How to Navigate the Technical Sessions

There are four primary resources to help you understand and navigate the Technical Sessions:

- This Technical Session listing, which provides the most detailed information. The listing is presented chronologically by day/time, showing each session and the papers/abstracts/authors within each session.
- The Author and Session indices provide cross-reference assistance (pages 518-560).

Quickest Way to Find Your Own Session

Use the Author Index (page 518) — the session code for your presentation will be shown along with the room location of your session.

The Session Codes

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<tr>
<th>TA01</th>
<th>Room number. Room locations are also indicated in the listing for each session.</th>
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Time Blocks

Sunday - Tuesday
8:00am - 9:30am
11:00am - 12:30pm
1:30pm - 3:00pm
4:30pm - 6:00pm

Wednesday
8:00am - 9:30am
11:00am - 12:30pm
12:45pm - 2:15pm
2:45pm - 4:15pm
4:30pm - 6:00pm

Rooms and Locations /Tracks

All tracks / technical sessions will be held in the Music City Center and Omni Hotel. Room numbers are shown on the Quick Reference and in the Technical session listing.

Sunday, 8:00AM - 9:30AM

SA01
101A-MCC

Temporal Data Mining and Pattern Discovery
Sponsored: Data Mining
Sponsored Session
Chair: Mustafa Gokce Baydogan, Bogazici University, Bebek, Istanbul, 34342, Turkey. baydoganmustafa@gmail.com

1 - Discovering Distinct Features Using Deep Learning For Arrhythmia Detection
Seho Kee, Arizona State University, Tempe, AZ, United States, skee4@asu.edu, Phillip Howard, George Runger

Although domain knowledge-based features have been widely adopted in anomaly detection studies, they still suffer from the limitations of the insufficient known features or unavailability in practice. To address these problems, we propose an autoencoder model that is able to discover useful features that identify abnormal patterns in temporal heartbeat data without assuming any prior knowledge. The results show that the discovered features obtained from just a two-dimensional projection layer can effectively distinguish abnormal beats from normal beats without training on pre-labeled data.

2 - Process Control For Time-varying Situations
Seoung Bum Kim, Korea University, sbkim1@korea.ac.kr, Seulkil Lee

In modern manufacturing systems containing the complexity and variability of processes, appropriate control chart techniques that can efficiently handle the nonnormal and nonlinear processes are required. In this talk, I will present some recently developed multivariate control charts to handle both nonnormal and time-varying process situations.

3 - On The Use Of Support Vectors For Time Series Pattern Discovery
Mustafa Gokce Baydogan, Bogazici University, Istanbul, Turkey, mustafa.baydogan@boun.edu.tr, Mehmet R Kamber, Erhun Kundakcioglu

Similarity search and classification on time series (TS) databases has received great interest over the past decade. The definition of similarity between TS is a major problem in this context. Nearest-neighbor (NN) classifiers are widely used for TS classification but these approaches compute the similarity over the whole TS which might be problematic with the long TS and relatively short features of interest. Moreover, these classifiers are not directly interpretable as they do not describe why a TS is assigned to a certain class. This study utilizes margin maximization to discover the regions of the time series that have potentially representative patterns related to the classification task.

4 - Machine Learning For Predicting Heart Failure Readmission
Wei Jiang, Research Assistant, Johns Hopkins University, 3400 N Charles St, Baltimore, MD, 21218, United States, wjiang1990@gmail.com, Scott R Levin, Lili Barouch, Frederick Korley, Sauleh Ahmad Siddiqui, Diego A. Martinez, Matthew Toerpel, Sean Barnes, Eric Hamrock

Predicting risk of heart failure (HF) readmission has gained increasing attention, with existing studies mainly using administrative data. We will focus on using clinical data from EMR for predicting HF readmission by doing pattern recognition with time series clinical data. We will then use classification models for predicting the drivers of readmission.
1 - Nicholson Student Paper Prize

Invited: Nicholson Student Paper Prize

Invited Session

Chair: Maria Esther Mayorga, North Carolina State University, 400 Daniels Hall, Raleigh, NC, 27695, United States, memayorg@ncsu.edu

1 - Nicholson Student Paper Prize

Maria Esther Mayorga, North Carolina State University, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu

This session highlights the finalists for the 2016 George Nicholson Student Paper Competition.

2 - A Necessary and Sufficient Condition for Throughput Scalability of Fork and Join Networks with Blocking

Yun Zeng, Ohio State University, Columbus, OH, United States, zeng.153@buckeyemail.osu.edu, Augustin Chaintreau, Don Towsley, Cathy Xia

3 - Household-level Economics Of Scale In Transportation

Mehdi Behroozi, Northeastern University, Boston, MA, 02115, United States, behro040@umn.edu

4 - Online Decision-Making With High-Dimensional Covariates

Hamsa Bastani, Stanford University, Stanford, United States, bayati@stanford.edu

Big data has enabled decision-makers to tailor choices at the individual-level in a variety of domains such as personalized medicine and online advertising. This involves learning a model of decision rewards conditional on individual-specific covariates. In many practical settings, these covariates are high-dimensional; however, typically only a small subset of the observed features are predictive of a decision’s success. We formulate this problem as a multi-armed bandit with high-dimensional covariates, and present a new efficient bandit algorithm based on the LASSO estimator. Our regret analysis establishes that our algorithm achieves near-optimal performance in comparison to an oracle that knows all the problem parameters. The key step in our analysis is proving a new oracle inequality that guarantees the convergence of the LASSO estimator despite the non-i.i.d. data induced by the bandit policy. Furthermore, we illustrate the practical relevance of our algorithm by evaluating it on a real-world clinical problem of warfarin dosing.

5 - Distributionally Robust Stochastic Optimization With Wasserstein Distance

Rui Gao, Georgia Institute of Technology, Atlanta, GA, United States, rgao32@gmail.com

1 - PPMF: A Patient-based Predictive Modeling Framework For Early ICU Mortality Prediction

Mohammad Amin Moridi, The David Eccles School of Business, University of Utah, 130 University Village, Salt Lake City, UT, United States, amin.moridi@business.utah.edu, Olivia R. Liu Sheng, Samir Abdelrahman

This paper presents a patient based predictive modeling framework (PPMF) to improve the performance of early ICU mortality prediction. PPMF consists of three main components. The first component captures dynamic changes of patients’ status in the ICU using their time series data. The second component is a local approximation algorithm that classifies patients based on their similarities. The third component is a Gradient Descent wrapper that updates feature weights according to the classification feedback. Experiments show that PPMF significantly outperforms: (1) the severity score systems, (2) the aggregation based classifiers, and (3) baseline feature selection methods.

2 - The Emergency Response Community Effectiveness Modeler: A Simulation Modeling Tool To Analyze EMS vs. Smartphone-based Samaritan Response

Michael Khalemsky, Graduate School of Business Administration, Bar Ilan University, Ramat Gan, Israel, khalemsky@gmail.com, David G. Schwartz

Smarthones and location-based social networking technologies present an opportunity to re-engineer certain aspects of emergency medical response by establishing Emergency Response Communities (ERC). The ERC Effectiveness Modeler (ERCME) estimates the efficacy of smartphone-based Samaritan response for given medical condition and geographic region. The ERCME uses parameters such as population density, prescription adherence, smartphones penetration etc. and performs Monte Carlo simulation to compare potential ERC response to traditional EMS response. We present the modeler and show how it assessed effectiveness of ERC for anaphylaxis in the USA based on data from the NEMSIS project.

3 - Public Health Data Sharing With Privacy Protection

Hasan Kartal, Management School of Business, University of Massachusetts Lowell, Lowell, MA, 01850, United States, hasan_kartal@uml.edu

This study examines privacy disclosure risks in health data when patients have multiple records in a dataset. Existing data privacy approaches typically assume that each individual in a dataset corresponds to a single record, which tends to underestimate the disclosure risks in the multiple-record problems. We propose a new privacy measure, called g-balance, and develop an efficient algorithm based on the g-balance measure to protect against the multiple-record linkage attacks. The effectiveness of the proposed approach is demonstrated in an experimental study using real-world data.

101C-MCC

Nicholson Student Paper Prize I

101B-MCC

Healthcare Analytics and Medical Decision Making

Sponsored: Data Mining

Sponsored Session

Chair: Hasan Kartal, University of Massachusetts Lowell, One University Avenue, Lowell, MA, 01854, United States, Hasan_Kartal@uml.edu

1 - PPMF: A Patient-based Predictive Modeling Framework For Early ICU Mortality Prediction

Mohammad Amin Moridi, The David Eccles School of Business, University of Utah, 130 University Village, Salt Lake City, UT, United States, amin.moridi@business.utah.edu, Olivia R. Liu Sheng, Samir Abdelrahman

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101D-MCC

Electricity Markets and Contract Design

Sponsored: Energy, Natural Res & the Environment, Energy I Electricity

Sponsored Session

Chair: Edward James Anderson, University of Sydney, H70 - Abercrombie Building, Sydney, NSW 2006, Australia, edward.anderson@sydney.edu.au

1 - Retail Equilibrium With Switching Consumers In Electricity Markets

Carlos Ruiz Mota, Universidad Carlos III de Madrid, Madrid, Spain, caruizm@est-econ.uc3m.es, F. Javier Nogales, F. Javier Prieto

We consider a game theoretical model where asymmetric retailers compete in prices to increase their profits by accounting for the utility function of switching consumers. Consumer preferences for retailers are uncertain and distributed within a Hotelling line. We analytically characterize the equilibrium of a retailer duopoly, establishing its existence and uniqueness conditions for a wide class of utility functions. The duopoly model is extended to a multiple retailer case.

2 - Flow-based Market Coupling In The European Electricity Market

Mette Bjorndal, Professor, NHH Norwegian School of Economics, Bergen, Norway, Mette.Bjorndal@nhh.no

From May 2015, the Flow-based Market Coupling (FBMC) model replaced the Available Transfer Capacity (ATC) model in parts of the European power market. The FBMC model aims to enhance market integration and to better monitor the physical power flow, and it is expected to lead to increased social welfare in the day-ahead market and more frequent price convergence between different market zones. This paper gives a discussion on mathematical formulations of the FBMC model and the procedures of market clearing. We examine the FBMC model in two test systems and show the difficulties of implementing the model in practice.

3 - Negotiating Forward Contracts With Private Information

Edward James Anderson, University of Sydney, edward.anderson@sydney.edu.au

We consider the use of forward contracts to reduce risk for firms operating in a spot market. Firms have private information on the distribution of prices in the spot market. We discuss different ways in which firms may agree on a forward contract (offers to a broker and direct bargaining). We also discuss an equilibrium in which two firms each offer a supply function and the clearing price and quantity for the forward contracts are determined from the intersection. In this context a firm can use the offer of the other player to augment its own information about the future price. It is interesting that these sophisticated strategies are likely to produce worse outcomes for both firms.
1 - A Multi-group Discrete Support Vector Machine – Theory And Computation
Eva Lee, Georgia Tech, evakylee@isye.gatech.edu

We describe a general-purpose machine learning framework, DAMIP, for discovering gene signatures that can predict vaccine immunity and efficacy. DAMIP is a multi-group “concurrent” classifier that offers unique features not present in other models: a nonlinear data transformation to manage the curse of dimensionality and noise; a reserved-judgment region that handles fuzzy entities; and constraints on the allowed percentage of classifications. Computational results for biological and medicine problems will be discussed.

2 - Optimized Risk Scores
Berk Ustun, MIT, Massachusetts Institute of Technology, Sloan School of Management, Cambridge, MA, 02142, United States, ustun@mit.edu, Cynthia Rudin

Risk scores are simple models that let users quickly assess risk by adding, subtracting, and multiplying a few small numbers. These models are widely used in healthcare and criminology, but difficult to create because they need to be risk-calibrated, use small integer coefficients, and obey operational constraints. We present a new approach to learn risk scores from data by solving a discrete optimization problem. We formulate the risk score problem as a MINLP, and present a cutting-plane algorithm to efficiently recover the optimal solution by solving a MILP. We demonstrate the benefits of our approach by creating risk scores for real-world problems.

3 - Supersparse Integer Regression Model For Nonparametric Failure Time Analysis
Keivan Sadeghzadeh, MIT Sloan School of Management, Cambridge, MA, United States, keivan@mit.edu, Cynthia Rudin

Analysis of failure time data has an inevitable role in predicting events occurrence. We develop an integer-based predictive model that is accurate and also interpretable, in order to determine effective features and potential failures. The strategy is to select appropriate covariates for censored large-scale and high-dimensional failure time data in a regression model. Our approach is to design robust algorithm to find the optimal integer solution for supersparse linear model. This optimal solution is reached by using machine learning techniques over a high-dimensional closed quadric hypersurface.

4 - Nested Clustering On A Graph
Gokce Kahvecioglu, Northwestern University, 2145 Sheridan Road Room C210, Evanston, IL, 60208, United States, gokcekahvecioglu2014@u.northwestern.edu, David P. Morton

We study a clustering problem defined on an undirected graph with weight function defined on the edges, which denotes the importance of the connection between vertices. We remove a set of edges in order to maximize the number of clusters in the residual graph while minimizing the weight of deleting edges. Solving this graph clustering problem parametrically identifies the solutions that lie on the concave envelope of efficient frontier and the breakpoints on this envelope have a nested structure. We propose to solve this parametric model in polynomial time by solving a sequence of parametric maximum flow problems, which yields the family of nested clusters on the efficient frontier.

SA05

101E-MCC
Power System Resilient Design and Optimization
Sponsored: Energy, Natural Res & the Environment, Energy I Electricity
Sponsored Session
Chair: Seyedamirabbas Mousavian, Clarkson University, 8 Clarkson Avenue, Potsdam, NY, 13699-5790, amir@clarkson.edu

1 - Self-healing Attack Resilient PMU Network For Power System Operation
Chen Chen, Argonne National Laboratory, Lemont, IL, United States, morningchen@anl.gov, Hui Lin, Jianhui Wang, Junjian Qi, Dong Jin

We propose a self-healing PMU network by exploiting the features of programmable configuration in a software-defined networking (SDN) to achieve resiliency against cyber-attacks. After a cyber-attack, by changing the configuration of the network switches, the disconnected yet uncompromised PMUs will be reconnected to the network to “self-heal” and thus restore the observability of the power system. Specifically, we formulate an integer linear programming (ILP) model to minimize the overhead of the self-healing process, while considering the constraints of power system observability, hardware resources, and network topology.

2 - Minimum Risk-maximum Availability Response To Electric Vehicle-initiated Smart Grid Attacks
Seyedamirabbas Mousavian, Clarkson University, amir@clarkson.edu, Mellique Erol-Kantarci, Thomas Ottmeier

Malware pose a significant threat to the power grid and the connected electric vehicle infrastructure. Penetration and propagation of cyber attacks including worms and viruses vary depending on the nature of the connected systems. Electric vehicles (EVs) being the mobile portion of the smart grid may easily spread worms and viruses in a large geographic area. We propose a probabilistic model for the worm propagation in EV to Electric Vehicle Supply Equipment (EVSE) networks, formulate threat levels and then, we propose a Mixed Integer Linear Programming (MILP) model as a protection scheme that relies on isolating infected nodes.

3 - Storage And Generation Expansion Problem Considering Primary Response
Hrvoje Pandzic, University of Zagreb, Zagreb, Croatia, hrvoje.pandzic@fer.hr, Yury Dvorkin, Miguel Carrion

A sustainable and efficient generation and storage expansion program needs to consider both the capacity needs and short-term operational requirements of a power system. A generation expansion formulation considering frequency regulation using both generators and storage units will be presented.

4 - Optimal Resilient Grid Design And Transmission Systems
Russell Bent, Los Alamos National Laboratory, rbent@lanl.gov, Enam Yaranoglu, Harsha Nagarajan, Pascal Van Hentenryck

Modern society is critically dependent on the services provided by engineered infrastructure networks, particularly distribution and transmission grids. When natural disasters (e.g. Hurricane Sandy) occur, the ability of these networks to provide service is often degraded. However, well-placed upgrades to these grids can greatly improve post-event network performance. Hence, we pose the optimal electrical grid resilient design problem as a two-stage, stochastic mixed-integer program with damage scenarios and propose decomposition-based algorithms to solve and analyze medium-sized networks.

SA06

102A-MCC
Joint Session DM/Optimization: Discrete Optimization and Machine Learning
Sponsored: Data Mining
Sponsored Session
Chair: Berk Ustun, Massachusetts Institute of Technology, Cambridge, MA, United States, ustunb@mit.edu

1 - A Multi-group Discrete Support Vector Machine – Theory And Computation
Eva Lee, Georgia Tech, evakylee@isye.gatech.edu

We describe a general-purpose machine learning framework, DAMIP, for discovering gene signatures that can predict vaccine immunity and efficacy. DAMIP is a multi-group “concurrent” classifier that offers unique features not present in other models: a nonlinear data transformation to manage the curse of dimensionality and noise; a reserved-judgment region that handles fuzzy entities; and constraints on the allowed percentage of classifications. Computational results for biological and medicine problems will be discussed.

2 - Collaborative Decision Making For Air Traffic Management
Hale Erkan, Bilkent University, Ankara, Turkey, hale.erkan@bilkent.edu.it, Nesim K. Erkip, Oguz Safak

We propose a model which can be utilized within a collaborative decision making (CDM) framework for rescheduling of flights. The proposed mathematical program is expected to be utilized by major stakeholders, airlines and air navigation service providers. After providing the constraints, we list possible equity and efficiency performance measures that will make-up the objective function to be used by a stakeholder. We suggest guidelines to utilize the model for any stakeholder within CDM. Finally, a case study is prepared using publicly available data to demonstrate possible benefits.
3 - A Reformulation Of The Appointment Scheduling Problem With Customer Choice Behavior And Multiple Customer Types
Cem Aydin, Koc University, Dept of Industrial Engineering, Istanbul, Turkey, cemaydin@ku.edu.tr, Alp Aribal, Cansu Erol, Begum Tuglu

In this paper, we propose a new formulation to the appointment scheduling problem with customer choice behavior and multiple customer classes. Using this new formulation and an approximation of the state space, we find an upper bound to the total expected revenue. We exploit the special structure created by our new formulation to present an efficient algorithm that can find this upper bound. We test methods commonly used in practice using our upper bound to rate their performance and show that performances of traditional methods decay as problem size increases.

