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Abstract Summary

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Session 1A – Healthcare Operations I

Evaluating Efficiency in Lean Emergency Department: A Slack-Based Model

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Lean healthcare was measured with multiple performance metrics but there is lack of tools that enabled lean assessment across a group of homogeneous peers. Slack-Based Measure Data Envelopment Analysis (SBM-DEA) developed by Tone (2001) may provide insights into lean efficiency, but such application in the healthcare system is still limited. This research aimed to assess the efficiency among lean emergency departments by comparing the before and after lean implementation outcomes. Results exhibited improvement in some public emergency department upon lean implementation and the proposed SBM-DEA model may offer benchmarking capability that may complement the lean continuous improvement philosophy.

Keywords: Healthcare operations management, Slack-based measure, Efficiency, Emergency care

Understanding Surgery Duration from New Perspectives: Evaluation from A Database on Thoracic Surgery

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Surgery duration is usually used as an input of the operation management (OM) problems in operation rooms (ORs). In contrast, we investigate whether the allocation decisions in turn influence surgery duration. Using almost two years of data from a large hospital in China, we find evidence in support of our conjecture. Surgery duration can be divided into three segments, each of which is performed by surgeons or anesthetists and nurse. We can predict surgery duration better by predicting the three segments separately. We provide new perspectives to understand surgery duration, and insights to reformulate OM problems in ORs.

Keywords: Surgery duration, workload, surgery sequence, surgeon, anesthetist

Mutual Referral in Healthcare with Patient Choice

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In China, patients have free access to doctors. Recently the Chinese government is launching a reform to build up a two-way referral healthcare system. In this paper, we study mutual referral with patient choice where a patient chooses to see general practitioner (GP) or specialist (SP) first according to his/her sensitivity to the doctor's ability (service quality) and waiting time in the chosen system. The government sets a treatment threshold in terms of disease complexity for referral, above which, the patient is referred up to SP and is referred down to GP otherwise. We compare the optimal policy between the independence and depdence of the sensitivity to service quality and waiting time. We further compare the optimal policy and total cost between the mutual referral system and the gatekeeper system where patients must go to GP first and can be referred from GP to SP only. Managerial insights are discussed as well.

The Efficiency Evaluation and Difference in Space and Time of Care in Rural Nursing Homes in China

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The construction of rural old-age service institutions is the meaning of building a moderately prosperous society in all respects. According to the existing research results about the efficiency evaluation of Care in rural Nursing Homes, this paper established evaluation index system regarding Care in Nursing Homes' efficiency and evaluation model; Then, selecting the statistical data from 2009 to 2014 of Care in Nursing Homes in 31 provinces of China. Using DEA method to evaluate the efficiency of Care in Nursing Homes from three perspectives including the comprehensive efficiency, return to scale, projection analysis. What's more, analyzing the dynamic change and characteristics of time and space on efficiency. Results show that the pure technical efficiency of Care in Nursing Homes in most provinces is lower than the scale efficiency, the low pure technical efficiency is the main reason for the lower comprehensive efficiency; From 2006 to 2013 year, the efficiency index ranged inconspicuously, the speed of improving efficiency of Care in Nursing Homes is relatively slow. It need to improve the comprehensive efficiency of Care in Nursing Homes from the level of efficiency and speed. Finally, the measures and suggestions on improving efficiency of Care in Nursing Homes were put forward.

Keywords: Care in rural Nursing Homes, DEA method, efficiency evaluation, difference in space and time

Session 1B – Emerging Supply Chain and Retailing

The Optimal Production Decision under Green Loan Policy

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This paper proposes a Stackelberg game with two players, including the government providing green loan to green products and a monopoly enterprise producing both primary products and green products with capital constraint respectively. The optimal interest subsidy and production decisions for both players are discussed under two kinds of green loan policies, which are interest rate discounts(Model I) and interest free loans (Model II).The result shows that the government's decision about whether to provide interest subsidy are determined by the environment effort coefficient of green products and the manufacturer will take different pricing strategies correspondingly. Some management insights about the green loan policies to improve the environmental efficiency are given in this paper.

Which Pre-Sale Contract to Choose: Locking the Regular Price or Locking the Benefit

Jiajing Lu, Yongquan Lan
School of Management, Xiamen University

This paper compares two pre-sale contracts that e-commerce sellers may choose before the promotion. The first contract provides full price information, which gives buyers both the pre-sale price and the regular price information, while the second contract provides incomplete price information, that is, buyers only know the regular price and additional benefits when participating in pre-sale.We consider the condition in which the external market promotion has an impact on the buyers' willingness to pay and incorporate it into our model. Specifically, we investigate the seller's pre-sale contract selection strategy, taking into account the inventory constraints, logistics cost, buyers' willingness to pay and so on. Moreover, some management insights are also discussed in this paper.

The Impact of Demand Uncertainty and Government Subsidy Constraint on Green Technology Adoption

Zhe Tan, Zhaowei Miao
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This paper proposes three models, including consumer rebates model (CRM), cost subsidy model(CSM), bi-subsidy model(BSM). We use the stackelberg model, the newsvendor model and the nonlinear programming to investigate the impact of demand uncertainty and government subsidy constraint on the adoption of green technology. The results show that, demand noise has no influence on the unit subsidy in CRM; for CSM, demand uncertainty decreases the price, the profits for the supplier and the unit subsidy; the government offers less subsidies for unit production in BSM. We also analyze the social welfare to get some management insights for different models and different market conditions respectively.

The Benefit of Uniform Price with Search Cost for Omnichannel Retailing

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With increasing concerns over omnichannel problems, uniform pricing is becoming an attractive strategy for many retailers. This paper studies how omnichannel retailers can effectively make pricing decisions for their online and offline channels and whether the uniform pricing strategy is effective based on consumers' search and purchase behavior. We incorporate consumers' online return probability, online return cost and search cost into a model and divide consumers into two types: myopic consumers and strategic consumers. Finally, we provide several managerial insights for omnichannel retailers through comparisons of search cost, return cost, return probability and consumer type.

Online Advertising by Competing Retailers

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In the contemporary e-commerce, it is important to distinguish between different types of advertising: persuasive advertising and advertising about price, representing different information. In this paper, through a two-stage game model with two heterogeneous retailers, we investigate whether there exists an equilibrium for the retailer to refer consumers to the other one through persuasive or price advertisement. Specifically, this paper not only investigates the equilibrium choice about advertisement, but also illustrates the impact of strategic and loyal customers on the referral strategy in order to demonstrate the retailer's referral motivations and the collusion between the two channels.

Session 1C – OM-Marketing Interface I

Selling Strategy in the Presence of Social Learning and Reference Effects

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We investigate a firm’s pricing decision under two strategies: price discount and surprise bonus. The firm launches a new product in two periods and confronts consumers with social learning behavior. Early consumers make purchase decision based on intrinsic valuations and also post reviews after purchase. Later consumers observe early reviews and then make purchase decision. The surprise bonus strategy is more beneficial to the firm, and also it enlarges the scope where reviews improvement is adopted. In addition to this, the firm may charge price lower than production cost with price discount, while it never happens with the bonus strategy.

Keywords: social learning, reviews, price discount, surprise bonus

How Barter Affects Probabilistic Selling?

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After buying probabilistic products, customers intend to barter with others. We explores the motivation of offering probabilistic product with barter choice and answer the question that how barter affect the optimal decisions and profitability of probabilistic selling. The results show that barter increases probabilistic products sales while cannibalizing the regular products sales. Barter broadens the application range of probabilistic selling and the range would increase with barter probability. If barter probability is below one threshold, barter can increase the profit of probabilistic selling when product cost is in a midrange. Besides, the cost range also increases with the barter probability.

Keywords: Probabilistic selling, Bartering, Pricing, E-commerce

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Extract Market Information from Strategic Inventory in New Product Launch

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In the literature of new product launch and product rollover, it's usually assumed that the manufacturer has perfect control towards the rollover strategy. However, this is not always valid in reality. In this study, we consider a manufacturer introducing a new product via a retailer who might deviate from the rollover strategy designed by the manufacturer, through strategic inventory. We find that such deviation would not only help coordinate the supply chain, but also enable the manufacturer to extract market information from the better informed retailer.

Keywords: New product launch, product rollover, strategic inventory, information asymmetry, supply chain management

Selling Discretionary Services to Strategic Customers with Peripheral Consumption

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Discretionary services are those in which customers prefer not to wait in line, but also derive more value from longer service. The fact that the service provider can obtain a proportion of the peripheral revenues complicates the speed-quality trade-off decision. We use a strategic queueing framework and find that if the peripheral price increases, the service provider reduces the service fee and improves service quality, but the demand rate still decreases. This effect is more profound if the service provider obtains a lower fraction of the peripheral revenues. Moreover, when the customers become more sensitive to service quality, counter-intuitively, the service provider might speed up the service, which lowers service quality. We also show insights with respect to social welfare and the effects of regulation policies.

Keywords: strategic customers, queueing games, service operations

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Session 1D – Empirical Research I

Gatekeeping under Congestion: An Empirical Study of Referral Errors in the Emergency Department

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Using data from over 350,000 visits to an emergency department (ED), we study the effect of congestion on the accuracy of gatekeeping decisions (hospital admission or discharge home) and the effectiveness of a second gatekeeping stage (a clinical decision unit (CDU)) in reducing errors. We find that when congestion increases, physicians prevent an increase in wrongful discharges – a more safety-critical concern – by lowering the threshold for hospital admission. We also show that introducing a second gatekeeping stage – to which front-line gatekeepers can pass customers if they are unable to make an accurate referral decision – can mitigate this effect.

Keywords: gatekeeping, congestion, health care, econometrics

Effects of Rescheduling on Patient No-Show Behavior in Outpatient Clinics

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Kum Khiong Yang: Independent
Zhichao Zheng: Singapore Management University

We study the effects of waiting time and rescheduling on no-show behavior in an outpatient appointment system for both new and follow-up patients. Previous literature has primarily focused on new patients and investigated the role of waiting time on no-show probability. We offer a more nuanced understanding of this costly phenomenon. Using comprehensive clinical data, we demonstrate that waiting time has little effect on no-show behavior of follow-up patients. Instead, their no-show probability decreases significantly if their appointments were rescheduled at their own requests but increases significantly if they were rescheduled by the clinic. New patients, in contrast, are only concerned about waiting time and are insensitive to who initiates the rescheduling. Our results provide useful implications for managing no-shows. First, clinics can strategically promote active rescheduling by follow-up patients to reduce no-shows; second, the slots freed up by such rescheduling can be offered to new patients, whose attendance would be boosted due to shorter waiting times. These policies can work collaboratively to reduce no-shows and increase throughput.

Keywords: Healthcare Appointment Scheduling, No-show, Rescheduling, Waiting Time

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Dynamic Pricing of the Ride Sharing Market in a Spatial Search Model

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Ride-sharing platforms employ flexible pricing during peak hours to match supply with demand. We build a spatial search model to study the geographic dynamics among drivers. Utilizing data from a leading ride-sharing platform we assess the impact of pricing on drivers' capacity distribution and the customer surplus. In the counterfactual analysis we compare the performance of current pricing scheme with a set of pricing strategies.

Keywords: Empirical, Ride sharing, Pricing

The Impact of Bundled Payment Policy on Healthcare Operations: Evidence from China

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The paper studies the impact of bundled payment on healthcare spending, utilization and quality, by using insurance claim data. We provide new evidence from China on the impact of bundled payment versus fee-for-service on health care operations. Our main results show that bundled payment reduces medical cost and length of stay in general, while increases readmission and revisit rates. We explore the impact of bundled payments in different types of hospitals, for example, small county hospitals and large provincial hospitals. Our results show that cost reduction in provincial hospitals is significant while the quality of care is maintained. However, the medical cost in country hospitals was not reduced after the implementation of bundled payment. To explain the difference, we investigate the impact of specified quota of bundled payment. The value (quota) of bundled payment varied in different hospitals. The quota for county hospitals is higher than their expected cost, while the quota for provincial hospitals is lower than the historical average cost. That is why county hospitals have less incentive to redesign care and control cost. In general, quota is positively correlated with cost and length of stay, and has weekly impact on quality.

Keywords: Bundled payment, healthcare operations, econometrics, length of stay, readmission

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Session 1E – Online Retailing

Shipping Consolidation with Delivery Deadline and Expedited Options for E-Commerce and Omni-Channel Retailers

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Shipment consolidation is commonly used to avoid some of the shipping costs. However, when delivery of current orders is delayed to consolidate them with future orders, a more expensive expedited shipment may be needed to meet shorter deadlines. In this paper, we study the optimal consolidation policy focusing on the trade-off between economies of scale due to combining orders and expedited shipping costs. The optimal policies and their structures are characterized in settings with up to two warehouses. Two easily implementable heuristics are proposed that perform within 1-2% of the optimal solution and outperform other benchmarks in numerical tests.

Incentive Issues in The Implementation of Urban Consolidation Centers

Qiyuan Deng, Xin Fang, Yun Fong Lim
Lee Kong Chian School of Business, Singapore Management University

The growth of urban migration and e-commerce worsens traffic congestion in cities, creating negative impacts on the well-being of the cities. An urban consolidation center ('UCC') is a potential solution to this problem. A UCC consolidates goods from multiple carriers before shipping them to city centers. However, many UCC initiatives are not successful in practice. In this paper, we explore the reasons for the failure of UCC initiatives and propose that a consolidator can develop a sharing platform among carriers for capacity sharing. We develop a game-theoretical model to capture the incentives of carriers/consolidator to use/develop a UCC and a capacity sharing platform. Our analysis reveals that there exists mismatch between the interests of the carriers and the consolidator.

Spatial Pricing and Inventory Allocation

Long He: NUS Business School, National University of Singapore
T. Tony Ke: MIT Sloan School of Management

We study how an online retailer of multiple products should allocate its products to fulfillment centers (FCs) to facilitate spatial price discrimination. When deciding between a centralized inventory allocation (i.e., different products are allocated to the same FC) and decentralized inventory allocation (i.e., different products are allocated to different FCs), the retailer faces the tradeoff between shipment pooling (i.e., shipping multiple products in one package) and demand localization (i.e., stocking products to satisfy local demand). We consider the interaction between the choice of inventory allocation scheme and two most commonly used spatial pricing policies: free on board (FOB) pricing that charges each customer the exact amount of shipping cost, and uniform delivered (UD) pricing that provides free shipping. Under centralized inventory allocation, the FOB pricing will essentially create bundles of multiple products sold at discount, due to cost savings via shipment pooling. Using a stylized model, we find that centralized inventory allocation is preferred when demand localization effect is relatively low or shipment pooling benefit is relatively high. Moreover, centralized inventory allocation is more preferred under the FOB pricing. When demand function is linear and shipping cost is moderate, we show that both the FOB and UD pricing yield the same profit under decentralized inventory allocation and the FOB pricing yields higher profit under centralized inventory allocation. We further extend the model to incorporate the inventory pooling effect in the presence of stochastic demands as well as a more general class of spatial pricing policies. To validate our analytical findings, we formulate the joint spatial pricing and inventory allocation problem as a second-order conic program, and conduct numerical experiments for a general setting with multiple products and discrete demand locations. Our computational results also support the analytical findings from the stylized models.

Matching Supply with Demand for Online Retailing

Song Jiu, Yun Fong Lim, Marcus Ang
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We consider an online retailer selling multiple products over a multi-period horizon. At the start of each period, the retailer replenishes from multiple suppliers, and allocates the received inventory to multiple fulfillment centers. At the end of each period, the retailer fulfills the realized demands of different zones from different fulfillment centers. We propose a two-stage robust optimization approach that first determines the binary replenishment decisions and then refines the replenishment, allocation, and fulfillment quantities subsequently. A case study with an online retailer suggests that the approach generates good-quality solutions for real-size instances.

Session 1F – Best Student Paper Competition Finalists I

Ranking and Selection with Covariates for Personalized Decision Making

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We consider a ranking and selection problem in the context of personalized decision making, where the best alternative is not universal but varies as a function of observable covariates. The goal of ranking and selection with covariates (R&S-C) is to use sampling to compute a decision rule that can specify the best alternative with certain statistical guarantee for each subsequent individual after observing his or her covariates. A linear model is proposed to capture the relationship between the mean performance of an alternative and the covariates. Under the indifference-zone formulation, we develop two-stage procedures for both homoscedastic and heteroscedastic sampling errors, respectively, and prove their statistical validity, which is defined in terms of probability of correct selection. We also generalize the well-known slippage configuration, and prove that the generalized slippage configuration is the least favorable configuration of our procedures. Extensive numerical experiments are conducted to investigate the performance of the proposed procedures. Finally, we demonstrate the usefulness of R&S-C via a case study of selecting the best treatment regimen in the prevention of esophageal cancer. We find that by leveraging disease-related personal information, R&S-C can improve substantially the expected quality-adjusted life years for some groups of patients through providing patient-specific treatment regimen.

Keywords: ranking and selection, covariates, probability of correct selection, least favorable configuration

Constant-Order Policies for Lost-Sales Inventory Models with Random Supply Functions: Asymptotics and Heuristic

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We consider an infinite-horizon lost-sales inventory model where the supply takes positive lead time and is a random function of the order quantity (e.g., random yield or capacity). The optimal policy for this model is very complex and intractable due to the curse of dimensionality; and no effective heuristic has been proposed in the literature. In this paper, we focus on a simple class of constant-order policies (COP) that place the same order in every period, regardless of the system state. Under some mild assumptions on the random supply function, we prove that the best COP is asymptotically optimal with large lead times and the optimality gap converges exponentially fast to zero. In addition, we prove that, if the mean supply capacity is less than the mean demand, then the best COP is also asymptotically optimal with large penalty cost; otherwise, the long-run average cost of the best COP asymptotically increases at the rate of square-root of the penalty cost. Furthermore, we construct a simple heuristic COP and show that it performs very close to the best COP. Finally, we conduct numerical studies to derive further insights into the performance of the best COP.

