RESEARCH
Inside IIE Journals

This month we highlight a pair of articles related to manufacturing and supply chain planning. The first article develops an effective approach for sequencing jobs on a closed-loop paint line where cyclical part geometry and consecutive unit color changes initiate setups. The second article examines the impact of information differences between retailers and suppliers when setting supply contracts and asks the question whether more accurate demand information is always better. These articles will appear in the August 2015 issue of *IIE Transactions* (Volume 47, No. 8).

Caught between two types of setups?

Scheduling problems with setups are common in manufacturing, where the sequence of jobs determines the number of setups required. Since setups require time and cost, it is imperative to create a production schedule that minimizes setups.

In "Modeling and Solving a Closed-Loop Scheduling Problem with Two Types of Setups," professors Subhamoy Ganguly from the Indian Institute of Management Udaipur and Manuel Laguna from the University of Colorado Boulder analyze and solve a closed-loop scheduling problem that involves two types of setups.

The scheduling problem, observed at a group facility for auto parts, involves painting parts of different geometries (shapes) and colors on a closed-loop paint line. The paint line at the SMR automotive parts manufacturing company contains a fixed number of positions (slots) for the parts on a moving train. Parts move past a stationary paint sprayer, and if two consecutive parts are to be painted in different colors, a setup is required at the paint sprayer.

A jig is placed in each position on the moving train in order to hang the parts to be painted. Each part geometry requires a different jig, but the same jig can be used to paint parts in different colors. When an unpainted part replaces a painted part in the same position, a setup is required if the two parts are of different geometries.

While color setups can be minimized by batch scheduling of parts of the same color, jig setups can be minimized by cyclic scheduling of parts of the same geometry. Thus, creating a sequence of parts such that it minimizes total setup costs is a combinatorial optimization problem that becomes mathematically intractable for large problem instances, as evident by the poor performance of integer program formulations. The authors propose two alternate metaheuristic approaches to solve this problem: one using an adaptation of commercial software (OptQuest) and another specialized variable-neighborhood-search (VNS) procedure tailor-made for this problem.

Adaptation of the commercial software requires less time and effort and can be useful for small- to medium-size problems. The specialized procedure, on the other hand, exploits the structure of the problem and performs better, particularly for very large instances. The research will be helpful for minimizing setup costs when scheduling jobs that involve these two types of setups.

Manuel Laguna co-authored "Modeling and Solving a Closed-Loop Scheduling Problem with Two Types of Setups."

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Information is a double-edged sword

Supply chain contracts are an integral part of managing modern supply chains. While contracts may cover many factors, such as delivery times, quality and purchase quantities, price is typically a primary factor. For example, a retailer (e.g., Target) might enter into a fixed-price contract with a supplier (e.g., Samsung), where the contract stipulates that each unit (e.g., a TV) that is purchased costs a fixed price.

Typically, the retailer faces uncertain customer demand and necessarily must

Professor Michael R. Wagner, shown here with executive MBA students in the Foster School of Business, said discussions with students triggered his research paper into supply chain contracts.

Dr. Stephen Traub (left), chairman of emergency medicine at Mayo Clinic Arizona, and professor Soroush Saghafian of Arizona State University collaborated to tackle emergency department issues using operations research and operations management.

create a forecast. In an educational setting, the focus is usually on the idealized case of perfect information, in that a retailer and supplier both have the same information about future customer demand (i.e., the forecast).

Of course this is not always the case in practice, where there is an informational asymmetry between the firms. What is the impact of this asymmetry?

This problem is studied in "Robust Purchasing and Information Asymmetry in Supply Chains with a Price-Only Contract" by professor Michael R. Wagner from the University of Washington Michael G. Foster School of Business. Wagner applies techniques from robust optimization to study this problem. This paper originally was motivated by discussions with students in executive MBA programs.

The findings are counterintuitive: While in many cases an informational advantage does indeed lead to a performance advantage, sometimes having more information can be detrimental. For example, if a retailer has a detailed high-quality forecast of demand, but a supplier has only a rough estimate of demand, the supplier might act unexpectedly, and the retailer's informational advantage might actually hurt its bottom line, as compared to the case where the supplier had the same information.

It is helpful to think about the interaction between the two businesses as a dance – if one partner is skilled but the other is not, then the overall performance can be quite poor. This paper identifies the business environments where a company, either the supplier or retailer, is motivated to hide, share or seek information from the partnering company in the supply chain.

