

## Research and Management Insights

### Transfer Pricing and Sourcing Strategies for Multinational Firms

Masha Shunko, Laurens Debo, Srinagesh Gavirneni

Masha Shunko, Laurens Debo, and Srinagesh Gavirneni analyze a multinational variation of the traditional “make-or-buy” decision, in which the “make” decision is hindered by the fact that the manufacturing facility is located offshore, forcing the MNF to make a transfer-pricing decision in addition to a sourcing decision. The authors characterize the optimal transfer-pricing strategies that accomplish the dual goals of motivating divisional management to make favorable sourcing decisions and taking advantage of favorable tax rates at offshore locations. It is intuitive that transfer-pricing systems that use separate transfer prices for tax and incentive purposes will always achieve the first-best solution, however, they carry with them the burden of administrative and possibly punitive costs. The authors quantify and analyze the maximum inefficiency of using a single transfer-pricing system in terms of the after-tax MNF’s profit and find that MNFs facing a small average outsourcing cost and MNFs facing outsourcing costs with skewed distributions can use single transfer pricing without significant efficiency loss. The authors also show that these results extend to two practical variations of MNF structures: an MNF that faces operational constraints on its offshoring capacity and an MNF that uses compensation contracts linked to after-tax firm-wide profits.

### Dynamic Pricing and Inventory Management with Dual Suppliers of Different Leadtimes and Disruption Risks

Xiting Gong, Xiuli Chao, Shaohui Zheng

Source diversification and dynamic pricing are two widely used strategies for companies to mitigate the impacts of supply disruption. An important question that arises is: How should a firm jointly manage its inventory and price when it has multiple suppliers with different lead times, reliabilities, and costs, and when it faces price-sensitive random demands? Xiting Gong, Xiuli Chao, and Shaohui Zheng investigate this problem using a dynamic inventory control model with two suppliers. Besides characterizing the firm’s optimal inventory and pricing policies, they show

that having source diversification or higher supplier reliability increases the firm’s optimal profit and lowers the optimal selling price; hence it benefits both the firm and its customers. In addition, they demonstrate that, when dynamic pricing is allowed, a supplier may receive more orders from the firm after an additional supplier is introduced; this, however, can never happen if the selling price is exogenously given. Their findings will help practitioners to better manage their inventory and pricing in the presence of multiple sourcing and potential supply disruptions.

### Optimal Procurement Design of an Assembly Supply Chain with Information Asymmetry

Xiang Fang, Jun Ru, Yunzeng Wang

Driven by an enthusiastic search for cost reduction in the global economy, many OEM firms have shifted their strategy from a traditional in-house manufacturing of everything to outsourcing of components production to independent suppliers. While the overall production costs can be lower, outsourcing brings in conflict of interest into the supply chain, and conflict of interest hinders the cooperation of independent firms (i.e., component suppliers and the final product assembler) that is critical to the success and profitability of each individual firm. In particular, in such an assembly supply chain, the severe lack of transparency in cost information among suppliers often causes a misalignment of production decisions and a misalignment of productions then leads to distrust and non-cooperative behavior among the firms. Xiang Fang, Jun Ru, and Yunzeng Wang develop a contractual mechanism for an OEM firm to optimally coordinate the production and price negotiation with component suppliers, so as to eliminate the potential misalignment of decisions due to asymmetry of information and to improve profitability for the OEM in the supply chain.

### Pay-Back-Revenue-Sharing Contract in Coordinating Supply Chains with Random Yield

Sammi Y. Tang, Panos Kouvelis

In supply chains where multiple retailers source from a common unreliable supplier, retailers often compete for not only the market, but also the limited supply when the supplier’s yield is poor. Retailer

competition and supply uncertainty lead to two distortions: the supplier may under-produce because of the risk of dealing with excess output in good yield realizations; retailers may over-order in order to secure their share of the supply and the market. To eliminate these inefficiencies, Tang and Kouvelis propose a contract that constructively combines two well-known coordination mechanisms: a pay-back mechanism, by having the retailer pay a discount price for the supplier's excess output, induces the supplier to produce more; and a revenue-sharing mechanism, by allowing the supplier to get a portion of the retailer's sales revenue, reallocates the retailer's revenue so their benefit from over-ordering is dampened. This pay-back-revenue-sharing contract can achieve coordination also for a linear supply chain facing both supply and demand uncertainties, if the supplier sells below cost. When the wholesale price is above cost, this contract seems to overdo it in supplier incentives and as a result the supplier over-produces. For this situation, Tang and Kouvelis propose a modified version of the pay-back-revenue-sharing contract in which the supplier does not get a portion of the retailer's entire revenue, but only gets a portion of the revenue made from sales of the output in excess of the retailer's original order. The proposed contracts not only have some practical basis, but also have the potential to streamline rather complex provisions in the contracts currently used in random yield environments.

