Research and Management Insights

The Implications of Utilizing Market Information and Adopting Agricultural Advice for Farmers in Developing Economies

Christopher S. Tang, Yulan Wang, Ming Zhao

To alleviate poverty in developing countries, more governments and non-governmental organizations (NGOs) are disseminating agricultural advice and market information to enable farmers to improve their planting and selling decisions. When facing uncertain market demand and process yield, would farmers be better off by using market information to improve their production plans (or adopt agricultural advice to improve their operations)? Christopher Tang, Yulan Wang, and Ming Zhao's analysis indicates that the provision of market information can improve the farmers' total welfare (i.e., total profit for both farmers). However, they find that agricultural advice is not always welfare improving unless the upfront investment is sufficiently low. Therefore, to improve farmers' welfare, governments should consider offering farmer subsidies.

Decision Making and Cognition in Multi-Echelon Supply Chains: An Experimental Study

Arunachalam Narayanan, Brent Moritz

Why does the bullwhip effect happen? While supply chain performance often depends on the decisions of channel members, even when individuals have full information, order variation tends to increase when moving up the supply chain. Although prior research has investigated several ways to mitigate the bullwhip effect, there is very little research as to why it is such a frequent and costly occurrence. This research by Narayanan and Moritz investigates this question using theory from judgment and decision making. Based in dual systems theories of cognition (as in Kahneman's well-known book Thinking, Fast and Slow), the authors show a difference in supply chain performance based on an individual's level of cognitive reflection. The results show that bullwhip-inducing decisions are related to the tendency of individuals to fail to override easily available but incorrect responses and engage in further reflection. Specifically, individuals with low cognitive reflection tend to underweight their inbound supply line, and are more likely to ignore inventory already on order but not yet received as they place their new orders.

Class-Based Storage with a Finite Number of Items: Using More Classes is not Always Better

Yugang Yu, René B.M. de Koster, Xiaolong Guo

Yugang Yu, René de Koster, and Xiaolong Guo study class-based storage policy in a warehousing system for a finite number of items, to derive retrieval times, the optimal number of storage classes, and space requirements. Current literature assumes products occupy a space equal to the time-average stock level, which is justified for an infinite number of items. In such a case, more storage classes give a shorter travel time due to a better allocation of products to classes and locations. However, a finite number of items need more space than their time-average stock, increasing the travel time. This trade-off leads to an optimal number of classes. The authors show that the optimal number is relatively small; three classes give near-shortest travel time for all ABC demand curves between 20%/50% and 20%/90%. The authors also find that the travel time is fairly insensitive to the number of storage classes in a wide range around the optimum. This is important for warehouse managers, as it suggests that any small (>2) number of classes is near optimal. As a result, warehouse managers may change the number of classes if necessary (e.g. for space use purposes), since the travel time is not sensitive to the number of classes. The authors validate the findings for various cases, including different ABC-demand curves, space-sharing factors, number of items, storage rack shapes, discrete storage locations, and stochastic item demand. Moreover, they find that the space needed for a warehouse with an optimal number of storage classes is at least 30% more than the average inventory level. The space-sharing due to a finite number of items can therefore not be ignored in the class-based storage system.

The Effects of Multitasking on Operations Scheduling

Nicholas G. Hall, Joseph Y.-T. Leung, Chung-Lun Li

Multitasking, or the interruption of a primary task by another task that is available, is something that is frequently observed and practiced. Everyday examples occur in manufacturing and service activities, health care, computer processing, business processes, and even in leisure activities and social interactions. Boredom with the task at hand, anxiety about others that are waiting, and interruption by routine scheduled activities all contribute to multitasking, Studies of organizational productivity estimate the cost of multitasking at up to 60%. The worldwide cost of multitasking is variously estimated at between $450 billion and $1 trillion annually. Discussions of multitasking abound within the literature of behavioral psychology, operations management, cognitive engineering, and project management. The multitasking environment is unique within the scheduling literature, in that the job that is scheduled is not always the job that is processed. This is an example of "inadvertent scheduling." Nicholas Hall, Joseph Leung, and Chung-Lun Li consider the influence of multitasking on the efficiency of a simple scheduling system. They provide mathematical analysis of the effect of multitasking on scheduling problems that arise in this system. Their study finds that several classical algorithms fail to find optimal solutions in the presence of multitasking. They therefore develop new optimal algorithms and accompanying intractability results for the multitasking environment. They also evaluate the cost and value of multitasking, which a computational study finds to be substantial in most cases. Their analysis informs companies about how much it would be worthwhile to invest in measures to eliminate multitasking. They provide an extensive list of open research problems in scheduling with multitasking. This work provides a link between the literatures of discrete optimization and behavioral psychology.

