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Research and Management Insights

Improving Voting Systems through Service-Operations Management
Muer Yang, Michael J. Fry, W. David Kelton, and Theodore T. Allen

Yang et al. analyze voting systems on the basis of efficiency and equity. Efficiency is defined as a system-wide metric related to voter waiting times, and equity is based on the differences in waiting times experienced by voters at different precincts. Past elections in the United States and elsewhere have resulted in extremely long voter waiting times and charges of inequity. In voting systems, equity is particularly important because voters should all receive the same access to the polls to cast their ballot to prevent disenfranchising certain voting subpopulations. The authors design new voting machine allocation methods based on simulation-optimization procedures that provide better efficiency and equity for voters. The authors also suggest several operational improvements for voting systems based on service-operations theory to reduce waiting times at the polls. The authors apply their allocation methods to historical data from elections in the United States and show that their approach could significantly reduce voter waiting times and greatly improve equity.

Improving the Milk Supply Chain in Developing Countries: Analysis, Insights, and Recommendations
Liying Mu, Milind Dawande, Vijay Mookerjee

The deliberate adulteration of milk by producers (farmers) has been extensively reported across the developing world. With quality-based pricing commonly used to induce high-quality milk, a milk-collection station – an intermediary between producers and processing firms in the milk supply chain – has an incentive to improve the quality of the mixed milk. High testing costs discourage the station from testing each producer individually and, instead, favor mixed testing. However, mixed testing increases the incentive for producers to free-ride. Thus, inducing producers to supply high-quality milk with minimal testing – both individual and mixed – is the station's basic challenge. Liying Mu, Milind Dawande, and Vijay Mookerjee show that, while small confessor rewards can help increase both the quality of milk and the station's profit, quality rewards can be detrimental. The ordering of individual testing and mixed testing is significant: *Pre-mixed individual testing*, where the station first tests a fraction of producers individually and then performs a mixed test on the milk from the remaining producers can be socially harmful. A desirable outcome – high quality milk from each producer with only one mixed test – can be achieved through the use *of post-mixed individual testing* and mild third-party intervention.

Cellular Bucket Brigades on U-Lines with Discrete Work Stations
Yun Fong Lim, Yue Wu

Yun Fong Lim and Yue Wu propose *cellular bucket brigade rules* to coordinate workers on a U-line with discrete stations. They show that a two-worker system always converges to a fixed point or a period-2 orbit. They identify a sufficient condition for the system to converge to the fixed point. Convergence to a fixed point could be desirable because each worker repeatedly works in the same loop on the U-line, which facilitates learning. The travel of workers is also reduced as each worker executes tasks that are physically close to each other. All other attractive characteristics of traditional bucket brigades on a straight-line layout are preserved under the U-line layout. Dividing the U-line into more stations will improve the throughput if there is blocking or halting in the system. The throughput is significantly improved as the number of stations in each stage increases from 1 to 2, but there is diminishing return if we further divide each stage into more stations. Simulations suggest that the cellular bucket brigade can better absorb the impact of random work velocities and maintain higher productivity compared to a team with optimized, static work allocation. Its performance relative to the static team improves as variability in velocity increases.

Browse-and-Switch: Retail-Online Competition under Value Uncertainty
Anantaram Balakrishnan, Shankar Sundaresan, Bo Zhang

Recent articles in the business press attribute the declining profits of brick-and-mortar retailers to "showrooming," the practice among some consumers of visiting these stores to browse or examine a product and then switching to an online seller or e-tailer to purchase the item. This browse-and-switch behavior occurs when consumers are unsure if they like the product (particularly likely for the many new products that manufacturers are rapidly introducing) and the e-tail price is lower. Anantaram Balakrishnan, Shankar Sundaresan, and Bo Zhang develop a model of competition between a retailer and e-tailer that captures this behavior while also simultaneously considering the possibility of consumers ordering directly from the e-tailer (and returning the product if not satisfied) or purchasing from the retail store. Analysis of the model shows that browse-and-switch behavior can occur in equilibrium and the ratio of consumer costs for using the retail and e-tail channels determines if some consumers adopt this behavior. Importantly, showrooming intensifies competition and reduces profits for both firms and the model serves to highlight and assess strategies to mitigate these effects. These insights extend to more general contexts, for example, when the retailer also operates an online store.