SA09
103B-MCC
Balancing Water Use for Food and Energy
Sponsored: Energy, Natural Res & the Environment / Environment & Sustainability
Sponsored Session
Chair: Hayri Onal, University of Illinois, 305 Munford Hall, 1301 W. Gregory Dr., Urbana, IL 61801, United States, h-onal@illinois.edu

1 - A Robust Planning Decision Model For Smart Water System
Mengqi Hu, University of Illinois at Chicago, 842 W. Taylor St., 3023 ERF, Chicago, IL 60607, United States, mhu@uic.edu, Afshin Ghassemi

Water is a critical resource for different sections and people’s everyday life. In this research, we propose a robust planning decision model for smart water system including sources, water plants, end users and waste water systems. In the smart water system, the concepts of dynamic pricing and onsite inventory and 3rd-party water plant are explored. Various levels of uncertainties from both water demand and pipeline efficiencies are considered. Three sets of experiments are developed to test the effectiveness of the proposed decision model. It is concluded that our proposed model provides a platform to transform novel smart grid concepts to renovate the existing water infrastructure.

2 - Assessment Of Ecosystem Services In A Semi-arid Agriculture-dominant Area: Framework And Case Study
Yihsu Chen, University of California, Santa Cruz, Yihsu Chen, Ramesh Dhungel, Rudy Maltos, Kumar Sivakumar, Andres Aguilar, Thomas Harmon

Evaluating ecosystem services is difficult as the services are not traded at an open market. In this study, we developed a framework that allows for assessing the effectiveness and implied costs of ecosystem services provided by a restored SJR (San Joaquin River) in a semi-arid agriculture-dominant area. This is done by explicitly linking economics-based farmers’ model with a reduced-form hydrological model that is loosely coupled to a physical-based stream-temperature model. We quantify the lower bound of the short-run economic costs and show that current mandated policies are unlikely to have a meaningful impact on restoring fish population.

3 - Predictive Analytics For Sustainable Water Consumption
Ellen Wongso, Student, Purdue University, West Lafayette, IN, 47906, United States, ewongso@purdue.edu, Zijian He, Roshanak Nateghi

According to a recent report by the EPA, 40 states will experience water shortages in the coming decade. Climate change and increased consumption trends will likely exacerbate the current water scarcity issues. Access to clean water is a basic human right and is an essential element for ensuring energy and food security. There is therefore a critical need to identify the main drivers of consumption to promote sustainable use. Previous research on water sustainably has been local in scope and mostly from management science perspective. In this research we will leverage advanced statistical learning methods to identify the main drivers of water usage in the US.

4 - Scheduling Water Reuse In The Food Industry: Theory And Application
Renzo Akkerman, Technical University of Munich, Munich, 80333, Germany, renzo.akkerman@tum.de, Sai Jishna Pulluru

Water considerations are increasingly relevant in the planning and scheduling of production activities in the food industry. This includes the reuse of various water streams and their proper treatment or regeneration. We develop a general production scheduling that integrates water flows and their possible treatment for reuse. We perform a numerical study to analyze the performance of the modelling approach, and also apply the model in a case application from the dairy industry. Over the course of the study, the relevance of the modelling approach and its computational performance. Furthermore, the work provides managerial insights for increased water efficiency in the food industry.

SA10
103C-MCC
Optimizing Distributed Energy Generation I
Sponsored: Energy, Natural Res & the Environment, Energy II Other Sponsored Session
Chair: Alexandra M Newman, Colorado School of Mines, Golden, CO, 1, United States, anewman@mines.edu

1 - Hybrid Energy System Dispatch Strategy For A Forward Operating Base
Mark Husted, Colorado School of Mines, mhusted@mines.edu

Given a set of systems (i.e., batteries, diesel generators, and photovoltaic arrays), we determine a dispatch strategy for a forward operating base, isolated from the grid. This cost-minimizing strategy subscribes to minute-level fidelity over a 24-hour time horizon given the expected demand profile and the anticipated solar generation. Operational constraints include (i) ramp-up and ramp-down and minimum up and down times of the generators, (ii) spinning reserve levels, and (iii) other interoperability requirements among the systems. We show how our model results improve over traditional rules of thumb used for real-time dispatch.

2 - A Capacity Expansion Model For Energy Planning For Turkey
Muhammed Surcu, Assistant Professor, Abdullah Gul University, Sumer Campus, Erkilet Bulvari, Kayseri, 38060, Turkey, muhammed.surcu@agu.edu.tr, Tugba Deigmenci

There has been a considerable effort to raise the share of their renewable energy (RE) sources in the total sum to reach an environmental sustainability. This study addresses the question of what level of each type of RE should actually be provided year by year to maximize the total productions by minimizing the associated costs for RE policies of Turkey. With this goal in mind, a multistage optimization model for years 2015-2023 is constructed and solved with the interpretation of the results throughout the study.

3 - Integrated Model For Power Interruption Contracts
Lakhimi Palaparambil Dinesh, University of Cincinnati, 601 Mc Alpin Avenue, Apartment 5, Cincinnati, OH, 45220, United States, lakshmi603@gmail.com, Uday S Rao, Jeffrey D. Camm, Kenneth Skinner

Demand response is changing electricity usage based on a change in price of electric power. We study a demand response program where residential customers participate. Each customer has to sign up for a contract to enroll in the program. We develop a model that helps to decide which power unit to turn on or off, which customers to cut power during peak demand hours, and what contract parameters to use while designing contracts between the supplier and residential customers. The proposed model leads to higher overall costs savings for the power supplier compared to the current model used in practice.

4 - Optimal Sizing Of An EV Parking Facility Within A Microgrid
Ebrahim Mortaz, Auburn University, 115 N. Debardeleben St. Apt 29, Auburn, AL, 36830, United States, emortaz@auburn.edu, Jorge F Valenzuela

Integrating the provided energy and storage capacity by the electric vehicles into the microgrid reduces the cost of electricity supply. In this talk, we assume that a grid-connected microgrid is set to transform an EV parking facility into a large energy storage resource by investing on the V2G technology. We propose a mathematical model that aims to determine the optimal number of V2G stations in the parking facility by minimizing the total cost of the microgrid. The results show that the investment in the V2G technology is an enhancement to the long-term economics of microgrids.

SA11
104A-MCC
Cliques and Clique Relaxations
Sponsored: Optimization, Network Optimization
Sponsored Session
Chair: Eugene Lykhovyd, Texas A&M University, College Station, TX, United States, lykhovyd@tamu.edu

1 - Exact Algorithms For The Minimum S-Club Partitioning Problem
Oleksandra Yezerska, Texas A&M University, Fort Worth, TX, United States, yaleksa@tamu.edu

Graph clustering (partitioning) is a helpful tool in understanding complex systems and analyzing their structure and internal properties. An $s$-club is a distance-based relaxation of a clique and is formally defined as a subset of vertices inducing a subgraph with a diameter of at most $s$. We study the minimum $s$-club partitioning problem, which is to partition the graph into a minimum number of $s$-club clusters. Integer programming techniques and combinatorial branch-and-bound framework are employed to develop exact algorithms to solve this problem. We also compare the computational performance of the proposed algorithms for the special case of $s=2$ on a test-bed of real-life graphs.
2 - High Communication Efficiency Subgraphs
Vladimir Stozhkov, University of Florida, Gainesville, FL, United States, vstozhkov@ufl.edu, Alexander Veremyev, Oleg A Prokopyev
We introduce a new clique relaxation model which is based on the notion of communication efficiency. The communication efficiency is assumed to be a non-increasing function of pair-wise distances in a graph. We prove that the corresponding maximization problem is NP-hard and present effective exact algorithms to solve it.

3 - Approximating The Maximum Edge Weight Clique Problem Using A Continuous Formulation
Seyedmohammadhossein Hosseini, Texas A&M University, 2027 Emerging Technologies Building, Mall stop 3131, College Station, TX, United States, hosseini@tamu.edu, Dalla B M M Fontes, Sergiy Butenko
The Maximum Edge Weight Clique (MEWC) problem, defined on an undirected and weighted graph, is to find a clique whose sum of edge weights is maximized. This work presents a continuous formulation for the MEWC problem, along with a heuristic based on solving the continuous form over a n-dimensional hypersphere, where n is the number of vertices of the graph. Results of the algorithm on some benchmark instances are also presented.

SA12
104B-MCC
Algorithms, Polyhedra and Games
Sponsored: Optimization, Integer and Discrete Optimization
Sponsored Session
Chair: Swati Gupta, Massachusetts Institute of Technology, Cambridge, MA, United States, swatig@mit.edu
1 - Algorithms For Stable Matching With Imperfect Transfer Of Utility (ITU)
Rajan Harish Udwnani, Massachusetts Institute of Technology, rudwnani@mit.edu, James B Orlin
The classical stable matching and utility transfer problems (also the dual of the assignment problem), are two extreme cases of the imperfect utility transfer problem, where we wish to find a stable matching in a bipartite graph, while allowing imperfect/lossy transfer of utility across matched pairs. In case of complete loss (or no transfer), we recover the former and in absence of loss we get the latter. We develop a novel combinatorial algorithm for this generalized stable matching problem under imperfect transfer of utility, when the loss function is linear. The model was inspired by a recent paper of Galichon et al. (2016)

2 - Polyhedral Study Of A Generalization Of The Continuous Mixing Set
Haochen Luo, Texas A&M University, College Station, TX, United States, hcluo@tamu.edu, Kavash Kianlar
We report our progress on polyhedral study of a generalization of the continuous mixing set. We provide facet-defining valid inequalities and discuss how they can be used to generate cuts for well-known problems such as lot-sizing.

3 - Learning Combinatorial Structures
Swati Gupta, Massachusetts Institute of Technology, Cambridge, MA, United States, swatig@mit.edu, Michel X Goemans, Patrick Jaillet
To find optimal strategies for dueling algorithms, we consider two online learning methods: multiplicative weights update (MWU) and online mirror descent (OMD). We first show how to simulate MWU over vertices of polytopes in R^n (e.g. spanning trees, bipartite matchings), in time poly(n) under last generalized counting oracles (even if approximate). Next, we solve a well-known computational bottleneck of computing projections for the OMD by giving novel algorithms for separable convex minimization over base polyomatroids (e.g. for spanning trees, truncated permutations, subset of experts). These results extend to applications in stochastic optimization, game theory and machine learning.

SA13
104C-MCC
Global Optimization: Algorithms and Applications
Sponsored: Optimization, Global Optimization
Sponsored Session
Chair: Emily Speakman, University of Michigan, MI, United States, eespeakm@umich.edu
1 - Strong Relaxations For Optimal Power Flows
Pascal Van Hentenryck, University of Michigan, pvanhen@umich.edu, Carleton Coffrin, Hassan Hijazi
This talk reviews recent progress in convex relaxations of the power flow equations, which combines the SDP relaxation, the QC relaxations, bound tightening, and valid inequalities. Computational results on state-of-the-art benchmarks are presented.

2 - Branching Point Selection For Trilinear Terms
Emily Speakman, University of Michigan, 2222 Fuller Court, Apt 702A, Ann Arbor, MI, 48105, United States, eespeakm@umich.edu, Jon Lee
The case of having three or more expressions multiplied together (each expression being possibly complex itself) occurs frequently in global-optimization models. For these ‘trilinear terms,’ we present some analytic results regarding the choice of branching point and branching variable in the context of spatial branch-and-bound, and we compare our results to common practice in software. In obtaining the ‘best’ branching point or variable we use n-dimensional volume as a comparison measure. Using volume as a measure gives a way to analytically compare formulations and corresponds to a uniform distribution of the optimal solution across a relaxation.

3 - Virtuous Smoothness For Global Optimization.
Daphne Skipper, US Naval Academy, daphne.skipper@gmail.com, Jon Lee
Virtually all exact solvers for global-optimization (GO) rely on NLP solvers, both to generate good feasible solutions and to solve relaxations. Convergence of most NLP solvers requires that functions be twice continuously differentiable. Yet many models naturally utilize functions with some limited non-differentiability. One approach to handle limited non-differentiability is via smoothing. We propose a method, mostly aimed at (concave) root functions ($|x|<\epsilon$ and $|x|^2<\epsilon|x|$), that provides a tighter lower bound than the obvious shift ($|x|+(|x|-\epsilon)$ or $|x|^2+(|x|^2-\epsilon|x|^2)$), and is smooth and globally concave, so it works well with local and global solvers.

SA14
104D-MCC
Operations Research Approaches to Plant Breeding
Invited: Agricultural Analytics
Invited Session
Chair: Lizhi Wang, Iowa State University, Ames, IA, United States, lz wang@iastate.edu
1 - Resource Allocation In Trait Introggression – A Markov Decision Process Approach
Ye Han, Iowa State University, yeh@iastate.edu
Lizhi Wang, William D Beavis, John N Cameron
Plant breeding companies continuously improve their cultivars through trait introgression projects, which are usually constrained with budgets and deadlines. In this presentation, we formulate the optimal allocation of money and time resources as a Markov decision process, in which the breeder incurs a cost for each progeny produced and receives a reward for producing an ideal progeny by the deadline. We will share preliminary results on a hypothetical trait introgression project and discuss future research opportunities.

2 - Maximizing Quantitative Traits In The Mating Design Problem
Susan R Hunter, Purdue University, West Lafayette, IN, United States, susanhunter@purdue.edu, Benjamin McClusky
We consider a version of the mating design problem in which breeders allocate a breeding budget to a set of parent pairs to maximize the expected maximum trait observed in the progeny population. In this context, the only parent pairs that receive nonzero breeding budget at optimality in the mating design problem lie on a Pareto set. Since the performance of each parent pair is assessed through Monte Carlo simulation, identifying the Pareto set is a bi-objective simulation-optimization problem. We derive an asymptotically optimal simulation budget allocation to estimate the Pareto set of parent pairs. This estimated Pareto set is used as an input to the mating design problem, which is an integer program.
3 - Response Surface Methodology In Plant Breeding
Reka Howard, University of Nebraska – Lincoln, NE, rekahoward@gmail.com, William Beavis, Alicia Carriquiry
We introduce Response Surface Methodology (RSM) as a strategy to find the combination of attribute levels that results in accurate predictions for a given genomic prediction (GP) method, and compare GP methods. We illustrate RSM with a simulated example where the response we optimize is the difference between prediction accuracy using the parametric best linear unbiased prediction (BLUP) and the nonparametric support vector machine (SVM). The greatest impact on the response is due to the genetic architecture of the population and the heritability. When epistasis and heritability are highest, the advantage of using the SVM versus the BLUP is greatest.

4 - A New Genomic Selection Approach
LiZhi Wang, Iowa State University, wang@iastate.edu. Matthew Gollfion, Guiping Hu, Aaron Kusmec, Patrick Schnable
Conventionally, plant breeders make selection decisions based on phenotype observations and intuitive judgement. The advent of genotyping techniques provides breeders with much more informative genetic data. However, the enormous volume and complexity of the genomic data also present great challenges in extracting the useful information deeply buried in the mountains of data. We present a new approach for genomic selection and demonstrate its improvement over previous methods using computer simulation with realistic genomic data.

SA15

104-E-MCC
Big Data in the E-Commerce Deliveries
Invited: Modeling and Methodologies in Big Data
Invited Session
Chair: Chung-Yee Lee, HKUST, IELM Dept, HKUST, Clear Water Bay, Hong Kong, 0000, Hong Kong, cylee@ust.hk
1 - The Benefits Of Randomization In Warehousing And Logistics
John Carlsson, University of Southern California, jcarlsson@usc.edu
A recent innovation in warehousing and logistics has been the use of randomization, such as a random snow, in which warehouse items are scattered throughout the floor map as opposed to being concentrated in one area. We use a continuous approximation model to describe how such a policy is beneficial in the long run.

2 - Resource Allocation With Unmanned Aerial Vehicle
Siyuan Song, University of Southern California, siyuanso@usc.edu, John Gunnar Carlsson
Unmanned aerial vehicles, commonly known as drones, have become more widely utilized in delivery nowadays. We study the efficiency of a so-called ‘horsefly’ delivery system, in which drones are used in conjunction with trucks. We propose a mathematical formulation of a ‘horsefly’ problem followed by some general properties of optimal solutions. Then some approximation results, including an approximation algorithm, are given to illustrate the benefit of horsefly system on a large scale. Lastly, we compare some practical heuristic algorithms in different scenarios for best choice in each case.

3 - The Last Mile Rush
Song Zheng, Cainiao Network, Hang Zhou, China, zhengsong.zs@alibaba-inc.com, Lijun Zhu
As e-commerce keeps its impressive growth, a large percentage of express orders are generated by e-commerce. In China, for example, it is over 60 percent. Increasing investments rush into China's express delivery industry, which now has thousands of delivery companies and millions of delivery workers. Alibaba group and Cainiao Network are building China Smart Logistics Network and developing a huge ecosystem with all major logistics companies in China. We will present an optimal solution to the last mile delivery, more specifically, arranging thousands of courier to deliver all kinds of packages in cities including online e-commerce packages and offline O2O packages.

SA16

105A-MCC
Inverse Optimization: Theory
Sponsored: Optimization, Optimization Under Uncertainty
Sponsored Session
Chair: Taewoo Lee, Rice University, #217, 7010 Staffordshire Street, Houston, TX, 77030, United States, taewoo.lee@utoronto.ca
Co-Chair: Timothy C.Y. Chan, University of Toronto, Toronto, ON, Canada, tcychan@mie.utoronto.ca
1 - Goodness-of-fit In Multi-point Inverse Optimization Optimization
Rafid Mahmood, University of Toronto, Toronto, ON, Canada, rafid.mahmood@mail.utoronto.ca, Timothy Chan, Taewoo Lee, Daria Terekhov
Inverse optimization is a model fitting technique that uses observed points to impute the cost function of an unknown optimization problem. Applications of inverse optimization often rely on ad-hoc or informal methods to evaluate the fit quality of the inverse solution to the data. A previous work introduced a general formulation for inverse optimization with a single observation and a measure for the goodness-of-fit. We extend both of these results to the case of multiple observed points. Our techniques are capable of comparing different models and identifying outliers that do not fit well with the remaining points.

2 - Inverse Optimization For Determining Constraint Parameters
Neal Kau, University of Toronto, Toronto, ON, Canada, neal.kau@mail.utoronto.ca, Timothy Chan
Most inverse optimization literature has focused on determining the objective function of an optimization problem, given an observed solution. In this work, we develop inverse optimization models that additionally determine unspecified parameters of the feasible set. First, we propose an inverse linear programming model to determine all problem data. Second, we propose inverse robust linear programming models to determine a cost vector and unspecified parameters of the uncertainty set, for two types of uncertainty: interval uncertainty and cardinality constrained uncertainty.