### **Optimal Sourcing and Lead-Time Reduction under Evolutionary Demand Risk**

Suzanne de Treville, Norman Schürhoff,  
Lenos Trigeorgis, and Benjamin Avanz

As the time between placing an order and delivering the product increases, the demand volatility faced by the ordering firm increases as well. Increased demand volatility exposure results in higher supply-demand mismatches. Although managers often have the intuition that the cost of these mismatches may be substantial, tools that give managers a clear understanding of how mismatch cost increases in lead time are not widely available. Suzanne de Treville, Norman Schürhoff, Lenos Trigeorgis, and Benjamin Avanzi present a tool based on quantitative finance theory that quantifies the relationship between lead time and mismatch cost.

Each additional instant of time between the production decision and termination date is assumed to add a dose of volatility, as is assumed under the Black-Scholes option-pricing model. This "constant volatility" assumption gives a plausible picture of how the demand density changes in lead time. The order

quantity is derived by applying the target service level to the demand density for a given lead time. The service level can be established to maximize profit or can be set higher to ensure customer satisfaction. The mismatch cost is minimized at the profit-maximizing service level, establishing a lower bound for the mismatch cost. The increase in mismatch cost as lead time increases is transformed into an indifference frontier that answers the question: For a given lead time, what percent cost reduction is required to make the decision maker indifferent between the mismatch cost and the cost reduction?

The demand forecast often does not evolve according to a constant volatility assumption. Information about demand often arrives in clusters rather than in a steady stream. De Treville et al. show that the mismatch cost increases in the volatility of volatility, thus the constant volatility assumption yields a lower bound of the mismatch cost for a given lead time. The first key managerial insight is that the cost differential required to compensate for increases in lead time becomes quite large as volatility increases even under the constant volatility model with a profit-maximizing order quantity, and becomes even larger as volatility becomes stochastic and the order quantity differs from that which maximizes profit. The second key managerial insight is that incremental lead-time reduction is often of substantially less value than lead-time reduction that allows the production decision to be made close to when demand is known. The tool shows how a company that reduces lead times from 10 weeks to seven weeks might experience little benefit and therefore conclude that lead-time reduction does not pay off, whereas a reduction to two weeks would have paid off richly.

### **Differences in Retail Inventory Investment Behavior During Macroeconomic Shocks: Role of Service Level**

Saravanan Kesavan, Tarun Kushwaha

Understanding how retailers change their inventory investment during economic uncertainty is vital for their suppliers to plan their inventory efficiently. While it is known that retailers tend to increase inventory investment during expansion shocks and reduce inventory investment during contraction shocks, it has been unclear whether all retailers react similarly or if there are differences across them and if so, what drives those differences? Saravanan Kesavan and Tarun Kushwaha use 25 years of archival data to show that inventory increases observed during expansion shocks are predominantly driven by high service level retailers while inventory decreases

during contraction shocks are predominantly driven by low service level retailers. Thus, suppliers should classify retailers based on their service level and plan inventory separately for different segments to reduce excess and shortages of inventory at their ends.

### **The Effect of Demand-Supply Mismatches on Firm Risk**

Kevin B. Hendricks, Vinod R. Singhal

Equity volatility, measured as the standard deviation of equity returns, is a common measure of overall firm risk. The level of equity volatility and changes in equity volatility can have a meaningful impact on the firm, its management, and stakeholders. Kevin Hendricks and Vinod Singhal study the effect of three different types of demand-supply mismatches (DSMs) on equity volatility. The evidence indicates that all three types of DSMs result in equity volatility increases with mean abnormal equity volatility increases of 5.62% for production disruptions, 11.19% for excess inventory, and 6.28% for product introduction delays. Volatility increases associated with excess inventory are significantly higher than the increases associated with production disruptions and product introduction delays. Across all three types of DSMs, volatility changes are positively correlated with changes in information asymmetry. The results provide some support that volatility changes are also correlated with changes in financial and operating leverage. Firms can take actions to mitigate volatility risk due to DSMs by changing their cost structure and/or capital structure. Reducing the frequency of DSMs or severity of DSMs can reduce the exposure of the firm to the negative impacts of increased volatility. Since increased information asymmetry among investors due to DSMs increases equity volatility, firms can attempt to reduce the information asymmetry by timely and relevant disclosures about DSMs, their potential impact, and what actions the firm is taking to deal with it.

### **Quality Risk Ratings in Global Supply Chains**

Zach Zhizhong Zhou and M. Eric Johnson

Managers within global extended enterprises face many challenges in managing the product quality of distant suppliers. Recent initiatives to characterize and rate the quality risk posed by value-chain partners have opened the possibility of new risk rating services. Using an analytical model, Zhou and Johnson investigate the impact of such quality rating services on suppliers and manufacturers under various market conditions. They show that when a manufac-

turer has sufficiently high willingness-to-pay for a unit increase of product quality, then risk rating benefits suppliers by encouraging them to offer higher quality products at higher prices. However, when manufacturers have low willingness-to-pay for a unit increase of product quality, risk rating can hurt suppliers by intensifying competition. The authors also show that risk rating can hurt manufacturers when the high-quality supplier identified by the rating subsequently increases price.