Key words: inventory, lost sales, random supply function, constant-order policy, lead time, penalty cost

Service Design under Acclimation and Non-homogeneous Memory Decay

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In today's "experience economy," service providers increasingly emphasize creating memorable, delightful service experiences, a crucial aspect of which is the schedule of activities a service package comprises. Empirical literature shows an ideal schedule often entails an interior peak; that is, the most engaging activity (aka peak activity) is scheduled neither at the beginning nor the end of the package. Theoretic literature, on the other hand, points to a U-shaped schedule such that the peak activity should be scheduled either at the beginning or the end. To bridge this gap between empirical and theoretical literature, we modify the acclimation and memory decay (AMD) model by incorporating heterogeneity in the memory-decay rates across different activities. We find, surprisingly, this heterogeneity alone is sufficient to explain the phenomenon of interior peaks often observed in practice but not explained by the theoretic literature. We show that whenever an interior peak is optimal, it is optimal to schedule a low-utility activity either before or after-but not both before and after-the peak activity. Furthermore, we find an interior peak is optimal when the memory-decay rate of the peak activity is neither too high nor too low. Our analysis also leads to several nonintuitive results. For instance, as the memory-decay rate of the peak activity increases, one might expect the optimal start time of the peak activity to increase. Our results, however, show such a start time may change in a non-monotonic fashion. Lastly, we devise a pseudo-polynomial time, dynamic programming algorithm for the optimal service design.

Keywords: service design, memory decay, acclimation, service operations, dynamic programming.

The Analytics of Bed Shortages: Coherent Metric, Prediction and Optimization

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Bed shortages in hospitals usually have a negative impact on patient satisfaction and medical outcomes. In practice, healthcare managers often use bed occupancy rates (BOR) as a metric to understand bed utilization, which is insufficient in capturing the risk of bed shortages. Based on the riskiness index of Aumann and Serrano (2008), we propose the entropic bed shortage metric, which captures more facets of bed shortage risk than traditional metrics such as the occupancy rate, the probability of shortages and expected shortages. Building upon this, we propose the entropic BOR, which represents the risk-corrected BOR and can be intuitively understood by practitioners. Our metric has the ability to incorporate high-fidelity statistical information without compromising its computability, and can be consistently used across the descriptive, predictive and prescriptive analytical approaches. We also propose optimization models to control the risk of bed shortages and plan for bed capacity via this metric. These models can be efficiently solved on a large scale via a sequence of linear optimization problems. The first determines the optimal scheduling policy by lexicographically minimizing the steady state daily entropic bed shortage metric for a given number of scheduled admissions. The second maximizes total elective throughput while managing the metric under a specified threshold. We validate these models using real data from a hospital and test them against datadriven simulations. We apply these models to study the real-world problem of long stayers, to predict the impact of transferring them to community hospitals, as a result of an aging population.

Keywords: Analytics, bed shortages, coherent metric, riskiness index, data-driven optimization, simulation

Session 1G – Business Analytics in OM I

Managing the Cross-Channel with the Uniform Pricing: Theory and Empirical Findings

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The uniform and the dual pricing strategies for a cross-channel firm have attracted the interest from both academics and practitioners. In this paper, we assume the product has the digital and the nondigital attributes and the consumers' random preferences for the attributes are correlated. We derive and compare the firm's optimal prices and profits under the uniform and the dual pricing. An important finding is that the uniform pricing can outperform the dual pricing even with a price lower than both the online and the offline prices, which creates a mutually beneficial situation for the consumers and the firm. In addition, we show that this win-win situation is more achievable when the correlation between the digital and the nondigital attributes is higher and/or the offline-to-online cost is higher, and this result is interpreted from the perspectives of the operations efficiency and the information disclosure. Our analysis also indicates that the high correlation between the digital and the nondigital attributes benefits the firm. The theoretical results are assessed by the empirical analysis conducted using the real data from Suning Commerce Group.

Key words: uniform pricing, multiple attributes, cross-channel

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Inventory Management under Corporate Income Tax

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The growth of urban migration and e-commerce worsens traffic congestion in cities, creating negative impacts on the well-being of the cities. An urban consolidation center ('UCC') is a potential solution to this problem. A UCC consolidates goods from multiple carriers before shipping them to city centers. However, many UCC initiatives are not successful in practice. In this paper, we explore the reasons for the failure of UCC initiatives and propose that a consolidator can develop a sharing platform among carriers for capacity sharing. We develop a game-theoretical model to capture the incentives of carriers/consolidator to use/develop a UCC and a capacity sharing platform. Our analysis reveals that there exists mismatch between the interests of the carriers and the consolidator.

The Impact of Supply Chain Green Integration on the Triple Bottom Line: Evidence from China

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The study investigates the impact of supply chain green integration on the triple bottom line, which consists of environmental, economic, and social performance. This study extends the extant literature by (1) conceptualizing green integration into green strategic alignment, information sharing, and process coordination, (2) considering the supply chain wide green initiatives, and (3) analyzing the effects on three aspects of the triple bottom line. Based on data from 206 manufacturers in China, we find that supplier green integration impacts financial performance; internal green integration improves environmental and social performance; customer green integration increases social performance.

Keywords: supply chain green integration, triple bottom line, China

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Estimating Sensitivities of Portfolio Credit Derivatives and Portfolio Credit Risk Using Monte Carlo

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Michael C. Fu: University of Maryland

Credit risk refers to losses caused by the failure of an obligor to make a contractual payment. A portfolio approach is always used to measure and manage the overall credit exposure when facing multiple sources of credit risk. Portfolio credit derivatives are contracts that are based on an underlying portfolio of defaultable assets and whose payoffs depend on the default times of these assets. Estimating the sensitivities of portfolio credit derivatives contract value with respect to underlying model parameters is an important issue in pricing portfolio credit derivatives. In this paper, we consider two important portfolio credit derivatives - basket default swaps and collateralized debt obligations (CDOs) and derive SPA (Smoothed Perturbation Analysis) estimators of their sensitivities with respect to both idiosyncratic and macroeconomic parameters. Our results are also applicable to portfolio credit risk problems where performance measures can be written as an expectation of a performance function of the portfolio credit loss. We give conditions under which the SPA estimators are unbiased and illustrate their application in threshold models (latent variable models) which are popular in basket default swaps pricing and portfolio credit risk management.

Session 1H – Sharing Economy I

The Impact of Estimation Accuracy in Car Rental

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In this paper, we consider a car rental problem with behavioral effects. Penalty cost will be incurred for customers if they return the cars later than scheduled. While the penalty cost is at higher level, the customers will be more prudent and hence make more accurate estimation on their uncertain length of rental. We study how this effect would influence the decision making of customers, and hence that of the car rental firm.

Keywords: hourly car rental, late penalty cost, Erlang distribution, behavioural operations management

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Cannibalization and Market Expansion Effects of On-Demand Car Rental on Mobility Demand

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On-demand car rental, also called B2C car sharing, is promoted as a new mobility mode to reduce private car use and ownership. We conducted a choice-based conjoint analysis in Beijing to unpack the underlying factors that influence the demand for on-demand car rental in comparison with other urban mobility modes. A random parameters logit model uncovers potential cannibalization effect of car sharing on the potential demand for adopting private cars, but more importantly market expansion effect that may increase the self-driving mobility demand, which provides implications on consumer preferences toward mobility modes and pricing strategy of on-demand car rental services.

Keywords: On-Demand Car Rental, Consumer Preference, Mobility Modes, Cannibalization Effect, Market Expansion Effect

Supply-Side Incentives in Centralized Ride Matching

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Centralized platforms match riders and drivers who were otherwise invisible to each other instantly, reducing the searching cost to almost zero. “Surge pricing”, a form of dynamic pricing which increases fare prices in periods of demand surge, is at the core of this efficiency gain. But this innovation has not been unreservedly welcomed. Consumers take price hikes as exploitation of people’s emergency. It is perceived as a business strategy that creates man-made incentives for drivers to exploit riders when they need a ride the most. By contrast, in decentralized taxi matching, the incentive variables that drivers respond to are mostly the spatial characteristics of demand. Riders understand that spatial heterogeneity, after all, is the intrinsic nature of transportation. When unwilling consumers vote No to the service, it is a business risk.

This motivates us to investigate alternative incentive schemes. Our starting point is that dynamic pricing is price differentiation. Price differentiation is discrimination reflecting economic choices. Those who discriminate are motivated to. If a firm values profits over customer satisfaction, there is nothing wrong to discriminate. However, if the firm cannot take the business risk and worries about market share, we suggest breaking the link between prices and demand pressure and use supply-side subsidy as the alternative channel to provide incentives. This mutes the negative price signals that riders resent, thus removing the man-made suppressing of demand.

The goal of this paper is to systematically study the efficacy of supply-side subsidies as alternative strategies to surge pricing. An important assumption we make is that the supply is finite and reusable, which reflects the distinguishing feature of a property-sharing marketplace. We will begin by deriving the spatial-temporal dynamics of supply and demand. We will then use it to find out the endogenous forces that give rise to the imbalances between supply and demand, in absence of any incentives. Further, we will take a game approach to quantify the effectiveness of a given level incentive. More importantly, we will investigate how incentives accumulate in agents account through time and how they are distributed across populations in long-term. It is a dynamic problem that combines the game setup with derived stochastic evolution. Understanding it helps us identify sources to control the Matthew effect.

Strategic Switcher, the Unique Feature of Ridesharing

Rowan Wang, Yini Gao: Singapore Management University
Saif Benjaafar: University of Minnesota

In this paper, we analyze the dynamics of ridesharing systems such as BlaBlaCar and DiDi Hitch. One unique feature of these ridesharing systems is the existence of a pool of users who can be both drivers (supply side) and riders (demand side) when they have a trip need. We call these users the strategic switchers. Depending on the possibility and time to be matched as well as the fare and wage, the strategic swithcers make the decidion on whether to take a ride or to drive and offer a seat. Using equilibrium analysis, we capture the systme dynamics of such ridesharing systems. We show the benefits of having such strategic switchers.

Session 1I – Sustainable Operations I

Optimal Bidding Strategy for Market Participants Considering Both Renewable Generation and Price

Kai Pan
Hong Kong Polytechnic University
Yongpei Guan
University of Florida

We present an optimal bidding strategy which is adaptive for the independent power producers to participate in both day-ahead and real-time markets by considering both renewable generation and price uncertainties. This proposed strategy is theoretically justified of its significant advantages over existing alternative ones. To improve the computational efficiency, polyhedral structures have been explored to strengthen the corresponding deterministic equivalent formulation.

Planning PEV Fast-Charging Stations on Coupled Transportation and Power Networks

Wei Qi
McGill University
Hongcai Zhang, Zechun Hu, Yonghua Song, Scott Moura

This work studies siting and sizing of plug-in electric vehicle (PEV) fast-charging stations on coupled transportation and power networks. We develop a closed-form service rate model of highway PEV charging stations' service abilities, which considers heterogeneous PEV driving ranges and charging demands. We explore schemes to enhance model accuracy and computational efficiency. We then propose a stochastic mixed-integer second order cone programming (SOCP) model for PEV fast-charging station planning. The model considers the transportation network constraints and the power network constraints with AC power flow. Numerical experiments are conducted to illustrate the effectiveness of the proposed method.

The Value of Energy Storage in Energy Shifting

Shanshan Guo
Shanghai University of Finance and Economics
Shanshan Hu, Gilvan C. Souza

Energy storage can be used to shift electricity from the time it is generated to a later time when the electricity is needed. We provide an analytical framework for assessing battery investment and operation decisions for energy shifting. The main challenge for such an analysis is that battery capacity deteriorates with usage and its deterioration rate depends on how deeply the battery is discharged. We develop a model to characterize the relationships between battery capacity and its useful life, and study the optimal operating policies when the battery is used in energy shifting.

Optimal Production and Recycling Strategy of Electric Vehicle Battery with Limited Capacity

Mengping Zhu, Zhixue Liu
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New energy vehicles are becoming popular for sustainable development. Consider a battery manufacturer that produces two kinds of batteries used for electric vehicles (EV) and electric motorcycles with limited capacity. EV batteries can be recycled for electric motorcycles by echelon use. The optimal strategies of capacity allocation and recycling investment are obtained. Compared with the case without echelon use, more capacity is allocated to EV. The return rate is higher and the manufacturer gains more profit. Numerical experiments show the effect of key parameters, such as the production cost and the efficiency of echelon use on system performance.

Keywords: electric vehicle, production strategy, battery recycling, echelon use, limited capacity

Session 1J – Revenue Management

Customized Product Assortment and Marketing Effort: A Robust Approach

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Jen-Yen Lin
Department of Applied Mathematics, National Chiayi University
Sean Zhou
Department of Decision Sciences and Managerial Economics,
The Chinese University of Hong Kong

We study a revenue management model where the retailer decides the product assortment and marketing effort under the multinomial logit choice model. We apply a robust approach to find the marketing effort that maximizes the worst-case revenue for the retailer under customized assortment. With given marketing effort, we analyze how to identify the customer preference vector(s) that lead to the worst-case revenue under various structures of the preference set. We examine two types of marketing effort: product-level promotion, and category-level promotion. We develop efficient algorithms to solve the problem and show the good performance of the robust approach.

An Approximate Dynamic Programming Approach to Dynamic Pricing for Network Revenue Management

Huan Zheng, Jiannan Ke
Antai College of Economics and Management, Shanghai Jiao Tong University
Dan Zhang
Leeds School of Business, University of Colorado at Boulder

We propose an approximate dynamic programming approach to the dynamic pricing problem for network revenue management. The approximate linear program (ALP) are semi-infinite linear programs and can be solved to any desired accuracy with a column generation algorithm. For the affine approximation under a linear independent demand model, we show that the ALP can be reformulated as a compact second order cone program (SOCP). The size of the SOCP formulation is linear in the number of resources, products, and periods. Numerical experiments show that solving the SOCP formulation is orders of magnitude faster and the ensuing pricing policies perform well.

Coordinating Inventory and Pricing Strategies under Total Minimum Commitment Contracts

Quan Yuan
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Xiting Gong
Department of Systems Engineering and Engineering Management and Department of Decision Sciences and Managerial Economics, The Chinese University of Hong Kong
Frank (Youhua) Chen
Department of Management Sciences, City University of Hong Kong

We study the joint inventory and pricing control for a finite-horizon periodic-review system with total minimum commitment (TMC) contract. Under this system, the buyer commits to purchase a minimum quantity of a product from the supplier over the entire planning horizon. It maximizes inventory and pricing decisions simultaneously in each period. We partially characterize the optimal policy for additive multiplicative demand model. We then characterize the optimal policy for additive demand. We further propose heuristic policies, which numerical tests show to perform very well. Finally, we use our results to examine the value of dynamic pricing.

Preservation of Additive Convexity and Its Applications in Stochastic Optimization Problems

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In this paper, we establish two new preservation results of additive convexity for a class of optimal transformation problems and a class of optimal disposal problems. For both classes of problems, there are multiple resources and the optimal policies provide different priorities to transform/dispose these resources; and we prove that the additive-convexity property preserves under the optimal transformation/disposal decisions. We demonstrate the applications of our preservation results to three important stochastic optimization problems in operations management: stochastic inventory management with remanufacturing, dynamic inventory rationing with multiple demand classes, and dynamic capacity management with general upgrading.

Session 2A – Behavioral OM I

Coopetition Behaviors and Environmental Regulations in Industrial Symbiosis Chain: A Perspective of Evolutionary Game

Binbin Cao, Zhongdong Xiao
School of Management, Xi'an Jiaotong University

Considering environmental regulations imposed by the government in waste emission standard, waste emission tax and subsidy for waste usage, we built an industrial symbiosis chain model including multi-upstream manufacturers and multi-downstream manufacturers where the downstream manufacturers recycle multi-wastes generated from the upstream manufacturers. Bounded rationality of the manufacturers' decisions on pricing and waste emission level has been investigated. The impacts of regulations on evolutionary dynamics of the manufacturers' decision processes have been also explored. We found that simultaneous implementation of waste emission tax and subsidy for environmental performance is beneficial to form stable solutions of the manufacturers' evolutionary game.

Keywords: supply chain management, industrial symbiosis, evolutionary game, environmental regulations, environmental performance

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Online Review's Impact on Casino Revenue Management

Jason Dou
Marbella Technology

There is emerging trend in the Operations Research Community studying revenue management under "social world setting". In this project, we explore online review from social media sites' impact on revenue management. Multi-Arm Bandit problem is a classic model in Optimization, Artificial Intelligence, Probability Theory. Interestingly, it is derived from casino setting. We will use real data from casinos in Macau for empirical study and model validation.

Keywords: Online Review, Multi-arm Bandit, Revenue Management, Text Mining

Supplier's Fairness Concern Regarding Order Allocation in a Supply Chain: An Experimental Examination of Multifactor Influence

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In order to determine whether the supplier's fairness concerns change with different mechanisms in the order allocation of the supply chain, this paper uses multi-method to explore and verify the theoretical findings. Firstly, this paper presents order allocation game models in a supply chain that is comprised of two suppliers with fairness concerns and one retailer without such concerns. The paper considers two scenarios: simultaneous bidding and sequential bidding. After a series of behavioral experiments are conducted, it is found that the inequity aversion level changes. Indeed, the inequity aversion level of the supplier in sequential bidding is significantly different from that in simultaneous bidding. In the bidding process, both disadvantageous and advantageous inequity aversions tend to decrease when the status quo of the supplier changes from a same competitiveness position to an inferior position. When a supplier moves from a position of the same competitiveness to an advantageous position, both the disadvantageous and advantageous inequity aversions tend to increase. Except for the factors of bidding sequence, subjective factors, such as gender differences, risk concerns, and emotional diversity, do not influence the inequity aversion level in our experiment.

Keywords: order allocation, inequity aversion, bidding mechanism, behavioral experiment, supply chain management

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Alleviating Time Inconsistent Behaviors via a Competition Scheme

Yun Shi: Shanghai University
Xiangyu Cui: Shanghai University of Finance and Economics

When the decision makers with quasi-hyperbolic discounting consider dynamic decision problems, they encounter time inconsistency issue. The product sale problem faced by the salesperson with quasi-hyperbolic discounting function is a typical example. We propose a winner-takes-all competition to alleviate the time inconsistent behaviors of the salespersons, and allow the company to maximize its revenue. We show that the competition always improves the group welfare and the company revenue. However, the effect on group time inconsistency degree is mixed. When the optimal bonus is moderate (extreme high), the competition motivates (over-motivates) the salesperson to work hard, thus alleviates (worsens) the time inconsistent behaviors.

