Research and Management Insights

Environmental Taxes and the Choice of Green Technology
Dmitry Krass, Anton Ovchinnikov, Timur Nedorezov

Can environmental taxes, imposed per unit of pollutant emitted, motivate firms to adopt green technologies? Dmitry Krass, Anton Ovchinnikov, and Timur Nedorezov show that a policy consisting of taxation alone may be quite limited in its effect—in fact, that sufficiently high taxes may motivate the firm to bypass green technologies altogether. The authors show that the motivation of such technology adoption is rather nuanced and depends a great deal on the specific technology in question. From the society's standpoint, to justify the adoption the amount of emission reduction must be commensurate with the required capital investments and increased operating costs. For technologies that meet this criterion, by looking at the public welfare (cumulative impact on all relevant stakeholders—firm, consumers and the environment), the authors show that using a carefully chosen combination of environmental taxation, subsidies given to firms and rebates given to consumers, the government regulator can ensure that the firm is motivated to select the desired green technology and the production level that maximizes public welfare. If, on the other hand, the regulator is limited to the tax-only policy, the loss in welfare can be substantial, and the government regulator's ability to motivate green technology choice may be severely compromised.

Sales Forecasting with Financial Indicators and Experts' Input
Nikolay Osadchiy, Vishal Gaur, Sridhar Seshadri

Nikolay Osadchiy, Vishal Gaur, and Sridhar Seshadri present a method for forecasting sales using financial market information and test this method on annual data for U.S. public retailers. The method is motivated by the permanent income hypothesis in economics, which states that the amount of consumer spending and the mix of spending between discretionary and necessity items depend on the returns achieved on equity portfolios held by consumers. Taking input forecasts from such other sources as equity analysts or time-series models, the authors construct a market-

based forecast by augmenting the input forecast with one additional variable, lagged return on an aggregate financial market index. This forecast achieves an average 15% reduction in mean absolute percentage error (MAPE) compared to forecasts given by equity analysts at the same time instant on out-of-sample data. The method also yields correlation coefficients between retail sales and market returns for all firms in the data set. Besides forecasting, these results can be applied in risk management and hedging.

The Changing Face of Distribution Channels: Partial Forward Integration and Strategic Investments
Anil Arya, Brian Mittendorf

Recent years have seen a rapid shift in the way products reach consumers that has, in turn, revolutionized the face of distribution channels. In particular, the introduction of online channels has eased the way in which manufacturers can directly reach consumers. At the same time, manufacturers continue to rely on traditional "bricks-and-mortar" retailers. Thus, retailers are both wholesale customers and retail competitors of many manufacturers. Anil Arya and Brian Mittendorf examine how operating in the changed environment impacts the competing firms' strategic investments. They find that the manufacturer's desire to both supply its retailers and reach end consumers shifts the environment from being one in which firms invest to undercut retail rivals to one in which firms invest more in boosting demand, even that of their competitors. A case in point is the tendency for a manufacturer to invest broadly in brand promotion (benefiting both itself and its retail competitor), rather than heavy promotion of its own sales channel. The shift in the nature of strategic investments implies that the blurring boundaries between suppliers and retailers can benefit firms and consumers alike.

How Collection Cost Structure Drives a Manufacturer's Reverse Channel Choice?
Atalay Atasu, L. Beril Toktay,
Luk N. Van Wassenhove

Atalay Atasu, Beril Toktay and Luk Wassenhove build on their interactions with practice to illustrate

the last mile effect, an important property of reverse channels. They show that reaching remotely located customers to collect used products for recovery may be prohibitively expensive, and in turn, reverse channels may exhibit scale diseconomies. Taking this into account, the authors consider a game theoretic analysis of a closed-loop supply chain to show that the balance between scale economies and diseconomies determines the optimal reverse channel configuration. While a retailer-managed reverse channel is preferred when scale economies dominate, a manufacturer-managed reverse channel is preferred when scale diseconomies dominate.

