

## Research and Management Insights

### Inspecting a Vital Component Needed upon Emergency

Alireza Sabouri, Steven M. Shechter,  
Woonghee Tim Huh

Catastrophes may arise when a vital component, equipment, or stand-by system is not operating at the time of an emergency. Examples include a hospital's back-up power generator needed during a power outage or smoke detectors needed at the time of a fire. Maintaining such systems is especially challenging when equipment failures are silent and may go unnoticed until an inspection takes place, or worse, when the equipment is needed. Alireza Sabouri, Steven Shechter, and Tim Huh develop a model and a solution algorithm that help managers to answer important questions such as when to inspect vital components and when to preemptively replace them. Their decision model optimally balances the risk and costs of a catastrophic outcome, with the costs of inspecting and replacing the components. In comparison to constant-interval inspection policies, commonly applied in practice, the authors' numerical study suggests significant cost savings by implementing the optimal inspection and replacement policy.

### Strategic Capacity Management When Customers Have Boundedly Rational Expectations

Tingliang Huang, Qian Liu

In retailing industries, such as apparel, sporting goods, customer electronics and appliances, many firms deploy sophisticated modelling and optimization software to conduct dynamic pricing in response to uncertain and fluctuating market conditions. However, the possibility of markdown pricing creates an incentive for customers to strategize over the timing of their purchases. How should a retailing firm optimally account for customer behavior when making its pricing and stocking/capacity decisions? For example, is it optimal for a firm to create rationing risk by deliberately understocking products? Tingliang Huang and Qian Liu develop a stylized modelling framework to answer these questions. In their model, customers strategize over the timing of their purchases. However, customers have

boundedly rational expectations in the sense of anecdotal reasoning about the firm's fill rate, i.e., they have to rely on anecdotes, past experiences, or word-of-mouth to infer the firm's fill rate. In their modelling framework, they distinguish two settings: (i) capacity commitment, where the firm makes a long-run commitment commits to its capacity level, or (ii) the firm dynamically changes it in each season. For both settings, within the simplest form of anecdotal reasoning, the authors prove that strategic capacity rationing is not optimal independent of customer risk preferences. Then, using a general form of anecdotal reasoning, they provide sufficient conditions for capacity rationing to be optimal for both settings respectively. They show that the result of strategic capacity rationing being suboptimal is fairly robust to different valuation distributions and utility functions, heterogeneous sample size, and price optimization.

### How Costs and Heterogeneous Consumer Price Sensitivity Interact with Add-On Pricing

Xianjun Geng and Jeffrey D. Shulman

Managers often look for elements of their product or service offering for which to charge customers an additional fee. An economic model by Xianjun Geng and Jeffrey Shulman helps managers predict how competitors will respond to such a decision and the net effect on profitability. The research shows that when considering add-on pricing, a manager should use market research to address four questions: (1) How does the price sensitivity of consumers who buy only the base product compare to the price sensitivity of consumers who value the add-on? (2) How many consumers will use the add-on if and only if it is offered for free? (3) How great is the marginal add-on cost? and (4) Will the competitor independently discover and implement the add-on pricing opportunity? Interestingly, add-on pricing can reduce company profit if the add-on has a high variable cost and consumers who enjoy the add-on are more price sensitive than other consumers. This profit reduction occurs because the competitor will have incentive to also charge for the add-on, but over-aggressively pursue consumers with a low price on the main offering.

### Strategic Consumer Cooperation in a Name-Your-Own-Price Channel

Tatsiana Levina, Yuri Levin, Jeff McGill and Mikhail Nediak

Reluctance of name-brand suppliers to openly advertise highly discounted products on the internet has stimulated development of ‘name-your-own-price’ sales channels that allow consumers to place bids for products or services within specified quality ranges without knowing the specific supplier – so-called ‘opaque’ products. Unfortunately (for suppliers) there is significant potential for consumers to improve bid success in such channels through collaboration in online social networks. T. Levina, Y. Levin, J. McGill, and M. Nediak study three possible forms of consumer collaboration. In the first, consumers act independently but exchange the results of their bids; in the second, they actively collaborate in their choices of bids but win or lose independently; and in the third they collaborate and also ‘pool’ the risks by sharing benefits after bidding is completed. A bidding strategy using just information exchange gives almost the same benefits to consumers as coordinated bidding, but coordinated bidding with risk pooling can lead to significantly greater benefits. Fortunately, suppliers that actively adjust for such strategic consumer behaviour can greatly reduce the impact on their businesses and, under some circumstances, even increase revenues.

### Impulse Balance and Multiple-Period Feedback in the Newsvendor Game

Axel Ockenfels, Reinhard Selten

The newsvendor game is used to describe optimal inventory levels in a simple context with stochastic demand and fixed prices. It is a building block in most procurement models. Yet the behavior of decision makers deviates from the normative solution in important and systematic ways. Axel Ockenfels and Reinhard Selten propose a model that explicitly takes into account cognitive limitations of decision making. Behavior is assumed to follow a simple ex-post rationality principle, and does neither involve maximization nor rational information processing. The model accurately predicts the key deviations from optimal inventory policy. Yet, understanding the cognitive limitations in human decision making is important not only for modeling purposes, but also for guiding efforts to organize feedback and experience for improved decision support systems. Here, their model suggests that, in line with empirical evidence, constraining newsvendors to make a standing order for a sequence of periods promotes better performance.