SA17

105B-MCC
Optimal Statistical Learning
Sponsored: Optimization, Optimization Under Uncertainty
Sponsored Session
Chair: Nana Kwabena Abogye, Princeton University (ORFE), 1 Nassau Hall, Princeton, NJ, 08544, United States, abogye@princeton.edu
1 - Uncertain Date Envelopment Analysis
Allen Holder, Rose-Hulman Institute of Technology, holder@rose-hulman.edu
We motivate an inverse optimization problem that calculates a decision making unit’s maximum efficiency within the context of uncertain data envelope analysis. One of the sub-problems is a robust linear program, but unlike a traditional robust model that satisfies the objective to hedge against uncertainty, the data envelope model leverages uncertainty to promote efficiency. We apply the method to a set of prostate radiotherapy treatments to help discern appropriate treatments.

2 - Optimal Learning Of Expensive Quadratic Functions
Nana Kwabena Abogye, Princeton University, abogye@princeton.edu
We study the problem of learning the unknown parameters of an expensive function where the true underlying surface can be described by a quadratic polynomial. We present a previously studied Bayesian optimization algorithm known as the knowledge gradient for the parametric belief model. Originally established in the limited context of drug discovery (see Negoescu et al. (2011)), the knowledge gradient for the parametric belief model remains under-studied with regards to its behavior. We seek to understand the behavior of this algorithm and exploit this understanding to derive a simple heuristic that performs just as well as the knowledge gradient for the parametric belief model.
3 - Dueling Bandits With Dependent Arms
Bangru Chen, Cornell University, bc496@cornell.edu
We consider online content recommendation with implicit feedback through pairwise comparisons. We study a new formulation of the dueling bandit problems in which arms are dependent and regret occurs when neither pulled arm is optimal. We propose a new algorithm, Comparing The Best (CTB), appropriate for problems with few arms, and a variation of this algorithm for problems with many arms. We show both algorithms have constant expected cumulative regret. We demonstrate through numerical experiments on simulated and real dataset that these algorithms improve significantly over existing algorithms in the setting we study.

4 - Asymptotic Optimality In Finite Horizon Multi-armed Bandits With Multiple Pulls Per Period
Weichi Hu, Cornell University (ORIE), wh343@cornell.edu
We view the finite horizon multi-arm bandit problem with multiple pulls per period (MABMP) as a special case of a weakly coupled dynamic program (WCDP). A WCDP is a class of optimal control problems for which the complexity can be reduced by Lagrangian Relaxation. We propose an index-based policy that utilizes the Lagrange multiplier in the relaxed problem, and give a proof that this index-based policy is asymptotically close to the optimal policy as the problem size gets larger. We also use simulation to show that this index policy performs better than state-of-art heuristics in various problem sizes.

SA18
106B-MCC
High-Performance Computing for Stochastic Optimization
Invited: High Performance Computing
Invited Session
Chair: Jean-Paul Watson, Sandia National Laboratories, P.O. Box 5800, MS 1326, Albuquerque, NM, 87185, United States, jwatson@sandia.gov
1 - Parallel Branch-and-bound Based On PH For Stochastic MIPs
David Woodruff, University of California Davis, dwwoodruff@ucdavis.edu, Jason Barnett
Progressive hedging (PH), though an effective heuristic for stochastic mixed integer programs (MIPs), is not guaranteed convergence in the integer case. Here, we describe BBPH, a branch and bound algorithm that uses PH within each node that, given enough time, will always converge to the optimal solution. In addition to providing a theoretically convergent wrapper for PH applied to MIPs, computational results are given that demonstrate that for some difficult problem instances branch and bound can find improved solutions within a few branches.

2 - Schuripopt: A Parallel Optimization Package For Structured Nonlinear-Programming Problems
Gabriel Hackett, University of Michigan, Ann Arbor, MI, United States, hacketbeg@umich.edu, Jose Santiago Rodriguez, Jean-Paul Watson, Carl Laird
In this work, we develop Schuripopt, a parallel extension to Ipopt that solves structured NLP problems efficiently on shared memory and distributed memory parallel architectures. Our implementation uses a Schur-complement decomposition strategy to exploit the structure of NLP problems arising in multi-scenario and dynamic optimization applications. The implementation achieves high parallel efficiency by parallelizing the solution of the KKT system and related vector-vector and matrix-vector operations. We interface Schuripopt with PySP — a Python-based software package for modeling stochastic programming problems, which is an extension of the open-source AMPL Pyomo (pyomo.org).

3 - Parallel Solution Of Large-scale Stochastic Economic Dispatch And Unit Commitment Problems
Jean-Paul Watson, Sandia National Laboratories, jwatson@sandia.gov
We consider the solution of large-scale, industrially relevant economic dispatch and unit commitment problems, for systems with large renewables penetration levels, using parallel scenario-based decomposition methods. We discuss both lower and upper bounding performance, in the context of CAISO and other realistic data sets. We will detail tuning and implementation issues that impact and in some cases limit scalability of scenario-based decomposition (in particular, progressive hedging) on these problems.
4 - Anesthesiology Practice Redesign
Michael J Brown, Mayo Clinic-Rochester, NY, United States,
Brown.Michael3@mayo.edu
The Department of Anesthesiology led perioperative practice redesign initiative
improved the quality and increased the value of perioperative care. Utilizing an
analytical approach to identify, prioritize, assimilate, and interpret impactful
information, multiple high-value strategies were implemented that optimized
Mayo Clinic’s perioperative facilities, human resources, workflows and clinical
outcomes. The majority of interventions were perioperative specialty specific,
however others were generalizable to the entire practice. *

■ SA22
107B-MCC
Incentives and Resource Allocation in Healthcare Settings
Invited: ORInformed Healthcare Policies
Invited Session
Chair: Karthik Natarajan, University of Minnesota, Edina, MN, United
States, knataraj@umn.edu
1 - Optimal Patient And Provider Incentives In Funding-constrained
Humanitarian Healthcare Service Settings
Karthik Natarajan, University of Minnesota, Minneapolis, MN,
United States, knataraj@umn.edu, Mill Mehrotra
We analyze how a budget-constrained humanitarian organization managing
a healthcare service program should design incentives to the provider and patients
to maximize program coverage. We explore how the incentives change with the
service offered and operating environment. We also compare the optimal
incentive scheme to incentive schemes used in practice.
2 - Competing For Donations In The NPO Sector
Milind Sohoni, Indian School of Business,
milind_sohoni@isb.edu, Srpal K Devalkar, Neha Sharma
We study the impact of competition under two fund-raising models, commonly
observed in the non-profit sector, when donors and non-profit organizations face
challenges due to information asymmetry and outcome (benefit) uncertainty. We
also analyze implications on benefits delivered from a social planner’s perspective.
3 - Discharge Decision In Emergency Departments: Impact Of
Operational Measures And Pay-for-performance Incentives
Eric Park, University of Hong Kong, J, Hong Kong,
ericpark@hku.hk
We study how operational measures in the emergency department such as
number of patients waiting to be seen and physician’s patient load affect patient
discharge decisions. We also analyze the impact of a provincial government level
pay-for-performance incentive scheme on discharge decisions. We empirically
study several major hospitals in the metro Vancouver, Canada area.

■ SA23
108-MCC
Evaluating Health Policy Decisions
Sponsored: Health Applications
Sponsored Session
Chair: Zhaowei She, Georgia Institute of Technology, 755 Ferst Drive,
NW, Atlanta, GA, 30332, United States, zhaowei@gatech.edu
1 - Positive Externalities In Disease Intervention:
A Study Of Mosquito Borne Viruses
Anneke Claypool, Stanford University, annekecl@stanford.edu
Jeremy Goldhaber-Fiebert
Health interventions often result in positive externalities that are not captured in
traditional cost-effectiveness analysis. This study uses a dynamic transmission
model to analyze the cost-effectiveness of Chikungunya prevention measures. We
compare a potential Chikungunya vaccine to vector control methods that result in
fewer Chikungunya, Zika and Dengue cases. By using this model, the additional
health benefits of interventions that impact multiple diseases can be captured.
2 - Modeling Health Insurance Marketplaces  
Zhaowei She, Georgia Institute of Technology, zhaowei@gatech.edu
As part of the Affordable Care Act, Health Insurance Marketplaces (HIX) has significantly reduced the number of uninsured in the United States. However, concerns exist about quality and accessibility of services in HIX. Motivated by these concerns, we propose a theoretical framework to understand the current state of HIX, and make projections about its future and sustainability. Our analysis shows that the current design of HIX may unintentionally incentivize health plans to ration services to attract low risk enrollees, leading to adverse selection and narrow-network phenomena in HIX. Moreover, HIX’s limitations in addressing upcoding behavior can lead to an unraveling of the market.

3 - Balancing Functional And Technical Quality In Health Services Under Provider Consolidation And Shifts In Payment Structure  
Aaron H Ratcliffe, University of North Carolina at Greensboro, 438 Bryan Building, University of North Carolina at Greensboro, Greensboro, NC, 27402-6165, United States, aaron.ratcliffe@ung.edu, Ann Marutchek, Wendell G Gilland
We develop a competitive queuing model to analyze how healthcare providers balance investments in functional quality (experiential elements of service) against investments in technical service quality (positive service outcomes). Our analytical derivations measure the impact of provider consolidation and alternative payment structures on the equilibrium technical quality and functional quality efforts and equilibrium wait times for health service.

2 - Innovation In Ecosystems  
Gwendolyn K Lee, University of Florida, 2822 SW 94th Drive, Gainesville, FL, 32608, United States, gwendolyn.lee@cbu.ufl.edu, Martin Garco, Rahul Kapoor
We consider the context for innovation to comprise of interdependent industries within an ecosystem. Using a simulation model, we explore how the structure of interdependencies shapes the pattern of innovation across industries. The notion is that an industry’s close proximity to end-use provides firms with a larger pool of components to combine but also more complex objective function to solve. A larger pool presents more choices and covers a wider variety of choices. However, certain architectural configurations impose heavy constraints on downstream firms. We show innovation outcomes depend on the architecture of interdependencies across and within the different industries in an ecosystem.

3 - Effect Of Competitor Investments On Established Firms’ Redeployment Entry Into Nascent Markets: Evidence From The U.S. Electric Utilities’ Adoption Of Solar Energy  
Shaohua Lu, Tulane University, Freeman School of Business, New Orleans, LA, 70118, United States, slu@tulane.edu, Jay Anand
This paper examines the effect of competitor investments on established firms’ entry into an emerging, uncertain market. To understand information effect, we shift attention to the “flow” of recent competitor investments rather than analyzing the “stock” of cumulative investments. We further postulate that this information effect interacts with a competition effect in oligopolistic market competition. We construct formal models and predict a U-shaped relationship. We further examine how competitor similarity and existing capacity affect this U-shaped relationship. Using data on investor-owned utilities’ entry into the solar market, we find supporting evidence for our predictions.

4 - Stock Market Undervaluation Of Resource Redeployability  
Arkadiy Sakhartov, University of Pennsylvania, Wharton School of Business, 3620 Locust Walk, Philadelphia, PA, 19104, United States, arkadiys@wharton.upenn.edu
The study uses three steps to establish the applicability of the strategic factor maximization theory to acquisitions of firms in stock markets. First, the study compiles literature on resource valuation and finds a likely source of the undervaluation, ambiguity about redeployability of resources to a new business. Second, the study compiles a case of Apple Inc., revealing a prolonged undervaluation of redeployability of the firm’s resources to the smartphone business. Third, the study builds a valuation model deriving the undervaluation as a function of observable resource properties.

SA24

Dynamics of Scope and Innovation  
Invited: Strategy Science
Invited Session
Chair: Brian Wu, University of Michigan, Tappan Street, Ann Arbor, MI, 48109, United States, wux@umich.edu
1 - Adaptation On Multiple Landscapes: Relatedness, Complexity And Dynamic Coordination Costs  
Aseem Kaul, University of Minnesota, Minneapolis, MN, United States, aakaul@umn.edu, Mo Chen, Xin Wu
We introduce and explore the concept of dynamic coordination costs, i.e. the reduction in a diversified firm’s ability to adapt within its businesses resulting from the coordination of activities across them. Using a modified NK simulation, we show that a combination of rigidity and learning means that these costs are highest at moderate levels of relatedness across business, with the level of interdependency within businesses moderating this effect. We also show that diversifying entrants in new markets experience a short-term learning advantage, but a long-term rigidity disadvantage. Our study speaks to work on organizational adaptation and strategic renewal in multi-business firms.

2 - Innovation In Ecosystems  
Gwendolyn K Lee, University of Florida, 2822 SW 94th Drive, Gainesville, FL, 32608, United States, gwendolyn.lee@cbu.ufl.edu, Martin Garco, Rahul Kapoor
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Procurement Auctions and Bidding
Invited: Auctions
Invited Session
Chair: Kartikeya Puranam, La Salle University, 1900 West Olney Ave, Philadelphia, PA, 19141, United States, puranam@lasalle.edu

1 - Behavioral Analysis Of A + B Sealed Bid Procurement Auctions
Bernardo F. Quiroga, Assistant Professor, Clemson University, Clemson, SC, 29634, United States, bquirog@g.clemson.edu
Brent Morritz, Xiaosong Wu

Using a laboratory experiment, we study the effect of complexity in multidimensional bidding in A + B governmental procurement auctions. Varying the number of bidders and the dimensionality of the bid, we offer an explanation for over/underbidding, and suggest potential solutions to the welfare implications of the observed biases. In our analyses, we evaluate several different explanations to rationalize this behavior, including risk attitudes, bounded rationality, loss aversion, quantile response equilibria measures, and structural estimation of the implied private value of the contracts.

2 - Score Auction Bidding Under Quality Uncertainty:
Effort, Risk And Agency Considerations
Daniel Niembowicz, Clemson University, dnieubub@g.clemson.edu
Bernardo F. Quiroga

In a price-and-quality score procurement auction setting, we model the effect of quality uncertainty on bidding behavior under the presence of moral hazard, using a sealed-bid-first-score mechanism. In our scenario, bidders submit prices and target quality levels, and are subject to a failure-to-deliver penalty from deviations below said target. We present our analytical model and offer policy implications in presence and absence of default risk/renegotiation, and offer light to a dynamic extension of this model (in which credibility plays a fundamental role).

3 - Bidding With Learning In Repeated Auctions
Kartikeya Puranam, La Salle University, puranam@lasalle.edu, Michael N Katchakis

We consider the problem of a firm that procures items in a sequence of auctions by bidding against the “market.” The firm has two bid levels available (High and Low). The firm and the “market” learn from each winning bid. We study bidding strategies for the firm when the objective of the firm is to minimize the expected total cost of acquiring items to meet demand.

Behavioral Operations

Sponsored: Manufacturing & Service Oper Mgmt
Sponsored Session
Chair: Javad Nasiry, Hong Kong University of Science and Technology-HKUST, Hong Kong, nasiry@ust.hk
Co-Chair: Xiaoyang Long, Hong Kong University of Science and Technology. Hong Kong, xlongaa@connect.ust.hk

1 - Trust, Social Networks, And Information Sharing: Among Executives
Xiaolp Ozer, The University of Texas at Dallas, Richardson, TX, 75080, United States, ooezer@utdallas.edu, Emily Choi, Yanchong Zheng

We experimentally study how trust and social networks influence forecast information sharing behavior among executives with an average 17 years of professional experience. We demonstrate how trust preconditioned by prior experiences and trust measured from social network jointly influence information sharing behavior and the resulting supply chain efficiency.

2 - A Behavioral Study On Abandonment Decisions In Multi-stage Projects
Xiaoyang Long, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, xlongaa@connect.ust.hk
Javad Nasiry, Yaozhong Wu

We experimentally investigate continuation/abandonment decisions in a multi-stage project under two conditions: when the project is reviewed at every stage and when review opportunities are limited. We find systematic deviations from the optimal solution: subjects may wrongly continue or abandon the project, and their decisions are path dependent. We propose a behavioral model which explains the behavioral regularities.

3 - Newsrader Problem In The Presence Of Strategic Customers:
Theory And Laboratory Evidence
Yang Zhang, Tsinghua University, yangzhanguser@mail.tsinghua.edu.cn, Benny Mantin, Yaozhong Wu

How would a newsrader react to strategic customers who may delay their purchase until a price discount to take place? In theory, the newsrader should optimally order less than the conventional critical fractile, in order to signal a shortage of products so that strategic customers herd into purchases at full price. In the laboratory however, retailers tend to psychologically overreact to the strategic customer behavior, which produces the so-called pull-below-center bias. We develop a behavioral model based on reference dependence to explain the observed ordering patterns, comparative statics, and the presence and asymmetry of pull-below-center bias across treatments.

4 - Competitive Dynamic Pricing Under Capacity Constraints: An Experimental Study
Bahriye Cesaret, Ozyegin University, Istanbul, Turkey, bahriye.cesaret@ozyegin.edu.tr, Elena Kato

We present an experimental study of a stylized competitive dynamic pricing model for a duopoly. We designed a set laboratory experiments to investigate how human decision makers price their fixed units of capacity over a multiple-period selling season when they face a competition in the market. We report on the results of four experiments. The results show that our laboratory participant tends to underprice (i.e., price over-competitively) at the beginning of a selling season, and as the selling deadline gets closer she tends to overprice (i.e., price not competitive enough) her units.
We study the dynamic mechanism design problem of a firm repeatedly selling items to budget-constrained buyers when the seller has limited commitment power. We argue that this problem is generally intractable. Thus motivated we introduce a fluid model that allows for a tractable characterization of the optimal mechanism. We leverage our characterization to provide insights into the dynamic structure of the optimal mechanism and show that the proposed mechanism is a good approximation in large markets.

We study a supply chain consisting of a supplier and a retailer faced with random demand over multiple periods. At the beginning of each period, the supplier offers a one-period contract and the retailer chooses order quantity before the demand is realized. The retailer carries leftover inventory or backlogs unmet demand, which is unobservable by the supplier. We find that in the infinite-horizon setting with exponentially distributed demand, for a large parameter set, the optimal sequence of short-term contracts is a generalized base-stock policy, where the base-stock level weakly increases with the beginning inventory.

We consider a principal repeatedly allocating a single resource in each period to one of multiple agents without relying on monetary payments over an infinite horizon. Agents' private valuations are independent and identically distributed. We show that as the discount factor approaches 1, the optimal dynamic mechanism without money achieves the first-best allocation (the welfare maximizing allocation when valuations are public). As part of the proof, we provide an incentive compatible dynamic mechanism that asymptotically achieves the first-best.