Designing Service Level Agreements for Inventory Management
Liping Liang, Derek Atkins

Service Level Agreements (SLAs) are widely employed forms of performance-based contracts to manage suppliers, internal agreements, or external customer agreements. They have a number of design characteristics that need careful tuning to ensure that incentives are properly aligned. Using an application of SLAs for outsourcing inventory management, Liping Liang and Derek Atkins investigate these design issues and make a number of recommendations on the design of SLAs. First, to mitigate a supplier's strategic ("gaming") behavior, it is preferable that penalties be proportional to the underperformance rather than lump-sum ones. Second, in the case of large percentage service rate targets, penalties and bonuses are not equally effective, and penalties will normally be preferred over bonuses by the buying firm. Third, for proportional penalties, acceptable performance deviations should be close to the target. Although these results come from a particular inventory application, it is likely that the lessons are applicable to SLAs in general.

A Note on Optimal Selling to Asymmetric Retailers
Dimitris Kostamis

Dimitris Kostamis studies a retail channel with a manufacturer selling her product through multiple competing retailers, which might have different costs and/or demand potentials. The author focuses on a setting with two retailers and designs the manufacturer's optimal selling strategy when she must offer the same contract options to all retailers. If the retailers are not too asymmetric and competition between them is moderately intense, the author shows that the manufacturer is better off selling a larger quantity through the least profitable, (e.g., the higher-cost) retailer. To make that happen, the manufacturer

should offer a quantity discount to lure her preferred retailer into choosing a larger quantity. This finding offers an argument against manufacturers always aiming quantity discounts at the low–cost (or high–demand) retailers at the expense of smaller or less efficient ones. Although quantity discounts should always target the larger buyers, this research shows that when the retailers are quite similar and competition between them is moderate, a manufacturer can better discriminate by inducing the less efficient (or smaller) retailer to be the larger buyer. The author also demonstrates how the optimal selling mechanism can be implemented in practice using a menu of two-part tariffs.

Optimal Crop Choice and Irrigation Allocation and the Impact of Contract Farming
Woonghee Tim Huh, Upmanu Lall

Food security is an important social goal, and the concerns over food security as well as the changing climate raise issues related to the supply chain reliability and profitability of agriculture-based commodities and products. Contract farming has been considered as a potential lever to moderate the supply and price risk and to contribute towards crop diversification and water efficiency. Woonghee Tim Huh and Upmanu Lall consider the impact of the forward contract in the farmer's crop choice and irrigation decisions. Based on data from Rajasthan in India, they show that the farmer's decisions depend on a number of factors such as water requirement of each crop, irrigation cost, and the degree of the farmer's risk aversion.

Design Principles for Flexible Systems
Sigrún Andradóttir, Hayriye Ayhan, Douglas G. Down

Sigrún Andradóttir, Hayriye Ayhan, and Douglas G. Dowconsider systems with heterogeneous servers, and provide means to identify cross-training strategies that are "capacity effective," that is, throughput is optimal and adaptable to changes in demand and/or service rates. To accomplish this, they introduce the notion of a bottleneck set that limits system performance. The bottleneck set may include several tasks and servers. It may not be obvious a priori, however it is easily determined by solving several associated linear programming problems. The authors also show that it is desirable for the unique bottleneck set to be the entire set of tasks because this allows capacity to be shifted to compensate for fluctuations in demand and/or service rates. Finally, when demand and service ability are sufficiently balanced, skill chaining is known to be an effective strategy, but

it is suboptimal in more heterogeneous settings. Explicit criteria are provided for determining precisely when chaining and other cross-training strategies are capacity effective, including the well-known "N" and "W" structures defined in the call center literature.

Pricing and Replenishment of Competing Perishable Product Variants under Dynamic Demand Substitution
Arvind Sainathan

Arvind Sainathan considers a situation in which a retailer sells a perishable product that has a shelf-life of two periods. This product is "new" in the first period and becomes "old" in the second. Every period, the retailer can decide on the prices for the new and old products, and the order quantity of the new product. Any of these decisions may be constant or may vary across different periods, depending on the context. The author also considers dynamic demand substitution in which consumers can substitute between the old and new products in the face of stock-outs. Any unsatisfied demand is lost. The author then attempts to answer several questions: Should the old product be offered? Which decisions should the retailer vary? How much does the retailer benefit from these actions? How do these actions change when the problem parameters change? He finds that demand uncertainty is necessary for the sale of old product to be profitable and that based on numerical experiments, most of the benefit can typically be obtained by selling the old product and just changing the order quantity.