### Elective Patient Admission under Multiple Resource Constraints

Christiane Barz, Kumar Rajaram

The patient admission control problem decides which patient to admit to the hospital and at what time. Its solution is particularly complicated because many hospitals face multiple resource constraints and depending upon the patient mix any one of them can become the bottleneck. Further, patient arrivals are uncertain and there is a stochastic evolution of care requirements across these multiple resources. In this setting, Christiane Barz and Kumar Rajaram suggest a so-called newsvendor heuristic, which accounts for the randomness of the arrival process and approximates the marginal cost of the resources. They test this heuristic in a scenario based on data from the Ronald Reagan UCLA Medical Center. They find that simple admission rules used in practice often do not adequately account for the randomness of new arrivals and the opportunity costs of future resource usage, especially when uncertainty is high and capacity is tight. This increased value of their newsvendor heuristic comes with its ability to incorporate multiple sources of variability but it also leads to increased data requirements. Given the move to electronic medical data in the healthcare industry, this data should be more accessible over time.

### The Impact of Limited Supply on a Firm’s Bundling Strategy

Qingning Cao, Kathryn E. Stecke, Jun Zhang

The conventional wisdom suggests that bundling allows a firm to exploit consumer demand heterogeneity when the two products in a bundle is symmetric (in how they are valued by consumers) and has a low consumer valuation correlation. In reality, however, it is observed that asymmetric products with a high consumer valuation correlation are bundled, e.g., Nintendo Wii with a peripheral or a game in a package. Qingning Cao, Kathryn Stecke, and Jun Zhang bridges the gap between the bundling literature and practice by proposing that in the latter case, bundling is driven by the limited supply of a product rather than by the consumer demand-side factor (i.e., heterogeneity) solely. The benefit of supply-driven bundling depends on the severity of supply limitation. When supply limitation is moderate, bundling creates value by expanding the market of the less attractive product. When supply limitation is severe, bundling enables the firm to extract a higher margin from the less attractive product.

### **Incentive Contracts for Managing a Project with Uncertain Completion Time**

Christopher S. Tang, Kairen Zhang, and Sean Zhou

When project delays affect the manager's payoff negatively, what kind of incentive contracts should the manager offer especially when she does not have perfect information about the amount of work involved or the contractor's cost structure? Tang, Zhang and Zhou evaluate two commonly used time-related incentive contracts (C1 and C2 contracts) when the manager conducts a reverse auction. Under the C1 contract, the contractor with the lowest bid price wins; however, the manager imposes a linear and symmetric incentive/disincentive for early/late completion. Under the C2 contract, the winning contractor has the lowest composite score that is based on the quoted price and the quoted due date; however, the contractor is subject to an additional late completion penalty. The authors' analysis reveals that, unless the project is truly urgent, the more complicated C2 contract adds no value to the manager: the simple C1 contract will suffice.

### **Optimal Descending Mechanisms for Constrained Procurement**

Shivam Gupta, Wei Chen, Milind Dawande, Ganesh Janakiraman

In addition to cost, operational considerations play an important role in procurement. Common examples of constrained procurement include (i) individual and group capacities: Suppliers typically have finite production capacities. In addition, buyers often need to impose upper bounds on the total amounts procured from different subsets of suppliers. (ii) business rules: Lower and upper bounds on the number of suppliers to source from, as well as lower and upper bounds on the quantity that can be sourced from any selected supplier. Shivam Gupta, Wei Chen,

Milind Dawande and Ganesh Janakiraman study two procurement problems, one with individual and group capacities as constraints, and the other with business rules as constraints. In both problems, there is a buyer who wants to procure a fixed, aggregate quantity of a product from a set of potential suppliers. For both problems, the authors derive optimal procurement mechanisms that the buyer can use to minimize her cost and show how these mechanisms can be implemented in the popular descending-auction format.

### **Managing Logistics in Regional Banknote Supply Chain under Security Concerns**

Yunxia Zhu, Subodha Kumar, Sara Rodriguez-Sanchez, Chelliah Sriskandarajah

Reduce operating costs while circulating currency securely is a common thread across currency supply chains around the world. Due to the high value and low weight of the products (banknotes), the banknote supply chain faces unique challenges, e.g., security issues during the transportation of the product. A variety of security policies have been adopted to handle these issues in different countries throughout the world. Yunxia Zhu, Subodha Kumar, Sara Rodriguez-Sanchez, and Chelliah Sriskandarajah propose a simple methodology that can be used to utilize the capacity of trucks efficiently when transporting banknotes in a currency supply environment. The methodology proposed in the paper is flexible enough to be applied to other supply chains with slight modifications. The authors also illustrate that the security policies have significant impact on the central bank's operating cost of providing banknotes to the society. Several observations have been derived, and suggestions have been provided regarding revising those security policies at the central bank. The central bank can utilize these results to fine-tune its security policies in order to improve the supply chain efficiency.