We consider a principal incentivizing an agent to exert effort in order to raise the arrival rate of a Poisson process. The effort is costly to the agent, unobservable to the principal, and affects the instantaneous arrival rate. Each arrival yields a constant revenue to the principal. A contract involves payments and a potential stopping time in order to motivate the agent to always exert effort. Although payments can take general forms contingent upon past arrival times, the optimal contract has a simple and intuitive structure, which depends on whether the agent is less patient than the principal.

Our procedure crucially exploits the symmetries of the Mallows model and leads to a compact IP formulation for assortment optimization. We also give an efficient near-optimal approximation for the IP.

We study the dynamic assortment planning problem, where the demand is stochastic, and retailers' decisions need to be robust (revenue-wise) to stock-out events, elicited by the inventory limitations. While being key to revenue management, particularly in retailing and airlines, the computational aspects of such problems are still wide open. We devise the first efficient algorithms with provable performance guarantees, under several common modeling primitives, including the widespread Multinomial Logit choice model. In practical comparisons against incumbent heuristics, our algorithms improve the revenue by 9% to 33%, with better computational efficiency and robustness in most cases.

We study the dynamic assortment planning problem, where the demand is stochastic, and retailers' decisions need to be robust (revenue-wise) to stock-out events, elicited by the inventory limitations. While being key to revenue management, particularly in retailing and airlines, the computational aspects of such problems are still wide open. We devise the first efficient algorithms with provable performance guarantees, under several common modeling primitives, including the widespread Multinomial Logit choice model. In practical comparisons against incumbent heuristics, our algorithms improve the revenue by 9% to 33%, with better computational efficiency and robustness in most cases.

Our procedure crucially exploits the symmetries of the Mallows model and leads to a compact IP formulation for assortment optimization. We also give an efficient near-optimal approximation for the IP.

This paper studies two risk-neutral processors procure two substitutable commodities from spot markets to process and sell through a retailer. First, we characterize the optimal index-based contracts for processors that indicates the processor's optimal contract consists of a processing margin which is independent of its financial hedging decisions and a hedge ratio which is a function of commodity price volatility. Next, we characterize conditions under which, the retailer prefers to be exposed to commodity price risks. We show that processors can benefit from market pricing, where these prices are linked to input commodity prices and index-based contracts are a means to achieve it.

In this paper, we examine the integrated operating and financial hedging decisions of a value maximizing firm, in the presence of capital market imperfections. Our results show that the working capital and the hedging policies of the firm interact with each other in a multi-period dynamic inventory model. In particular, looser working capital policies lead the managers to take relatively more speculative positions in the market to maximize firm value.

We study production planning integrated with risk hedging by considering shortfall (from a pre-specified target) as the risk measure. The optimal hedging strategy is identified via a dual lower-bound problem, and takes the form of a digital option combined with a put option: and optimizing the production quantity, given the optimal hedging, is shown to be a convex minimization problem. With both production and hedging optimized, we provide a complete characterization of the efficient frontier, and an explicit quantification of the shortfall reduction achieved by hedging.
4 - Dual Sourcing: Optimal Procurement Policy With Option Hedging Against Freight Rate Risk
Arun Chockalingam, Eindhoven University of Technology.
a.chockalingam@tue.nl, Taimaz Soltani, Jan C Fransoo,
Chung-Yue Lee
Raw materials cost less to procure on offshore markets as opposed to domestic markets. However, offshore procurement requires ocean shipping, the price of which is highly volatile, and firms usually have to charter ships, even if they do not use the whole capacity of ships. We consider a commodity processor with two sourcing choices and develop models to determine the firm’s optimal sourcing policy. The models allow for three sources of uncertainty: demand, commodity spot price and freight rate. Using option contracts as hedging tools against freight rate risk, we develop a model that integrates a firm’s optimal sourcing decision with the integer constraint on hiring ships.

2 - Scheduling Student Volunteers For The Inform’s Annual Meeting
Neil Desnoyers, Adjunct Instructor, Saint Joseph’s University, 5600 City Avenue, Philadelphia, PA, 19131, United States, ndesnoye@sju.edu
The 2015 INFORMS Annual Meeting in Philadelphia required the assistance of 59 student volunteers. Each student volunteer was required to serve two half-day shifts out of the eight shifts available over four days (AM and PM shift each day). Via a web survey, student volunteers indicated five of eight shifts they were available to work. Between 12 and 14 student volunteers were required for each shift, and student volunteers were assigned to 9 or 10 locations/roles each shift. The problem was set up and solved as a binary integer programming problem. The problem provides lessons for volunteer scheduling in general.

2 - Cloud-based Collaborative Application Development
Susanne Heipcke, Principal Engineer, FICO, FICO House, Starley Way, Birmingham, B37 7GN, United Kingdom, susanneheipcke@fico.com, Oliver Baster
Integrated development environments are critical for efficient development but tooling for algebraic modeling languages has been lacking adoption of the latest technologies, no single tool covering the whole application development process so far. FICO Optimization Designer provides a novel approach for collaborative web-based development of optimization solutions. It supports model development in Xpress-Mosel, add-in predictive models implemented in R, deployment as an application and packaging the application as a Docker image or as a cloud application.

3 - Adaptive Sampling Trust-region Optimization For Derivative-based And Derivative-free Simulation Optimization Problems
Sara Shashaani, PhD, Purdue University, Lafayette, IN, 47901, United States, ssasha@purdue.edu, Raghu Pasupathy
We present ASTRO and ASTRO-DF – adaptive sampling trust-region optimization algorithms – for solving derivative-based and derivative-free continuous simulation optimization problems. Sampling in ASTRO and ASTRO-DF is done adaptively in an attempt to keep stochastic and structural errors in lock-step as the algorithm iterates evolve through the search space. We show consistency and discuss finite-time performance for a set of low to moderate dimensional optimization problems.
Co-Chair: Tianjun Feng, Fudan University, Shanghai, China, tfeng@fudan.edu.cn
Fuqiang Zhang, Peiwen Yu
Tianjun Feng, Fudan University, tfeng@fudan.edu.cn, Fuqiang Zhang, Peiwen Yu
Tianjun Feng, Fudan University, Shanghai, China, tfeng@fudan.edu.cn
Fuqiang Zhang, Peiwen Yu
Tianjun Feng, Fudan University, Shanghai, China, tfeng@fudan.edu.cn
Fuqiang Zhang, Peiwen Yu
This paper investigates the network effect in automobile sales by using a unique dataset from a large city in China. We demonstrate the existence of a positive but diminishing marginal effect of the local owner base on the sales of automobiles.

2 - The Operational Value Of Social Media Information
Dennis Zhang, Northwestern University, 1500 Chicago Avenue, Apt.712, Evanston, IL, 60201, United States, j-zhang@kellogg.northwestern.edu, Antonio Moreno-Garcia, Ruomeng Cui, Santiago Gallino
This paper empirically studies whether using publicly available social media information can improve the accuracy of daily sales forecasts. We collaborated with an online apparel retailer to implement a variety of machine learning methods to create daily sales forecasts. We find that using social media information results in statistically significant improvements in the out-of-sample accuracy of the forecasts, with relative improvements ranging from 12.85 percent to 23.23 percent over different forecast horizons.

3 - Analyzing The Impact Of Surgical Process Changes On Patient Flow
Justin Kistler, University of South Carolina, Columbia, SC, United States, justin.kistler@grad.moore.sc.edu
Ramkumar Janakiram, Vikram Tiwari, Subodha Kumar
Leveraging unique patient-level encounter data through econometric techniques, we examine the impact of two process changes on surgical operations at a medical center. Building on management and operations literature, we posit that a process change, and a subsequent intra-operative IT enabled process change, will significantly improve surgical operations flow time. Given the high opportunity cost of resources associated with surgical procedures, this finding has important implications for surgical process owners and participants.

3 - Exploring The Rational Behind Outlet Stores
Juar Bai, University of California, Irvine, jaubai@uci.edu, Harsh Gurnani, Shuya Yin
Outlet stores have been both complementary to and competing with the main stores. In this project, our goal is to understand the tradeoffs involved in offering outlet stores. In particular, we study how much differentiation should be kept between the main and outlet stores from three perspectives: price, product and location.

3 - Replenishment Strategies For Micro-retailers In Developing Countries
Sean Zhou, Chinese University of Hong Kong, Hong Kong, Hong Kong, zhoux@baf.cuhk.edu.hk, Christopher S. Tang, Kaiwen Zhang
When formal distribution channels are absent in developing countries, micro-retailers travel long distances to replenish their stocks directly from key suppliers. We examine a model where multiple competing retailers collectively determine the replenishment strategy among three possible strategies: informal, formal, and hybrid. We show that when the stores engage in quantity competition, the hybrid strategy maximizes the retailers’ total welfare when either the travel cost is sufficiently high or the fixed operating costs are sufficiently low.

4 - Ceo Overconfidence And Inventory Management
Fuqiang Zhang, Washington University in St. Louis, zhang@olin.wustl.edu, Tianjun Feng, Qing Zhang
Using the data of the US-listed companies in the manufacturing industry during 1999-2011, this study empirically investigates the relationship between CEO overconfidence and firms’ operations efficiency. Specifically, we focus on inventory turnover, a widely used operations efficiency measure for inventory management. We find that firms with overconfident CEOs are associated with higher inventory turnover.

4 - Impact Of Physical Retail Channel On Customers’ Online Purchase Behavior
Anuj Kumar, University of Florida, akumar1@ufl.edu
Amit Mehra, Subodha Kumar
We use customer-level data of a large apparel retailer to estimate the treatment effect of store openings on the online purchase behavior of its existing customers. The retailer’s store openings resulted in a 29 percent increase in annual online purchase revenue of the existing customers. The increase in online purchases of existing customers after store opening could be attributed to: (1) higher engagement with the retailer from their higher store interactions and (2) availability of a low cost option of returning their online purchases in store if it does not fit their needs. The effect of store opening was found to be higher for customers who experience higher geographic distances.

5 - When The Bank Comes To You: Branch Network And Customer Multi-channel Banking Behavior
Vibhanshu Abhishek, Carnegie Mellon University, vibs@cmu.edu
Belbei Li, Dan Geng
Customers today increasingly interact with their banks using digital channels, lifting the necessity for banks to rethink the distribution of physical branches and customer behavior in a multi-channel environment. Using approximately 1.2M anonymized individual-level data from a large commercial bank in US over 6 years, our paper investigates the traditional channel - bank branches - and the impact of its network change (branch opening or closure) on customer multi-channel preferences and other banking behavior. Our results show that both branch opening and closure are associated with decreasing transactions through offline channels and increasing transactions in online banking.
3 - Inventory Management In An Omnichannel Environment
Yong-Pin Zhou, Professor, Foster School of Business, University of Washington, Seattle, Seattle, WA, 98195-3226, United States, yongpin@uw.edu, Elnaz Jallilpour Aliashah
We consider a single newsvendor-type product that is sold both online and offline. We present two models where each channel is used as a backup for the other channel, and derive structural and qualitative results on effective inventory management policies. Specifically, we consider inventory positioning, inventory level, and real-time inventory rationing decisions. When it is possible to shift some customer demand using discounts, we also investigate the level of discount and customer reaction.

4 - The Omni-channel Fulfillment Dilemma
Santiago Gallino, Dartmouth College, Dartmouth, NH, United States, santiago.gallino@tuck.dartmouth.edu, Antonio Marco, (Co-Chair), Robert P. van der Weerdt
Using transaction level data from a multi-channel retailer we explore how customer interact with the retailer over time. We study the underlying patterns of customers’ interactions and discuss the implications for retailers that have both an online and a brick and mortar presence.

SA38
207A-MCC
Product Development and Competition
Invited: New Product Development
Invited Session
Chair: Morvarid Rahmani, Georgia Institute of Technology, Atlanta, GA, 30308, United States, morvarid.rahmani@scheller.gatech.edu
Co-Chair: Kartik Ramachandran, Georgia Institute of Technology, Atlanta, GA, 30308, United States, kartik.ramachandran@scheller.gatech.edu
1 - Knowledge Search In Mobile App Development
Nilam Kaushik, PhD Candidate, UCL School of Management, London, United Kingdom, uceikau@ucl.ac.uk, Bilal Gokpinar
The process of search, identification, and acquisition of new knowledge is essential for the success of new products. We explore how firms search for ideas in sequential product development through the highly competitive and dynamic setting of mobile application development. Using novel text-mining techniques, we derive measures of similarity between a focal app’s update and updates made by competitor apps and study performance implications thereof. We also explore the performance implications of the distance of an app’s update with respect to its past updates.

2 - Decision Options At Project Gate Reviews: Beyond The Go/ Kill Model
Alison Olechowski, Massachusetts Institute of Technology, Cambridge, MA, United States, alisono@mit.edu
Steven D Eppinger, Nitin Joglekar
Most current academic models of project gate reviews represent the gate decision as a simple choice between go and kill. In reality, product developers often reach the gate with incomplete or unacceptable deliverables, and managers consider more than just the kill option if a go is not appropriate. We have created a simple model which adds options of: waiver, waiver with re-review, delay and switch to back-up plan. This decision tree model compares the value of this more realistic set of options based on costs, payoffs and confidences. We demonstrate the application of this model to complex product development gate decisions via multiple case examples from industry.

3 - Capacity Investment For Product Upgrades Under Competition
Ram Bala, Santa Clara University, ram.bala@gmail.com, Milind Sohoni, Sumit Kunnukmal
Firms often introduce a vertical line extension of an existing product to consolidate their market position after loss of monopoly status. However, introducing a line extension is fraught with uncertainty as it may fail to be technically feasible as originally intended. We analyze a two stage competitive game between an incumbent and an entrant where the firms make capacity investment decisions before uncertainty resolution and then set production quantities. We uncover conditions on innovation level which determine whether the incumbent will continue to offer the existing product once the new product succeeds. We also determine the innovation level beyond which competitive entry is deterred.

4 - Institutional Design And The Creative Process: An Experimental Study
Lakshminarayana Nittala, University of California San Diego, La Jolla, CA, 92037, United States, nittala@ucsd.edu
Sanjiv Erat, Viswanathan Krishnan
The process of innovation often takes the form of problem solving and requires creative insights for achieving success. In an experimental setting we use tasks that are representative of such problems and study the role of institutional design on the creative output and the underlying search process.

SA39
207A-MCC
A/B Testing, Experiments, and Learning
Sponsored: Applied Probability
Sponsored Session
Chair: Ramesh Johari, Stanford University, Stanford, CA, United States, ramesh.johari@stanford.edu
Co-Chair: David Walsh, Stanford University, Department of Statistics, Stanford, CA, 94305, United States, dwalsh@stanford.edu
1 - Using Simulation To Improve Statistical Power In Switchback Experiments At Uber
Peter Frazier, Cornell University, Ithaca, NY, 14850, United States, pf98@cornell.edu
We consider A/B testing of systemic changes with time-varying effects, such as changes to the algorithm used to dispatch cars at Uber. Testing such changes is made difficult by correlations in outcomes across dispatches, and by seasonal and autocorrelated random variation in riders’ demand for trips. One standard A/B testing method is a switchback experiment, which applies the treatment and control on alternating days over two weeks. We show how to combine simulation-based predictions of a change’s effects with data from a switchback experiment to improve statistical power, and make analysis robust to missing data.

2 - A/B Testing In A Changing World
David Walsh, Stanford University, dwalsh@stanford.edu
The purpose of A/B testing is to let any technology company iterate on its products quickly and stay ahead of a rapidly changing market. Given this dynamic context, it is odd that the existing statistical approaches to A/B testing view the environment as static. The outcome: inferences that do not generalize beyond the life of the experiment, which then lead to actions that perform substantially worse than expected. I present new methodology that anticipates temporal variation, generating the right inferences to support dynamic product optimization.

3 - Simple Bayesian Algorithms For Identifying The Best Arm In A Multi-armed Bandit
Daniel Russo, Northwestern University, Evanston, IL, United States, Dan.Joseph.Russo@gmail.com
This talk considers the optimal adaptive allocation of measurement effort for identifying the best among a finite set of options or designs. An experimenter sequentially chooses designs to measure and observes noisy signals of their quality with the goal of confidently identifying the best design after a small number of measurements. I propose three simple Bayesian algorithms for adaptively allocating measurement effort. Each is shown to have strong performance in numerical experiments, and a unified analysis establishes each satisfies a strong asymptotic optimality property.

4 - Sequential A-B Testing With Constraints
Vivek Farias, Massachusetts Institute of Technology, Cambridge, MA, United States, vivekf@mit.edu, Ciamac Cyrus Moallemi
We consider the problem of sequential A-B testing when the impact of a treatment is marred by a large number of covariates. Our main contribution is a tractable algorithm for the online allocation of test subjects to either treatment with the goal of maximizing the efficiency of the estimates treatment effect under a linear model, which due to a surprising state space collapse, reduces to solving a low dimensional dynamic program. Our approach is robust and covers many variations of the problem, including cases where there are budget constraints on individual treatments, where the number of trials is to be endogenously decided, and where the objective is to balance a tradeoff between efficiency and bias.
The second part of the talk will explore differences in market dynamics over different time scales and price sensitivity to the shape of the order book. Efforts to find evidence for the concerns detailed in Part I will be explained.

3 - On A New Class Of Pairs-trading Strategies
Atul Deshpande, University of Wisconsin, Madison, WI, United States, adeshpande@wisc.edu, B. Ross Barmish

The starting point for this paper is a new class of pairs-trading strategies which have rather weak requirements on the underlying stocks. We allow the user to define a rather arbitrary spread function to relate the two stocks prices under consideration. Moreover, when this function, in conjunction with the price processes, satisfies a certain mean-reversion condition, we deem the stocks to be a tradeable pair. For such a case, we prove that our trading strategy results in positive expected growth in the account value. For a limited number of backtests using popular spread functions from literature, we see robust growth while avoiding huge drawdowns.

4 - Robust Empirical Optimization Is Almost The Same As Mean-variance Optimization
Jun-ya Gotoh, Chuo University, jwtoto@indsys.chuo-u.ac.jp

We consider a robust optimization problem. Our main finding is that a large class of robust empirical optimization problems are essentially equivalent to an sample mean-variance. With this insight, we suggest a robust version of cross-validation which can be beneficial to high-dimensional-small-data situation such as portfolio optimization.

The roles of technical efficiency of production, capacity utilization, and the adoption of energy efficient technology in determining energy efficiency is specifically addressed.

The starting point for this paper is a new class of pairs-trading strategies which have rather weak requirements on the underlying stocks. We allow the user to define a rather arbitrary spread function to relate the two stocks prices under consideration. Moreover, when this function, in conjunction with the price processes, satisfies a certain mean-reversion condition, we deem the stocks to be a tradeable pair. For such a case, we prove that our trading strategy results in positive expected growth in the account value. For a limited number of backtests using popular spread functions from literature, we see robust growth while avoiding huge drawdowns.