Keywords: time inconsistency, quasi-hyperbolic discounting, present bias, winner-takes-all competition

Session 2B – Innovative Operations I

Two-Stage Pricing Model of Hybrid Channel Supply Chain Based on Graph Model for Conflict Resolution

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A two-stage pricing model of hybrid channel supply chain based on graph model for conflict resolution is proposed to offset the shortcomings of classical pricing-game model at the strategic analysis level. We also analyze how the optimal scheme of pricing strategies being affected by parameters designing. Firstly, we construct a price graph model of hybrid channel based on graph model for conflict resolution, and obtain three equilibrium schemes of pricing strategies with the method of stability analysis. Considering the impact of bundled sales, service efforts and advertising on the demand function and profit function, we respectively construct sequential pricing-game models under three equilibrium schemes of pricing strategies, and obtain the optimal solutions of each scheme. Some conclusions can be drawn by comparing the optimal solutions of these models: Marketing channels can adjust the cost of bundling, service efforts or advertising to change the optimal scheme alone or together. Besides, while retailer adopts bundling strategy, the optimal price of the channel who adopts the bundling strategy is proportional to the cost of bundling and sensitivity coefficient of bundling strategy. While retailer offline channel adopts service strategy, the optimal price of the channel is proportional to the cost of service efforts and sensitivity coefficient of service strategy, and the ratio in all three schemes are the same.

Key words: hybrid channel, supply chain, two-stage pricing, graph model for conflict resolution, sequential pricing-game model

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Impact of Asymmetric Spillovers on the Process Investments of a Duopoly with Heterogeneous Products

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A key approach for firms to gain a cost competitive advantage is to reduce production costs through process investment, which, however, may exist spillovers and hence benefit their rivals. This paper develops a game model to investigate the impact of asymmetric spillovers on the optimal process investments of a duopoly with heterogeneous products. We show that each firm's optimal pricing decision, profit and investment policy, as well as consumer surplus are affected by a number of factors such as the degree of spillovers and product differentiation.

Keywords: supply chain management, process investment, spillovers, consumer surplus

An Inventory Perspective for Omnichannel Design

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Xiaolin Xu: School of Business, Nanjing University
Weili Xue: School of Economics and Management, Southeast University
Yi Yang: School of Management, Zhejiang University

The future of retailing seems to be omnichannel as the mix of online vs. offline selling. Online retailers such as Amazon move offline by setting up local stores, whereas brick-and-mortar retailers such as Walmart and Target have long set up online stores. We study the optimal design of ominchannel of a retailer facing two segments of customers: one intended to shop only offline (i.e., store-only customers) and the other contemplating between the online and offline channel (i.e., omni-customers). Without BOPS, the retailer uses a dedicated distribution center to fulfill online orders. With BOPS, the retailer uses limited local inventory to serve both the store-only customers and omni-customers who choose BOPS. We show that buy-online, pick-up-in-store (BOPS) has a drastically different impact on retailers of different natures. The retailer makes local-inventory decisions taking into account customers' rational belief of about the offline inventory availability. For a retailer that has a low density of local stores (or a traditional online retailer), BOPS (or setting up limited local stores) benefits both segments of customers as well as the retailer. This is because, BOPS allows local inventory to serve a pool of offline customers with omni-customers who would otherwise shop online, leading to a higher availability (and variety) of local-store products. However, for a retailer that has a high density of local stores (or a traditional offline retailer), BOPS hurts the store-only customers and the retailer, but benefits the omni-customers. This is because, BOPS uses costly local inventory to serve omni-customers who would otherwise still shop offline but now pay at a lower online price. We show that buy-online, ship-from-store (BOFS) has similar impacts on retailers as BOPS. One remedy for such retailers is to implement buy-online, ship-to-store (BOSS), instead of BOPS and BOFS.

Influenza Supply Chain Management with Overconfident Agents

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In this paper, we study the influenza supply chain management problem with overconfident agents. The overconfidence effect is a well-established bias in which a person's subjective confidence in his or her judgements is reliably greater than the objective accuracy of those judgements, especially when confidence is relatively high. We focus on how consumer over-confidence, and manager overconfidence affect the influenza supply chain. First, we characterize the threshold value for a overconfident consumer to search for the vaccine. Then, we characterize the optimal production policy for the manufacturer. We compare the impacts of consumer overconfidence and manager overconfidence on the influenza supply chain.

Session 2C – OM-Marketing Interface II

Optimal Bundling Strategy Considering Resale

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Bundle is often used as a competition tool in a competitive market. But sometimes consumers may unbundle and resell one of the components, and this will surely affect a firm's profit. We explore which bundling strategy is optimal for common product and exclusive product when reselling is forbidden or allowed. We also explore how reselling affects profit and market share. Our findings suggest mixed bundling is optimal when reselling is forbidden, but it depends when reselling is allowed. We also find bundle will decrease rather than increase market share when reselling is allowed.

Keywords: Bundling, Reselling, Competitive Market

Service Dependency and Labor Productivity in Retailing

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Most retail studies in the OM literature assume that customers patronizing a store have homogeneous service requirements. This study aims to bridge this gap and empirically examines the effect of shoppers' service dependency on labor productivity in a low-conversion retail environment. Using panel data from a major retail chain in the United States, we show that service dependency moderates labor productivity measured in conversion rate and customers' average spending. Our findings provide important implications for staff scheduling and management.

Keywords: Retail, empirical studies, service dependency

Pricing and Coordination Decision in Closed-loop Supply Chain Considering Joint Advertising

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With the consideration of ordinary and green consumers' different willingness to pay for new and remanufactured products, the market was segmented into two scenarios by the utility theory, And further considering the impact of cooperative advertisement on new product demand, demand functions under different scenarios were obtained. The optimal pricing strategy and advertising strategy in decentralized decision under different dominant modes and centralized decision-making under each market scenario were compared, and the impacts of advertising effect on CLSC were analyzed, and improved two part tariff contract was proposed to coordinating of the CLSC with the effect of cooperative advertisement.

Keywords: Closed-loop Supply Chain, Consumer preference, Pricing, Advertising, Coordination

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Feature-Based Information Sharing on Retail Platforms

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We study the information sharing strategy for a platform on which independent sellers engage in Cournot competitions. The platform possesses superior information than the sellers and may choose to share the information with the sellers. We characterize the optimal sharing strategy for the platform.

Keywords: information sharing, feature-based market, retail platforms

Channel Strategy for Manufacturers in the Presence of Service Free Riders

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Dalhousie University

We examine the case of a manufacturer that must decide whether to sell its product directly and/or indirectly through a retailer, and both firms decide on the service effort. When a channel provides a high service level, some customers may first visit this store, and then buy the product from another store (freeriding). We find that the cost bearer of freeriding (the firm on which the customers freeride) can be better off, while the benefiter of freeriding can be worse off when customers can freeride. Total demand can be smaller when customers can freeride.

Keywords: channel conflict, freeriding, marketing-operations interface

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Session 2D – Empirical Research II

The Operational Impact of New Product Introductions into Consumer Packaged Goods Supply Chains: the Case of a Spanish Manufacturer

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We analyze and measure the operational impact of introducing new products into the supply chain of a consumer packaged goods manufacturer. By conducting an in-depth statistical analysis of a Spanish poultry products company, we identified factors that impact its operational performance and should be considered when analyzing exploration versus exploitation trade-offs.

Keywords: Supply Chain, Operations, Strategy, Innovation

Does Social Sustainability Matter? Empirical Analyses of How Layoffs Influence on-Time Performance in the Passenger Airline Industry

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Airline operations are characterized by volatile demand and immense cost pressures. Consequently, decisions to adjust capacity, catering to market demands, are important for an airline's sustainable success. While decisions to reduce capacity are usually viewed as a means for cost control to improve financial performance, there may be subtle ramifications of capacity reductions on operational performance, which could imply a detrimental effect on financial outcomes. Particularly layoffs may lead to unintended understaffing and increased fatigue of employees, and consequently increase human error and other incidents. Considering the service-oriented nature of the passenger airline industry, we argue that layoffs undermine airlines' on-time performance and lead to an increase in customer complaints. We empirically test our hypotheses based on a data sample of roughly 22 million flights in the US domestic market collected over 77 months. Our findings add to the social sustainability discussion in the aviation literature and provide managerial insights on capacity management and hiring strategies in service-based industry sectors.

Keywords: Airline, event study, on-time performance, social sustainability, service operations management

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Key Success Factors in Value Adding for Agricultural Products: A Reference to Germany and Taiwan Experience

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This study discusses value adding to agricultural products through a comparative study of agricultural research institutions in Taiwan and Germany. We discuss the agricultural technology, commercialization of agricultural technology and products business models. In addition, we also discuss the recent government organizational reform in the German agricultural department in order to study the sustainability of German agricultural industry and food safety. The successful German experience may help Taiwan government and industry to identify her agricultural development niche, and to create a high-value, safe and environment-friendly agricultural industry.

Keywords: agricultural products, value add, business model, sustainability

Session 2E – Topics in OM

Zoning for Last Mile Delivery: A Data-Driven Approach

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In this study, we propose a data-driven approach for strategic zoning planning in last mile delivery services. Using historical data to calibrate driver behaviors, we construct a practical routing distance prediction model. We then develop a mixed integer linear program as a sample average approximation model and design a tailored branch-and-price algorithm to improve computational efficiency. Using a real-world data set of food delivery in the numerical studies, we show significant delay reductions from the benchmark model where driver behaviors are not calibrated.

Combating Child Labor: Incentives and Information Disclosure in Global Supply Chains

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Singapore University of Technology and Design

Nearly 200 million children are engaged in child labor, many in developing countries that are part of the supply base of global manufacturing networks. We investigate multinational firms' strategies to control their suppliers' use of child labor in global supply chains. We find that pricing and inspection strategies work as strategic substitutes in combating child labor, so reducing the cost of inspections alone does not necessarily help reduce child labor. When information about the manufacturer's inspection policy is disclosed, inspections can become more effective, but it may inadvertently induce more child labor unless the manufacturer adopts a zero-tolerance policy against child labor.

Keywords: Game Theory, Global Operations Management, Social Responsibility, Supply Chain Management

Combat Effectiveness Analysis based on Message Complexity between UGVs

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Recently, the importance of simulation in military area increases very fast as rapid adoption of unmanned weapon system. One of critical condition for successful combat simulation is communication between UGVs (unmanned ground vehicle). Especially, the message complexity significantly affects the communication success probability. In this paper, we analyze a message complexity's effect on combat effectiveness. AnyLogic software is used for agent-based modeling and we apply the wireless channel module to derive actual communication success probability. As a result, we found that the message complexity directly affects combat results as a degree of message complexity increases.

Keywords: combat simulation, message complexity, communication success probability, agent-based modeling, combat effectiveness

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Coopetition and Profit Sharing for Ride-sharing Platforms

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NYU Stern

The recent introduction of on-demand ride-hailing and ride-sharing platforms totally changed the way people commute. We consider a setting in which two competing platforms engage in a profit sharing contract by introducing a new hybrid service. We model the price competition between the platforms by using the Multinomial Logit model, and show that a unique equilibrium exists. Then, we analyze the impact of introducing the new joint service to the market. Interestingly, we show that a well-designed profit sharing contract benefits every single party (riders, drivers and both platforms).

RFQ, Sequencing, and the Most Favorable Bargaining Outcome

Ying Rong, Huan Zheng
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Leon Zhu
University of Southern California

We study quantity-dependent pricing contracts with exclusion clauses in a dual-sourcing setting when the suppliers are imperfect substitutes. We analyze the negotiations between a buyer and two suppliers both with and without a request for quotation (RFQ) stage that precedes the negotiation. We show that the buyer can leverage the RFQ stage even under a full information setting when the negotiation sequence is endogenously determined by the final quotations of the RFQ process. Specifically, the buyer's equilibrium payoff with RFQ dominates the most favorable equilibrium under bargaining without RFQ.

Session 2F – Best Student Paper Competition Finalists II

Value of By-product Synergy: A Supply Chain Perspective

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By-product synergy (BPS) is an innovation method to dispose wastes and create value from wastes. We examine a supply chain composed of two competing manufacturers and one downstream processing plant with limited BPS capacity. The plant generates a by-product with wastes from manufacturers and sell the by-product in a market with uncertain prices. We derive each manufacturer’s equilibrium decisions (production quantity and disposal amount), and the plant’s capacity investment plan (ex ante). We show that BPS always benefits manufacturers, but the extent depends on two opposite effects (competition effect and cost-saving effect). A counterintuitive result that higher investment cost may increase each manufacturer’s profit, arises due to these two effects. Finally, we discuss implications of different market parameters (investment cost, intensity of competition and efficiency of production process) and extend our basic model in two directions.

Should On-Demand Ride Services Be Regulated? An Analytical Evaluation of Chinese Government Policies

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On-demand ride services (e.g., Uber) receive praises from consumers and investors. However, governments in the United States and Europe are challenging these innovative services by raising legal concerns over labor laws, unfair pricing, and consumer safety. At the same time, the Chinese government is facing a dilemma. On one hand, the Chinese government wants to support these innovative startups as examples of its "mass entrepreneurship and innovation" initiative launched in 2015. On the other hand, the Chinese government needs to ensure the survival of the traditional taxi industry that supports millions of taxi drivers and to reduce traffic congestion and air pollution in major cities. Facing with this dilemma, we develop a unified modeling framework that captures the strategic interactions of multiple stakeholders (i.e., the government, an on-demand ride service company, independent drivers, taxi drivers, and passengers). Our intent is to analyze a two-period dynamic game so as to evaluate multiple performance measures, e.g., business and job creation, viability of taxi service, consumer welfare, social welfare (environmental and traffic issues), and labor welfare (economic and social issues), associated with three basic policies: No regulation, Complete ban, and Basic regulation. By considering the new regulations of on-demand ride services (vehicles, drivers and price regulations) implemented by the Chinese government in 2017, our analysis reveals that, relative to no regulation and complete ban, the Chinese government's new regulatory framework provides a better balance of multiple objectives across multiple stakeholders.

Keywords: On-demand ride services, socially responsible operations, innovative business models, public policy, consumer welfare, social welfare

Optimal Mechanism Design for Vehicle Ownership Control

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Due to traffic and air quality concerns in urban cities, many big cities have begun to adopt the vehicle licenses quantitative control policies by releasing a fixed number of vehicle licenses every month. The current pricing and allocation mechanisms differ from city to city. Several mechanisms have been developed and implemented in reality, such as auction, lottery, lottery
with reserved price, and the simultaneous auction and lottery. In this work, we target to design the optimal mechanism to balance efficiency and equality in practice. We first propose
a unified two-group mechanism framework that either includes or outperforms all the existing
mechanisms. Besides, the unified framework also leads to easy implementation in reality due to its truthfulness and simple structure. Under this framework, we prove the optimal mechanism is always sequential auction and lottery. Besides, the optimal allocation rule depends only on the number of players and the number of licenses for all commonly used distributions. We then extend the two-group framework to a general multi-group framework. The experimental results show us sequential auction and lottery is the best mechanism to use in practice. We also discuss possible applications of our result to resource allocation in other settings.

Keywords: smart city, public resource allocation, hybrid mechanism design, optimal policy

Session 2G – Business Analytics in OM II

Empirical Study on Temporal Pattern of Labor Supply on Sharing Transportation Platform

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Tsinghua University
Zhixi Wan
Didi Chuxing

We study the temporal pattern of labor supply on the on-demand sharing transportation platform. Many factors, including temporal demand, time-based incentives, and seasonal factors affect the dynamic number of actives drivers providing service on the platform. We propose a seasonal time series model to describe the labor supply and provide an empirical study using real data from an on-demand sharing transportation platform. We also propose a model to identify the decline of the number of active drivers and temporary loss of labor supply due to wage lock-in before the bonus boosting period during peak hour.

Keywords: Labor Supply, Sharing Transportation, Time Series, Wage Lock-in

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The Incentive Game under Target Effect in the Ride-Sharing Market: Theory and Evidence

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To wield a flexible self-scheduled supply to match the ever-changing demand and maintain market shares, ride-sharing platforms such as Uber and Didi strive to keep more registered drivers active on the road, especially during peak hours in which the demand tends to be the highest. Usually, platforms offer monetary bonuses to incentivize drivers to work longer. However, drivers' responses to bonuses can be affected by the target effect, which if present may undermine the effectiveness of such bonus schemes. In this paper, we provide a theoretical and empirical analysis of the impact of monetary bonuses on ride-sharing drivers' working hours as well as the platform's best incentive strategy under the target effect.

Keywords: Empirical, Ride sharing, Target Effect

Location and Emergency Inventory Pre-Positioning for Disaster Response Operations: Min-Max Robust Model and a Case Study of Yushu Earthquake

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The Hong Kong Polytechnic University

Pre-positioning emergency inventory in selected facilities is commonly adopted to prepare for potential disaster threat. In this paper, we simultaneously optimize the decisions of facility location, emergency inventory pre-positioning, and relief delivery operations within a single commodity disaster relief network. A min-max robust model is proposed to capture the uncertainties in both the left- and right-hand-side parameters in the constraints. The former
corresponds to the proportions of the pre-positioned inventories usable after a disaster attack,
while the latter represents the demands of the inventories and the road capacities in the disaster affected areas. We study how to solve the robust model efficiently and analyze a special case that minimizes the deprivation cost. The application of the model is illustrated by a case study of the 2010 earthquake attack at Yushu County in Qinghai Province of PR China. The advantage of the min-max robust model is demonstrated through comparison with the deterministic model and the two-stage stochastic model for the same problem. Experiment variants also show that the robust model outperforms the other two approaches for instances with significantly larger scales.

Keywords: disaster relief, facility location, network flow, inventory pre-positioning, min-max robust optimization

Call Center Arrivals: When to Jointly Forecast Multiple Streams?

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We consider call centers that have multiple (potentially inter-dependent) demand arrival streams. Workforce management of such labor intensive service systems starts with forecasting future arrival demand. We investigate the question of whether and when to jointly forecast future arrivals of the multiple streams. We first develop a general statistical model to simultaneously forecast multi-stream arrival rates. The model takes into account three types of inter-stream dependence. We then show with analytical and simulation studies how the forecasting benefits of the multi-stream forecasting model vary by the type, direction, and strength of inter-stream dependence. In particular, we find that it is beneficial to simultaneously forecast multi-stream arrivals (instead of separately forecasting each stream), when there exists inter-stream lag dependence among daily arrival rates. Empirical studies using two real call center data sets further demonstrate our findings, and provide operational insights into how one chooses forecasting models for multi-stream arrivals.