Storing Fresh Produce for Fast Retrieval in an Automated Compact Cross-dock System

Nima Zaerpour, Yugang Yu, René B.M. de Koster

Nima Zaerpour, Yugang Yu, and René de Koster study temporary storage of fresh produce in a cross-dock center. In order to minimize cooling cost, a compact (i.e. high-density) storage system is used. A major disadvantage of these systems is that additional retrieval time is needed, caused by reshuffles due to the improper storage sequence of unit loads. In practice therefore, a 'dedicated' storage policy is used where each product is stored in a separate storage lane. Such a policy uses much space and it disregards information on the planned arrival time of the outbound trucks. The authors propose a mathematical model for a 'shared' storage policy that minimizes total retrieval time, by exploiting these planned arrival times. The policy allows different products to share the same lane. In order to solve real-sized problems, an effective and efficient heuristic is proposed. The resulting shared storage policy is generally robust against disturbances in outbound truck arrival times. The authors compare the shared storage heuristic with dedicated storage to determine which policy performs best under which circumstances. For most practical cases, shared storage appears to outperform dedicated storage, with a shorter response time and better storage lane utilization. Therefore, using shared storage, the required storage space can become smaller, reducing building and cooling costs.

Capacity Sharing and Cost Allocation among Independent Firms with Congestion

Yimin Yu, Saif Benjaafar, Yigal Gerchak

Capacity sharing has been studied mostly in situations where a single firm, or a sub-division within a firm, owns all the capacity in the system, and has responsibility for serving all the demand. This firm makes the decision about whether or not to share capacity and how much capacity to acquire. Yimin Yu, Saif Benjaafar, and Yigal Gerchak consider a system with multiple independent firms, or sub-divisions within a firm, each facing its own demand and each having the option of either operating its own independent facility or joining some or all the other firms in a shared facility. The firms may vary in their demand levels and in their tolerance for capacity shortage. If some or all of the firms decide to share capacity, they must also decide on how to allocate the cost of the shared facility. They must do so in a manner that benefits everyone and prevents any of the firms from defecting and perhaps sharing a facility with a subset of the firms or staying on their own. Hence, firms that contribute more to the cost of the shared facility (because of their higher usage of capacity or lower tolerance for capacity shortage) are expected to pay a greater share of total cost. In this paper, we consider applications where facilities can be modeled as queueing systems. The authors describe how capacity can be optimally determined in a shared system and propose an allocation scheme that guarantees that all firms prefer a system shared among the firms (the grand coalition) to systems that

involve sharing among only subsets of the firms or no sharing at all. They do so for systems that operate under a first come-first served policy and for systems that operate under an optimal priority policy. They also describe settings under which sharing among all the firms may not be preferable to other configurations. They show that this can be the case when the firms are heterogeneous in their characteristics, including their work contents, service time variability, and delay costs. For these cases, they characterize conditions, under which capacity sharing may still be beneficial for a subset of the firms. These conditions provide insights into the characteristics of firms that would benefit from forming sub-coalitions. In general these results indicate that capacity sharing should be considered with caution when differentiated service levels are not possible.