Joint Stocking and Product Offer Decisions under the Multinomial Logit Model
Huseyin Topaloglu

Finding the right assortment of products to offer is a challenging problem in many retail settings. A larger product variety is useful to attract a larger share of the market, potentially increasing revenues. However, a number of products may also mean that the demand has to be split among them, effectively increasing the variability of the demand for each product and resulting in larger safety stocks and operational costs. Furthermore, when customers choose among the different products that are available to them, the demand model should capture the fact that there are substitution effects between the different products. Topaloglu shows that it is possible to develop a tractable model to find the right product variety to offer, while taking the inventory consequences and the substitution effects into consideration. The model indicates that if the demand

volumes are large, then giving priority to products with larger margins is a sensible thing to do, but this approach may not perform well when dealing with small demand volumes.

The Retail Planning Problem Under Demand Uncertainty
George Georgiadis, Kumar Rajaram

George Georgiadis and Kumar Rajaram consider the Retail Planning Problem in which the retailer chooses suppliers, and determines the production, distribution and inventory planning for products with uncertain demand in order to minimize total expected costs. This problem is often faced by large retail chains that carry private label products. They provide three sets research and management insights. First, the optimal inventory level when solving the joint supplier choice, production, distribution and inventory problem is smaller than when the inventory subproblem is solved separately. Thus, in order to minimize total supply chain costs, one needs to adopt an integrated approach to solve the joint. The authors's model provides a framework to analyze these decisions. Second, the two major costs that influence total (expected) supply chain costs are production costs and the understock costs associated with the variance in demand. Therefore retailers should focus on reducing these costs first before considering the effects of supplier capacity and contracting costs. Third, it is important to consider establishment, production, distribution and inventory costs together when choosing suppliers, because a supplier who is desirable in any one of these aspects may in fact not be the best overall choice. The authors' analysis provides a mechanism to integrate these aspects and pick the best set of suppliers.

How Inventory Cost Influences Introduction Timing of Product Line Extensions?
Te Tony Ke, Zuojun Max Shen, Shan Li

Determining the optimal product introduction timing is the key to a successful down-market stretch. One major question is how to penetrate market fast while reducing sales cannibalization among successive product generations. High inventory cost is pervasive, but its impact has long been ignored during the presale planning stage. Ke, Shen and Li attempt to fill this by jointly considering simultaneously demand-side diffusion and substitution effect as well as supply-side inventory cost. The authors show that under low inventory cost or frequent replenishment ordering policy, the optimal introduction timing follows the "*now-or-never*" rule. As the inventory holding becomes substantial or the product life cycle

gets shorter, managers should consider sequential introduction strategy. An increase in inventory cost could either expedite or postpone the optimal introduction timing, depending on characteristics of the specific product market.

Impacts of Power Structure on Supply Chains with Uncertain Demand
Ruixia Shi, Jun Zhang, Jun Ru

Power has shifted from manufacturers to retailers over the past two decades. However, it is not clear whether retailers benefit from this power shift. The key to answering this question is the relationship between the retail price and the expected market demand for the manufacturer's product. When the relationship is linear, the rise of retail power benefits the retailer while hurting the manufacturer. The relationship between the retail price and expected demand also determines how demand uncertainty affects the performance of supply chain members. When the relationship is linear, the reduction in demand uncertainty does not benefit the retailer, contrary to our intuition. On the other hand, reducing demand uncertainty always benefits the manufacturer. Consequently, a manufacturer should always encourage or even subsidize a retailer's endeavors to reduce demand uncertainty.