Keywords: arrival rate uncertainty, staffing, system flexibility, workforce management

Session 2H – Sharing Economy II

Sparse and Efficient Rebalancing Network: Exploiting the Circadian Rhythm in Bicycle Sharing Systems

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Mabel C. Chou, Chung-Piaw Teo: NUS Business School, National University of Singapore
Linfeng Li: Hunan University

Motivated by the Bike Angels Program in New York's Citi Bike system, we study the use of crowdsourcing as an alternative to rebalance bikes in a bicycle sharing system before the morning and evening peak hours. While the daily demand for bikes is random, we develop a method to design a static sparse network to support the re-distribution activities. Our results show that when restricting the work of the Angels to only a small subset of arcs in the network, the system can still perform almost as well as the fully flexible system, in which bikes can be moved between any pair of stations based on actual usage. This simplifies dramatically the complexity of bike rebalancing operations on the ground, without affecting the system's service performance too much. Our problem is similar to the classical transshipment network design problem, where the focus has been on the design of long chain structures. Interestingly, the structure used by Citi Bike in its Angels program in New York uses a different design philosophy. We argue that the Bike Angels structure can be better in rebalancing bikes in the system because of the ''Circadian Rhythm" of transport demand in the city that leads to spatial and temporal mobility patterns of uneven bicycle usage. More importantly, depending on the operating conditions, our method often produces a hybrid structure that outperforms both the long chains and the Bike Angels structure. We use this technique to develop a near optimal rebalancing network for a system with 60 docking stations, using a data set from the Hubway system in Boston. Our results show that using a much smaller set of arcs (15%) to support the rebalancing activities of the volunteers in the system only causes a small loss (around 4%) of the performance efficiency.

Key words: Crowdsourcing, Bicycle Sharing, Sparse Network Design, Conic Program

Dynamic Repositioning for Vehicle Sharing with the Fixed Cost

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Free-float vehicle sharing service has been widely promoted for its flexibility nowadays, but it poses operational challenges in fleet management due to the mismatch between supply and demand. It becomes necessary therefore to propose a repositioning policy to alleviate the mismatch. In this paper, we first develop a stochastic dynamic programming model for the periodic review inventory system with the fixed repositioning cost involved. Then, the optimal repositioning policy for the two-station system is characterized theoretically. Finally, an extensive numerical study is conducted to obtain the optimal repositioning policy for the general n-station system.
Keywords: dynamic repositioning, vehicle sharing, fixed cost, two-station system, n-station system

Increasing Operational Efficiency of Public Bicycle System Based on Public Data Analysis

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The public bicycle system (PBS) is one of the certain methods to avoid the traffic jam in major city. By virtue of shared economy, the number of bicycle increase very fast and every administrative office look forward to enhancing the operational efficiency of PBS as deficit increases. In this paper, we suggest various methods to increase an operational efficiency in view point of user, station, and administration. We analyze 3-years of PBS usage data. With network analysis, re-balancing scheme of bicycles in crowed station is visualized. Air quality and temperature significantly affects the intention of riding.

Keywords: public bicycle system, operational efficiency, PBS usage data, user survey, network analysis

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Pricing and Capacity Allocation: Implications for Manufacturers with Product Sharing

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In recent years, product sharing has been emerging as a new business model because of its great benefits to consumers, firms as well as the whole society. In this paper, considering both peer-to-peer(P2P) sharing and manufacturer-to-consumer(M2C) sharing, we investigate the manufacturer's pricing and capacity allocation strategies for both product retailing and sharing market. We first explore the manufacturer's pricing strategies, and then obtained the context when the manufacturer should add the product sharing business model. Furthermore, the capacity allocation strategies for both retailing and sharing market are investigated to obtain some managerial implications for manufacturers with product sharing.

Keywords: product sharing, pricing, capacity allocation, capacity constraint

Session 2I –Sustainable Operations II

Time to Change? Product Line Design for Two-Dimensional Quality Products

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The purpose of this paper is to explain why some traditional big food manufacturers are adopting local sourcing and other sustainable approaches while others are not when developing new products. We build a model which incorporates two quality valuations - traditional and sustainable - and two market segments - low and high sustainable valuation. We characterize explicitly how the interplay between sustainable-valuation uncertainty, production cost and the size of the green segment affect a monopolistic manufacturer's optimal product line design.

Keywords: product line design, multi-dimensional quality differentiation, market segmentation, sustainable operations

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How Do Firms Prepare for Natural Disasters: A Study of the Impact of Earthquakes on Chinese Firms?

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A natural disaster can impose tremendous challenges to firms. It is important for both investors and managers to understand the consequence of the natural disaster. Utilizing earthquakes happened in mainland China from 2008-2017, we first measure the market response of those affected firms. Then, we investigate the effectiveness of various operational means to cope with natural disasters.

Keywords: Natural disaster, operational strategy, event study

Green Technology Development and Adoption: Competition, Regulation, and Uncertainty – A Global Game Approach

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When a government is considering tightening a standard on a pollutant, their decision often is influenced by the number of firms being able to meet the tightened standard, because a higher number indicates a more feasible standard. We study how such regulation may affect a firm's incentive to develop a new technology to reduce a pollutant. We find that regulation that considers industry capability, compared with regulation that ignores it, can more effectively motivate development of a new green technology. Surprisingly, uncertainty in the payoff can also promote development of a new green technology.

Keywords: Environment, global game, regulation, sustainability, technology

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Effect of Consumer Awareness on Corporate Social Responsibility under Asymmetric Information

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Olin Business School, Washington University

We develop a signaling game model to analyze the impact of consumers' social responsibility concerns on a firm's pricing decision and profit performance. The firm can be either socially responsible or irresponsible, and consumers do not have perfect information about the firm's type. We find that the existence of information asymmetry may distort some conventional wisdoms and have interesting implications for the firm regarding corporate social responsibility.

Keywords: Corporate social responsibility, consumer behavior, information asymmetry, signaling

Session 2J – Flexible Production and Service Systems

Capacity Allocation in Flexible Production Networks: Theory and Applications

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South China University of Technology

In many production environments, a fixed network of capacity is shared flexibly between multiple products with random demands. What is the best way to configure the capacity of network and to allocate the available capacity, to meet pre-determined fill rate requirements? We develop a new theory of network capacity allocation, and characterize the relationship between the capacity and the attainable fill rate levels for the products, considering the flexibility structure of the network. We apply our results on problems arising in the design of last mile delivery operations, and in semi-conductor production planning, using real data from two companies.

Keywords: Production Networks, Capacity Configuration, Process Flexibility, Fill Rate Targets

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How to Efficiently Serve a Finite Number of Jobs in a Tandem System with Flexible Servers?

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University of Minnesota

We consider a tandem system with two stations and two servers. The total number of jobs to be processed is finite. The servers are cross-trained to work at both stations. We assume the time duration for each server to serve a job at each station is exponentially distributed with a rate that depends on the server, the station, and the job. Our goal is to maximize the average throughput of the system. We also extend our model to incorporate transfer costs of the servers' movements between the stations as well as the effects of service defects.

Keywords: Tandem service system, flexible servers, heterogeneous jobs, transient analysis

On the Design of Sparse but Efficient Structures in Operations

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Despite the extensive literature on the performance of a limited flexibility, we are not aware of any general methodology to design sparse (i.e., slightly flexible) and yet efficient operations. We address this issue using a distributionally robust approach to model the performance of a stochastic system under different process structures. We use the dual prices obtained from a related conic program to guide managers in the design process. This leads to a general solution
methodology for the construction of efficient sparse structures for several classes of operational problems, including the workforce deployment in response to deviations and disruptions in the operational environment and the classical process flexibility problem. Our methodology can recover the k-chain structures that are known to be extremely efficient for the latter problem.

Keywords: Sparse and efficient operation, sensitivity analysis, conic program, manufacturing flexibility, strong duality

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Worst-Case Analysis of Process Flexibility Designs with Price Differentials

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In the operations literature, the theoretical investigation of the effectiveness of limited flexibility has mainly focused on the performance metric that is based on the maximum sales in units. However, this could lead to substantial profit losses when the maximum sales metric is used to guide flexibility designs whereas the products have considerably large price differences. We address this issue by introducing price differentials into the analysis of process flexibility designs. We introduce the Profit Plant Cover Index (PPCI) and prove that a general class of worst-case performance measures can be expressed as functions of the design's PPCIs and the given uncertainty set. Moreover, the PPCIs suggest a method to compare the worst-case performance of different designs, and lead to a heuristic for generating flexibility designs that perform well under expected profit.

Keywords: Process flexibility; Flexible Production; Profit maximization; Robust Optimization; Worst-case Analysis

Session 3A – Behavioral OM II

Modeling Behavioral Biases in Reorder Decisions under Continuous-Review Policies

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In this talk, a distribution supply chain consisting of one warehouse and multiple retailers under the continuous-review (R,Q) policy is considered. The retailers' reorder decision biases are modeled when they have tendency to minimize the ex-post inventories. Although the optimal decision of the warehouse is known in previous researches, they do not consider the decision bias of the retailers. In this research, we model the ordering behavior of the retailers considering the ex-post inventory minimization bias of the retailers, and methods to optimize the reorder decisions of the warehouse using the knowledge about the retailer's irrationality levels.

Keywords: behavioral operations management, reorder decision biases, continuous-review, (R,Q) policy

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Optimal Clustering of Stations for the Bike Sharing System in Seoul

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Department of Industrial and Management Engineering, Hansung University
Heejong Lim
College of Business Administration, University of Seoul

Like many cities around the world, bike sharing system has been introduced and operated to decrease both traffic and pollution in Seoul since 2015. As the use of shared bicycles increases, managerial issues such as relocation and maintenance of bicycles should be solved to offer better service. In this paper, we develop a mixed-integer programming model for finding optimal clusters of bike stations. For each station, we obtain the net demand from user data for pickups and returns at 210 stations in Seoul. Then, we perform computational experiments to propose better clustering for efficient management of bike sharing systems.

Keywords: Shared Bicycle, Clustering, Mixed-Integer Programming

Arm's Length Principle under Market Asymmetries When a Rival is also a Customer

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ETRI
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We consider a vertically integrated producer (VIP) with wholesale and retail divisions, and a rival retailer who competes with the retail division of the VIP. The rival is also a wholesale customer of the VIP. The retailers in the market are not necessarily symmetric and may have different selling costs or different accuracy of information about the market condition. We investigate the impact of the arm's length principle that does not allow wholesale price differentials between retailers on VIP, rival, and consumers in the market. We also investigate the implications of allowing some wholesale price differentials in the regulation.

Keywords: vertically integrated producer, retail competition, arm's length principle, market asymmetries

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Behavior-Based Pricing with Incomplete Information on Purchasing History

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Behavior-based pricing (BBP) is a pricing strategy that the firms offer different prices to consumers with different historical purchasing behavior. In competitive market, firms can set equilibrium prices using BBP. However, it is hardly possible that the firms catch each consumer's behavior. Thus, the firms have incomplete information. We analyze the impact of incomplete information on firms' profits, consumer surplus, and social welfare. We conclude that incomplete information can benefit the firms. Moreover, improving consumer surplus and social welfare by changing information completeness are not necessarily conflicted with increasing firms' profits.

Keywords: behavior-based pricing, incomplete information, price discrimination

Session 3B – Innovative Operations II

Incentivizing R&D for Neglected Diseases

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Many developing countries grapple with neglected diseases due to a lack of effective/safe biopharmaceutical treatments. The world health organization calls on non-government organizations (NGOs), and biopharmaceuticals to act in concert to eliminate neglected diseases. We model the interaction between an NGO, an Innovator and a Marketer. First, we characterize the conditions for a disease to be neglected in the absence of incentives. Subsequently, we evaluate the effectiveness of different incentive mechanisms in inducing collaboration to bring products targeting neglected diseases to market.

Keywords: Innovation, Sustainable Development, Neglected Diseases, Incentives

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Perils of Bargaining Power in Biotechnology R&D Licensing

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Both the fate of a product and future payments to the innovator (licensor) in R&D license agreements depend on go/no go decisions. This presents a tradeoff between enhanced outcomes due to partner expertise and terminations purely due to a partner's economic concerns even when clinical prospects are good. We find support for the argument that a larger deal value creates a higher hurdle to clear, thereby increasing the likelihood of a termination. Further investigation reveals that this is due to endogeneity: Underlying drivers of deal value determine whether its effect is positive or negative.

Keywords: R&D license, innovation, bargaining power

Rights of First Negotiation and Rights of First Refusal in New Product Development Partnerships

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Strategic control rights such as the right of first negotiation (ROFN) and the right of first refusal (ROFR) are commonly used in the pharmaceutical industry for creating partnerships between biotech and pharmaceutical firms. We build a stylized principal-agent model to study the contract design problem with the ROFN and ROFR. We investigate the efficacy of different control rights being offered from the innovator's (biotech firm) perspective. We also investigate the role of strategic control rights in resolving the adverse selection problem for the innovator. Our results address an important issue, viz., which control right to offer under which circumstances.

Key words: new product development, R&D partnership, right of first negotiation, right of first refusal

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Natural Disasters, Technology Diversity, and Operating Performance

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National Taiwan University
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Hong Kong Baptist University

In this paper, we empirically measure the impact of natural disasters on firm-level operating performance and examine if these impacts can be mitigated by technology diversification. Using major natural disasters specified by Barrot and Sauvagnat (2015) and factory location data from the toxic release inventory (TRI) database, we first find that firms with factories located in states affected by natural disasters perform significantly worse with respect to profitability. Secondly, we find that firms with diversified technologies are significantly less subject to the impact of natural disasters, suggesting that technology diversity enhances firms' sustainability.

Keywords: natural disasters, innovation, operating performance

Session 3C – OM-Marketing Interface III

On Stackelberg Structures and the Introduction of Store Brand

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Store brand problem has become increasingly important as the competition between national brand manufacturers and retailers intensifies. This paper compares two alternative Stackelberg games between a national brand manufacturer and a retailer who may introduce a store brand. We assume that the retailer possesses better demand information due to its close proximity to consumers. We find that the two players' profits under the two Stackelberg games are different. In addition, both players prefer to be the leader when the demand information is perfect, while the first-mover advantage may disappear under incomplete information.

Keywords: Stackelberg structures, store brand, asymmetric information

Dynamic Price Competition Among Single-Channel Sellers with Fixed Capacities

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In this article, we study a multi-period price-setting stochastic-game among multiple sellers, each has a distribution channel to sell its product with limited capacity. Employing stylized linear demand model, we prove the existence of a unique sub-game perfect normalized Nash equilibrium at which sellers have identical shadow prices. We show that the normalized Nash equilibrium is determined by sellers' reservation costs. The structure of reservation cost sheds light on the joint impact of a seller's internal monopolistic power and external competitive advantage on equilibrium behavior.

Keywords: revenue management, dynamic price competition, sub-game perfect normalized Nash equilibrium, equilibrium channel control, reservation cost

Incentive Mechanisms for Managing Hidden Rebates and Inflated Quotes of a Procurement Service Provider

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When sourcing through a procurement service provider, the buyer (e.g., a retailer) relies on the service provider to solicit price quotes from different sellers (e.g., contract manufacturers). Some service providers charge their buyers low service fees to be competitive, but they collect rebates (or sales commissions) from some willing sellers that are "hidden" from the buyers. Due to conflicting interests and information asymmetry, the service provider has strong incentive to "inflate" the quote submitted by those unwilling sellers, in order to help those willing seller to win the buyer's business. Consequently, the buyer can end up selecting an inefficient seller by paying a higher price (and even a higher import tax due to hidden rebates).

We present a model of a supply chain comprising a buyer, a procurement service provider, and two (i.e., one willing and one unwilling) sellers. Our equilibrium analysis reveals that, when the buyer selects the seller with the lowest quote, the inflated quote caused by the hidden rebate will make the buyer end up paying higher procurement costs and higher import taxes. When the buyer cannot enforce a penalty on the intermediary for quote inflation, we show that a deterministic incentive mechanism based on a simple selection rule and a contingent service fee is optimal. We also show that this optimal mechanism creates incentive to: (1) deter the service provider to inflate the quote submitted from the unwilling seller; (2) reduce the incidence of hidden rebates; and (3) reduce the buyer's procurement cost and the corresponding import tax significantly. More importantly, relative to the "lowest quote wins" selection rule, this optimal deterministic mechanism creates a win-win solution for the buyer and the service provider. However, when the buyer can enforce a high (but bounded) penalty on the intermediary for quote inflation, a stochastic incentive mechanism is optimal, and the deterministic mechanism is no longer optimal.

Keywords: Mechanism design, Hidden rebates, Deceptive quotes, Global sourcing

Managing Perishable Inventory Systems with Product Returns and Remanufacturing

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We study a periodic-review inventory system with remanufacturing for a perishable product with a lifetime of two periods. There are two separate demands for different ages of the product and stockout substitution is considered. One distinctive feature is that a random portion of the sold product with two-period lifetime is returned and can be remanufactured into product with one-period lifetime. We show that the optimal remanufacturing policy is a modified base-stock policy and the optimal manufacturing quantity is decreasing in the total inventory after remanufacturing. Numerical study is conducted to study the effects of the remanufacturing and demand substitution.

Keywords: inventory control, optimal policy, perishable product, remanufacturing, substitution

Efficient Algorithms for Reliable Facility Location Problem under Uncertain Disruptions

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Jia Shu: Southeast University
Miao Song: The Hong Kong Polytechnic University

This paper studies the reliable uncapacitated facility location problem, where the joint distribution of facility disruptions could be partially characterized and are allowed to have any prespecified dependency structure. A distributionally robust model is formulated to find a location decision that minimizes the fixed location cost and the expected transportation and penalty cost of serving customers under the worst-case disruption distribution. It generalizes all existing models, including the stochastic model with known joint distribution and the robust model specified by marginal moments. We propose a cutting plane framework to solve this problem exactly and design an efficient approach for the separation problem, which evaluates the worst-case expected transportation and penalty cost under a given location decision. The numerical results show that the proposed algorithm not only outperforms the best algorithm in the literature for the stochastic model under independent disruptions, but also satisfactorily solves the robust model with both marginal and cross moments.