We present a general definition of complexity appropriate for financial counterparty networks, and derive several topologically based implementations. These range from simple and obvious metrics to others that are more mathematically subtle. It is important to tailor a complexity measure to the specific context in which it is used. This paper introduces measures of the complexity of search and netting in dealer markets. We define measures of line graph homology and collateral line graph homology that are sensitive to network interactions, such as collateral commingling and interdependent chains of obligations, that can be difficult or intractable to unwind.

The order book is a rich source of information detailing trading dynamics in equity markets. Recent concerns with algorithmic trading activities suggest that high frequency traders have unfair advantages compared with nominal traders. The first part of this talk will introduce the order book and explore the data set used in the analysis. Public concerns related to high frequency trading and Siren orders will also be discussed.

The second part of the talk will explore differences in market dynamics over different time scales and price sensitivity to the shape of the order book. Efforts to find evidence for the concerns detailed in Part I will be explained.

The starting point for this paper is a new class of pairs-trading strategies which have rather weak requirements on the underlying stocks. We allow the user to define a rather arbitrary spread function to relate the two stocks prices under consideration. Moreover, when this function, in conjunction with the price processes, satisfies a certain mean-reversion condition, we deem the stocks to be a tradeable pair. For such a case, we prove that our trading strategy results in positive expected growth in the account value. For a limited number of backtests using popular spread functions from literature, we see robust growth while avoiding huge drawdowns.
2 - Tradespace Tools For Engineering Resilient Systems
Valerie B. Sitterle, Senior Research Engineer, Georgia Tech Research Institute, Atlanta, GA, United States, valerie.sitterle@gti.gatech.edu, Santiago Balestrini-Robinson, Dane F. Freeman, James Arruda, Simon R. Goerger, Tommer R. Ender

Engineered Resilient Systems (ERS) is a U.S. Department of Defense (DoD) program focusing on efficient, effective and resilient complex engineering systems across their lifecycle and different future operational needs and mission contexts. This presentation will describe the ERS TRADESPACE toolset being collaboratively developed for the DoD Acquisitions community to support the end-to-end set of integrated processes necessary to specify stakeholder needs and create tradespaces for exploration in synergy with decision analysis methods. We will also discuss how traditional decision analysis may be a foundation from which to explore additional questions relevant to key decision makers.

3 - Decision Analysis In The Engineering Body Of Knowledge
Gregory S. Parnell, University of Arkansas, gpArnell@uark.edu

We review the definitions of decision analysis and list the decision analysis articles in the body of knowledge for the following professional societies: INFORMS, the Society for Decision Professionals, the Military Operations Research Society (MORS), The International Council on Systems Engineering (INCOSE), and the American Society for Engineering Management (ASEM).

4 - Evaluating Stakeholder Requirements To Assess Resiliency For Engineered Resilient Systems
Christina Rinaudo, USAE Engineer Research and Development Center (ERDC), Vicksburg, MS, United States, Christina.H.Rinaudo@usace.army.mil, Randy K Buchanan

Engineered Resilient Systems (ERS) research focuses on identifying methods and incorporating processes to enable model-based systems engineering analysis early in the acquisition life cycle. ERS research efforts include defining, quantifying, and developing a methodology to analyze system resiliency. Previous research described an aspect of resilience as robustness and proposed a workflow to quantify robustness using Multi-Attribute Utility Theory (MAUT). This presentation describes the application of the robustness workflow to evaluate design alternatives using the system requirements generated during the development of the Mine Resistant Ambush Protected (MRAP) vehicle.

SA44

206B-MCC

Applications of Decision Analysis to Natural Resource Management
Sponsored: Decision Analysis
Sponsored Session
Chair: Karen Jenni, US Geological Survey, DFC, MS 939, Denver, CO, 80225, United States, kjen@usgs.gov
Co-Chair: Michael Runge, US Geological Survey, Patuxent Wildlife Research Center, Laurel, MD, 20708, United States, mrunge@usgs.gov

1 - Optimal Design Of Protection Zones For Wildlife.
Julien Martin, US Geological Survey, julienmartin@usgs.gov

The establishment of protection areas to reduce mortality risk of wildlife is a common management action, yet implementation of these zones can be contentious. We apply optimization approaches to determine optimal configuration of protection zones that meet management objectives under various costs and constraints scenarios. One key management objective is to minimize risk of deadly collisions. We apply encounter rate theory to quantify the relative risk of lethal collisions between marine mammals and watercraft.

David R Smith, Research Statistician, US Geological Survey, Leetown, WV, 25430, United States, dsmith@usgs.gov

In collaboration with NPS, we developed a decision framework to help guide restoration of an ecologically degraded estuary, restricted from tidal influence for 100+ years. Decisions involve the timeframe under which restored tidal exchange will occur via modified water control structures, and implementation of secondary actions to address specific concerns. Decision complexity is magnified by multiple objectives, a long restoration horizon, high uncertainty about ecosystem response to hydrologic changes and low risk tolerances by numerous stakeholders. Although leaning is anticipated to occur rapidly, problem complexity limits the application of formal adaptive management principles.

3 - Models And Tools To Support Decision Making On Multiple, Future, As-yet Unclear Management Issues
Karen Jenni, US Geological Survey, kjenni@usgs.gov

The USGS is developing a set of approaches and tools for conducting multi-resource analyses. These tools are intended to support decision making on a variety of future issues related to landscape-scale resource management. The tools can be used to consider multiple natural resources and sources of change and to address the relationships among resources and the social and economic impacts of resource change over time. We will discuss some of the unique challenges in scoping, defining, and building such models, focusing on the benefits a decision analysis approach brings even to problems without a clearly defined issue or specifically identified decision-makers.

4 - Casting Endangered Species Recovery As A Budget Allocation Problem
Michael C. Runge, USGS Patuxent Wildlife Research Center, Laurel, MD, 20708, United States, mrunge@usgs.gov, Leah R. Gerber, Jeff Newman, Lynn A. Maguire, Richard P. Maloney, Deborah T. Crouse

The U.S. Fish and Wildlife Service (FWS) is charged with managing recovery programs for species listed under the Endangered Species Act. At an agency level, this can be seen as the allocation of scarce resources to a portfolio of individual recovery efforts, taking into account the potential synergies among programs, as well as the opportunity to motivate additional funding from external partners. We are working with FWS to frame such decisions, using combinatorial optimization to explore solutions. Initial results suggest recovery outcomes could be improved with strategic budget allocation. Further, this framework provides a way to clearly articulate the benefits of increased funding.

SA45

209A-MCC

Financial Network Structure and Systemic Risk
Invited: Risk and Compliance
Invited Session
Chair: Rafael Mendoza, McCombs School of Business, University of Texas, Austin, TX, 78712, United States, rafael.mendoza-arriaga@mccombs.utexas.edu
Co-Chair: John R Birge, University of Chicago, 5807 S Woodlawn Ave, Chicago, IL, 60637, United States, John.Birge@ChicagoBooth.edu

1 - Financial Network Structure And Systemic Risk
John R Birge, University of Chicago, John.Birge@ChicagoBooth.edu

This talk will present a tutorial on financial network structure and systemic risk, the impact of the structure on the propagation of shocks and the potential for failure cascades. The talk will describe basic models and their implications and an examination of the inclusion of endogenous decisions on inter-relationships.

SA46

209B-MCC

Pricing and New Product Management
Sponsored: Revenue Management & Pricing
Sponsored Session
Chair: Nur Sunar, UNC, Chapel Hill, NC, United States, nur_sunar@kenan-flagler.unc.edu

1 - Optimal Subscription Pricing For Free Delivery Services
Chinmoy Mohapatra, Ph.D. Student, The University of Texas at Austin, McCombs School of Business, Austin, TX, 78712, United States, chinmoym@utexas.edu, Anant Balakrishnan, Shankar Sundaresan

We study the subscription pricing problem of a retailer that offers its consumers two delivery choices: a per-delivery option and a subscription option with free delivery. The retailer balances the “loss” incurred in covering the shipping costs of subscribers against the increase in revenue from the “lift” in their purchase quantity. We develop a model based on a novel utility-based framework that captures consumer heterogeneity, both in terms of their utility and preference across different firms, characterize the retailer’s optimal subscription pricing policy, and develop interesting insights.
2 - Optimal Dynamic Product Development And Launch For A Network Of Customers
Nur Sunar, UNC, nur_sunar@kenan-flagler.unc.edu
John Birge, Siniti Vitavasiri
We consider a firm that dynamically chooses its effort to develop a product for a network of customers represented by a general connected graph. In addition to dynamically choosing its development effort, the firm chooses when to launch or abandon the product. If the firm launches the product, the firm also chooses a selling price, a promotional price and a target customer to offer promotion. Once the target customer accepts the product, the product dynamically diffuses over the customer network based on the topology of the graph and the selling price. In a continuous-time setting, we explicitly solve the firm’s jointly-optimal development, launch and post-launch strategies for any connected network.

3 - Quantity Pre-commitment And Cournot Equivalence
Amr Farahat, Washington University-St. Louis, Campus Box 1133, 1 Brooksings Drive, St. Louis, MO, 63130, United States, farahat@wusl.edu, Woonghee Tim Huh, Honglin Mi
We study a two-stage oligopolistic competition game, called the Quantity Pre-commitment game, in which firms compete on quantity in the first stage and then compete on price in the second stage. This game is compared to a single-stage Cournot game, in which firms compete on the quantity only and the prices are set to clear the market. We show an equivalence result that the Quantity Pre-commitment game coincides with an equilibrium of the Cournot game, under certain conditions. The conditions that we identify are more general than those of specific models used in the seminal papers in the literature.

4 - A Stochastic Model For Pricing In Reverse Supply Chains
Elnif Acali, University of Florida, Dept of Industrial and Systems Engineering, 303 Well Hall PO Box 116395, Gainesville, FL, 32611-6595, United States, acali@ise.ufl.edu, Sila Cetinkaya, Yi Zhang
We address channel coordination issues in a two-echelon reverse supply chain that consists of a collector and a manufacturer. We develop stochastic models to maximize the manufacturer's and collector's profits in a game-theoretic framework. We develop an effective mechanism to coordinate manufacturer's and collector's decisions.

3 - A Dynamic Clustering Approach To Data-driven Assortment Personalization
Fernando Bernstein, Duke University, fernando@duke.edu
Sajad Modarest, Denis R. Saure
A retailer faces heterogeneous customers with initially unknown preferences. The retailer can personalize assortment offerings based on available profile information; however, users with different profiles may have similar preferences, suggesting that the retailer can benefit from pooling information among customers with similar preferences. We propose a dynamic clustering approach that adaptively adjusts customer segments and personalizes the assortment offerings to maximize consumer utility.

4 - Assortment Rotation And The Value Of Concealment
Kris Johnson Ferreira, Harvard Business School, kferreira@hbs.edu, Joel Goh
The frequency at which retailers change their assortment varies widely across fashion retailers. Some retailers choose to sell products simultaneously throughout the season, whereas others stagger their releases. This paper studies how the consumer make purchase decisions before seeing the subsequent products for sale. By offering products sequentially, retailers can introduce uncertainty in consumer choice that affects purchase decisions. We develop a consumer choice model and finite-horizon stochastic dynamic program to study when this uncertainty is advantageous for a retailer: a phenomenon we refer to as the retailer’s value of concealment.

SA47
209C-MCC
Topics in Assortment Planning and Consumer Choice
Sponsored: Revenue Management & Pricing
Sponsored Session
Chair: Kris Johnson Ferreira, Harvard Business School, Boston, MA, United States, kferreira@hbs.edu
1 - A Data-driven Approach To Customer Segmentation
Ashwin Venkataraman, New York University, 719 Broadway, 7th Floor, New York, NY, 10003, United States, ashwin@cs.nyu.edu
Srikanth Jagabathula, Lakshminarayanan Subramanian
We propose a new “model-based” projection technique for segmenting customers based on partial observations for each customer. We suppose that data are available in the form of categorical responses for a collection of n variables for each customer. This unified representation allows one to combine diverse signals (clicks, demographics, purchases, etc.) to obtain accurate segmentation. Our method relies on a combination of model-based projections and matrix completion techniques to obtain the clusters. We theoretically and empirically show how our method is superior to existing benchmarks.

2 - Analysis Of Choice Models: A Welfare-based Framework
Xiaobo Li, University of Minnesota, Minneapolis, MN, 55414, United States, lxx3195@umn.edu, Guiyun Feng, Zihuo Wang
We propose a framework for discrete choice models through a welfare function. The framework provides a new way of constructing choice models. It also provides great analysis convenience for establishing connections among existing choice models. We define a new property in choice models: substitutability/complementarity and study conditions for a choice model to be substitutable. We show that our framework is flexible in this property, which is desirable in capturing practical choice patterns.

SA48
210-MCC
Social Media Analysis I
Invited: Social Media Analytics
Invited Session
Chair: Chris Smith, Air Force Institute of Technology, 2950 Hobson Way, 2950 Hobson Way, Wright-Patterson AFB, OH, 45433, United States, cms3am@virginia.edu
1 - User Reward Programs In Online Social Media
Fouda H Mirzaei, Santa Clara University, Unit 3, 559 Alviso St, Santa Clara, CA, 95050, United States, fhm.phd@ivey.ca, Fredrik Odgaard, Xinghao Yan
Online social media (OSMs) have become a popular and growing Internet phenomenon, as exemplified by the millions of followers of websites like YouTube, Twitter, and Facebook. Given the Internet’s ease of access and the high degree of competition to attract users to these sites, a question arises as to whether OSMs should develop revenue-sharing programs as a way to reward their contributing users. We present an ex ante asymmetric duopoly OSM game, where heterogeneous users are either active or passive with respect to each OSM. In this study, we explore how online users’ actions and perspectives impact the outcome of the competition among OSMs.

2 - Research On The Influence Of Microblog Advertising Of Theatre Chain On Its First Week Box Office Revenue
Jiayin Qi, Shanghai University of International Business and Economics, Shanghai, 100876, China, qijiaoy@139.com, Jiaqi Liu
With the participation of enterprise in social network, a question arises of how enterprise can gain more real profit from social network advertising. This article analyzes the relationships among contents of enterprise’s online post, consumer’s participation on microblog, and short-term product sales. Taking movie market as research set, this research finds that short-term product sales is positively influenced by the information quantity of enterprise’s post, and the influence is mediated by the “ repost” of other users of Sina microblog. The mechanism examined in this research on the influence of microblog advertising on short-term sales can be guidelines of social network advertising.

3 - Social Media Use And New Product Development Performance
Debashish N Mallick, Associate Professor, University of St. Thomas, Opus College of Business, 1000 La Salle Avenue # TMH 443, Minneapolis, MN, 55403, United States, dmallick@stthomasm.edu
Use of social media is becoming increasingly popular in new product development (NPD). Yet, the performance impact of social media use in NPD remains inconclusive. Using a cross-industry survey of new product development projects, we explore the factors affecting the relationship between social media use and NPD performance.
2 - It's A Man's Job: Income And The Gender Gap In Industrial Research
Myriam Mariani, University, 1, Bocconi, Italy, myriam.mariani@unibocconi.it
This study examines differences in income and job performance between women and men in creative jobs tasked with achieving technological inventions. By building on data pertaining to 9,692 inventors from 23 countries, this study shows that female inventors represent only 4.2% of total inventors, and they earn 14% less than their male peers. The gap persists after controlling for sources of heterogeneity, the selection of inventors into types of jobs and tasks, and potential parenthood, instrumented by exploiting religious practices. The income gap is not associated with differences in the quality of the inventions.

3 - An Agenda For Diversity And Inclusion-related Research within OR/MS/Analytics
Michael P. Johnston, University of Massachusetts Boston, 100 Morrissey Blvd, M-3-428A, Department of Public Policy and Public Affairs, Boston, MA, 02124, United States, michael.johnston@umb.edu
Diversity and inclusion have been widely studied and debated, most often within the social sciences. What contributions can operations research, management science and analytics make to this domain of inquiry? This talk will critically examine assumptions and practices within the decision sciences that may support as well impede diversity- and inclusion-related research, and propose a research agenda that can challenge yet enrich our profession.

4 - Bridging The Gap: Optimal Responses To Equal Pay Legislation
Margret Bjarnadottir, University of Maryland, R H Smith School, College Park, MD, 20, United States, margret@rhsmith.umd.edu, David Anderson
We study how firms can reduce any measured demographic-based pay-gap (such as the gender pay gap), in the most cost efficient way possible. We show that by prioritizing wage increases and targeting workers that will have the greatest impact, a manager can meet the Equal Pay for Equal Work standard for less than half the cost of the naive methods. We further formulate a trade-off optimization model that balances the need to close a pay gap with employee fairness, given a fixed budget during the annual review cycle.

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3 - Information Dissemination Through Social Media In Humanitarian Operations

Eunae Yoo, Arizona State University, Tempe, AZ, United States, eunae.yoo@asu.edu, Elliot Rabinovich, Bin Gu, William Rand, Mahyar Eftekhari

For humanitarian operations, the distribution of information is critical to support the effective and efficient delivery of goods and services. Since social media facilitates real-time information sharing, humanitarian organizations have started leveraging these platforms to communicate with their stakeholders. Our research examines information diffusion patterns on social media during disasters, taking into account the underlying social network among users. From our results, we identify how humanitarian organizations can improve information propagation on social media in emergencies.

4 - Disaster Cycle Management: Matching Supply And Demand Of Social Support Through Social Media.

Alfonso Pedraza-Martinez, Indiana University, alpedraza@indiana.edu, Lucy Yan

We study information management during the disaster cycle. This research investigates the match of social support supply provided by organizations and social support demand from social media users during the stages of preparedness, response and early recovery. Using the case of Hurricane Sandy, 2012 we find a mismatch between supply and demand for social support and provide discussions on alleviating the mismatch. Moreover, we study how actionable operations management content posted by organizations affects their interaction with users through social media.

SA53

Music Row 1 - Omni

Topics in Revenue Generation from Innovation

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Pascale Crama, Singapore Management University, 50 Stamford Road, Singapore, 178899, Singapore, pcrama@smu.edu.sg

1 - Retaining Capable New Employees: Role Of Strategic Interaction And The Learning Rate

Onesun Steve Yoo, University College London, London, United Kingdom, onesun.yoo@ucl.ac.uk, Dharma Kwon

We study a two-sided game involving a firm and a newly hired employee whose capability is not initially known to either party. As the employee performs, both players learn and are presented with an option: the firm can terminate an incapable employee, and a capable employee can leave the firm for greater financial remuneration elsewhere. We examine the Markov perfect equilibrium (MPE) termination strategies and payoffs that unfold. We report a counterintuitive result: slower learning can increase the equilibrium payoff for both parties. Our result identifies a nonfinancial way for firms to improve retention of highly capable employees and create a win-win situation for both parties.

