RESEARCH

Inside IISE Journals

This month we highlight two articles from *IISE Transactions*. The first article studies a problem of inventory and mobile capacity logistics planning under uncertain demands. The authors formulate a dynamic programming model for problem planning and provide a heuristic solution to address the curse of dimensionality issues and further make production and inventory decisions. A simulation study demonstrates great robustness and cost savings by using the developed method. The second article investigates how to effectively manage randomized clinical trials of new drugs or vaccines. The authors developed a capacity reservation planning methodology to manage patients' visits, shared resources required, timeliness and cost. This research is timely especially considering the COVID-19 pandemic and the urgent need for a vaccine. These articles will appear in the August 2020 issue of *IISE Transactions* (Volume 52, No. 8).

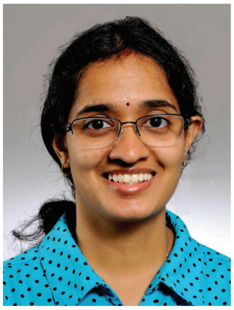
Managing transportable capacity logistics in tandem with multilocation inventory control

The manufacturing industry has welcomed the advent of on-demand mobility of production capacity. Bayer, a pharmaceutical and agricultural chemicals company, developed containerized production units operating intensified continuous batch processes for fertilizer production. Pfizer innovated miniaturized modular production technology for oral drugs and recently opened a flexible continuous manufacturing plant. E-commerce giant Amazon patented a make-to-order mobile additive manufacturing service in 2018.

The mobility of production capacity offers leverage to firms through smaller capacity investments due to capacity sharing via relocation; faster response to demand for perishable products; the capability of new market reconnaissance with recoverable, relocatable assets; and an alternate strategy to handle spatial demand variation.

Satya S. Malladi, who received her doctorate in May 2018, and professors Alan Erera and Chip White from Georgia Tech consider a problem of inventory and mobile capacity logistics planning under uncertain demands in their paper, "A Dynamic Mobile Production Capacity and Inventory Control Problem." In such systems, production modules provide capacity and can be moved from one location to another to produce stock and satisfy demand. The authors formulate a dynamic programming model for a planning problem that considers production and inventory decisions.

The problem suffers from the curse of dimensionality that prevents determining exact solutions at realistic problem sizes. The authors tackle this challenge by developing heuristic look-ahead and rollout policies that use value function approximations based on location-wise decomposition. Several single-period optimization problems that define these policies and generalize a formulation for the single-period news-vendor problem are presented, and in some cases the feasible region polyhedra contain only integer extreme points allowing efficient solution computation.



Satya S. Malladi

A computational study with stationary demand distributions provides an analysis of the effectiveness of these policies and the value that mobile production capacity provides. For problems with 20 production locations, the best suboptimal policies produce an average savings of 13% over fixed capacity allocation policies when the costs of module movement, holding and backordering are accounted for. Greater savings result when the number of locations is increased.

Additionally, production systems with mobile capacity perform significantly more robustly under poorly chosen initial capacity allocations compared to production systems with in-the-ground capacity.

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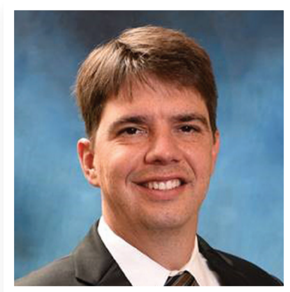
The trials of the operations that conduct clinical trials

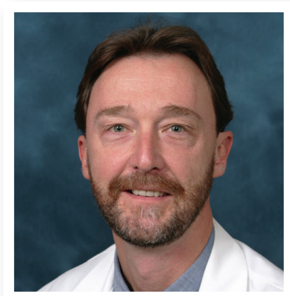
The world has struggled with the COVID-19 pandemic and eagerly awaits a vaccine treatment demonstrated to be safe and effective. Normally, this is accomplished through a randomized clinical trial. The operations that conduct trials are often

Jivan Deglise-Hawkinson



David L. Kaufman

Mark Van Oyen



Blake Roessler

found at academic medical centers, and they are highly complex.