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The most recent issue of *IIE Transactions on Healthcare Systems Engineering* (Volume 5, Issue 2) contains four articles covering a range of healthcare system problems and solution methods. The two articles summarized below involved collaborative efforts between university personnel and healthcare professionals. The first article reviews the literature that focuses on how operations research and operations management techniques can improve patient flow in emergency rooms. The second discusses using optimization techniques to develop joint drug and radiation administration (chemoradiotherapy) schedules with the goal of enhancing primary tumor control.

Operations research/management: The prescription for emergency departments?

Rising healthcare expenditures accentuate the importance of improving the efficiency of healthcare delivery methods. Hospital emergency departments are a vital part of healthcare delivery systems, one where innovative changes can have significant effects. This is in part because emergency departments are the first point of contact for nearly half of all hospital admissions.

Unfortunately, various studies, including one conducted by the U.S. Government Accountability Office and reported to the U.S. Senate, show crowding continues to plague many emergency departments, and some patients wait longer than recommended time frames. Such reports highlight the unquestionable need to improve both operational efficiency and patient safety in emergency departments. What can operations research and operations management do to address this vital need?

In "Operations Research/Management Contributions to Emergency Department Patient Flow Optimization: Review and Research Prospects," professor Soroush Saghafian of Arizona State University and the Mayo Clinic College of Medicine (currently in transfer to Harvard University), his undergraduate student Garrett Austin and Dr. Stephen Traub of the Mayo Clinic Arizona tackled that question.

The authors reviewed more than 300

papers, demonstrated the contributions of operations research and operations management in patient flow optimization and highlighted opportunities and challenges for future researchers to explore. By considering three components of patient flow (flow into, within and out of the emergency department), their work assists both researchers and practitioners to understand the operations research and operations management techniques that can have significant impact in improving patient flow.

While focusing mainly on patient flow in emergency departments, their work also addresses operations research and operations management techniques simulation, Markov models and game theory that can be used for patient flow optimization beyond the emergency department, such as mathematical programming, queuing theory, simulation, Markov models and game theory. Their work is partially supported by a grant from Mayo Clinic, for which Saghafian serves as a principal investigator.

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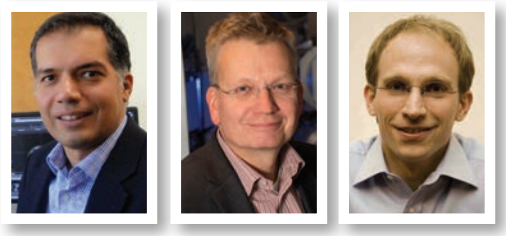
Combining chemotherapy with radiotherapy for the best results



Ehsan Salari (from left), Thomas Bortfeld and Jan Unkelbach developed a mathematical approach to optimize the combination of chemotherapy and radiotherapy in cancer treatment.

The American Cancer Society estimates that in 2015, more than 1.6 million new cancer cases will be diagnosed in the United States. Cancer patients are treated using one or a combination of therapies, including surgery, radiotherapy, chemotherapy, hormone therapy, immune therapy and targeted therapy. The therapies chosen depend on the type and extent of the disease.

For many advanced-stage inoperable cancers, radiotherapy is combined with chemotherapy, so-called chemoradiotherapy, to eradicate the tumor. It has been shown clinically that combining the two therapies leads to better tumor control. The therapy is attributed mainly to the cooperation between the radiation and chemotherapeutic drugs. In addition to independent cell kill, some chemotherapeutic drugs have radio-sensitization properties that make cells more susceptible to radiation damage. This property is leveraged in chemoradiotherapy to enhance radiation cell kill in the tumor.

However, radio-sensitization also may occur in neighboring healthy tissues, which can lead to additional harm to those tissues. Therefore, chemoradiotherapy treatments should be planned carefully to ensure that the enhanced tumor cell kill due to radio-sensitization outweighs the increased harm to the normal tissue.

In "A Mathematical Programming Approach to the Fractionation Problem in Chemoradiotherapy," Ehsan Salari of Wichita State University and Jan Unkelbach and Thomas Bortfeld of Massachusetts General Hospital and Harvard Medical School developed a mathematical framework to study how chemotherapy and radiotherapy should be combined in order to maximize the therapeutic gain for the patient. In particular, radiation treatment schemes currently used in chemoradiotherapy are uniform in the radiation dose administered per treatment session. However, the proposed framework reveals that when using potent radio-sensitizers that are toxic to normal tissue, nonuniform schemes might outperform uniform ones.

The work was motivated by prior studies on chemoradiotherapy suggesting that the radio-sensitization activity is time and dose dependent, which raises questions about what changes should be made to radiotherapy treatment plans when chemotherapeutic drugs are added.

The research can help clinicians design new promising treatment regimens for chemoradiotherapy to be tested in clinical trials and tailor the chemoradiotherapy to patient-specific requirements.

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