2 - The Impact Of Valuation Heterogeneity And Network Structure On Equilibrium Prices In Supply Networks

Alper Nakkas, Nova School of Business and Economics, Campus de Campolide, VAT - 506030636, Lisbon, 1099-032, Portugal, alper.nakkas@novasbe.pt, Yi Xiú

We study how valuation heterogeneity and network structure on equilibrium prices in supply networks by identifying the main factors that influence the equilibrium prices, trading pattern and surplus allocation in such networks. We also show what types of links can be added into a supply network to improve its competitiveness and/or efficiency.

3 - Signalling Product Quality Through A Trial Period

Gulru Özkan-Seely, University of Washington – Bothell, Bothell, WA, 98033, United States, gulru@uw.edu, Shouliang Wang

We evaluate a firm's pricing and timing strategies when launching via a time-locked trial period a new product that has privately observable product quality. While the trial period allows consumers to learn about the product quality (a phenomenon we term a learning effect), a longer trial period increases the heterogeneity of consumers' willingness-to-pay for the firm (a phenomenon we term a dispersion effect). The dispersion effect exacerbates the firm's pricing difficulty and generates an informational cost, warranting a longer trial period as a credible signal of the firm's superior product quality. In a key finding, we show that a firm can use the price and the trial length as dual signals.

4 - An Experimental Study Of Idea Evaluation Process

Zhiqian Cui, IE Business School, Zhiqian.cui@ie.edu

With an online experiment, this study compares the efficacy of two idea evaluation processes commonly observed in practice: ranking and scoring. We find that the scoring process has a higher evaluation accuracy than the ranking process. In addition, providing more information and domain-specific expertise could improve the evaluation accuracy of scoring process, but not the ranking process.
4 - Exploring The Synergy Between Online Reviews And Structured Surveys
Jie Zhang, University of Victoria, jz@bu.edu
Service organizations have relied on guest surveys to assess satisfaction and identify opportunities for operational improvement. Increasingly, online reviews present opportunities to collect real-time feedback. In this study, we describe a study that explores how to use the insights from online reviews to adapt survey questions for more focused performance evaluation.

SA56
Music Row 4 - Omni

Analytics in Social Media and Sharing Economy
Sponsored: EBusiness
Sponsored Session
Chair: Young Jin Lee, Assistant Professor, University of Denver, 2101 S. University Blvd., Denver, CO, 80208, United States, YoungJin.Lee@du.edu
1 - Visualizing The Dynamics Of Multivariate Time-series Data From Social Media During Emergency Management And Disaster Response
Dave Yates, Assistant Professor, University of Denver, Denver, CO, 80208, United States, dave.yates@du.edu, Joe Ryan
This project develops visualization approaches for dynamic multivariate time-series data shared via social media during emergency and disaster response, a focus area in which decision making is of paramount importance. The data is similar to that shared on social media such as blogs or social networks for entertainment, personal connections, and many other purposes. In this research we discuss the nature of social media data and the particular challenges of visualizing it in ways that make sense for decision makers. Synergizing social theory with visualization techniques we present best practices, lessons learned, and a research agenda.

2 - Using Social Capital Theory In Social Network Sites To Improve Innovative Performance
Valerie Bartelt, Texas A&M University - Kingsville, TX, vbartelt@gmail.com, Murad Moqbel
Innovative performance has become increasingly essential for business success. This research compares how social capital through social network site (SNS) affects innovative performance. Survey research from 276 professionals found that work SNS use significantly increased innovative performance while social SNS use significantly decreased innovative performance. Structural capital significantly moderated the relational capital on innovative performance. These findings open new avenues for further research by identifying the type of SNS use that will cultivate innovation in businesses.

3 - Are Multi-listing Hosts Better Off? How Host Attributes Affect The Performance Of Airbnb Listings
Karen Xie, University of Denver, Karen.Xie@du.edu
This study investigates the relationship between Airbnb hosts' attributes, in terms of both the quality of host services and the quantity of host listings. Our unique sample included 5,805 active listings of 4,608 hosts in Austin, of which 12.26% or 565 hosts had more than one listing. We found that the host may make a tradeoff between quantity and quality as he/she manages more listings. Such research into Airbnb hosts will unveil important business and policy strategies for Airbnb to improve and grow its business more strategically.

4 - User Engagement In Social Media: Evidence From A Field Experiment
Jane Tan, University of Washington, xuetan@uw.edu
Yingda Lu, Yong Tan
User engagement in charitable campaigns over social media environment is critical for raising awareness, which is key to the success of fundraising. In this study, we analyze the impacts of different solicitation approaches. Specifically, we evaluate the effect of adding compassionate followers to prospective users and the effect of adding prospective users into a charitable list. Using a randomized field experiment at Twitter, we find that adding compassionate followers positively affect users' propensity of engagement, while adding them to a charitable list has negative effect.
2 - Fuel Procurement Strategy With Inventory Consideration For Electric Power Utilities
Chung-Hsiao Wang, LG&E and K, 102 Spruce Lane, Louisville, KY, 40207-1701, United States, chunghsiao@hotmail.com, K Jo Min

In recent years, natural gas combined cycle power plants have started to replace aging and less efficient coal power plants. Furthermore, due to cheap natural gas prices, economic dispatching has resulted in high coal inventory levels. Under these circumstances, in this paper, we develop mathematical models for structured and analytical guidelines on fuel procurement strategies for a utility owning both natural gas and coal generation units.

3 - Modeling And Analysis Of Remote, Off-grid Microgrids
Sreenath Chalil Madathil, Doctoral Candidate, Clemson University, 110 Freeman Hall, Clemson, SC, 29634, United States, schall@g.clemson.edu, Emre Yamangil, Harsha Nagarajan, Arthur K Barnes, Russell Bent, Scott Backhaus, Scott J. Mason, Salman Mashayekh, Michael Stadler

We develop a mixed-integer, quadratically-constrained quadratic program for minimizing total installation and operation costs of remote off-grid microgrids with renewable and non-renewable energy sources under N-1 contingencies and one day time horizon. We compare various relaxations for this NP-hard problem and present efficient decomposition algorithms for our problem. We model the nonlinear efficiency curves associated with these devices using a piecewise linear approximations and demonstrate the efficiency of proposed relaxation and decomposition methods using benchmark test problems.

4 - An Empirical Study On A Demand Response Program With Battery Storage Systems
Arnab Roy, PhD Student, University of Louisville, 2719 South 4th Street, Apt. #2, Louisville, KY, 40208, United States, arnab.roy@louisville.edu, Prajwal Khadgi, Lihui Bai

Demand response (DR) in smart grid aims to reduce peak load, thus the needs for ancillary services in generation. On the other hand, any DR programs must be implemented with incentives to ensure consumers' active engagement. In this paper, we investigate the effects of the DR implementation measures by one utility company on the load consumption of approximately 300 homes. The DR measures include the introduction of an innovative residential rate structure, direct load control, installation of efficient heat pump water heaters, and reliable utility-grade power storage systems.

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3 - Modeling Plug-in Electric Vehicles Driving And Charging Behavior Using Real-world Connected Vehicles Data
Kulmin Zhang, Assistant Professor, Michigan Technological University, Houghton, MI, 49931, United States, klzhang@mtu.edu
Shuaidao Zhao
We propose to investigate driving and charging behavior of Plug-in Electric Vehicles using real-world connected vehicles data. We use a data-driven approach to estimating 24-hour activity-travel dynamics of individual drivers from connected vehicles data collected in real-world. Based on this real-world driver's activity and mobility pattern, we formulate an optimization model to address driving and charging behavior of Plug-in Electric Vehicles to better understand the battery performance of electric vehicles under real-world conditions.

4 - Operation Of Electricity And Transportation Networks With Ev Wireless Charging
Mohammad Khodayar, Southern Methodist University, mkhodayar@smu.edu, Saeed D Manshadi, Khaled Abdelghany, Hallit Uster
This research presents the coordinated operation of wireless electric vehicle charging stations (WECs) in electricity and transportation networks. The traffic flow pattern in transportation network is assumed to follow the user equilibrium (UE) traffic assignment, where the cost of utilized electricity is incorporated in the total travel cost. The presented formulation leverages consensus optimization to address the unit commitment in the electricity network as well as user equilibrium traffic assignment in the transportation network.

SA60
Cumberland 2- Omni
Topics on Shared Public Transportation Systems
Sponsored: TSL, Urban Transportation
Sponsored Session
Chair: Hai Wang, Singapore Management University, Singapore Management University, Singapore, Singapore, Singapore, haiwang@smu.edu.sg
1 - Matching Problem For A Stochastic And Dynamic Online Vehicle Sharing System
Hai Wang, Singapore Management University, haiwang@smu.edu.sg, Chiwei Yan
We study a stochastic and dynamic matching problem for online vehicle sharing platform: match the spatial and temporal changing demand (ride request) with supply (vehicle). We propose an algorithm to determine the pairings of drivers to riders' requests. At any decision epoch, we consider the set of known available drivers and potential available drivers, as well as the set of known existing in the passengers and potential passengers. We use an iterative procedure which calls a static and deterministic matching problem as a sub-routine. The objective is to minimize the average waiting time until picked-up for ride requests. We demonstrate the advantages of our algorithm by testing in real-world data sets.

2 - Estimating Primary Demand In One-way Vehicle Sharing Systems
Chiwei Yan, Massachusetts Institute of Technology, Cambridge, MA, United States, chiwei@mit.edu, Chong Yang Goh
Observed trip data for one-way vehicle sharing systems do not always correspond to true demands for the service due to varying vehicle and parking availability. For example, in bike-sharing systems, passengers arriving at an empty pickup station may either leave the system or spill over to nearby stations. We propose efficient methods to estimate the true origin-destination demands in a one-way vehicle sharing system using observed trip data. Our approach models a customer's station substitution behavior based on a ranking-based choice model. We demonstrate the effectiveness of our approach using data from a bike-sharing system in Boston.

3 - The Learning Curve Of Taxi Drivers In an Urban Area: An Empirical Analysis
Youngsoo Kim, Singapore Management University, Singapore, Singapore, yskim@smu.edu.sg
This study aims to better understand the dynamic change of individual taxi drivers' performance on both an aggregated output level (e.g., revenue and trips) and process level (e.g., occupancy rate and zone selection decision). We also conduct counterfactual policy experiments that capture the change derived through knowledge sharing of demanding zone on both individual and company levels. The implications of our findings for both theory and practice are discussed.

SA61
Cumberland 3- Omni
RAS Student Paper Award
Sponsored Session
Chair: Steven Harrod, Technical University of Denmark, KGS, Lyngby, Denmark, sten@transport.dtu.dk
Rail Applications Section (RAS) sponsored a student research paper contest on analytics and decision making in railway applications. Papers must advance the application or theory of OR/MS for improvement of freight or passenger railway transportation, and it must represent original research that has not been published elsewhere by the time it is submitted. Authors of the First, Second and Third Place award winning papers will present their papers in this session.

SA62
Cumberland 4- Omni
Aviation Applications Section: Best Student Presentation Competition
Sponsored: Aviation Applications
Sponsored Session
Chair: Lavanya Marla, University of Illinois, lavanyam@illinois.edu

SA63
Cumberland 5- Omni
Facility Logistics
Sponsored: TSL, Facility Logistics
Sponsored Session
Chair: Jennifer A Pazour, Rensselaer Polytechnic Institute, 110 8th street, CII 5217, Troy, NY, 12180, United States, pazouj@rpi.edu

1 - Facility-level Item Allocation Problem In Ship-from-Store Environment
Seyed Shahab Mofidi, Rensselaer Polytechnic Institute, 110 8th Street, RPI ISE Department, CII 5015, Troy, NY, 12180, United States, mofidi@rpi.edu, Jennifer A Pazour
Leading retailers are using their brick-and-mortar stores to fulfill online order requests, which results in ambidextrous stores that use inventory to serve both in-store and on-line shoppers. We develop a novel multi-product optimization model that captures the tradeoff between applying resources in advance when the demand is unknown or applying resources after the demand realizes. A case study illustrates how our model can be used to recommend item allocation policies for omni-channel supply chains.

2 - Parallel Algorithms For Large Assignment Problems On Graphics Processing Unit Clusters
Rakesh Nagi, University of Illinois, Urbana-Champaign, 117 Transportation Building, MC-238, 104 South Mathews Avenue, Urbana, IL, 61801, United States, nagi@illinois.edu, Ketan Date
We discuss efficient parallel algorithms for solving large instances of the Linear Assignment Problem (LAP) and the Quadratic Assignment Problem (QAP). Our parallel architecture is comprised of CUDA enabled NVIDIA Graphics Processing Units (GPUs) on a computational cluster. We propose novel parallelization of the Hungarian algorithm on the GPUs, which shows excellent parallel speedup for large LAPS. We also propose a novel parallel Dual Ascent algorithm on the GPUs, which is used for solving the REL2 linearization of the QAP, which also utilizes our parallel Hungarian algorithm. We show that this GPU-accelerated approach is extremely valuable in a branch-and-bound scheme.
Spatial Multicriteria Decision Making: Challenges and Current Developments

1 - Geographically Weighted Multi-attribute Decision Making For Taxi Assignment
Ali Esmaeili, University of California, Irvine, Irvine, CA, United States, esmaeili@uci.edu, L Robin Keller

Taxi assignment problem is usually considered as one part of the more general vehicle routing problem (VRP) with a known value function. In this work, we extend this viewpoint to match the problem more with the real world conditions. We consider a map with weighted regions and propose a method to find the best option for each taxi request based on two different attributes. These attributes are the average response time for each region and the rate of accepted requests for each region. We show how to combine these attributes and how to include the region weights into the main value function. Moreover, we present a method for finding the best assignment option based on our defined value function.

2 - Spatial Multi Criteria Decision Analysis In The Energy Sector: A Preliminary Application To Deep Geothermal Energy Systems
Matteo Spada, Risk Analyst, Paul Scherrer Institut, OHS/A/D19, Villigen PSI, 5232, Switzerland, matteo.spada@psi.ch

This study presents the preliminary application of a spatial MCDA to the energy sector. In particular, Deep Geothermal Energy (DGE) systems are considered in the analysis. DGE is gaining quite some interest as new renewable energy system, since it offers the prospect of supplying base-load power in a decentralized fashion and a theoretically large resource potential. The proposed approach will combine spatial information from both explicit data (e.g., heat flow) and calculated ones (e.g., risk indicators, environmental impact indicators, etc.) for specific a priori defined capacity plants. The results will be presented for different hypothetical stakeholders for the case study of Switzerland.

3 - Case Studies With Gear, A New Tool For Geospatial Multi-Criteria Decision Analysis
Matthew Bates, Research Engineer, US Army Corps of Engineers, Concord, MA, United States, matthew.bates@usace.army.mil

Michelle Hamilton, Jeffrey Cegan, Cate Fox-Lent, John Nedza

GEAR (the Geospatial Environment for Analysis and Reasoning) is a new, state-of-the-art geospatial multi-criteria decision analysis (GIS-MCDA) tool developed by the Engineer Research & Development Center of the US Army Corps of Engineers. GEAR has a friendly and intuitive user interface, accepts diverse web-service and file data inputs, and guides users through data exploration, criteria development, value function and weight specification, and running the analysis. It is designed for both practiced analysts and non-expert users. In this presentation, we introduce the GEAR functionality through a series of spatial decision case studies.

4 - Behavioural Issues In Spatial Decision-making Processes
Valentina Ferretti, London School of Economics and Political Science, V.Ferretti@lse.ac.uk

Behavioral decision research has demonstrated that judgments and decisions of ordinary people and experts are subject to numerous biases. While these biases have already been extensively discussed in several disciplines, e.g. economics, game theory, finance, and risk analysis, so far the most relevant, is now a need to pay more attention to behavioral and cognitive effects in spatial environmental decision-making processes. Within this context, this talk explores which biases are relevant in the field and proposes a first behavioral experiment focusing on the weights elicitation step

5 - Landscape Multi-methodological Evaluations: Approaches For Collaborative Spatial Decision-making Processes
Maria Cerreta, University of Naples, cerreta@unina.it

The paper, starting from the evolution of the landscape’s concept and related evaluative approaches, focuses on the management of its complexity in transformation processes included in the dynamic context of landscape’s values and in its local development strategies. A multi-methodological synergistic evaluations framework for a Collaborative Spatial Decision-Making Process has been tested in some case-studies for context-aware planning strategies and scenarios of local sustainable policies, combining Multi-Criteria Analysis (MCA), Multi-Group Analysis (MGA) and Geographic Information Systems (GIS).

Economic of Information System

1 - E-commerce In The Manufacturing Supply Chain: An Empirical Analysis
Patricia Angle, Georgia Institute of Technology, Patricia.Angle@scheller.gatech.edu, Christopher M Forman, Kristina Stelfrenson McElheran

In this paper, we explore the value of e-commerce technologies on the total factor productivity (TFP) of manufacturing plants. We find that, on average, e-selling adoption is associated with a 1.4% increase in TFP. However, these returns differ significantly between small and large plants. For large plants, those above the 25th percentile in number of employees, the increase in TFP is 2%. For plants below that size threshold, the returns to e-selling are statistically indistinguishable from zero. We further find that plants with prior experience with enterprise IT realize greater productivity gains from their e-selling investments.

2 - Piracy-induced Competition In Information-good Supply Chains
Antonio Kim, Indiana University, Bloomington, IN, United States, antonio@iu.edu, Debabrata Dey, Atanu Lahiri

In an otherwise monopolistic information goods market, piracy presents itself as a “shadow competition” to the legal product by providing consumers with other means to use the product, albeit at a lower quality. In this work, we analyze the effect of this shadow competition by comparing it to competition in a manufacturer-retailer setting.

3 - Impact Of Promoting Free Wi-fi On Mobile Data Usage:
Evidence From A Field Experiment
Karthik Babu Nattamal Kaman, Georgia Institute of Technology, KarthikBabu.NK@scheller.gatech.edu, Jeffrey Hu, Sridhar Narasimhan

With the rapid proliferation of free Wi-Fi hotspots in public locations such as restaurants, shopping malls, airports etc., mobile users have the choice of accessing Internet either via paid mobile data plans or through the free Wi-Fi hotspots. We conduct a field experiment in July 2015 to study the impact of promoting free Wi-Fi service on mobile data usage. We work with a leading national mobile carrier in the USA to randomly choose 500,000 subscribers who receive a promotional text message about the availability of free Wi-Fi hotspots and compare them with a control group made of 500,000 customers who do not receive any promotional message.