Point-of-Dispensing Location and Capacity Optimization via a Decision Support System

Adrian Ramirez-Nafarrate, Joshua D. Lyon, John W. Fowler, Ozgur M. Araz

Adrian Ramirez-Nafarrate, Joshua Lyon, John Fowler, and Ozgur Araz design and analyze a mathematical model and a solution approach to simultaneously optimize the location and capacity of point-of-dispensing (PODs). Similar systems described in the existing literature use a sequential optimization approach to first optimize the location and then the capacity of PODs. The authors show that simultaneous optimization is able to find feasible solutions for stressed scenarios by trading off the following three measures: a) travel time to PODs; b) average waiting time within PODs; and c) time to complete dispensing. Meanwhile, the sequential approach may determine locations that are later found to not be feasible in some stressful scenarios. The model and the solution approach proposed by the authors assume that a collection of servers is available to be assigned to different PODs in order to dispense prophylaxis to the target population within a target completion time. This approach is different from optimizing the number of servers around a specific scenario (uncapacitated location problem), which is a common approach used in the existing literature and which always finds feasible solutions. Hence, the authors designed a framework to deal with infeasible solutions that allow the decision makers to relax one constraint. This feature of the solution approach identifies locations that have critical resource shortages so that decision makers can modify the dispensing plan to efficiently face the stressed scenarios. For instance, the proposed system is able to estimate the additional number or servers required or the additional time over the target needed to complete the dispensing task. It also provides alternate solutions that do not require additional resources, but that do require a flow control mechanism to ensure that member of the population visits their assigned POD. The proposed constraint relaxations have not been explored in the existing literature, yet they return valuable information that facilitates the design of effective plans under resource shortages.

Strategic Inventory and Supply Chain Behavior

Robin Hartwig, Karl Inderfurth, Abdolkarim Sadrieh, Guido Voigt

The authors show that buyers in supply chains quickly learn to hold an inventory for strategic reasons only. The controlled experiments in this study confirm the theoretical result that strategic inventories can restrain the supplier's monopoly power, curb average wholesale prices, and reduce inefficiency in supply chains. Moreover, as the efficiency in the supply chain is enhanced by strategic inventories, fairness perceptions shift in favor of the buyer leading to even lower prices and higher buyer profits than theoretically predicted. For industries with low inventory holding cost, these results suggest that buyers hold higher levels of strategic inventories (i.e. more inventory than otherwise necessary) and collect greater supply chain profit shares than in industries that are plagued by high holding cost. Suppliers, however, are not harmed by the increased buyers' profits. The overall efficiency gains attained in the supply chain interaction is generally distributed fairly using adapted wholesale price contracts that empirically perform much better than theoretically predicted.

Supply Chain Consequences of Subsidies for Corporate Social Responsibility

Anil Arya, Brian Mittendorf

In the interest of promoting greater charitable activity, governments often provide business tax breaks and other subsidies for corporate social responsibility (CSR). While it is widely accepted that these incentives encourage greater CSR endeavors, there has been little examination of their broader consequences. Anil Arya and Brian Mittendorf develop an economic model of supply chain and CSR behavior and demonstrate that CSR incentives can have notable unintended consequences.

A key feature of many government incentives, like the "enhanced" tax deduction for inventory dona-

tions to charity, is that they are tied to the market value of the items businesses put to use for the social good. The paper's results demonstrate that this feature encourages businesses to inflate the market values of its products. The consequence is that while incentives can nudge businesses toward more socially beneficial behavior, they can also promote retail price hikes that harm the typical consumer. On the other hand, an unforeseen upside for supply chain efficiency is that the boost in charitable activity naturally promotes cuts in supplier prices. The primary results are shown to be robust to variation in both supply and retail market characteristics. Taken together, the results demonstrate key considerations for both legislators and businesses facing a landscape of blurring boundaries between profit and social good.

Competition and Coordination in a Two-Channel Supply Chain
Amy David and Elodie Adida

Suppliers often may sell their products both via independent retailers and directly to consumers through an online channel or an exclusive store. These suppliers that extend into the retail space find themselves competing with the retailers to whom they sell products for the dollars of the end consumer. The authors show that under certain conditions, the supplier should sell its product to as many retailers as possible, even if doing so causes nothing to be sold through the direct channel or its own retail price to be undercut. Hence, manufacturers that operate direct channels through which they sell products that are either exclusive or clear market leaders may benefit more from increased wholesale revenues than from direct retail sales: their exclusivity may better serve them at the wholesale level, selling to many retailers, rather than at the retail level, acting as a monopoly retailer. Additionally, forging relationships with retailers through a coordinating contract such as the linear quantity discount contract further maximizes the leverage of the manufacturer's exclusivity advantage.