Approximation Approaches for Inventory Systems with General Production/Ordering Cost Structures

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The production/ordering cost structure is fundamental to determining an optimal inventory control policy. For example, it is well known that a base-stock policy is optimal for inventory systems with linear production costs, whereas an (s, S) policy is optimal if both linear and fixed costs exist. However, many of the cost structures that have arisen from the practice are quite complex and make the optimal policies too complicated for managers to implement. In this paper, we propose several easy-to-implement and efficient heuristic policies for inventory systems with general production costs which, include multiple linear pieces and fixed costs, suggesting a wide application to many practical problems that were previously difficult to solve. We establish the worst-case performance bounds on the proposed heuristic policies by using the concept of K-approximate convexity. Our extensive numerical studies, which are designed to reflect practical inventory control applications, evaluate the performance of the heuristic policies and show that the best heuristic policy we propose performs extremely well. We also try to provide explanations for the performance of different heuristic policies.

Newsvendor Problem with Endogenous Price and Partial Demand Information

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We consider the problem in which a retailer selling a perishable product needs to make price and order quantity decisions simultaneously to maximize the expected profit. The demand is stochastic and price-dependent. The retailer only has a partial information of the demand (e.g. expected demand on a few prices and the distribution of the random error). We build a minmax regret model and derive the optimal price and order decisions for both additive and multiplactive model. We also provide an e learning policy to reduce the minmax regret with a convergence rate.

Session 3E – Robust Optimization

Tractable Distributionally Robust Optimization with Data

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We present a unified and tractable framework for distributionally robust optimization that could encompass a variety of statistical information including generalized moments, constraints on expectation, scenario-wise ambiguity, uncertain probabilities defined by phi-divergence, and Wasserstein distance. For optimization problems with recourse, we introduce the tractable adaptive recourse scheme (TARS), which is based on the classical linear decision rule and can also be applied in situations where the recourse decisions are discrete.

Keywords: Distributionally robust optimization, data-driven optimization, ambiguity set, Wasserstein distance, adaptability

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Risk Minimization in Robust Inventory Routing Problem

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We study a finite horizon stochastic inventory routing problem. In this problem, the supplier acts as a central planner who determines the replenishment quantities as well as the times and routes to all customers. We allow ambiguity in the probability distribution of uncertain demand at each customer. To quantify the risk in fulling the demand, we propose a decision criterion called Collective Requirement Violation (CRV) Index, which takes into account both the frequency and magnitudes of violation. The whole problem can be formulated as a mixed integer programming problem and the exact optimal solution can be found effectively. We compare the performance of our solutions with several benchmarks.

Keywords: Inventory routing problem, Distributionally robust optimization, Risk management

On The Heavy Tail Behavior of Distributionally Robust Newsvendor Models

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Scarf (1958) in his pioneering work on the newsvendor problem assumed that only the mean and variance of demand are known. This solution is often criticized for being conservative. However, this solution is also optimal for a student-t distribution with infinite variance. In this paper, we show that this ``optimality" property extends to models when demand information is available on the first and the kth moment. While this problem does not appear to be solvable in closed form, we show that for high critical fractile levels, the robust newsvendor solution is optimal for a regularly varying distribution with heavy tails.

Keywords: Robust optimization, Newsvendor, Heavy tails

Calibration of Distributionally Robust Optimization Models

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We study the out-of-sample properties of robust empirical optimization and show that the first-order benefit of introducing a ``little bit of robustness" to a sample average optimization problem is a substantial reduction in the variance of the out-of-sample reward, and that this can be achieved with negligible loss in expected value. One important implication of these insights is that estimates of the out-of-sample variance (as well as the mean) should be taken into consideration when calibrating robust optimization models. Inventory models and applications in statistics and finance are studied.

Keywords: Data driven optimization, robust optimization, model uncertainty, calibration, data driven inventory models

Session 3F – Inventory Management I

Newsvendor Decision with Two Reference Profits: Minimum Requirement and Status Quo

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This paper studies a newsvendor model with two reference profits: minimum requirement and status quo, based on which the psychological values are divided into gains, losses, and failures. With the purpose to maximize the total expected value the optimal decision is to balance the values for under-order and over-order quantities. We find that the decision bias is significantly dependent on the endowed reference profits and the shortage cost. In addition, the optimal order quantity may increase in wholesale price and decrease in retail price, which can never occur for a risk-neutral newsvendor.

Managing Inventory for a Multidivisional Firm with Cash Pooling

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We consider a multi-divisional firm in which each division replenishes its inventory and the headquarter coordinates the cash flow through a master account over a finite horizon. The demands of the divisions are stochastic and may be correlated. In each period, cash is received from customers and paid to the outside vendor at the order epoch. The objective is to find an optimal joint inventory replenishment and cash retention policy which maximizes the firm's end-of-horizon working capital. We show that this problem is equivalent to minimizing the total system cost, and the optimal policy is difficult to obtain due to the allocation problem. Nevertheless, we characterize the properties of the optimal policy and develop a simple heuristic, based on which we can propose a coordination scheme that regulates the divisions to achieve the supply chain's optimal cost. A numerical study shows that our heuristic performs stable despite of high demand volatility. To quantify the value of financial integration, we compare the cash pooling model to systems without financial integration. The numerical results show that the value of cash pooling is most significant when the demands of the divisions are negatively correlated.

Risk Sharing, Inventory and Financial Decisions with Cooperative Financing

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We study two financially constrained firms that differ in financial status, cost, revenue or demand parameters selling two products to the (different) markets with stochastic demands. Using a non-cooperative game, we then explicitly analyze a debt-financed model with the two firms getting the needed loan cooperatively and identify the existence of equilibrium inventory levels of the firms. In this financing mode, we find that the two firms are more aggressive in ordering as the additionally sharing risk goes up. Importantly, we find that if the two firms' cash levels are relatively low and the advantage of cooperative financing over individual lending is considerable, they simultaneously finance their ordering decisions by cooperation; otherwise, they choose individually financing.

Dual-index Policies for Two-echelon Inventory Systems with Dual Delivery Modes and Batch orders

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In this paper, we consider a two-echelon inventory system with dual delivery/supply modes (for both echelons). These two modes provide different lead times, incur different costs and have different base order batch size requirements. We study a nature extension of the well-studied dual-index policy that has been proved to be near-optimal for the single-echelon inventory system with dual-soucing (Veeraraghavan and Scheller-Wolf, 2008). We call the policy dual-index echelon-(R,nQ) policy. We analyze the system dynamics of the policy and show separability results for the policy parameters. In particular, we show that the reorder point of the expedited mode of the downstream stage can be computed by a newsboy fractile. Based on these properties, we provide a simulation-based optimization procedure for the policy. A simple while efficient heuristic is provided to find the near-optimal policy parameters. In the numerical study, we investigate the value of the dual delivery modes in the systems. One interesting observation is that as long as the regular delivery mode of the upstream echelon is not too unfavorable compared with the regular delivery mode of the downstream echelon, when firms consider to add an expedited mode to the system, the downstream echelon should be given the priority.

Session 3G – Practice-Driven OM

Multi-Objective Optimization for the Vehicle Routing Problem with Outsourcing and Profit Balancing

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An importer in Hong Kong employs vehicles all from external transport companies to deliver products to its customers geographically scattered in difference locations. The delivery plan needs to simultaneously minimize the total traveling cost and balance the profits among all transport companies. This transportation practice engenders a new variant of vehicle routing problems, called the vehicle routing problem with outsourcing and profit balancing (VRPOPB). The profits are balanced by maximizing the minimum unit profit of all transport companies, which can effectively avoid the occurrence of distorted solutions. We develop two multi-objective local search (MOLS) algorithms for the problem to solve the problem effectively.

Mining Triage Notes to Predict Emergency Department Admissions

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Emergency department (ED) overcrowding is a worldwide problem that undermines hospitals' ability to provide timely care to patients. One of the primary reason for ED overcrowding is long ED boarding time due to the lack of coordination between ED and inpatient units. Our study aims to develop models that use patient information collected during triage to predict the inpatient admission decisions, and to test how the information derived from free-text triage notes by text mining can increase the prediction power. With the predictive information available in advance, hospitals can be proactive on the admission process to reduce ED overcrowding.

Data Driven Assortment Planning for Online Commerce

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City University of Hong Kong

We design an efficient reinforcement learning framework that is driven by online sales data to dynamically learn customers' choice behaviour and update assortments for an online shop. Experiments with real data demonstrate that our approach is very effective and improves the current best practice significantly.

Effects of the Price Cap Regulation on the Pharmaceutical

Xu Chen, Huan Yang
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Xiaojun Wang
University of Bristol

This paper considers a pharmaceutical supply chain comprising of one pharmaceutical manufacturer and one pharmacy. We investigate how the price cap regulation affects pharmaceutical firms' pricing decisions. We also evaluate the economic and social performance of the pharmaceutical supply chain and assess the risks associated to the price cap regulation. The derived equilibriums under different price cap regulations including the retailer price cap regulation, the manufacturer price cap regulation and the linkage price cap regulation are compared to that without regulation. Our results show that one sided price cap regulation will damage the economic performance of the regulated firm although the unregulated firm may gain financial advantage. The regulation may increase the risk of supply shortage if the pharmaceutical firms cannot cope with the financial loss. In contrast, the linkage price cap regulation can be an effective policy that improves both the economic and social performance of the pharmaceutical supply chain.

Session 3H – Sharing Economy III

Robust Repositioning for Vehicle Sharing

Long He, Zhenyu Hu: NUS Business School, National University of Singapore
Meilin Zhang: SIM University

With the flexibility in serving one-way trips, free-float vehicle sharing systems, e.g., car2go for car sharing and Mobike for bike sharing, are gaining more popularity. On the one hand, free-float systems bring convenience in rental and return of vehicles compared with the conventional station-based systems, e.g., Zipcar and Citi Bike. On the other hand, it poses challenging operational difficulties in fleet management. In this paper, we study the fleet repositioning problem aiming to dynamically match the vehicle supply and travel demand at the lowest total cost of repositioning and lost sales. We first formulate the problem as a stochastic dynamic program assuming temporal independence of demand. Under a 2-region system, we find that a simple reposition up-to and down-to policy to be optimal. To solve for a multi-region system, we deploy the distributionally robust approach that can incorporate demand temporal dependence. We first propose a "myopic" two-stage robust model that serves both as an illustration of the distributionally robust optimization framework as well as a benchmark for the later multi-stage model. We then develop a computationally efficient multi-stage robust model with enhanced linear decision rule (ELDR). Moreover, we show that the ELDR solution preserves the reposition up-to and down-to structure in the 2-region system and its numerical performance is close to the exact optimal solution from the dynamic program. In a real-world case study for a free-float car sharing system in California, we compare with several benchmarks to demonstrate that the ELDR solutions are computationally scalable and in general result in lower cost with less frequent repositioning.

Charging Electric Vehicle Sharing Fleet

Long He: NUS Business School, National University of Singapore
Guangrui Ma: Tianjin University
Wei Qi: McGill University
Xin Wang: University of Wisconsin-Madison

Electric vehicles have been considered as key to cutting carbon emissions in urban transportation. Moving forward to a low-carbon society, several cities have welcomed electric vehicle (EV) sharing services and supported them by building charging infrastructure. Despite the efforts by the cities and operators, it remains challenging for the operators to recharge the fleet due to limit or costly access to charging facilities. Such operational difficulty discourages the use of EV in the sharing fleet and forces some operators to switch to gas-powered cars or even cease their operations. In this paper, we address the charging infrastructure planning problem in joint with fleet repositioning and recharging operations in the context of EV sharing. We further conduct numerical experiments to discuss planning issues, such as the use of private or public chargers, for sustainable electric vehicle sharing service.

An Empirical Analysis of Price Formation, Utilization, and Value Generation in Ride Sharing Services

Liu Ming: CUHK Shenzhen
Tunay Tunca, Yi Xu: University of Maryland
Weiming Zhu: IESE Business School

Ride-sharing platforms, such as Uber and Lyft and their Chinese counterpart Didi, set prices dynamically to balance the demand and supply for their services. Fare setting rules and proprietary algorithms used by these services for managing their operations play an important role in value generation for their customers as well as their drivers, and important questions center around their pricing and regulation. In this paper, we provide an empirical model and analysis of price formation and surplus generation of these services. We first develop a two-sided-market discrete choice model, capturing the formation of mutually dependent demand (consumer) and supply (driver) sides that jointly determine the pricing. Based on this model, we then use a comprehensive data set obtained from Didi on two distinct and competing markets they host on their platform to estimate consumer and driver price elasticities as well as other factors that affect market participation. Based on the estimation results and counterfactual analysis, we demonstrate that proposed regulation imposing price caps that match current Taxi rates can decrease consumer surplus by 39.84% while causing a relatively moderate 5.66% decrease in Kuaiche driver surplus. Further, we estimate that restricting driver capacity to equal local Taxi levels would result in 18.07.06% and 23.40% reductions in consumer and Kuaiche driver surpluses respectively.

Maximizing the Benefits of an On-Demand Workforce: Fill Rate-Based Allocation and Coordination Mechanisms

Tao Lu: Rotterdam School of Management, Erasmus University Rotterdam
Zhichao Zheng: Lee Kong Chian School of Business, Singapore Management University
Yuanguang Zhong: School of Business Administration, South China University of Technology

With the rapid growth of the sharing economy, on-demand staffing platforms have emerged to help companies manage their temporary workforce. In this paper, we study how to maximize and distribute the benefits of an on-demand workforce in this n ew business context. We consider an on-demand staffing platform and multiple employers with uncertain and possibly time-varying demands. To compare this method with traditional staffing solutions, we first investigate when an on-demand staffing platform can be beneficial from the perspective of a central planner. Next, we propose a novel fill rate-based allocation and coordination mechanism that enables the on-demand workforce to be shared optimally when individual employers and the platform operator make decisions in their own interest. Our result provides a win-win-win solution: Individual employers and the platform operator share the maximum benefits of on-demand staffing, while workers are able to set their own hours.

Session 3I – Sustainable Operations III

Using Flexible Substitution in Remanufacturing Programs to Become More Sustainable

Baolong Liu, Felix Papier: ESSEC Business School

We investigate inventory and production management of a hybrid manufacturing/ remanufacturing system that serves demand for new and for remanufactured products and that allows for substitution between both products. The system manager aims at minimizing "strategic" cost, i.e., economic cost and environmental impact. First, we analyze single-component products and show that the optimal policy is of threshold-type. Then, we analyze multi-component products and develop a close-to-optimal heuristic. Our results show that flexibility reduces the strategic cost. We also find that handling components as an aggregated system and that a stronger weight on environmental impact increase the need for product substitution.

Keywords: Remanufacturing, Two-way substitution, Substitution flexibility, Component flexibility, Markov Decision Process

Optimal MTS and MTO Hybrid Production System for a Single Product under the Cap-and-Trade Environment

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Shouyao Xiong: Central South University, Changsha University of Science and Technology, McMaster University
Kai Huang: DeGroote School of Business, McMaster University

This paper studies the optimal production planning in a hybrid Make-To-Stock (MTS) and Make-To-Order (MTO) production system for a single product under the cap-and-trade environment. The manufacturer aims to minimize the total cost in production, inventory and emissions allowances trading. The decisions include the selection of production mode (pure MTS, pure MTO or hybrid MTS/MTO), the inventory and emissions trading quantity. We derive the optimal solution analytically. We show that when the emissions are a source of cost, the manufacturer has to face more cost pressure even if there is no emissions allowance trading. Moreover, the manufacturer's decisions are mainly affected by emissions (production and inventory), costs (inventory, emissions and delayed delivery), initial emissions allowance, market demand, manufacturing capacity and (length of) lead time specified in the order. Especially, the results show that the initial emissions allowance determines the production mode in some case that the unit order delayed delivery cost is between the maximum and minimum inventory cost and has no effect on production mode and emissions allowances trading decision in other cases. The cost of optimal MTO/MTS hybrid production strategy is remarkably less than that of either pure MTO or pure MTS production strategy alone. The hybrid MTO/MTS production strategy changes into pure MTO production strategy when the demand is small, or the production capacity is big, or the lead time is long, or the delivery delay cost is low.
Keywords: Make-To-Stock, Make-To-Order, Emissions trading, Production planning

Two-period Manufacturing and Remanufacturing Production Planning under Carbon Tax Regulation

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We model a manufacturer who produces new products in the first period and makes new and remanufactured products in the second period under carbon tax regulation where the tax price differs over the two periods. It is shown that improving the carbon tax price of the first period always decreases the total carbon emission, while improving the carbon tax price in the second period may enlarge the overall emission. From the perspective of regulators, to effectively control the total emission, the tax price could be raised selectively according to the manufacturer's production decision and the characteristic of remanufacturing.

Keywords: remanufacturing, carbon tax regulation, different tax prices

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Crowdfunding for Green Energy Investment

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Ronghuo Zheng
The University of Texas at Austin
Katia Sycara
Carnegie Mellon University

This paper studies crowdfunding in green energy investment, in which green energy projects are financed by a number of individuals who are also energy consumers. In this paper we develop a sequential game theory model to study the interactions among three players: the group of crowfunders /consumers, electricity company which purchase the electricity generation of green energy, and green energy project manager who initiates and manages the funded green energy project. In particular, we examine the impact of energy supply chain structure as well as the dual role of crowdfunders and consumers on the total green energy investment volume.

Keywords: Sustainable operations management, Supply chain management, Emerging OM issues

Optimal Pricing and Equilibrium Queueing Strategy with Rating Information

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We model a manufacturer who produces new products in the first period and makes new and remanufactured products in the second period under carbon tax regulation where the tax price differs over the two periods. It is shown that improving the carbon tax price of the first period always decreases the total carbon emission, while improving the carbon tax price in the second period may enlarge the overall emission. From the perspective of regulators, to effectively control the total emission, the tax price could be raised selectively according to the manufacturer's production decision and the characteristic of remanufacturing.

Keywords: remanufacturing, carbon tax regulation, different tax prices

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Price-Directed Cost Sharing and Demand Allocation among Service Providers with Multiple Demand Sources and Multiple Facilities

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Yimim Yu, Saif Benjaafar
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We consider capacity sharing through allocating/transferring customer flows among firms with multiple demand sources and multiple service facilities. Firms decide on the allocation of demand from different sources to different facilities to minimize waiting costs and service fulfillment costs possibly subject to service level requirements. If firms decide to operate collectively as a coalition they must also decide on a scheme for sharing the total cost. We formulate the problem as a cooperative game and identify a cost allocation rule that is in the core. The cost allocation rule is price-directed and equivalent to a market equilibrium.