4 - Strategic Intellectual Property Sharing: Competition on an OpenTechnology Platform Under Network Effects
Marius Niculescu, Georgia Institute of Technology, marius.niculescu@scheller.gatech.edu, D. J. Wu, Lizhen Xu

This study explores when an incumbent software developer might find it optimal to utilize the open business model to share its intellectual property with entrants in markets for software products with network effects.

High-Dimensional Functional Data Analysis

Sponsored: Quality, Statistics and Reliability
Co-Chair: Kamran Paynabar, kpaynabar3@ga tech.edu

1 - Difference Detection Between Two Images For Image Monitoring
PoJhua Qiu, University of Florida, pqiu@ufl.edu

Comparison of images is a fundamental task in image-based quality control. This problem, however, is complicated because 1) observed images often contain noise; and 2) the related images need to be geometrically matched up first before images of different products could be geometrically mismatched. In this paper, we propose effective methods for detecting difference between two images of products, and our proposed methods can accommodate both noise and geometric mismatch mentioned above.
2 - Online Adaptive Sampling And Estimation For Clustered Anomaly Detection
Hao Yan, Georgia Institute of Technology, yanhaopku@gmail.com
In point-based sampling and sensing system, adaptive exploration in complex sampling space can dramatically reduce the sampling time. Most of the existing techniques focus on reducing the overall fitting error for the entire sampling space. However, in many application, such as anomaly detection, only sparse clustered anomalous regions are important. In this paper, we develop a two adaptive sampling strategies together with estimation methods to recover the clustered region and discuss their properties to balance the space filling property and focus sampling near the anomalous region. Finally, the proposed methodology is validated by simulation study and real datasets in Guided Wave Experiment.

3 - A Penalized (log)-Location-Scale Tensor Regression Model For Residual Useful Lifetime Prediction
Xiaolei Fang, Georgia Institute of Technology, xfang33@gatech.edu
Kamran Paynabar, Nagi Gebrael
We develop a penalized prognostic model whose covariates are tensor-based degradation signals. To address the ultrahigh dimensionality challenge, the coefficient tensor is decomposed as a product of some basis matrices (CP decomposition) or a product of a core tensor and some factor matrices (Tucker decomposition). Instead of estimating the coefficient tensor itself, we estimate these basis matrices or core tensor and factor matrices, which have far much smaller dimensions. Two algorithms with global convergence property are developed for model estimation. The effectiveness of our models is validated using a simulation study and an infrared image-based degradation signal dataset.

4 - Multivariate Profile Monitoring Based On Sparse Multichannel Functional Principle Component Analysis
Chen Zhang, National University of Singapore, zhangchen@nus.edu.sg, Hao Yan, Jianjun Shi
This paper presents a new monitoring framework for multi-channel profile data. In particular, we first propose a sparse multichannel functional principle component analysis (SMFPCA) to model multiple profiles. SMFPCA on one hand can capture the auto-correlation structure of profile data well, and on the other can allow flexible cross-correlations of multiple or even high-dimensional profiles with different features. Then using SMFPCA scores, we further propose a monitoring scheme that can detect sparse out-of-control changes efficiently. Numerical studies together with a real example in the semiconductor manufacturing demonstrate the application and effectiveness of our methods.

SA67 Mockingbird 3 - Omni
Journal of Quality Technology Invited Session
Sponsored: Quality, Statistics and Reliability
Sponsored Session
Chair: Fugee Tsung, HKUST, Hong Kong, season@ust.hk
1 - Bayesian Life Test Planning For Log-Location-Scale Family Of Distributions
Yili Hong, Virginia Polytechnic Institute, yilihong@vt.edu
This paper describes Bayesian methods for life test planning with censored data from a log-location-scale distribution. We use a Bayesian criterion based on the estimation precision of a distribution quantile. A large-sample normal approximation gives a simplified, easy-to-interpret, yet valid approach to this planning problem, where in general no closed-form solutions are available. We present numerical investigations using the Weibull distribution with type II censoring. We also assess the effects of prior distribution. A simulation approach of the same Bayesian problem is also presented.

2 - Multivariate Exponentially Weighted Moving-average Chart For Monitoring Poisson Observations
Nan Chen, National University of Singapore, isecn@nus.edu.sg
In this talk, we develop a feasible multivariate monitoring procedure based on the general multivariate exponentially weighted moving average (MEWMA) to monitor the multivariate count data. The multivariate count data is modeled using Poisson log-normal distribution to characterize their interrelations. We systematically investigate the effects of different charting parameters and propose an optimization procedure to identify the optimal charting parameters. To further improve the efficiency, we integrate the variable sampling intervals (VSI) in the monitoring scheme. We use simulation studies and an example to elicit the application of the proposed scheme.
1 - Stacking Containers In An Automated Terminal
Amir Hossein Gharaghzoli, Texas A&M University at Galveston, P.O. Box 1675, Galveston, TX, 77553, United States, ggharag@tamug.edu
We study temporary stacking of containers in an automated terminal. In such terminals, containers to be transported the hinterland or other terminals are stacked in compact stacks with multiple piles of containers. Transfer zones located at both ends of each stack are used to stack and retrieve containers. We propose a mathematical model to stack containers.

2 - An Economical, Reliable And Sustainable Transport Strategy: Synchronmodality From Shipper's Perspective
Chuanwen Dong, Kuehne Logistics University, Grosser Graben 17, Hamburg, 20457, Germany, chuanwen.dong@the-klu.org
Robert Boute, Alan McKinnon, Marc Verelst
In order to cut the GHG emission by 60-80% by 2050, innovation is needed to shift more volume from trucks to trains. We argue that the current standstill of modal split is due to a lack of holistic understanding of the supply chain changes driven by modal split. Building on a literature review, we broaden the conventional focus of multimodal transport to a supply chain viewpoint and propose a new concept: synchronmodality from shipper's perspective. We apply our approach to a case of an FMCG firm and quantitatively demonstrate that the shipper can significantly reduce its emission without sacrificing cost or service level.

3 - Design Of Truck Appointment System
Mohammad Torkjazi, University of South Carolina, Columbia, SC, 29205, United States, torkjazi@email.sc.edu, Nathan Hyun
The truck appointment system can adjust the length of queue at the gate of the maritime container terminals. This adjustment affects the terminal operations as well as trucking companies’ schedule. This study proposes a new mathematical formulation for the truck appointment system which optimizes terminal operations as well as trucking companies’ schedule.

3 - A Mixed Integer Programming Model For Dynamic Taxi Sharing Considering Provider Revenue
Yeming Hao, Research Assistant, University of Maryland-College Park, 8136 Paint Branch Dr, 0147C Engineering Laboratory, College Park, MD, 20742, United States, yhao@umd.edu, Ali Haghani
This paper proposed an optimization model for Dynamic Taxi Sharing (DTS), which allows two groups of taxi users to ride on the same taxi together. The significance of the taxi-sharing service was evaluated. A customized matching algorithm for taxi drivers and user pairs was developed to maximize taxi providers’ revenue. We also designed a DTS fare calculation scheme which can automatically calculate the fare for each DTS user and self-adjust to balance the taxi occupancy rate in real time. A real world case was studied to demonstrate the DTS system is beneficial to taxi users, drivers and providers.

4 - Bike System Rebalancing In Omaha Nebraska
Betty Love, University of Nebraska - Omaha, Mathematics Department, Omaha, NE, 68182, United States, blove@unomaha.edu, Livvia Bechtold
Heartland B-cycle in Omaha, Nebraska is a bike sharing system that operates over 70 stations and 150 bikes. Rebalancing is done daily using one truck. We present the results of our work on the rebalancing problem using both integer programming and heuristic approaches.

2 - Swapping Inventory Between Competing Firms
Seung Jae Park, Assistant Professor, Ewha Womans University, Seoul, Korea, Republic of, park.s@ewha.ac.kr
We investigate how competing firms swap inventory. We first show that the firms would not swap inventory without a sophisticated method. However, under our proposed inventory swapping method, competing firms swap a positive amount of inventory. We also find that the swapped quantity increases as transportation costs decrease, and swapping inventory may not be beneficial if the transportation cost is either too low or too high. In addition, we show that firms may prefer to return the physical products to pay the value difference, especially if they are risk-averse.

3 - Manufacturers’ Strategic Responses To Power Imbalance In Supply Chains
Zhexing Tao, McGill University, 1001 Rue Sherbrooke O, Montreal, QC, H3A1G5, Canada, zhexing.tao@mail.mcgill.ca, Shanling Li, Saibal Ray
Our research presents a model of the manufacturer’s strategic responses to the imbalance of power in supply chain relationships and empirically tests it using plant-level data. Analysis results show that in different contexts, the manufacturer will adopt different strategies and integration mechanisms to counteract the dominance of the strong actors.

4 - Debt Financing And Specific Capacity Investment
Qiaoibai (Joice) Hu, City University of Hong Kong, AC-1, Room 7605, Dept of Management Science, Kowloon, Hong Kong, joice.hu@gmail.com
The supplier has to commit to building specific capacity for the buyer before demand uncertainty has been resolved. After uncertainty has been resolved, the parties engage in a bargaining game to decide whether or not to trade and at what price. We show that debt financing can improve supplier’s bargaining position. However, this expanded capacity is still below the channel-efficient level because debt financing reduces the probability of trade. Surprisingly, the supplier’s debt financing may also benefit the buyer and encourage the buyer to invest in value enhancement. Actually, the supplier’s debt may result in Pareto improvement.
**Managing I**

**Contributed Session**

Chair: Mohsen Moghaddam, Postdoctoral Researcher, Purdue University, Grissom Hall, 315 N. Grant Street, West Lafayette, IN, 47907, United States, mmoghadd@purdue.edu

1. **Identifying Shifting Production Bottlenecks Using Clearing Functions**
   - Reha Uzsoy, Professor, North Carolina State University, Dept. of Industrial & Systems Engg. 300 Daniels Hall Camps Box 7906, Raleigh, NC, 27695-7906, United States, ruzsoy@ncsu.edu, Baris Kacar, Lars Moench

Production planning models using clearing functions can provide meaningful dual prices for resources that are not fully utilized. We present a case study of the analysis of a semiconductor wafer fabrication system using this approach, and demonstrate the rapidly shifting nature of production bottlenecks even under stable demand.

2. **Determinants Of CommercialExploitation For European Funded Technological R&D In Manufacturing**
   - Vasco Figueiredo Teles, Researcher, MIT Portugal Program, Porto, Portugal, vteles@inesctec.pt, Abilio P. Pacheco, Abilio P. Pacheco, Joao Claro, Joao Claro

A significant number of technologies resulting from R&D funded by the European Commission and aiming at commercial exploitation, do not achieve success in the marketplace, or in fact even reach it. We use regression analysis and a data set describing 60 technologies from European R&D projects in manufacturing, to identify potential determinants of exploitation. The technologies are classified in a 4-stage exploitation scale, and their characteristics (type, sector, geography, technology readiness level, or platform potential, among others) are compared among stages. Based on the identified determinants, we offer a set of suggestions on how to improve exploitation support in these contexts.

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**Sunday, 10:00AM - 12:30PM**

**SB01**

**101A-MCC**

**Machine Learning**

Sponsored: Data Mining

**Sponsored Session**

Chair: Cynthia Rudin, MIT, 100 Main Street, Cambridge, MA, 02142, United States, rudin@mit.edu

1. **Generalized Inverse Classification**
   - Michael Lash, University of Iowa, Iowa City, IA, United States, michael-lash@uiowa.edu, Qihang Lin, Nick Street, Jennifer Robinson, Jeffrey W Ohlmann

Inverse classification (IC) is the process of perturbing a test point such that the predicted probability of a specific class is minimized. In previous work, we outlined an IC framework that incorporated a linear cost function but solved the problem by assuming the classifier was differentiable. In this talk we extend the framework to non-linear costs and relax our assumptions. We demonstrate that, using heuristic-based methods, the IC problem can be solved using arbitrary classifiers, about which only basic assumptions are made.

2. **On Difference Of Convex Optimization To Visualize a Word Storm**
   - Dolores Romero Morales, Copenhagen Business School, drm.eco@cb.s, Emilio Carrizosa, Vanesa Guerrero

In this talk we address the problem of visualizing in a bounded region a set of individuals, which has attached a dissimilarity measure and a statistical value. This problem, which extends the standard Multidimensional Scaling Analysis, is written as a global optimization problem whose objective is the difference of two convex functions (DC). Suitable DC decompositions allow us to use the DCA algorithm in a very efficient way. Our algorithmic approach is used to visualize a dynamic linguistic real-world dataset.

3. **Consensus Based Modeling Using Distributed Feature Construction**
   - Haimonti Dutta, University at Buffalo, haimonti@buffalo.edu

Inductive Logic Programming can be used as a tool for discovering relational features for subsequent use in a predictive model. However, such models often do not scale. In this paper, we address this computational difficulty by allowing features and models to be constructed in a distributed manner. There is a network of computational units, each of which employs an ILP engine to construct a small number of features and build a (local) model. Then a consensus-based algorithm is learnt, in which neighboring nodes share information to update local models. For a category of models (those with convex loss functions), it can be shown that the algorithm will result in all nodes converging to a consensus model.

4. **Regulating Greed In Multi-Armed Contextual Bandits**
   - Stefano Traca, MIT, stet@mit.edu

**Abstract to come**

**SB02**

**101B-MCC**

**Data Mining in Medical and Sociological Decision Making**

Sponsored: Data Mining

**Sponsored Session**

Chair: Kamran Paynabar, Georgia Institute of Technology, Atlanta, GA, United States, kamip@umich.edu

1. **Single Stage Prediction With Text Data Using Dimension Reduction Techniques**
   - Shawn Mankad, Cornell, sm263@cornell.edu

Text data is playing an increasingly important role within the business world for economic analyses and operations management. There are many ways to summarize and transform unstructured data into actionable insights. We compare several modern text analysis methods for prediction of economic outcomes to derive guidelines for researchers and practitioners.
2 - A Multi-response Multilevel Model With Application In Nurse Care Coordination
Bing Si, Arizona State University, Tempe, AZ, United States, bingsi@asu.edu, Jing Li
Nurse care coordination plays a vital role in promoting patient outcomes. The recently developed Nurse Care Coordination Instrument (NCCI) enables quantitative data to be collected on nurses’ coordination activities, demographics, workload and practice environment. Driven by this, we propose a novel multi-response multilevel model with joint fixed/random effect selection across multiple responses and apply it to a dataset collected across four U.S. hospitals using the NCCI. Our study conducts the first quantitative analysis linking multiple care coordination metrics with multilevel predictors and thus provides important insight into how care coordination might be impacted or improved.

3 - Optimal Expert Knowledge Elicitation For Bayesian Network Structure Identification
Yan Jin, University of Washington, Seattle, WA, United States, yanjin@uw.edu, Cao Xiao
This talk is about a systematic approach that combines observational data and expert knowledge to better learn the influential relationships between variables for networked systems, as well as automates the expert elicitation process and collect the most informative expert knowledge, optimally matched to the observational data, to improve the learning of the BN structure.

Applications include event cascade modeling of Alzheimer’s disease and human resource management key performance indicator measurement.

4 - Temporal Monitoring Of Dynamic Attributed Networks
Mostafa Reisi, Georgia Tech, mostafa.reisi@gmail.com
We consider the problem of change detection in dynamic attributed networks. First, networks are modeled through a generalized linear model (GLM). Then, a state-space model is built by considering a linear state model over the parameters of the GLM. Extended Kalman filter is used for estimating and predicting the parameters of the state-space model. For each upcoming network, a Pearson residual based on the actual network and its prediction is calculated. The Pearson residuals are monitored through an EWMA control chart. Comparison of this method with its static counterparts shows significant improvement in detecting changes.

SB03

101C-MCC
Nicholson Student Paper Prize II
Invited: Nicholson Student Paper Prize
Invited Session
Chair: Maria Esther Mayorga, North Carolina State University, 400 Daniels Hall, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu

1 - Nicholson Student Paper Prize
Maria Esther Mayorga, North Carolina State University, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu
This session highlights the finalists for the 2016 George Nicholson Student Paper Competition.

2 - Robust Monotone Submodular Function Maximization
Rajan Harish Edwani, James B. Orlin, Andreas S. Schulz, Massachusetts Institute of Technology, Cambridge, MA,rudwani@mit.edu
We consider a robust formulation, introduced by Krause et al. (2008), of the classical cardinality constrained monotone submodular function maximization problem, and give the first constant factor approximation results. The robustness considered is w.r.t. adversarial removal of up to t sum elements from the chosen set. We give both, fast and practical approximation algorithms with sub-optimal guarantees as well as more theoretical ones achieving the best possible guarantee. Finally, we also give a black box result for the more general setting of robust maximization of monotone submodular functions subject to an independence system.

3 - A Constant-Factor Approximation For Dynamic Assortment Planning Under The Multinomial Logit Model
Ali Aouad, Massachusetts Institute of Technology, Cambridge, MA, aouad@mit.edu
Abstract to come

4 - Delay, Memory, and Messaging Tradeoffs in Distributed Service Systems
Martin Zubeldia, Massachusetts Institute of Technology, Cambridge, MA, Contact: zubeldia@mit.edu
Abstract to come

SB04

101D-MCC
Energy Storage and Virtual Trading in the Smart Grid
Sponsored Session
Chair: Miguel F Anjos, Polytechnique Montreal, C.P. 6079, Succ. Centre-ville, Montreal, QC, H3C 3A7, Canada, anjos@stanfordalumni.org
1 - Optimizing Energy Flows For A Grid Connected Smart House Producing Renewable Energy
Luce Brotoorne, INRIA, luce.brotorome@inria.fr
Ekaterina Aleksheeva, Michel Gendreau, Mohammed Skiredi
We focus on optimizing energy flows for demand management of a grid connected smart house equipped with a system combining photovoltaic electricity and battery. The smartly scheduled way of using, storing, generating, buying and selling energy allows customers to reduce electricity payments, to be less dependent on the grid and avoid creating peak power demand in the grid. We propose a stochastic mathematical linear program to make an optimal decision with the lack of perfect information related to purchasing electricity prices and energy produced by PV generator.