Judgmental Forecasting: Cognitive Reflection and Decision Speed
Brent Moritz, Enno Siemsen, Mirko Kremer

Good demand forecasting is central to effective supply chain management. While quantitative methods of time-series forecasting are widely available, often forecasts require managerial judgment. Brent Moritz, Enno Siemsen, and Mirko Kremer analyze how individual differences impact forecasting performance and find that individuals with the ability to balance intuitive judgment with cognitive deliberation tend to have lower forecast errors; this was not due to intelligence. Additionally, forecasts that were either very fast or very slow had larger forecast errors. The authors also tie their results to theory in judgment and decision making applicable to time-series forecasting.

Is Safe Production an Oxymoron?
Mark Pagell, David Johnston, Anthony Veltri, Robert Klassen, Markus Biehl

Operations and safety management have traditionally been studied independently even though the workers who are most likely to get injured at work are those who create a company's good or service. This research simultaneously examines safety and operational management practices and outcomes. The results show that it is possible to manage a production system to be safe and productive, but that many organizations fail at this task. Creating a safe production system requires a culture that prioritizes safety and is process focused, preventative and encourages worker participation. Such a culture supports the adoption of a management system that allows for the joint management of operations and safety. And the adoption of a joint management system is associated with high performance on safety and operational outcomes. Absent such a culture organizations manage operations and safety separately and poorly; leading to poor performance on safety and operational outcomes.

Uniform vs Retailer-Specific Pricing: Incentive Alignment to enhance Supply Chain Efficiency
Asoo J. Vakharia, Lan Wang

A critical decision for a consumer goods manufacturer/supplier selling its products through independent retailers is wholesale pricing. Asoo Vakharia and Lan Wang show that when downstream retailers operate in non-competing markets which are of similar size, the supplier would prefer to price discriminate based on retailer efficiencies. In essence, the supplier would prefer to charge a higher wholesale price to the more efficient retailer and a lower wholesale price to the less efficient retailer. Such a result creates a potential conundrum supplier for two reasons. First, it could lead to the more efficient retailer contemplating other sources of supply and hence, a potential loss of a market for the supplier. Second, if the supplier chooses to charge an equal wholesale price to all retailers (to signal "fairness") then it stands to realize lower profits. In attempting to resolve this dilemma, we first show that equal wholesale prices are always the preferred option when we consider the total supply chain. Using this result, the authors propose a unique wholesale price contract complemented with a slotting allowance or a side payment which simultaneously ensures that the supplier is always better off and the more efficient retailer is less likely to leave the supply chain.

Impeding the Juggernaut of Innovation Diffusion: A Production Constrained Model
P.V. (Sundar) Balakrishnan, Surya Pathak

Balakrishnan and Pathak suggest that the inexorable juggernaut of a new product diffusion process can be impeded by production shortage and thus impair the speed of diffusion. Such shortage leads to poor service quality due to a build-up of waiting customers who in turn can impact future demand through

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their social influence. They build a rich, integrated model of product diffusion incorporating multiple social influences on the demand side, with the supply side aspects of production constraints and inventory. They examine a number of production policies representing emerging markets to those of fashion products. This will be of significant interest to analysts, managers and policy makers. Their intuition is that there is an "optimal" capacity that implicitly balances the need to maintain high inventory to aid service quality and speed of diffusion against the need to minimize inventory holding and fixed capacity costs. Their empirical results indicate that a number of innovations ranging from vacuum cleaners to iPhones suffered from product shortage. Their model and estimation procedure in tandem provides practical solutions to understanding hi-tech firms' production capacity when such information is closely held.

Managing Disruptions in Decentralized Supply Chains with Endogenous Supply Process Reliability
Sammi Y. Tang, Haresh Gurnani, Diwakar Gupta