### **Linking Process Quality and Resource Usage: An Empirical Analysis**

Dimitrios A. Andritsos, Christopher S. Tang

Using a sample of US hospitals and cardiac care as our context, Dimitrios Andritsos and Christopher Tang show empirically that stricter adherence to evidence-based medical guidelines (or improved “process quality”) can reduce resource usage in the course of a patient’s treatment. This finding complements existing medical literature which suggests that improved process quality can also positively impact outcomes such as mortality rates. Taken together, these two findings imply that pay-for-performance programs that reward improved process quality have the potential to be a winning proposition under which better outcomes can be attained at lower costs. Nevertheless, this work also suggests that anticipated cost savings are modest in magnitude. Therefore, such savings need to be weighed against the costs of instituting and running P4P programs. Second, the authors show that the increased standardization of care that is attained through stricter adherence to evidence-based medical guidelines can be especially beneficial to cardiac departments that deal with a wider range of medical conditions. Higher process quality has a bigger impact on the resource usage of such less “focused” cardiac departments. Due to the wider range of conditions that these less “focused” departments treat, they are faced with increased operational complexity. Adherence to guidelines can help mitigate any associated operational issues.

### **Life is All about Timing: An Examination of Differences in Treatment Quality for Trauma Patients Based on Hospital Arrival Time**

David Anderson, Guodong (Gordon) Gao, Bruce Golden

Improving the quality of care is a challenge. While most studies focus on the cross-hospital quality variations, David Anderson, Guodong Gao, and

Bruce Golden find substantial within-hospital quality variation, using a large dataset from the National Trauma Database. Even after controlling for differences in patient characteristics, the mortality rate is significantly higher off-hours (6 PM – 6 AM) than during the daytime. Additionally, the authors find that surgical complication rates, lengths of ICU stays, and the likelihood of needing multiple surgeries are all higher for patients arriving off-hours. The difference in quality of care is even more pronounced at low level trauma centers. The authors find supporting evidence that the increase in mortality in off-hours is consistent with the lack of high quality resources, such as specialized surgeons, available during off-hours.

This work highlights the significance of the variation in quality of care associated with patient arrival time. The decreases in quality of care lead to on the order of a \$1 billion increase in medical costs and roughly 8,000 extra deaths a year. Insights from this study contribute to a better understanding of what causes quality fluctuation in a hospital, which should be valuable to hospital administrators. The results also should be considered when writing ambulance routing laws, such as those that require patients be taken to the nearest hospital. These findings indicate that hospitals could reduce the above variation by making more high quality resources available to treat patients arriving at off-hours.

### **Measuring the Contribution of Workers' Health and Psychosocial Work-Environment on Production Efficiency**

Fredrik Ødegaard, Pontus Roos

Increasingly many firms are implementing programs intended to improve various quality aspects of their softer or human-resource based operations. Two common initiatives include improving the health of the workers and the psychosocial work-environment. A key question that arises is how an operations manager can evaluate the impact from these initiatives on firm productivity? Or even more generally, how can sustainability issues regarding employees' work-related well-being be measured and evaluated with regard to firm productivity? Ødegaard and Roos develop a model for measuring the contribution that labor quality attributes may have on firm productivity. In order to assess the contribution the authors consider firm productivity as the outcome of two separate processes within a firm: the physical production process and the labor quality process. Firm

productivity is then measured by a Malmquist-like productivity index and is computed by Data Envelopment Analysis. The labor quality attributes are modeled at an individual worker level as latent variables and estimated through Item Response Theory, and then aggregated to a firm level. Their empirical analysis, conducted at three Swedish manufacturing plants over a four year period, indicate that improvements in labor quality attributes may provide small – at the order of a few per cent – but significant contribution to improvements in firm productivity. A key benefit with their model is that it is practical, easy to implement and very fast to compute.

### **Panel Size and Overbooking Decisions for Appointment-based Services under Patient No-shows**

Nan Liu, Serhan Ziya

Patient no-show is a serious problem faced by many outpatient providers. Many studies have found that patients are more likely to miss their scheduled appointments when their appointment delays (the time between the call for the appointment and the appointment date) are longer. On the one hand, clinics do not want to lose patients by turning them away but on the other hand, more patients mean longer appointment delays, which in turn lead to higher no-show rates and essentially reduce the effective capacity of the clinic. Thus, clinics need to find the right balance. Nan Liu and Serhan Ziya investigate how a clinic aiming to achieve this balance makes decisions regarding its patient load through its choice of panel size and service capacity possibly through overbooking. Specifically, they develop a single server queueing model, which captures the relationship between no-show probabilities and appointment delays in a stylized manner. They investigate two scenarios. In the first, the service capacity is fixed and the decision variable is the panel size; in the second, both the panel size and the overbooking level are decision variables. They characterize the optimal decisions for both problems, and find that in addition to the magnitudes of patient show-up probabilities, the sensitivity of these probabilities to incremental delays also play a crucial role. As many providers are engaged in interventions (such as sending reminders) that can improve patient attendance rate, the findings in this article are particularly useful to inform decisions that should be adjusted in response to potential changes in patient no-show behavior.