chosen is solved repeatedly by dual ascent and periodically by subgradient optimization. A new branching strategy is introduced that results in a smaller search tree.

Problems With Incomplete Information

Decision makers must sometimes make decisions with incomplete information, knowing that they will learn more as time passes: a physician may prescribe treatment with incomplete information about the patient's condition, and based on patient response update the assessments and prescriptions; a fisheries manager may implement a harvesting policy knowing that actual harvesting levels will supply additional information about the true health of the fish stock; an inventory manager must often proceed with stocking decisions before the true demand distribution is known, but knowing that information about customer response will accrue as actual demand is observed. These situations of simultaneous estimation and control, are known as partially observed systems. These processes have been notoriously difficult to solve owing to their size and complexity. In "Computationally Feasible Bounds for Partially Observed Markov Decision Processes," William Lovejoy develops an algorithm to provide tractable policies for this class of problems, and provides bounds, relative to optimal cost, on the value of these policies. This algorithm allows for the solution of problems that have been unsolvable by any means.