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MSOM Society Student Paper Competition: Abstracts of 2013 Winners

The journal is pleased to publish the abstracts of the six finalists of the 2013 Manufacturing and Service Operations Management Society's student paper competition.

The 2013 prize committee was chaired by Felipe Caro (UCLA Anderson School of Management, University of California, Los Angeles), Guillaume Roels (UCLA Anderson School of Management, University of California, Los Angeles), and Gabriel Weintraub (Graduate School of Business, Columbia University). The other committee members were Philipp Afèche, Vishal Agrawal, Gad Allon, Aydın Alptekinoğlu, Atalay Atasu, Göker Aydın, Opher Baron, Achal Bassamboo, Damian Beil, Omar Besbes, Kostas Bimpikis, Robert Bray, René Caldentey, Carri Chan, Li Chen, Xin Chen, Ying-Ju Chen, Soo-Haeng Cho, Laurens Debo, Nicole DeHoratius, Sarang Deo, Lingxiu Dong, David Drake, Wedad Elmaghraby, Pnina Feldman, Qi Feng, Srinagesh Gavirneni, Karan Girotra, Ming Hu, Tim Huh, Dan Iancu, Foad Iravani, Srikanth Jagabathula, Ganesh Janakiraman, Diwas KC, Eda Kemahlıoğlu-Ziya, Saravanan Kesavan, Sang Kim, Mirko Kremer, Harish Krishnan, Mümin Kurtuluş, Guoming Lai, Jun Li, Ilan Lobel, Ruben Lobel, Elisa Long, Lauren Lu, Victor Martínez-de-Albéniz, Toni Moreno, Hamid Nazerzadeh, Rodney Parker, Ali Parlaktürk, Margaret Pierson, Ramandeep Randhawa, Paat Rusmevichientong, Soroush Saghafian, Denis Saure, Sergei Savin, Nicos Savva, Nicola Secomandi, Kevin Shang, Max Shen, Melvyn Sim, Amitabh Sinha, Larry Snyder, Greys Sošić, Brad Staats, Xuanming Su, Ravi Subramanian, Robert Swinney, Alireza Tahbaz-Salehi, Brian Tomlin, Senthil Veeraraghavan, Gustavo Vulcano, Wenqiang Xiao, Nan Yang, Fuqiang Zhang, Jiawei Zhang, Yao Zhao, Leon Zhu, and Serhan Ziya.

The 2013 prize winners are as follows:

Two First Prizes

Song-Hee (Hailey) Kim, Columbia University
"ICU Admission Control: An Empirical Study of Capacity Allocation and its Implication on Patient Outcomes"

Xuan Wang, New York University
"Process Flexibility: A Distribution-Free Bound on the Performance of k-Chain"

Finalists

Dragos Florin Ciocan, Massachusetts Institute of Technology
"Model Predictive Control for Dynamic Resource Allocation"

Nitish Jain, INSEAD
"Managing Global Sourcing: Inventory Performance"

Anyan Qi, University of Michigan
"Capacity Investment with Demand Learning"

John Yao, Columbia University
"Optimal Price and Delay Differentiation in Queueing Systems"

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ICU Admission Control: An Empirical Study of Capacity Allocation and its Implication on Patient Outcomes

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Advisors: Carri W. Chan, Columbia University; Marcelo Olivares, Columbia University and University of Chile

We examine admission control of the intensive care unit (ICU), which provides care for a hospital's most critically ill patients. We focus on how congestion can impact ICU admission decisions and ultimately patient outcomes. We build an econometric framework to explain how ICU admission decisions are made in practice, which captures key trade-offs in allocating beds to patients with heterogeneous medical needs and stochastic arrival patterns. In addition to describing the actual admission policy used by hospitals, this econometric model provides instrumental variables that can be used to identify the effect of endogenous ICU admission decisions on patient outcomes. We estimate these models using patient data from an integrated healthcare delivery system with nearly 200,000 hospitalizations. We show that busy ICUs are associated with lower chance of admission, which can further lead to significant health implications. In turn, providing ICU care can improve patient outcomes substantially. Using our empirical results, we study the performance of an admission policy that minimizes adverse outcomes based solely on objective metrics available to all patients admitted from the ED and compare it with the current policy used by hospitals in our study. Because the current policy also uses the discretion of physicians (which is not captured in the available objective metrics), we see that the policy based on objective criteria can sometimes underperform, but not always. Additionally, we find that slight adjustments to the current hospital's policy, which account for the dynamic nature of the admission control problem while still exploiting physician discretion in the admission decisions, can improve outcomes without increasing costs.

Process Flexibility: A Distribution-Free Bound on the Performance of k-Chain

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Advisor: Jiawei Zhang, New York University

Intense competition in today's consumer markets has been placing increasing pressure on manufacturers to produce customized products in a more responsive manner. In response, firms have employed an operations strategy known as process flexibility to better match supply with uncertain demand. An important flexibility concept is the long chain proposed by Jordan and Graves. The effectiveness of the long chain has been investigated via numerical as well as theoretical analysis for specific probability distributions of the random demand. However, it is not clear how sensitive the (relative) performance is to the choice of different demand distributions. In this paper, we subsume the full probability distribution of the random demand into its first and second moments and obtain in closed form a distribution-free lower bound on the ratio of the expected sale of the long chain relative to that of full flexibility. Our bound depends only on the mean and standard deviation of the random demand, but compares very well with the bound that uses complete information of the demand distribution. This suggests the robustness of the performance of the long chain under different distributions. We also prove a similar result for k-chain, a more general flexibility structure. Our bound on k-chain provides useful insights regarding, for example, the marginal benefits of the added flexibility under different degree of demand uncertainty, which can aid flexibility configuration planning decisions.