Managing Production and Distribution for Supply Chains in the Processed Food Industry
Katy S. Azoury, Julia Miyaoka

A supply chain in the processed food industry tends to have a large number of similar products with a wide range of demand levels. These numerous products typically share a small number of production lines that require significant production set-up times due to food safety standards. Moreover, trucking costs from the production facility to the warehouses are high. The problem of determining effective production planning and inventory allocation decisions is complex due to the above factors. These decisions involve which products to produce, in what quantities, and how to allocate what was produced to the warehouses. Azoury and Miyaoka propose an efficient and effective periodic review modeling approach to this problem which consists of two steps. In each period, the first step determines what and how much to produce by applying an algorithm that prioritizes products based on requirements. The second step allocates the production quantities to the warehouses by implementing a non-linear integer optimization program. In both steps, they incorporate various "look-ahead" features that consider future periods. They tested the model against an actual oper-

ation at Amy's Kitchen and found that the model leads to a balanced allocation of inventory across warehouses, which significantly reduces both inventory levels and stockouts.

Pricing and Capacity Rationing with Customer Disappointment Aversion
Qian Liu, Stephen Shum

Customers are averse to disappointment that arises when the outcome falls short of their expectations. Qian Liu and Stephen Shum explore the impact of disappointment aversion on strategic customers' purchasing decisions and the firm's pricing and rationing decisions. Without disappointment aversion, rationing is not effective in deterring customers from waiting until a low price, and hence it is not profitable. However, when customers are averse to disappointment, a firm may be able to increase profits with an appropriate amount of rationing. A carefully designed mark-down policy with rationing can effectively deter some customers from waiting until a low price and increase the firm's profit. In a mark-up pricing policy, customers have a second chance to purchase the product even if they are rationed out at a low price. Thus, whether the firm should create rationing to induce customer disappointment aversion behavior depends on how customers evaluate outcomes in different periods when forming utilities mentally. Rationing is profitable when customers compartmentalize outcomes in different periods to form utilities, but not when customers combine outcomes in different periods when forming utilities.

Broadband Network Management and the Net Neutrality Debate
Hong Guo, Hsing Kenneth Cheng, Subhajyoti Bandyopadhyay

The debate of net neutrality has the potential to fundamentally change the way digital content is delivered through the internet. The original design of the internet follows the net neutrality principle, i.e., all data packets are delivered with equal priority. Recently some broadband service providers (BSPs) have proposed several broadband management options that deviate from the net neutrality principle. Hong Guo, Hsing Kenneth Cheng, and Subhajyoti Bandyopadhyay study a complete spectrum of broadband network management options based on both the supply (content providers) and demand (consumers) sides of the market. These options are evaluated from both the BSP's perspective and the social planner's perspective. The findings support the case-by-case approach adopted by the Federal Communications Commission. Furthermore, specific market

conditions are identified to help distinguish "reasonable network management" from "unreasonable discrimination."

The Role of Contract Negotiation and Industry Structure in Production Outsourcing
Qi Feng, Lauren Xiaoyuan Lu

Qi Feng and Lauren Xiaoyuan Lu study the strategic impact of low cost outsourcing on manufacturers' profitability by investigating the contractual form of outsourcing agreements and the industry structure of the upstream supply market. Their analysis shows that wholesale-price contracts always mitigate the competition between manufacturers regardless of whether they compete with price or quantity. In contrast, two-part tariffs intensify the competition when the manufacturers compete with quantity, but soften it when they compete with price. As a result, when outsourcing with two-part tariffs, the manufacturers may earn lower profits than they would from in-house production. This suggests that managers have to be wary about the downside of using coordinating contracts such as two-part tariffs when pursuing low-cost outsourcing strategies. Their analysis also sheds some light on the profitability of using an exclusive supplier for outsourcing. With wholesale-price contracts, the manufacturers are better off outsourcing to an exclusive supplier. However, with two-part tariffs, the manufacturers may earn higher profits by outsourcing to a common supplier than to an exclusive one when the manufacturers' bargaining power is sufficiently strong (weak) under quantity (price) competition.