Buyers facing uncertain delivery from their suppliers may adopt different approaches to mitigate their risk. One approach involves working with the supplier and investing in processes that improve supplier reliability, whereas an alternative approach diversifies procurement and orders from multiple suppliers. Suppliers' reliability improvement efforts are costly. Consequently, they may choose to underinvest, which is not beneficial for the supply chain. A buyer may wish to provide incentives to the supplier to invest in more costly effort – the incentive may be in the form of a subsidy on the cost of effort (direct incentive) or a higher order quantity (indirect incentive). Conversely, the buyer may choose to benefit from order diversification by placing smaller "individual" orders from multiple suppliers. If suppliers have fixed ("exogenous") reliabilities, order diversification has the potential to reduce disruption risk for the buyer. However, with endogenous reliability, a lower order size also reduces the incentive for each supplier to invest in reliability improving effort. Sammi Y. Tang, Haresh Gurnani, and Diwakar Gupta examine this conflict in order allocation decision for the buyer and its resulting impact on supply reliability. They also consider the case of stochastic demand and show that the buyer may increase use of subsidy and order quantity incentives simultaneously. This is in contrast to the deterministic demand case where there is a strict preference for the use of the subsidy option rather than a larger order quantity.

Integrated Procurement Planning in Multi-division Firms
Anantaram Balakrishnan, Harihara Prasad Natarajan

In the strategically important area of procurement, enterprise integration has enabled multi-division firms to leverage company-wide purchasing power by coordinating the procurement policies across divisions. To take advantage of corporate volume discounts, firms have established corporate procurement organizations that are responsible for developing tactical plans specifying the vendors that each division must use. Such supplier assignment decisions, if based solely on maximizing the vendor discounts, can result in high order management costs for divisions. Motivated by the experience of a large industrial products manufacturer, Anantaram Balakrishnan and Harihara Prasad Natarajan propose a new integrated procurement planning model that incorporates both the firm's annual net purchasing costs, after discounts, and divisional order management costs. This model provides a unifying tactical planning framework for procurement managers. Since the large-scale optimization problem is very difficult to solve using general purpose solvers, the authors develop an advanced polyhedral solution approach based on theoretical results and insights about the structure of the problem. Computational tests for problems with varying characteristics show that solution method generates near-optimal solutions quickly, and demonstrate that the integrated model can provide significant cost savings compared to autonomous sourcing decisions by individual divisions or using manual decision rules for supplier assignment.

Inventory Commitment and Prioritized Backlogging Clearance with Alternative Delivery Lead Times
Haifeng Wang, Xiaoying Liang, Suresh Sethi, Houmin Yan

Products responsiveness, usually reflected as the delivery lead-time, has become a key performance measure these days. To meet customers' heterogeneous lead-time requirements and not lose on inventory efficiency, it is necessary for sellers to allocate their inventory stocks dynamically to different customer segmentations. Motivated by the practice at dealerships of a large automobile manufacturer, Wang, Liang, Sethi and Yan consider inventory models in which a supplier offers two delivery lead-time options to serve two segments of customers with different lead-time and price requirements. While paying a premium price, a short lead-time customer prefers an immediate delivery of the product, whereas a long lead-time customer may have to wait

for his/her order fulfillment. The supplier replenishes its inventory periodically and allocates the on-hand inventory to the two classes of customers dynamically between replenishments. Of particular interest is the question of how to allocate replenished inventory to serve outstanding customers and incoming customers before the next replenishment arrives. Three backlogging clearance rules, differing in the priority given to short lead-time customers, are discussed. The optimal inventory commitment policy is characterized under each rule. They further compare the performances of the rules under varying conditions.

Advertising in Asymmetric Competing Supply Chains
Bin Liu, Gangshu (George) Cai, Andy A. Tsay

Advertising is a crucial tool for demand creation and market expansion. When a manufacturer uses a retailer as a channel for reaching end customers, the advertising strategy takes on an additional dimension: which party will perform the advertising to end customers. By comparing manufacturer advertising and retailer advertising in two competing supply chains, Bin Liu, Gangshu Cai, and Andy Tsay discover that firms, especially smaller retailers, can benefit from showing restraint in their advertising when product substitutability is high. Cost sharing arrangements ("cooperative advertising"), which decouple the execution of the advertising from its funding, offers a way to adjust the incentives of the various entities. However, the authors find that firms – especially the retailers in these competitive supply chain settings – should be wary of cooperative advertising. The advertising subsidy might quietly trigger a disadvantageous change in some other term of the supply contract. These adjustments could have the counterproductive net effect of intensifying the competition. Perhaps for this reason, in practice some firms prefer to bear the full costs of their own advertising. This research compares the implications of all these configurations of advertising strategy for overall supply chain efficiency and consumer welfare.