Jivan Deglise-Hawkinson and professors David L. Kaufman, Mark Van Oyen and Blake Roessler, M.D., all affiliated with the University of Michigan, developed an optimization methodology and report on a case study driven by their experience with the Michigan Clinical Research Unit in "Access Planning and Resource Coordination for Clinical Research Operations."

Clinical trials must deal with the uncertain arrivals of people willing to participate. Every trial has a unique protocol for treatments that may require multiple visits spanning many weeks. Each visit may have a time window constraint necessary to accomplish the trial's objectives. Each visit of a protocol requires specific physical resources and particular skills and tasks from research nurses.

With many trials operating simultaneously on shared physical and human resources, sophisticated planning is required to avoid excessive overtime and long delays between the time a participant is enrolled and when visits can begin. To better serve the needs of patients and conclude trials more quickly, the authors developed a capacity reservation planning methodology that constrains the time from a participant's enrollment until the day of their first visit of the protocol. A key goal is to achieve these timely visits via a capacity reservation plan optimized to limit the overtime costs while simultaneously setting a daily nurse staffing plan.

Because of delay/wait time targets to begin visits and the shared resources required for visits, accepting all new trial requests will eventually deteriorate the cost and timeliness offered to the existing clinical trials that are active. The methodology supports the administrator in ensuring that newly arriving trial requests are only accepted if the resulting set of trials would not break the promises made to the existing trials concerning timely access for participants.

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This month we highlight an article from *The Engineering Economist* (Volume 65, No. 2). Motivated by the increases in coastal flooding due to climate change, it describes a game theoretic analysis of possible incentives by governments to encourage residents to proactively relocate to safer areas before floods cause major damage.

Theoretic model directs governments to encourage relocation from flood-prone areas

Many types of disasters such as earthquakes, floods and hurricanes can cause population displacement. However, coastal flooding is almost unique among these because it is possible to know with some certainty well in advance which cities are most likely to be affected. In addition, those areas may be affected permanently and the increase in flood frequencies due to sea-level rise can be estimated quantitatively. Thus, though the timing of floods is highly uncertain, knowledge of which cities are most likely to be affected can facilitate anticipatory relocation, avoiding the disruption and large losses that accompany a disaster.

In their article, "Game-Theoretic Modeling Of Pre-Disaster Relocation," Vicki M. Bier, Yuqun Zhou and Hongru Du formulate a game theoretic model predicated on the idea that governments typically have lower discount rates than most residents, care more about future flooding and thereby can "nudge" residents in high-hazard areas to relocate to safer areas in advance of severe flooding.

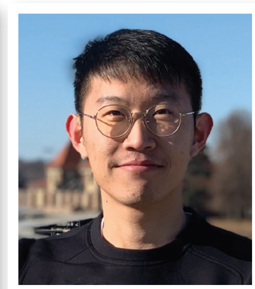
They analyze this situation as a two-player game in which the government moves first by announcing a subsidy or incentive to encourage relocation. Residents then respond by deciding whether and when to move. Under some circumstances, this can result in a "win-win" situation: Governments can reduce the burden of future disasters by encouraging residents to leave the most at-risk areas, while residents benefit by becoming less "myopic" and relocating before they experience extensive flood damage.

This work is a novel application of engineering economics to the study of climate change and demonstrates the feasibility of the proposed approach. Thus, it provides a conceptual foundation for future work in which the model could be quantified with more realistic parameter values.

Another important extension is to allow for resident heterogeneity since different residents in the same region will have different flooding risks and different discount rates. Nonetheless, the authors hope this work will encourage

Vicki M. Bier

Yuqun Zhou



Hongru Du

greater attention to proactive relocation as a strategy for managing sea-level rise.

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