Keywords: service collaboration, queueing systems, demand allocation, cooperative game, market mechanism

Efficient Inaccuracy: Information Sharing in a Queue

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Shared congestion information takes the form of a snapshot of the service system with a time stamp. Future customers can access the information shared by previous customers. We focus on the equilibrium behavior of customers with shared, lagged queue length information to address the following research question: How does this shared information structure affect the throughput and social welfare compared with the full and no information structures? Perhaps surprisingly, we show that shared information always generates higher social welfare than no information, and then full information when the offered load is high or the service popularity is high.

Key words: observable queue; unobservable queue; information sharing; service operations

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Limit Theorems for Stationary Hawkes Processes and Applications to Infinite Server Queues

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Florida State University

A univariate Hawkes process is a simple point process that is self-exciting and has clustering effect. The intensity of this point process is given by the sum of a baseline intensity and another term that depends on the entire past history of the point process. Hawkes process has wide applications in finance, social networks, online advertisements, neuroscience, criminology, seismology, and many other fields. In this paper, we prove a functional central limit theorem for stationary Hawkes processes in the asymptotic regime where the baseline intensity is large. The limit is a non-Markovian Gaussian process with dependent increments. We use the resulting approximation to study an infinite-server queue with high-volume Hawkes traffic. We show that the queue length process can be approximated by a Gaussian process, for which we compute explicitly the covariance function and the steady-state distribution. We also extend our results to multivariate stationary Hawkes processes and establish limit theorems for infinite-server queues with multivariate Hawkes traffic.

Session 4A – Healthcare Operations II

Scheduling in Operating Theatres with an Entropic Index

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Gies College of Business, UIUC

In this talk, we propose a simple index to study the scheduling problem in the Operating Theatres (OT). We first use empirical data to explore the features of the scheduling issue in OT. Specifically, many surgeries can start earlier than the scheduled time. Then we formulate the scheduling problem such that the waiting time for each surgery and overtime should meet the service requirement. We propose an index named Entropic Deviation to capture both the variance and skewness of the uncertain surgery time. By simply ranking the Entropic Deviation for each type of surgery, we can make the sequencing decisions and achieve relatively good performance.

Keywords: Scheduling, Operating theatres, Entropic index, Healthcare Operations

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Variability Scaling in Health Demands

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Antai College of Economics and Management, Shanghai Jiaotong University
Jingui Xie
School of Management, University of Science and Technology of China

Demand variability is one of the major sources of uncertainty that affect performance of healthcare systems worldwide. We discover that healthcare demands exhibit a universal variability scaling law in both temporal and spatial dimensions. This appears to be the first time that it is discovered in healthcare systems comprehensively. We develop two network models that are capable of explaining the scaling phenomena caused by different types of demand correlations. Our findings also suggest that commonly used Poisson models are inappropriate in modeling healthcare demands and in healthcare resource planning, and they tend to misestimate the level of resource requirement needed to deliver quality healthcare services.

Keywords: healthcare demands; variability scaling; mean and variance

Personalized Treatments with Contrast-Specific Propensity Score

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Joel Goh: NUS Business School, National University of Singapore, Harvard Business School
Donald Rubin: Department of Statistics, Harvard University

The area of personalized medicine, which focuses on making medical decisions from multiple drugs based on individual treatment effects, is of considerable current interest. Often, the observational data to assist such decisions is consistent of a setting where multiple treatments are prescribed to a population of units, each of which is associated with pre-treatment covariates that are measured before being exposed to the multiple treatments. The personalized treatments are estimated from on a strata of data with similar observed covariates, where each unit is associated with only one of the multiple potential outcomes. However, these units might not be comparable and thereby produce estimates with cycle dilemma, e.g., drug A is more effective than no-drug, no-drug is more effective than drug B, drug B is more effective than drug A. In this study, we attempt to eliminate such cycle dilemma through developing a contrast-specific propensity score approach.

Keywords: multiple treatments, personalized treatment effects, diabetes

Bed Allocation to Reduce Overflow

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Mabel C. Chou: NUS Business School, National University of Singapore
Marcus Ang: Singapore Management University
David D. Yao: Columbia University

Hospital emergency department boarding time, i.e. the duration between the impatient bed request time and the patient admission time to inpatient wards, is a key performance in many hospitals. In order to avoid this waiting time to exceed certain level, some hospitals including the one under study in this paper may set a maximum boarding time level, say six hours, beyond which patients will be assigned to any available beds in the impatient wards despite the medical specialties required. As a result, patients may be overflowed all over the hospital, causing physicians wasting their time on the way to visit their patients. High overflow rates also cause many other problems such as worse patient outcomes and more complicated bed allocation process. To address the overflow issue, we build an analytical model and propose two easy-to-compute bed allocation polices. We use the real data from the only university hospital in Singapore and a simulation model to evaluate the effectiveness of our proposed polices against the base case provided by the empirical study of the hospital. Through the simulation study, we show that the proposed policies can reduce the overflow rate from 18.91% to about 4-5% without sacrificing other performance measures. More surprisingly, our simulation studies suggest that the existing capacity actually can accommodate 50% more elective patients while keeping the overflow rate at a level of less than 10%.

Keywords: Bed allocation, overflow, queueing models, simulation, data analysis

Logistics Service Quality Measurement in Supply Chain: A Study in China

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Delivering high service quality has become the key to gain sustainable competitiveness, especially for logistics in supply chain. This paper explores the critical factors influencing logistics service quality in supply chain, and develops a measurement scale (SC-LSQ). We employ a Delphi study with 16 experts to refine the draft scale drawn from literature review and industry survey. Then, a comparative study of SC-LSQ, SERVQUAL and LSQ Model is performed to verify its reliability. Finally, we get a scale with 7 dimensions (timeliness, intact, reliability, economy, communication, service competence and innovation) and 22 items.

Keywords: Logistics service quality, Supply chain, Delphi study, Comparative study, Measurement scale

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Matching Policy Optimization of City LCL Carpool Based on Time Windows under the Background of O2O

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Bin Dai
School of Economics and Management, Wuhan University

Combining with field research to the Zallsoon Enterprise, this paper simultaneously considers the demand of drivers and clients to propose the optimized matching policy of LTL carpool in order to reasonably realize matching and planning. First, we propose the optimized policy. Then under the premise of considering the factors of clients' OD points, time windows and drivers' working time windows, start-end terminals and vehicle capacity, we construct the mathematical model which called the half-open multi-depot vehicle routing problem with pick-up and delivery and time windows, aiming at minimizing the total cost. Finally, we select Zallsoon Enterprise's practical data to confirm the superiority and feasibility of the model and algorithm.

Key words: LTL carpool, route optimization, pick-up and delivery, time windows

Agent-Based Simulation Analysis for Measuring Effectiveness of Unmanned Ground Vehicle

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In general, Unmanned Ground Vehicle like robot is one of the most effective weapon system based on leading edge technology in the modern warfare. However, measuring its effectiveness is still a difficult question to answer. Moreover, since the future warfare is getting more network centric rather than platform centric, it is even more difficult and complex to estimate its operational effectiveness. Therefore, it is challenging task to develop a methodology or approach to show how efficiency it is during a ground battle of the network centric warfare. One clear distinction of this paper from others is that we are considering communication error effects depending upon terrain condition near each platform. The terrain condition is defined based on a small cell and its altitude in each cell. In this paper, we propose a new simulation framework for how to measure the operational effectiveness of unmanned ground vehicle in a small unit combat scenario. The framework is processed with following three phases. At first, we consider all relational factors for input and output variables in communication network environment of all platforms. Secondly, build a simulation model and select a measure of effectiveness based on purpose of the system performance. Thirdly, execute a simulation model and produce MOE do the output analysis. We compared and showed the difference among three cases based on terrain condition.

Keywords: Operational Effectiveness, Measure of Effectiveness, Communication Error

Tracking Technologies for the Efficient Operations of Distribution Center

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Our work was motivated by a real-world problem in a large air mail centre. We have developed an RFID-based location-positioning platform for the application. The RFID-tag attachments to carts and reader mounts at the top of the building allow the facility operators to locate target carts quickly. We have also conducted an initial analysis of data collected using this technological infrastructure to understand issues on cart movements and operational efficiency.
Keywords: Air mail centre, distribution centres, RFID, tracking technologies, analytics

Pricing Strategy and Structure Selection in Dual Channel E-Retail

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This paper investigates the impact of the operational pattern and service quality of e-retail platform on the e-retail price and channel selection strategy in dual channel e-retail. From the perspective of manufacturers, the dual channel structure can be divided into three kinds: dual platform with dual pattern (RS), dual platform with single pattern (RR and SS) and single platform with dual pattern (R+S). The results show that the improvement of service quality of one e-retail platform will raise its e-retail price, but will reduce the competitors' e-retail price. The analysis also suggests the preference lists of the manufacturer over e-retail channel structures.

Keywords: Channel selection, Channel competition, Pricing game, E-retail

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Pricing Substitutable Products when Consumers Regret

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This paper studies the effects of second period valuation uncertainty and anticipated regrets on consumer behavior and firm's pricing decisions. We consider a firm selling two substitutable products in a selling season with two periods, where each product is sold in each period. At the beginning of the selling season, the firm announces all his prices and each consumer decides to purchase-or-wait. A consumer may experience purchase regret or wait regret. We define the optimal prices and find that the effects of regret on the optimal second period price are non-monotonic.

Keywords: substitutable products, anticipated regret, second period valuation uncertainty

Continuously Promotional Effect on Two-Stage Pricing and Promotion Strategy for New Product

Gaoyan Lyu, Lihua Chen
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Different orders of price and promotion have impacts on profits of suppliers and retailers on the condition that the supplier determines retail price and the retailer makes sales effort, when they are going to launch a new product. Meanwhile, sales effort in the first period has effect on the demand in the second period. This paper seeks to shed light on the impacts of different strategies on the profits of supplier and retailer considering the cross-time sales effort effect. We consider four strategies: pricing first in both of the two periods (C-C strategy), pricing first in the first period and promote first in the second period(C-F strategy), promote fist in the first period and pricing in the second period(F-C strategy), promote first in both of the two periods(F-F strategy). Our results show that: 1) Either the supplier or retailer should not choose F-C strategy. 2) When price sensitivity or promotion cost is higher, these strategies coordinate or conflict between the supplier and the retailer. Particularly, when revenue sharing coefficient is smaller and cost allocation coefficient is bigger, it benefits both of the supplier and the retailer to choose C-F strategy; when revenue sharing coefficient is bigger and cost allocation coefficient is smaller, it benefits both of the supplier and the retailer to choose C-C strategy. We contribute the price strategy literature in considering sales effort and price strategies in two periods, and the effect of continuous sales on the market in the second period.

Keywords: New product, Game theory, Pricing, Promotional effect

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Robust Contract Designs: Linear Contracts for Sales Force Compensation

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We consider sales force compensation where the principal has parameter uncertainty over the output: the parameters of the output distribution are in an ellipsoidal uncertainty set. The principal evaluates possible contracts by their worst-case performance over all possible parameters. Interestingly, we find that linear contracts are uniquely optimal and robust to the parameter uncertainty. We provide a new explanation for the popularity of linear contracts in practice. We also analyze the trade-off between robustness and worst-case performance, and perform robustness checks in a variety of settings. Our paper introduces a flexible modeling approach for robust contract designs with parameter uncertainty.

Keywords: sales force incentives, robust contract design, linear contracts, worst-case

Session 4D – Supply Chain Management II

The Significance of "Time" in Supply Chain Interaction

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Supply chain interaction emphasizes tangible objects exchanged and the processes that are associated. In this paradigm, time is a resource that can be converted in monetary terms, a duration and a process delimiter. Based on evidence from a longitudinal cross-case study in a Swiss corporation's global supply chains, this established operationalization of time in research and management is expanded and a temporality checklist introduced. Clock time and social time become coexisting synchronizing devices for events and processes. Accessed by diverse sources and viewpoints, time can thus be understood as flexible and a negotiable entity among actors in a supply chain.

Keywords: SCM, Temporality, Collaboration, Processes, Flexibility

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Information Protection in New Product Development Projects

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Motivated by the threat of industrial espionage during new product development, a project company minimizes information leakage by using decoy work. The competitor validates the information it observes in a cost-effective way, based on three alternative prior assumptions about its validity. We model this problem as a two stage Stackelberg game, identify an equilibrium solution, and obtain managerial insights. Coordinated setting of the project deadline and budget is needed to protect the project. Counterintuitively, it benefits the project company to announce that it uses decoy work.

Keywords: new product development, information loss, Stackelberg game, optimal protection strategy

Contracting for Product Support under Information Asymmetry

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Nishant Mishra
KU Leuven

We study contracting for MRO outsourcing when the information about product reliability is privately informed by the users. The supplier designs price as well as uptime level as contract terms to screen product failure rates and to maximize profit. We find that the highly- advocated advantages of the performance-based contracts (PBC) may disappear due to information asymmetry. On the other hand, the more traditional transaction-based contracts (TBC) can lead to lower information rent. Moreover, TBC can even be the preferable contract type for both supply chain partners.

Keywords: MRO, service contracts, capacity investment, mechanism design

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Price Strategy for CRH Express Supply Chain in Allotments and Spot Market

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CRH express supply chain is a logistics service supply chain which takes advantage of the high-speed railway transport to provide users with small parcel express service. The price strategy for CRH express supply chain consisting of one high-speed railway company and multiple courier companies in Allotments and Spot Market is researched. The game process of CRH express supply chain is analyzed, and the sequential pricing model and joint pricing model are constructed respectively. The optimal pricing decision in these two models is analyzed and compared with each other.

Keywords: CRH express supply chain, Sequential pricing, Joint pricing, Uncertain demand

Session 4E – Data-Driven Research I

A DEA Method for Selecting Suppliers in Sustainable Supply Chain Management

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In sustainable supply chain management (SSCM), selecting the most sustainable suppliers becomes an important issue to meet stakeholder requirements including profit improvement, ecological efficiency and social responsibility. DEA analysis, considering different performance factors, is an effective method for the supplier's selection process. These factors can be classified into three dimensions (economic, environment, and social). Although a simple DEA model for each dimension can generate efficiency scores of each supplier, the model is not suitable for some factors belonging to two dimensions simultaneously. To resolve this issue, this paper proposes an overlapping approach so as to conduct DEA analysis effectively.

Keywords: sustainable supply chain management, sustainable supplier selection, data envelopment analysis

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New Product Demand Forecast: Hybrid Structure & Data Driven Approach

Shanshan Huang, Andrew Lim, Tong Wang
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We propose a model for forecasting new product demand with a cosmetic retailer. One of the main challenges is sparsity of the data. Even though we have 20 millions of data points including sales, store, time and product information, we don't have historical sales data for new products. To address the issue, we construct a function-regime matrix representing two dimensional product category. We apply mixture of choice models to extrapolate total demand for new function-regime combinations. We compare our method with other nonparametric methods such as random forest with respect to predicting new products demand.

Keywords: New product, demand forecast, data driven OM

Data-Driven Consumer Debt Collection via Machine Learning and Approximate Dynamic Programming

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In this paper a framework is presented that allows for data-driven optimization of the scheduling of outbound calls made by debt collectors. More precisely, this paper considers the problem of deciding throughout time which debtors to call next, provided that the debt collector is constrained in the number of phone calls that its agents can make. We approach this problem by formulating a Markov Decision Process and, given its intractability, approximate the value function based on historical data through the use of state-of-the-art machine learning techniques. Specifically, we predict the likelihood with which a debtor in a particular state is going to settle the debt and use this as a proxy for the value function, allowing us to optimize the schedule by marginalizing the value of making additional phone calls to a particular debtor. In doing so, the framework schedules phone calls based on all available relevant data that may affect payment behavior. We find that in a holdout sample our machine learning technique achieves 0.689 AUC for repayment predictions, and that following the optimal policy prescribed by our framework could potentially lead to a ten-fold improvement in marginal gain per outbound call as compared to the incumbent policy. The improvement comes mostly from selecting debtors that have been in the collection process longer, have not been contacted recently, and have previously answered calls or contacted the debt collector themselves.

A Novel Method of Variable Selection in Data Envelopment Analysis with Entropy Measures

Zhaotong Lian, Qiang Deng, Qi Fu
University of Macau

We develop a novel method to facilitate variable selection in DEA using entropy theory to avoid information redundancy. The proposed method produces a lower Akaike information criteria (AIC) value than other approaches. It not only removes redundant information, but improve efficiency on key factors and superior resources. Further, it enables to choose the optimal number of variables.

Keywords: Data envelopment analysis, variables selection, entropy theory, Akaike information criteria (AIC)

Session 4F – Inventory Management II

Size Matters, So Does Duration: A Joint Optimization of Offer Size and Offer Deadline

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Zhenyu Hu
NUS Business School

This paper addresses the simultaneous determination of offer size and deadline in a Stackelberg game involving a proposer and responder. The proposer makes an offer to the responder with a deadline, and the responder, concurrently searching for alternative offers, has to respond to the proposer's offer by the deadline. We capture the responder's strategy by a "reservation value policy". Taking this into account, the proposer's optimal strategy can vary from an exploding offer to an offer with extended deadline under different market conditions. Finally, we analyse cases where only the offer deadline or offer size is at the proposer's disposal.

Keywords: deadline, exploding offer, dynamic programming, Stackelberg game

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Allocation Inequality in Cost Sharing Problem

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This paper considers the problem of cost sharing, in which a coalition of agents, each endowed with an input, shares the output cost incurred from the total inputs of the coalition. Two allocations-average cost pricing and the Shapley value-are arguably the two most widely studied solution concepts to this problem. It is well known in the literature that the two allocations can be respectively characterized by different sets of axioms and they share many properties that are deemed reasonable. We seek to bridge the two allocations from a different angle-allocation inequality. We use the partial order: Lorenz order (or majorization) to characterize allocation inequality and we derive simple conditions under which one allocation Lorenz dominates (or is majorized by) the other. Examples are given to show that the two allocations are not always comparable by Lorenz order. Our proof, built on establishing Lorenz order over certain input vectors, maybe of independent interest.