Model Predictive Control for Dynamic Resource Allocation

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Advisor: Vivek Farias, Massachusetts Institute of Technology

We develop a simple, easy to interpret model predictive control algorithm for a large class of dynamic allocation problems with unknown, volatile demand. Potential applications include online advertising problems of the ad display and first price or generalized second price AdWords variety, and network revenue management problems. The algorithm operates in an online fashion and relies on re-optimization and forecast updates. The algorithm is robust (as witnessed by uniform worst-case guarantees for arbitrarily volatile demand), and in the event that demand volatility (or equivalently deviations in realized demand from forecasts) is not large, the method is simultaneously optimal. Computational experiments, including experiments with data from real-world problem instances, demonstrate the practicality and value of the approach. From a theoretical perspective, we introduce a new device—a balancing

property—that allows us to understand the impact of changing bases in our scheme. Motivated by the huge problem instances that occur in applications such as online advertising, we also address the issue of computational efficiency of our algorithm, by exhibiting a first-order iterative scheme for solving massive allocation linear programs in a distributed fashion. Besides giving theoretical convergence guarantees, we demonstrate the practical performance of our solver by benchmarking it versus existing LP implementations—we find that it successfully solves large instances for which current state of the art LP solvers fail due to memory limitations, while matching their speed on smaller instances.

Managing Global Sourcing: Inventory Performance

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Advisors: Serguei Netessine, INSEAD; Karan Girotra, INSEAD

The use of global suppliers has increased considerably over the last three decades. Operations management theory establishes that global sourcing requires more units of inventory, but since these units are often procured at a lower cost from global suppliers, the capital invested in inventory and the consequent financial burden may increase or decrease with global sourcing. This study provides rigorous firm-level empirical evidence that links the global sourcing practices of public U.S. firms and their inventory investments. We process bill of lading manifests (customs forms) to extract information on over half a million sea shipments from global suppliers to U.S. public firms and link this information with quarterly financial data from the Compustat database. We provide stylized facts on the participation of different firms and sectors in global trade. Using a simultaneous equation model, we find that an increase in global sourcing results in an increase in inventory investment. A 10% shift in sourcing from domestic to global suppliers increases the inventory investment by 8.8% for an average firm in our sample. We also find that increasing the number of suppliers can mitigate this increase in inventory investment: for example, going from single to dual sourcing reduces inventory investment by about 11%. We illustrate the use of our estimates to identify the impact of changing global sourcing strategy on inventory investment and operational performance metrics.

Capacity Investment with Demand Learning

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We study a firm's optimal strategy to adjust its capacity using information from demand. We consider two scenarios: the firm has a *single* or *multiple* opportunities to adjust its capacity, reflecting the impact of different capacity adjustment lead time and costs. For both scenarios, we first formulate the problem as a stochastic dynamic program, and then characterize the firm's optimal policy: when to adjust and by how much. We show that the optimal policy can be counterintuitive and complex. For example, when the firm can change the capacity only once, the optimal decision on when and by how much to change the capacity is not monotone in the likelihood of high demand. This phenomenon is particularly surprising as the corresponding problem is an optimal stopping problem, where monotonicity of the optimal policy is quite common. When the firm can adjust the capacity multiple times, we characterize the optimal policy as a control band policy. As it is challenging to compute and implement the optimal policy, we develop a data-driven heuristic for each setting. In the single adjustment setting, we show that a heuristic that explores demand for an appropriately chosen length of time and adjusts the capacity based on the observed demand is asymptotically optimal, and characterize the convergence rate. In the multiple adjustment setting, we show that a heuristic under which the firm adjusts its capacity at a predetermined set of periods with exponentially increasing gap between two consecutive decisions is asymptotically optimal. We apply our heuristics to a numerical study inspired by real data and business scenario and demonstrate the performance and robustness of the heuristics.

Optimal Price and Delay Differentiation in Queueing Systems

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Advisors: Costis Maglaras, Columbia University; Assaf Zeevi, Columbia University

We study a multiserver queueing model of a revenue-maximizing firm providing a service to a market of heterogeneous price- and delay-sensitive customers with private individual preferences. The firm may

offer a selection of service classes that are differentiated in prices and delays. Using a deterministic relaxation, which highlights the first-order economic structure of the problem, we construct a solution that is incentive compatible and near-optimal in systems with large capacity and market potential. Our approach provides several new insights for large-scale systems: (i) the tractable first-order analysis characterizes essentially all salient features of the optimal solution; (ii) service differentiation is optimal when the less delay-sensitive market segment is sufficiently elastic; (iii) depending on system capacity and market heterogeneity, "intentional delay" (whereby delay is artificially added) in cheaper service classes may be used to justify price premiums in the more expensive service classes, akin to the role of "damaged goods" in the economics literature; and (iv) connecting economic optimization to queueing theory, the revenue-optimized system has the premium class operating in a "quality-driven" regime and the lower-tier service classes operating in an "efficiency-driven" regime (i.e., with noticeable delays that arise either endogenously or due to the injection of intentional delay by the service provider).