Keywords: cost sharing problem, average cost pricing, Shapley value, majorization, cooperative game

Dynamic Financial Hedging and Inventory Management for Storable Commodity: A Time-Consistent Approach

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Commodity risk management remains a major challenge in supply chains facing volatile raw material commodity prices. We present a time-consistent approach to integrating the dynamic financial hedging and inventory management strategy for a firm that purchases a storable commodity from spot market and processes it into an end product to meet uncertain demand while accessing the financial derivatives markets to hedge against the price risk. We characterize the optimal replenishment policy and financial hedging strategies under both vanilla hedge and exotic hedge and investigate how inventories and financial hedges interplay to shed new light into commodity risk management.

Keywords: Commodity risk, financial hedging, inventory management

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Population Monotonicity in Newsvendor Games

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Previous studies on cost allocation for a newsvendor game have focused on the core of the game, which ensures the stability of the grand coalition. Yet, an allocation that lies in the core does not necessarily guarantee the unhindered formation of a coalition, as some existing members' allocated costs may increase when new members are added. We use the concept of population monotonic allocation scheme (PMAS), which requires the cost allocated to every member of a coalition to decrease as the coalition grows, to study the newsvendor game.

Keywords: cooperative game theory, newsvendor game, inventory centralization, population monotonicity

Session 4G – Mechanism Design I

A Note on Optimal Incentive Contracts in Project Management

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We study the contract-design problem faced by a firm/organization for executing a project consisting of multiple tasks, each performed by an individual contractor whose efforts are not observable. We study the case when these tasks can be performed in parallel and the case when they have to be performed sequentially. While the contractors incur costs continuously during the course of their tasks, the firm realizes its reward or revenue only when the entire project is completed. The firm's contract-design decisions and the contractors' effort-level decisions are all governed by the goals of maximizing the respective party's expected discounted profit.

Keywords: Project Management, Contract Design, Unobservable Effort, Uncertain Completion Times

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The Informational Role of Buy-Back Contracts

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A manufacturer offers a retailer a buy-back contract specifying a wholesale price and a return price. The manufacturer has proprietary information about either her return risk (referred to as the likelihood that the return clause will be honored) or the product's demand potential (referred to as the probability of high demand realization). When the return risk is concerned, the less risky manufacturer offers lower wholesale and return prices. In contrast, when the demand potential is concerned, the manufacturer with higher demand potential offers higher wholesale and return prices. A novel signaling mechanism is identified as a result.

Keywords: Buy-back Contract, Signaling, Return Risk, Demand

Analysis of Scrip Systems: On an Open Question in Johnson et al. (2014)

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This paper is motivated by the analysis of scrip systems in Johnson et al. (2014) and addresses an open question in their paper. A scrip system refers to a resource-sharing market where scrips play the role of real currency – the beneficiary of a service "pays" scrips to the provider, who in turn can "purchase" services using scrips. Under mild assumptions, we show that everybody in the system being always willing to provide service is a Nash Equilibrium under the minimum-scrip-service-provider-selection rule. This suggests that this rule can lead to a high level of social welfare.

Keywords: Scrip Systems, Always-trade Strategy, Minimum-scrip Rule, Nash Equilibrium

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The Effects of Auction Pricing Mechanisms and Social Characteristics in Online Microloan Market

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We empirically investigate the effect of borrowers' selection of the auction pricing mechanism and its interaction with the effect of borrowers' social characteristics on the outcomes of online microloan markets. We show that a borrower's choice of the borrower pricing mechanism, as well as her group affiliation, exhibits an adverse selection effect. Also, we find that while a borrower' social friendship information may serve as a positive signal of her creditworthiness, her group affiliation may send a misleading signal. Moreover, the choice of the auction mechanism and borrowers' social characteristics serve as good predictors of default risk and credit loss.

Keywords: Online P2P lending, Auction Pricing Mechanisms, Social Characteristics

Session 4H – OM-Finance Interface I

Financial Pooling in A Supply Chain

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We study a supply chain in which the buyer uses trade credit to purchase from the supplier. The embedded stretch option of trade credit allows supply chain partners to pool their liquidity buffers. Due to this pooling effect, even as the supplier's financing costs are higher than the buyer's, trade credit can be more efficient than cash on delivery when the supplier's cost for collecting trade credit is low or when the supplier does not have access to a low-cost financing channel when facing liquidity shocks. The benefit of pooling increases as the buyer has a more diversified supplier portfolio. As an innovative financing scheme, reverse factoring further enhances the efficiency of this pooling effect.

Keywords: Trade credit, pooling, reverse factoring, supply chain finance, operations-finance interface

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Risk Aversion, Downside Risk Aversion and Cumulative Prospect Theory

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Cumulative Prospect Theory (CPT), featured by S-shaped value functions and probability weighting functions, challenges the predominance of Expected Utility Theory (EUT) in describing individuals' choice behavior under risk. Using stochastic dominance approach, our paper aims to bridge CPT and EUT by providing a choice-theoretic characterization for the tradeoff between overall risk (variance) and downside risk from both risk aversion and downside risk aversion perspectives in CPT paradigm where the degrees of risk aversion and downside risk aversion are measured by absolute risk aversion and prudence respectively. We also discuss downside risk measures like lower partial moments and third central moment.

Keywords: Decision making under risk; Cumulative Prospect Theory; Downside Risk Aversion; Risk Aversion

Quality Signaling through Crowd-funding Campaign Design

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We study an entrepreneur's strategy in a reward-based crowd-funding campaign to signal product quality to the crowd. There are two periods: the funding and the spot periods; the entrepreneur continues to sell to spot customers only after running a successful funding campaign. We study two signaling mechanisms: one- and two-price signaling. In one-price signaling, the entrepreneur posts a funding price alongside a target financing level on an online platform. In two-price signaling, the entrepreneur commits to both the funding and spot prices at the beginning of the campaign. We show that just the funding price might be enough to signal project quality; the spot selling opportunity and the probabilistic nature of project success in the funding period allow the entrepreneur to signal quality through charging lower prices. We also show that commitment to a higher future spot price can always signal project quality to potential campaign funders. When both one- and two-price signaling are possible, we show that two-price signaling dominates one-price signaling only when the gap in high and low quality levels is neither large nor small and the funding period market size is not small compared with the spot period market size.

A Perfect Financial Hedge for Certain Real Options

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We consider a manufacturer who has the real option of purchasing parts from several international vendors. Total quantity to be procured as well as prices in local currencies are fixed in advance, but purchased quantities are only determined once exchange rates are known. We show how the manufacturer can perfectly hedge the exchange rate risk, even in the presence of constraints (e.g. due to capacities) on the purchased quantities, as long as the constraints have a submodular structure. Similarly, the manufacturer can perfectly hedge the exchange rate risk of selling into several international markets.

Keywords: Supply chain management; Interface between OM and Finance; Risk management; Global operations management

Session 4I – Green Efforts and Channel Management

Can Carbon Cap and Trade Mechanism be Beneficial for Manufacturers?

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Remanufacturing is an environmentally friendly and profitable way for production operations. Carbon cap and trade mechanism aimed at reducing carbon emission is considered as a burden for manufacturers in previous studies and practices. We explore the possibility of a monopolistic manufacturer to make profits under this mechanism in a single period. We develop a mathematical model to derive the favorable conditions under which this mechanism is beneficial for the manufacturer, and obtain the manufacturer's optimal decisions. The results show that carbon cap and trade can be valuable for remanufacturing. The carbon trading price is effective on quelling carbon emission.
Keywords: sustainable operations management, carbon cap and trade, remanufacturing

Try-Before-You-Buy Strategy with Customer Self-Mending

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The development of e-commerce is interfered by product fit uncertainty (PFU), pioneering online retailers like Amazon and Warby Parker are trying to overcome PFU problems by "Try-Before-You-Buy" (TBYB) strategies with which consumers could try multiple products at home before buying, and return bad fit products hassle-freely. We also consider another PFU mitigation mechanism based on customer self-mending(CSM) behaviors by which consumers could mend bad fit products to gain proper fit at their own cost. In this study, we develop a parsimonious model to investigate the TBYB strategy for an online retailer, and we find CSM behaviors interplay with TBYB strategy. Without CSM, we find that TBYB strategy works as a Pareto improvement mechanism for the society since the retailer's profit is increased without reducing customer surplus. With CSM, TBYB strategy is totally different. First, we find the conditions for the retailer to adopt TBYB strategy is critically depending on the operation cost, product value, and the scale of members who use TBYB options. Specifically, TBYB strategy is viable if: 1) the operation cost is relatively low; or 2) although the operation cost is relatively high, the product value is relatively high; or 3) although the operation cost is relatively high and the product value is relatively low, the member scale is large enough. Second, we find TBYB strategy reduces customer surplus in average, excepting members' surplus is increased when there're enough members in the market. Third, TBYB strategy increases social efficiency with higher social welfare only if the operation cost is relatively low, the product value is relatively high, and the member scale is relatively small. The comparison of the findings between cases with and without CSM shows the importance of CSM in TBYB strategy, and indirectly implies that CSM is a useful PFU mitigation mechanism in its own right.

Keywords: “Try-Before-You-Buy” Strategy, Customer Self-mending, Product Fit Uncertainty

Active or Passive? Sustainable Manufacturing in Direct-channel Green Supply Chain: A Perspective of Two Types of Green Product Design

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In this paper, we consider a direct-channel supply chain model with manufacturer producing two types of green products under government interventions aiming to improve social welfare. Our research derives the closed form solutions to the optimal tax, green degree and price for the products and obtains the strategies for government and manufacturer under different environmental policies. By considering six scenarios, our models get the best choice from the comparison between the two cases in which manufacturer determines its product green degree actively or accepts the green standard set by the government passively. Then, we conduct some sensitivity analyses. The results of this research indicate that government setting the product green standard and providing manufacturer with subsidy is significant. We point out that with government paying more attention to environment, manufacturer and consumer can also benefit from it.

Keywords: supply chain management, government intervention, green product design, game theory, environmental protection policy

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How Much can MBG Help Manage the Competition from Gray Markets?

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Nowadays global companies are increasingly challenged by parallel importers who divert goods from authorized channels to gray markets. While the existing literature with respect to gray markets mainly focuses on pricing, in this paper we develop a model to investigate the role of Money Back Guarantee (MBG) as non-pricing mechanisms for coping with gray markets. We show that when MBGs are profitable, it is Nash equilibrium for the manufacturer and the parallel importer to offer MBG. Manufacturer’s MBG in the low-price market plays the major role in attacking gray markets. Interestingly, the parallel importer’s profit function may decrease with its satisfaction rate.

Keywords: Money Back Guarantee, Gray Market, Parallel Importation, Channel Management

Session 4J – Stochastic Models and Queueing II

Priority Service Pricing with Heterogeneous Customers

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This paper studies the priority service pricing problem of a service system that serves customers with heterogeneous delay sensitivity. We consider a service system with a single server and two queues: a fast track and a regular track. Customers in the fast track will be served with priority. Customers have heterogeneous delay cost rate (also named cost of delay or unit delay cost), which follows a general distribution. Upon each customer's arrival, the customer must decide which queue to join. If the customer joins the fast track, an additional price will be charged. We discuss the customers' choice behavior under a fixed price, and find that there might be multiple equilibria, the number of which depends on the distribution of customers' cost of delay. More importantly, we give a characterization of stability of these equilibria and show that the system can always reach the largest equilibrium by setting a proper initial delay announcement. We also consider the optimal pricing problem with the objective of maximizing the system's long run average profit or social welfare, and give a characterization of the profit-maximizing and social-welfare-maximizing prices. Our results show that different cost-of-delay distributions can lead to completely different pricing strategies for the service system.

Keywords: Priority service, pricing; cost of delay, delay announcement, equilibrium

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Many-Server Equilibria with Server Effort and Idleness Cost

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Most common queueing models used for service system design assume the servers work at fixed rates. However, real-life service system are staffed by people, who may change their service speed in response to their compensation incentives, effort and idleness costs. We study the symmetric equilibrium service rate(s) in a large many-server system. We identify conditions on the staffing level when there is a unique or multiple equilibria, which depend on the server utility function. The equilibrium service rate could be increasing or decreasing in staffing level.

Keywords: Many-server queue, equilibrium service rate, server utility, idleness cost

Dynamic Scheduling with Uncertain Job Types

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We study systems with uncertain job types, where a job assigned to a wrong-type machine must be re-scheduled with more information on its type. The question is to dynamically schedule all jobs to minimize the expected makespan. We obtain the near optimal policy, named Less-Uncertainty-First (LUF) policy when there are two types of jobs, insights from which are used to develop heuristics for more general cases. We also consider other objectives including number of mismatch and total sojourn time in the extension. Comparison with known benchmarks shows that our heuristics significantly improve the system performance under three different objectives.

Keywords: Uncertain job types, scheduling, less-uncertainty-first, makespan, total sojourn time

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Balanced Routing with Many Servers

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This project studies a paralleled service system with multiple-server stations and a single class of customers, where upon each customer's arrival the system manager decides which station he should be routed to, while the station information retrieval is costly. We consider a balanced routing policy, under which only a random number of stations' information will be retrieved at each routing epoch. By establishing the fluid limit and diffusion limit of the queue length process under heavy traffic regime, we show that our proposed routing policy is asymptotically optimal in minimizing the long-run average cost of waiting and information retrieval.

Keywords: balanced routing, fluid limit, diffusion limit, heavy traffic

Session 5A – Healthcare Operations III

Models for Congestion in Maternity Inpatient Wards

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Maternity ward congestion can lead to sub-standard maternity services such as "hallway medicine" and closures. Recognizing that in many places maternity service is differentiated based on price or health plan, health history, clinical evidence, etc, we compare two alternate stochastic models for multi-class capacity allocation. In the first phase, we propose a static model using a Level Crossing method to derive closed-form optimal allocative solutions. In the second phase, we use dynamic control policies that are asymptotically optimal in the Halfin-Whitt regime. We then compare the performance of the two policies, to determine the relative benefit of dynamic scheduling.

Keywords: health service management, maternity inpatient ward, queues with abandonment, level crossings, dynamic scheduling

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Simulation Analytics of Hospital Emergency Department Operations

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This talk presents our work which uses simulation to analyze patient flows in a hospital emergency department (ED) in Hong Kong. This simulation approach provides a tool for the operations manager in the ED to assess the impact of changes in the system on the daily operations. We will discuss how simulation can be integrated into an optimization algorithm to aid decision-making. We will also present insights into managing ED operations derived from the simulation experiments.

Keywords: Emergency departments, operations, simulation, simulation optimization

Sequential Clinic Scheduling with Patient Re-Entrant

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Mark Lawley
Texas A&M University

Mohs Micrographic Surgery (MMS) is a surgical method for skin cancers. It sequentially removes and examines one skin layer at a time until a cancer free layer is obtained. This results in patients re-entering the service queue on the same day. Currently patients often experience long waiting due to the stochastic nature of layer removals, pathology and re-entrant. To improve patient experience and clinic revenues, we develop a model for MMS clinic scheduling. The model captures the key characteristics of the surgery-pathology and stochastic re-entrants. Theoretical properties of the scheme and numerical study demonstrating the efficiency improvement are provided.

Keywords: Mohs Micrographic Surgery, Appointment Scheduling, Outpatient Clinic Scheduling, Patient Re-entrant

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Asymptotic Optimality of Constant Job-Allowance Policy for Appointment Scheduling

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Yichuan Ding
Sauder School of Business, University of British Columbia

Inspired by the “dome” pattern of the optimal schedule shown in the previous literature, we develop a simpler but effective plateau policy for the traditional appointment scheduling problem. We establish the explicit gap ratio bounds between the plateau policy and the optimal schedule. And we prove that the plateau policy is asymptotical optimal for the i.i.d. service durations. We also extend this asymptotic optimality result into piecewise i.i.d. service durations and more general setting, like no-shows and unpunctuality. The numerical experiments shows that the plateau policy performs well in various parameters combinations.

Key Words: appointment scheduling, plateau scheduling policy, asymptotic optimality

Session 5B – Logistics and Transportation II

A Modified NSGA-II for the Multi-Trip Vehicle Routing Problem with Workload Balancing

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The Multi-Trip Vehicle Routing Problem with Workload Balancing investigated in this paper is a variant of the Multi-Trip Vehicle Routing Problem where two objectives are simultaneously optimized. One is the traditional cost objective and the other is the workload balance objective among drivers. We propose a Modified NSGA-II algorithm integrated with a Split representation for individuals to address this problem. An efficient two-stage Split Assign procedure is proposed for turning the individuals of population into solutions. Experiments based on Solomon's benchmark demonstrate the effectiveness of the method. To prove its ability to deal with real-world complex problem, a practical example is tested and some management suggestions are concluded.

Keywords: Multi-Trip Vehicle Routing Problem, Workload balance, NSGA-II, Split, Bi-objective

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Flexibility and Visibility as Antecedents in Synchromodal and Resilient Networks: the Effect of the Development of Dynamic Capabilities with Logistics Service Providers

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MIT-Zaragoza Logistics Center

Synchromodality is seen as the natural evolution of supply chain. However, in order to fully embrace synchromodality, logistics and transportation companies first need to develop certain dynamic capabilities such as visibility and flexibility. Capabilities that have been tested to increase resilience in the supplier-buyer dyad. Using a survey-based research, we have empirically analyzed the European logistics network of a leading global consumer goods manufacturer and analyze how the level of visibility and integration among companies, do not only create resiliency and increase the overall performance of the supply chain, but are required antecedent in the development of synchromodal value networks.

Keywords: Logistics Management, Supply Chain Management, Resilience, Dynamic Capabilities, Empirical studies in the service and operations management

A Slots vs. Pricing Game when Routes are Substitutes

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We consider a three-city airport network where local governments independently choose between pricing and slots policies to manage own congestion. Governments may value airport profits or attach a zero value to airport profits. Pricing policies are weakly dominant strategies in the first case, while slots are weakly dominant strategies in the second case. We show that the equilibrium prices are excessive relative to first-best prices (which maximize the sum of the welfares of all jurisdictions) in the case of congestion pricing, while the equilibrium slot quantities can reach the first-best solution only if airline connections are considered as substitutes by passengers.

Keywords: Airports, slots, congestion pricing, local governments, dominant strategies

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Session 5C – OM-Marketing Interface V

Created Unequal: Bundling with Crowdsourced Products

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As consumer buying habits are trending toward more simple and hassle-free experiences, more and more companies are jumping into the innovative business model of subscription services. Subscription providers such as Spotify, Netflix and OneGo (an all-you-can-fly subscription service provider) crowdsource products/services from many vendors and bundle them for the price of one. The collected subscription fees for the bundle then are allocated according to the realized contributions by each crowdsourced product. We examine the incentive compatibility of different parties under various bundling strategies.

Keywords: Subscription, Bundling, Revenue Sharing Policy

When will Bundling of Cross-Industry Products be Preferable?

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This paper discusses the optimal decision of a retailer who sells two products of different industries, yet the retailer has an option of selling the bundle of these two products as a new product. The natural question is whether the retailer is willing to sell the new product or not. We built Newsvendor models to derive optimal quantities and profits of different choices, compared these optimal profits, and discussed the circumstances where the bundle product is preferable. Our research explains why bundle products of two entirely different industries exist, and also why such bundle products are not popular. Numerical analysis under uniform demand distribution and normal demand distribution supports our results.

Keywords: Cross-industry bundling, Newsvendor model, New product introduction

Try-Before-You-Buy Strategy with Customer Self-Mending

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The development of e-commerce is interfered by product fit uncertainty (PFU), pioneering online retailers like Amazon and Warby Parker are trying to overcome PFU problems by "Try-Before-You-Buy" (TBYB) strategies with which consumers could try multiple products at home before buying, and return bad fit products hassle-freely. We also consider another PFU mitigation mechanism based on customer self-mending(CSM) behaviors by which consumers could mend bad fit products to gain proper fit at their own cost. In this study, we develop a parsimonious model to investigate the TBYB strategy for an online retailer, and we find CSM behaviors interplay with TBYB strategy. Without CSM, we find that TBYB strategy works as a Pareto improvement mechanism for the society since the retailer's profit is increased without reducing customer surplus. With CSM, TBYB strategy is totally different. First, we find the conditions for the retailer to adopt TBYB strategy is critically depending on the operation cost, product value, and the scale of members who use TBYB options. Specifically, TBYB strategy is viable if: 1) the operation cost is relatively low; or 2) although the operation cost is relatively high, the product value is relatively high; or 3) although the operation cost is relatively high and the product value is relatively low, the member scale is large enough. Second, we find TBYB strategy reduces customer surplus in average, excepting members' surplus is increased when there're enough members in the market. Third, TBYB strategy increases social efficiency with higher social welfare only if the operation cost is relatively low, the product value is relatively high, and the member scale is relatively small. The comparison of the findings between cases with and without CSM shows the importance of CSM in TBYB strategy, and indirectly implies that CSM is a useful PFU mitigation mechanism in its own right.

Keywords: "Try-Before-You-Buy" Strategy, Customer Self-mending, Product Fit Uncertainty

The Role of Anticounterfeit Technology in Combating Counterfeit Products

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Counterfeits cause tremendous damages to brand companies by eroding market shares and reducing customer's willingness to pay. In this paper, we develop a game-theoretic model to study the role of anticounterfeit technology in combating counterfeit products.

Keywords: counterfeits, anticounterfeit technology, law enforcement

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Session 5D – Supply Chain Management III

The Effect of Information System Connectivity and Relationship Commitment on Structured and Non-Structured Information Sharing and Supply Chain Performance: An Extended Resource Based View

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Baofeng Huo: Zhejiang University
Qiang Zhou: Hong Kong Shue Yan University
Xiande Zhao: China Europe International Business School

Using the extended resource based view, this study investigates the impact of information system connectivity and relationship commitment on information sharing (IS) and supply chain performance (SCP). According to the characteristics of shared information and IS channels, customer IS is divided into structured and non-structured IS. Using date collected from 622 manufacturers in mainland China and Taiwan, we find that customer information system connectivity is positively related to both structured and non-structured IS, while customer relationship commitment only positively impacts unstructured IS. Both structured and non-structured IS positively influence SCP. Hierarchical regression analysis results indicate that the impact of interaction of customer information system connectivity and relationship commitment on SCP is significantly negative.

Keywords: Structured information sharing, non-structured information sharing, Information system connectivity, Relationship commitment, Supply chain performance

OEM Selling Channels and Supply-Chain Performance

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National Taiwan University
Hsiao-Hui Lee
The University of Hong Kong

This paper studies how an OEM's selling channel can enhance its product accessibility in the local market for developing countries. We consider an OEM that manufactures products for its brand buyer that sells to the domestic market and the international market. The OEM offers the brand a discount in exchange to produce and sell products through the OEM's selling channel. We find that authorizing the OEM selling channel can be a win-win strategy because of the economy of scales. Such insights are generally robust even when we consider a cost for the OEM's channel and a price constraint from the brand.

Keywords: Dual selling channel, sustainable sourcing, supply chain incentives and contracting

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Game Analysis and Mechanism Choices of Supplier Product Adulteration Behavior

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Supplier adulteration can affect the quality and safety of final product. This paper studies a decentralized supply chain with one supplier and one buyer and establish Stackelberg game model with a buyer as the leader. Comparing the effect of three mechanism (deferred payment mechanism, inspection mechanism and traceability mechanism) on the supplier adulteration. Our analysis shows that the inspection mechanism and traceability mechanism cannot completely deter the suppliers from product adulteration, whereas the deferred payment mechanism can. Production costs difference between adulterated and unadulterated product is the main factor influencing the three mechanisms. Furthermore, increasing the cost of the product liability can reduce the supplier's adulteration behavior effectively, while the financing rate differences between the buyer and the supplier would increase the cost of supply chain of supplier to prevent adulteration. Buyer can reduce adulteration by decreasing inspection cost and traceability cost. Finally, numerical examples are given to verify the above conclusions. We further analyze the influence of different parameters on the optimal decision and profit.

Keywords: supplier adulteration, deferred payments, inspection mechanism, traceability Mechanism

“At any cost”? Diagnosing the Acceptance of Industry Implementation in the Supply Chain

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The technological uncertainties of integrated Industry 4.0 implementations into capital-intensive supply chains call for differentiated analyses by managers and scholars alike. This longitudinal cross-case study in the German process and automation industry scrutinizes such an introduction of a blend of RFID, SNMP, Big Data analytics and artificial intelligence for large-scale automated decision systems. Technologies are not introduced at any cost; beta implementations may be brought to a halt at any stage by any member of the supply chain. Based on this study, an iterative methodological framework for diagnosing the Supply Chain’s acceptance levels of Industry 4.0 implementations is devised.

Keywords: Innovation, SCM, Integrated Services, Digitization, Added Value

Session 5E – Data-Driven Research II

Dynamic Pricing with Demand Learning: The Effect of Varying Cost

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We study a dynamic pricing problem where the observed cost at each selling period varies from period to period while the demand function is unknown and independent of the observed cost. The decision maker needs to select a price from a menu of K prices in each period to maximize the expected cumulative profit. Motivated by the classical upper confidence bound (UCB) policy for multi-armed bandit problem, we propose a UCB-like policy to select the price. When the cost varies continuously, we show that the expected cumulative regret grows in the order of (log T)2, where T is the number of selling periods. When the cost
takes discrete values in a finite set and all prices are optimal for some costs, we show that the expected cumulative regret is upper bounded by a constant for any T. For the case with continuous cost, we also develop a forced sampling (FS) policy whose expected cumulative regret grows in the order of log T. In spite of having a slower asymptotic growth rate, FS requires a problem-dependent parameter as an input and its practical performance appears worse than the UCB-like policy for reasonably large T. Taking into account these factors, we suggest to use the UCB-like policy no matter whether the cost is continuous or discrete or unknown.

Keywords: Dynamic pricing, Multi-armed bandit with covariates, Upper confidence bound, Regret analysis

Improving Display Advertising With Predictive Device Matching: A Machine Learning Approach

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Retargeting is a highly effective strategy of targeting display advertisements to potential online customers who have already visited the advertiser's website. Controlled field experiments have estimated that retargeting campaigns can increase an online retailer's website visits and purchases by over 17% and 10% respectively. Unfortunately, retargeting campaigns are limited in volume due to fragmentation of user information from poor online tracking. In this paper we develop a machine learning framework to probabilistically match HTTP cookies to users, thereby solving the fragmented user problem and increasing the volume of retargeting advertisements that can be served by as much as 14.3%.

Keywords: Operations-marketing interface, display advertising, machine learning

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Identify High-Cost COPD Patients Based on Machine Learning

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Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality and affected 9.9% of people over 40 years of age in 2012 in China. The objectives of this study were to use machine learning approaches to (1) predict the number high-cost COPD patients and identify high-cost patients and (2) rank the key predictors. Machine learning approaches were used to estimate the medical costs of COPD patients from the Medical and Health Survey data of a large city in western China. The prediction models are LASSO (Least Absolute Shrinkage and Selection Operator), RF (Random Forest), GBDT (Gradient Boosting Decision Tree), and XGBoost (Extreme Gradient Boosting). The results indicated that all four models showed good predictive performances and high predictive values. Particularly, XGBoost outperformed the others (the AUCs of LASSO, RF, GBDT, and XGBoost are 0.784, 0.788, 0.796, and 0.797). The precision and accuracy results indicate that the method obtains correct and reliable results. The results of this study can be used by healthcare data analysts, policy makers, insurers, and healthcare planners to improve the delivery of health services.

Keywords: COPD, high-cost patients; healthcare cost; machine learning

Session 5F – Inventory Management III

Joint Inventory and Pricing Control with Consumption Targets

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In this paper, we study the joint inventory-pricing decision problem with financing control under the target-oriented decision criterion. We provide algorithm to solve the optimal control policies. In addition, we also identify the structure of the optimal policies under some special cases. With the target-oriented framework, we can also solve the approximate solutions efficiently using decision rules. With numerical studies, we report favorable computational results for using targets in regulating uncertain consumption over time.

Keywords: inventory control, decision analysis, targets

Multi-Product Ordering Policy under Forecast Updates

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This paper considers that a retailer sells multiple products which have a long supply lead time and a short selling season. Before the sales season, the retailer can update its forecast and place multiple orders whose costs depend on the timing. The demands are stochastic and are correlated with each other. We derive the optimal ordering policy and analyze the decomposition property of the optimal stock levels under various conditions. We conduct numerical experiments to demonstrate the significance of our findings.

Keywords: inventory management, stockout-based substitution, forecast evolution, dynamic ordering

Multi-Season Production Planning under Export Quotas

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This paper studies a periodic-review multi-season production planning problem facing by an exporting firm where the total sales quantity in each season is restricted by an export quota. The problem is motivated by "export quota" in international trading. We formulate the problem as a MDP and study the structural properties of the value functions and the impact of export quota on the optimal policy.

Keywords: inventory management, export quota, international trading, optimal policy

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Supplier-Base Concentration and Inventory Efficiency: Evidence from Chinese Manufacturing Firms

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This study empirically examines the relation between supplier-base concentration and inventory efficiency in the Chinese manufacturing sector. Using hand-collected data from annual reports during 2007–2015, we find that manufacturers with a more concentrated supplier base hold fewer inventories, and the efficiency primarily flows through the raw materials and work-in-process inventory accounts. We address the association for firms of different sizes and find that small firms benefit more from a concentrated supplier base in inventory efficiency than large firms do. We also examine the relationship between supplier-base concentration and customer-base concentration, and find that the positive effect of supplier-base concentration on inventory efficiency is stronger as customer-base concentration increases.

Keywords: Supplier-base concentration, inventory, empirical research, China

Session 5G – Mechanism Design II

Sensitivity Analysis on Responsive Pricing and Production Under Imperfect Demand Updating

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This paper examines three types of sensitivity analysis on a firm's responsive pricing and responsive production strategies under imperfect demand updating. First, we show that both responsive production and responsive pricing resemble classic pricing newsvendor with posterior demand uncertainty in terms of optimal performance and first-stage decision. Second, we show that performance of responsive production is sensitive to first-stage decision, but responsive pricing is insensitive. Lastly, we find that firm performance is not sensitive to parameter uncertainty coming from market size, total uncertainly level and information quality, but is sensitive to uncertainty originating from procurement cost and price-elasticity.

Keywords: responsive pricing, responsive production, sensitivity analysis, imperfect updating

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Option Contract Design for Supply Chain under Aasymmetric Cost Information

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In this paper, we construct a principal-agent model to investigate option contract design within a two-echelon supply chain under asymmetric information scenario, in which the retailer, acting as a Stackelberg leader, offers a menu of the option contracts to mitigate the risk of uncertain demand. The optimal contracts are obtained under symmetric and asymmetric information scenarios. Compared with symmetric information scenarios, our results prove that level of information asymmetry plays a vital role in the option contracts and the profits. Finally, the impacts of the production cost on the optimal contracts and their profits are explored by numerical experiments.

Keywords: supply chain management, option contract, asymmetric cost information, information rent

Mechanism Design with Efficiency and Equality Considerations

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In this work, we consider the problem of allocating a set of homogenous resources (goods) among multiple strategic players to balance the efficiency and equality from a game-theoretic
perspective. For two very general classes of efficiency and equality measures, we develop a general truthful mechanism framework which optimally maximizes the resource holder's efficiency while guaranteeing certain equality levels. We fully characterize the optimal allocation rule, showing there exist at least one optimal allocation where all the players can be divided into at most four groups and players in the same group have the same winning probability. Based on this characterization, we show the optimal allocation and corresponding truthful payments can be computed in polynomial time, which means the truthful mechanism is computationally feasible. We also show how the optimal efficiency varies under different equality levels.

Key words: Truthful Mechanism design, Polynomial-time Algorithm, Efficiency, Equality

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Procurement Auctions with Ex Post Cooperation between Capacity Constrained Bidders

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The use of procurement auctions is a common practice for firms to procure goods and services. In this paper, we consider a first-price sealed-bid procurement auction consisting of two bidders with limited capacities. We investigate how the ex post cooperation affects bidders' bidding strategies and equilibrium profits as well as the competition intensity of the auction. Surprisingly, we find that a bidder's profit at equilibrium may decrease in its capacity level and increase in its unit cost. Further, it is shown that the bidder with a cost advantage may be hurt by the ex post cooperation.

Keywords: Manufacturing operations management and innovation, Auctions/bidding, Co-opetition, Subcontracting, Capacity constraint

Session 5H – OM-Finance Interface II

Capacity and Linkage Investments as Opportunity Exploitation and Exploration

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Capacity investment decisions are fundamental to operations strategy. In this research, we highlight that enhancing the added value of new production capacity generally requires parallel investment in building upstream and downstream linkages across the supply chain. Borrowing from entrepreneurship research, we conceptualize capacity and linkage investment as opportunity exploitation and exploration, and construct a model to examine how the interaction with competing firms affects a firm's decisions on these two types of investment when it enters a new market domain. This study therefore offers a conceptual bridge between operations management and entrepreneurship literatures.

Keywords: capacity strategy, supply chain management, manufacturing operations management and innovation

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Impact of Option Contract on Retailer's Financing and Ordering Decisions

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We study a supply chain with single supplier and a capital constraint retailer. The retailer finances its purchasing through either the bank, i.e., bank credit financing, or the supplier, i.e., trade credit financing. We explore the retailer's optimal decisions on financing and purchasing simultaneously by studying a Stackelberg game. Our results show that in the presence of bankruptcy risk on the retailer's side, both the supplier and retailer will be better off under trade credit financing. Compared to wholesale price contract, option contract improves supply chain performance. Compared to bank credit financing, trade credit financing stabilizes the retailer's order size.

Keywords: supply chain, capital constraint, financing, option contracts

Impact of Social Learning under Supply Disruption Risk

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We study the impact of social learning (SL) effect on consumers' panic buying decisions under supply disruption risk; and accordingly, how the retailer can optimize his inventory and pricing strategies to deal with it. First, we demonstrate that if the panic intensity exceeds certain level, the SL behavior will induce more panic buying. Furthermore, whether a herd of stockpiling occurs or not is also highly dependent on the initial panic intensity. Second, we derive the optimal ordering policy for the retailer. Only when consumer's panic intensity is relatively high, can consumer's SL behavior be beneficial for the retailer. Finally, the retailer should increase price only when the panic intensity is very low or very high, if the panic intensity is in a middle level, a price increase will hurt his profit.

Keywords: social learning, supply disruption, panic buying, ordering policy

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Supplier's Investment in Manufacturer's Quality Improvement with Equity Holding

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We consider a decentralized supply chain in which an upstream supplier sells a component to a downstream manufacturer facing a price and quality sensitive demand. The supplier may have a chance to invest in the manufacturer. The investment can not only enable the supplier to hold equity shares in the manufacturer and consequently achieve profit sharing with the manufacturer, but also provide needed resources for the manufacturer to improve its product quality. Under any given investment strategy of the supplier, we first characterize the equilibrium pricing and margin decisions of the two players in such a supply chain. Then, we derive the supplier's optimal investment strategy. We consider three competition models: supplier Stackelberg model, manufacturer Stackelberg model, and vertical Nash model, which
correspond to different market power structures. We find that the investment by the supplier in the manufacturer increases the production quantity in each of the three competition models; and the impact of the investment on the profits of the two chain members, in the manufacturer Stackelberg model, is quite different from that in the supplier Stackelberg model and vertical Nash model.

Session 5I – Supply Chain Management IV

Online Retailing Gift Rewarding: A Robust Optimization Methods

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This paper presents a case-based research with an online retailer (Hui-Liu-Tea) in China, who manages customer lifetime value (CLV) by rewarding their customers with free gifts. Motivated by this, we propose a model that simultaneously considers the optimization CLV and gift inventory. By analyzing this model, we provide robust inventory decision with closed form expressions, which is computationally efficient and near optimal. Based on the operational data, we present a numerical study. The numerical result shows that the solutions can significantly improve the online retailer's profits (the average profit increment is 25.631%).

Keywords: robust optimization, customer life-time value, online retailing, data-driven operations, inventory management

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Scheduling Aircraft Maintenance Tasks with State Constraints

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Scheduling maintenance tasks at an aircraft maintenance base is challenging and needs to consider aircraft states (e.g. power off/on, jack off/on), activity precedence relationship, uncertain activity duration, and resource availability. We formulate the problem as a project scheduling optimization model, which minimizes the expected project cycle. The model is NP-hard, and we solve it with a genetic algorithm. The model and the algorithm are applied to a real case. The results are satisfactory, compared with existing scheduling solutions.

Keywords: aircraft maintenance, project scheduling, state constraints