2 - Capacity Expansion Modeling For Storage Technologies
Elaine Thompson Hale, Senior Engineer, National Renewable Energy Laboratory, Golden, CO, United States, elaine.hale@nrel.gov, Brady Stoll, Trieu Mai
The Resource Planning Model (RPM) is a capacity expansion model designed for regional power systems and high levels of renewable generation. Recent extensions capture value-stacking for storage technologies, including batteries and concentrating solar power with storage. After estimating per-unit capacity value and curtailment reduction potential, RPM co-optimizes investment decisions and reduced-form dispatch, accounting for planning reserves; energy value, including arbitrage and curtailment reduction; and three types of operating reserves. Multiple technology cost scenarios are analyzed to determine level of deployment in the Western Interconnection under various conditions.

3 - Optimizing Storage Operations In Transmission-constrained Networks For Medium And Long-term Operation
Diego Alejandro Tejada Arango, Universidad Pontificia Comillas, IIT, Madrid, Spain, Diego.Tejada@iit.comillas.edu
Sonja Wogrin, Erfraim Centeno
The main objective is to present a new approach to model the storage operation in the context of Medium- and Long-Term Operational Planning (MLTOP). This approach is based on the system-state framework but including transmission constraints. A DC power flow approach is used to represent the transmission network. The methodology is related to clustering techniques using information such as wind and generation node per wind. Case studies are presented in order to compare the newly proposed methodology and the hourly approach. The results indicate the computational time reduction without loss of accuracy in the solution.

4 - A Model Of Virtual Trading And The Forward Day Ahead Market Gauthier De Maere D’Aertycynce, GDF Suez, Boulevard Simon Bolivar 34, Brussels, Belgium, gauthier.demaeredaertycynce@gdfsuez.com, Yves Smeers, Andreas Ehrenmann
The day ahead market plays an ambiguous role in restructured electricity markets. It is meant to help physical transactions such as the starting of machines in the unit commitment but is also intended to be a forward market capable of transferring the vages of real time prices into forward prices. Virtual trading was introduced for that purpose. We provide a model of virtual trading and give conditions for achieving the objective. We discuss what those conditions would imply in case of important penetration of decentralised energy. We also show some numerical experiment.
1 - Switching From Oil To Gas Production – Decisions In A Field’s Tail Production Phase
Kristian Store, Norwegian University of Science and Technology, Bodø, Norway, krm@uit.no, Verena Hagspiel, Stein-Erik Fleten, Claudia Nunes

We derive an optimal decision rule with regards to making an irreversible switch from oil to gas production. Assuming that both the oil and gas prices follow a geometric Brownian motion we derive a quasi-analytical solution for the exercise threshold. We also derive the related abandonment option. When comparing the use of a static decision rule to the proposed option approach we show that the value loss can be substantial for the abandonment option. For the switching option we find that with low gas prices the value loss can be more substantial than for the abandonment option, while for high gas prices it may be optimal to switch even as oil production is still generating positive cash flows.

2 - Resilience And Investment Valuation Of A Microgrid: A Real Options Approach
Reinhard Madlener, Full Professor of Energy Economics and Management, RWTH Aachen University, E.ON Energy Research Center, FCN, Mathieustrasse 10, Aachen, Germany, RMadlener@eonerc.rwth-aachen.de, Lisa Goebbels

In this study, microgrids are discussed as a possible decentralized system approach to stabilize local power supply. Microgrids are a way to achieve a higher resilience for a whole energy supply system. We introduce and empirically apply a definition and quantification method for the resilience of a microgrid. Investment feasibility of the installation of different combinations of components is evaluated by adopting a real options approach for the optimal time to invest that takes the uncertainty about future developments into account.

3 - Real Options In Renewable Portfolio Standards
Ryuta Takashima, Tokyo University of Science, takashima@rs.tu.tus.ac.jp, Makoto Goto

In order to promote renewable energy generation, the schemes as renewable portfolio standards have been introduced in various countries. Thus the power generators make investment decisions allowing not only for uncertain demands and competitors’ strategies but also for the schemes. In this work we model an equilibrium investment strategy of generators to analyze an effect of the schemes on the investment in competitive electricity market. The market is composed of non-renewable and renewable sectors. We show how the uncertainty affects the investment timing for both generators with the scheme.

4 - Structural Empirical Analysis Of Hydropower Scheduling
Stein-Erik Fleten, Norwegian University of Science & Technology, stein-erik.fleten@iot.ntnu.no, Maren Boger, Jussi Keppo, Alois Pichler, Einar M Vestbostad

Our goal is to study how price expectations are formed in an electricity market. In the context of a single hydropower producer in the Nordic market, we expect the forward curve to have a strong influence. The alternative we allow for is a seasonal autoregressive joint inflow and spot price model that takes dry- and wet year dynamics into account. Using observed time series of generation, reservoir trajectories and technical plant data, and a structural model of optimal releases, our initial findings indicate that forward prices have influence on price expectations. An important byproduct of the proposed procedure is estimates of marginal water values.
**SB09**

**103B-MCC**

**Renewable Energy Policies**

**Sponsored: Energy, Natural Res & the Environment I Environment & Sustainability**

**Sponsored Session**

**Chair: Sandra D. Eksioglu, Clemson University, Clemson, SC, United States, sekisog@clemson.edu**

1. **Biomass Supply Contract Pricing And Environmental Policy Analysis: An Agent-based Modeling Approach**
   - Shiying Huang, Iowa State University, Ames, IA, United States, shuang1@iastate.edu, Guiping Hu

This paper proposes an agent-based simulation model to study the biomass supply contract pricing and policy making in biofuel industry. Farmers’ decision making is assumed to be profit driven and the biofuel producer’s pricing decision is represented with a linear equation with an objective to maximize profits. A case based on Iowa has been developed to analyze the interactions between stakeholders. The impact of government environmental regulations on farmers’ decision making and biomass supply has also been analyzed, and managerial insights have been derived.

2. **- On The Effectiveness Of Tax Incentives To Support Biomass Co-firing**
   - Hadi Karimi, Clemson University, hkarimi@clemson.edu, Sandra D. Eksioglu

We present models which capture the efficiency of renewable energy policies (such as, the production tax credit (PTC)) on biomass co-firing in coal-fired power plants. The efficiency measure assumed here is the sum of utilities (profits) obtained when power plants adopt biomass co-firing. The utilitarian approach identifies a PTC which maximizes this summation. We use the utilitarian solution as a basis for comparison with other PTC schemes, such as, flat tax rate and capacity based rate.

**SB10**

**103C-MCC**

**Optimal Surveillance and Control of Bio-Invasions**

**Sponsored: Energy, Natural Res & the Environment I Environment & Sustainability**

**Sponsored Session**

**Chair: Esra Buyuktathtakin, Wichita State University, 1845 N Fairmount, Wichita, KS, Wichita, KS, 67260, United States, esxa@wichita.edu**

1. **- Cooperative Management Of Invasive Species: A Dynamic Nash Bargaining Approach**
   - Robert A. Haight, USDA Forest Service Northern Research Station, St. Paul, MN, 55108, United States, rhaight@fs.fed.us

We use a Nash bargaining framework to examine scope for bargaining in invasive species problems where spread depends on the employment of costly controls. Municipalities bargain over a transfer payment that slows spread but requires an infested municipality to forgo nonmarket benefits from the host species. We find that when the uninested municipality has a relative bargaining power advantage, bargaining may attain the first-best solution. However, in many cases a short-term bargaining agreement is unlikely to succeed, which suggests a role for higher levels of government to facilitate long-term agreements even when the details are left to municipalities to negotiate.

2. **- Stochastic Programming Approaches To Surveillance And Control Planning For Emeral Ash Borer Infestations In Cities**
   - Eyyub Yusuf Kibisi, Wichita State University, eykibisi@wichita.edu, Esra Buyuktathtakin, Robert Haight

In this study, our objective is to maximize the net benefits of the ash trees on a landscape by applying surveillance to the ash population, followed by treatment or removal of trees based on the emerald ash borer (EAB) infestation level. Specifically, we propose a new multistage stochastic programming model which allows us to consider all possible scenarios for surveillance, treatment, and removal decisions over a planning horizon to control the invasion. Due to the model complexity, we use a decomposition technique to reach to optimal solutions for various initial scenarios. Results provide insights into surveillance and control policies, and provide an optimal strategy to reduce EAB infestation.
4 - Optimal Control Of Bio-invasions With Eradication Success

Benmarks And Management Of High Program Costs

Denys Yemshanov, Natural Resources Canada, Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie, ON, CANADA
deny.yemshanov@canada.ca
Robert G Haight, Frank H. Koch, Robert Venette, Kala Students, Ronald Fournier, Jean J Turgeon

We present a scenario-based model that incorporates uncertainty about the spread of an invasive pest and optimizes the deployment of survey and control measures to eradicate the outbreak. The model accounts for program aspirations and controls the level of program costs. We apply the model to allocate surveys outside the quarantine area established following the discovery of Asian longhorned beetle in Greater Toronto Area, Canada. Our approach is generalizable and helps support decisions on surveys and control of invasive pests when knowledge about a pest’s spread is uncertain.

SB11

Clusters, Routes and Flows in Network Systems

Sponsored: Optimization, Network Optimization

Chair: Foad Mahdavi Pajouh, University of Massachusetts Boston, 100 Morrissey Boulevard, Boston, MA, 02125, United States, foad.mahdavi@umb.edu

1 - Extreme-point Search Heuristics For Generalized Interval-flow Network Problems

Angelika Leskovskaya, Southern Methodist University, Dallas, TX, United States, aleskovs@ylei.smu.edu, Richard Barr

Generalized interval-flow networks are a new extension of the classic generalization formulation that adds a conditional lower bound constraint on the arcs. An interval-pivoting heuristic that exploits the quasi-tree-forest basis structure to explore extreme points is developed and computational testing is presented.

2 - Detecting Central Clusters In Networks

Maciej Ryzs, NRC, mwrysz@ufl.edu, Foad Mahdavi Pajouh

We propose a solution algorithm for identifying the most central clusters in graphs and examine its effectiveness when the centrality measure is defined by betweenness and the clusters represent cliques. Numerical experiments demonstrating the computational performance of the proposed method are conducted and compared with results obtained from solving an equivalent mixed integer programming representation.

3 - An Integrated Assignment Routing Network Representation For Solving The Multi Vehicle Routing Problem With Pickup And Delivery With Time Windows

Monirsh Mahmoudi, Arizona State University, Tempe, AZ, 85283, United States, mmahmoudi@asu.edu, Chen Junhua, Xuesong Zhou

Generally, in the most commonly used exact approaches for solving the MVRPPDTW, i.e. column generation and branch-and-cut, generating additional columns and cuts is an exhausting and time-consuming task. In this research, we intend to reach optimality for local clusters derived from a reasonably large set of passengers on real world transportation networks. In our proposed multi-vehicle state-space-time network, in order to keep only the non-dominated paths, we introduce the assignment-based hyper paths which embed passengers’ cumulative service states. In addition, by the aid of our passengers’ cumulative service patterns, we are able to take control of the symmetry issue.
1 - Solving Standard Quadratic Programming By Cutting Planes
Andrea T. Lodi, École Polytechnique de Montréal, andrea.lodi@polyml.ca

Standard quadratic programs are non-convex quadratic programs with the only constraint that variables must belong to a simplex. If a famous result of Motzkin and Straus, those problems are connected to the clique number of a graph. We propose cutting planes to obtain strong bounds: our cuts are derived in the context of Spatial Branch & Bound, where linearization variables represent products. Their validity is based on Motzkin-Straus result. We study the relation between these cuts and the ones obtained by the first RLT level. We present extensive computational results using the cuts in the context of the Spatial Branch & Bound implemented by the commercial solver CPLEX.

2 - Some Cut-generating Functions For Second-order Conic Sets
Asteroidel Santina, Georgia Institute of Technology, Atlanta, GA, 30308, United States, asteroidelmtm@gmail.com
Sanatun Subhas Dey

In this paper, we study generating functions for conic sets. Our first main result shows that if the conic set is bounded, then cut generating functions for integer linear programs can easily be adapted to give the integer hull of the conic integer program. Then we introduce a new class of cut generating functions which are non-decreasing with respect to second-order cone. We show that, under some minor technical conditions, these functions together with integer linear programming-based functions are sufficient to yield the integer hull of intersections of conic sections in R2.

3 - Polynomial Dc Decompositions And Applications
Georgina Hall, Princeton University, Princeton, NJ, United States, gh44@princeton.edu, Amir Ali Ahmadi

Difference of Convex (DC) programming is a class of optimization problems where the objective and constraints are given as the difference of convex functions. Although several important problems (e.g., in machine learning) already appear in DC form, such a decomposition is not always available. We consider this decomposition question for polynomial optimization and present some new applications, primarily to distance geometry problems.

4 - A Second-order Cone Based Approach For Solving The Trust Region Subproblem And Its Variants
Nam Ho-Nguyen, Carnegie Mellon University, Pittsburgh, PA, United States, nhnh@andrew.cmu.edu, Fatma Kilinc-Karzan

We study the trust region subproblem (TRS) of minimizing a nonconvex quadratic function over the unit ball with additional conic constraints. We follow a second-order cone based approach to derive an exact convex formulation of the TRS, and under slightly stronger conditions, give a low-complexity characterization of the convex hull of its epigraph without any additional variables. Our study highlights an explicit connection between the nonconvex TRS and smooth convex quadratic minimization, which allows for the application of cheap iterative methods to the TRS.

1 - Government Interventions In Promoting Sustainable Practices In Agriculture
Duygu Akkaya, Stanford Graduate School of Business, Stanford, CA, United States, duygug@stanford.edu, Hau Lee, Kostas Bimpikis

Sustainable practices in agriculture such as organic farming have attracted immense attention lately due to the increase in environmental and health concerns. Government support is often used to incentivize producers to convert to sustainable practices. We investigate the effectiveness of government interventions including tax, subsidy and hybrid policies in terms of their impact on sustainable practice adoption, producers’ profits, consumer welfare, and return on government spending using a setting in which producers with traditional and sustainable production options serve consumers that have a high valuation for sustainable production.

2 - Accelerating Digital Agriculture Through Automated R&D Trial Placement Into Field Zones
Qinglin Duan, Monsanto, St. Louis, MO, United States, qinglin.duan@monsanto.com, David Ciemnoczołowski

The trend towards Digital Agriculture requires increasing information on conditions within fields and corresponding decisions about product selection and management. To provide placement and management prescriptions, products must be tested across differing conditions within fields. We formulate the zone mapping problem as a 2D bin-packing model with trials of known dimensions and operational constraints. The model is integrated into Monsanto’s geospatial field platform with analytics relating climate, soil, and topography to crop performance. Optimized placement has enabled representative testing across environments and set the foundation for advancements in digital agriculture.

3 - Combining Expert Estimates With Data To Obtain Hybrid Yield Distributions
Saurabh Bansal, Penn State University, sub32@psu.edu, Genaro J Gutierrez

We discuss a Copula based approach to combine expert judgments for yield distributions with data, and illustrate its application for the seed corn business.

4 - A Mathematical Model For Farm Scale Land Management Considering Uncertainty
Qi Li, Iowa State University, qill@iastate.edu, Guiping Hu

Farmers make decisions on types of crops to plant and irrigation frequency and pattern on an annual basis. This is often done under various uncertainties, such as precipitation amount, crop prices, and soil profile. In the study, a farm level precision farmland management model based on stochastic programming is proposed. The model focuses on the uncertainties in weather condition, yield and market prices. Advanced statistical methods such as time series analysis and spatial analysis are also investigated to generate representative realizations for the uncertainties.
4 - Lockers Network: A Solution To Last Mile Delivery Problem
Guodong Lyu, National University of Singapore Business School, #BI-01, BIZ2 Building, 1 Business Link, Singapore, 117592, Singapore, guodong.lyu@u.nus.edu
Chung-Plaw Teo
Lockers (Parcel Collection Point) are convenient for parcels collection. To maximize the coverage of failed delivery by using lockers, a novel locker location model is introduced. The problem is formulated as an input. We provide the mobile flow from stations to residence blocks, and use the mobility data to locate lockers. The mobile delivery flow is calculated based on the transportation data and failed delivery data. Customers’ parcel collection behavior is estimated from locker usage data. Furthermore, lockers location data from an Express are provided to validate our model. We demonstrate that the value of using mobility data for failed delivery coverage maximization is significant.

4 - First Order Approximation Methods For Estimating Decision Covariance In Stochastic Optimization
Sriram Sankaranarayanan, Johns Hopkins University, 3400 N. Charles St, Baltimore, MD, 21218, United States, ssrankar@jhu.edu, Felipe A Feijoo, Sauleh Ahmad Siddiqui
We use first order methods to efficiently approximate the covariance matrix of the optimal solution vector. The idea is extended for the covariance of the solution to a complementarity problem by posing the complementarity problem as an unconstrained minimization problem using the Fischer Burmeister merit function. Having done this, we estimate the variability in the estimated Market equilibrium of a Natural gas model, owing to uncertainty in the parameters of the demand function.

[SB16]
Algorithms for Stochastic Programming
105A-MCC
Sponsored: Optimization, Optimization Under Uncertainty
Sponsored Session
Chair: Natasha L Boland, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30332, United States, natalia.boland@isye.gatech.edu
1 - Scenario Set Partition Dual Bounds For Multi-stage Stochastic Programming
Ilke Bakir, PhD Candidate, Georgia Institute of Technology, Atlanta, GA, 30309, United States, ilkebakir@gatech.edu
Natasha Boland, Brian Dandurand, Alan Ereva
We propose expected partition (EP) bounds, a hierarchy of bounds based on partitions of the scenario set into subsets of (nearly) equal cardinality. Additionally, using the fact that solution of group subproblems for all subsets in a single partition also yields a dual bound, we establish that the best of even a very small number of such single partition bounds is likely to be better than the corresponding EP bound. By sampling partitions of the scenario set, we obtain an algorithm that computes confidence intervals for an EP bound, while also providing exact dual bounds. The practical value of these ideas is illustrated on benchmark problems, and the approach is compared to Sample Average Approximation.

2 - AMPL Representation And Solution Of Multiple Stochastic Programming And Robust Optimization Formulations
Christian Valente, OptIRisk Systems, One Oxford Road, Uxbridge, UB9 4DA, United Kingdom, christian@optrisk-systems.com, Gautam Mitra, Christian Alex Balle, Robert Fournier
Paradigms of ‘Uncertainty Models’, namely, recourse, chance constrained, integrated chance constrained, and robust optimization models, are introduced and represented through use cases examples. Through our continued research and close collaboration with AMPL Optimization, we have now developed AMPL templates and frameworks which can describe these classes of models and connect them to respective solvers, making them readily available to industry-based analysts and to the academic research community. We also describe an E-book (in preparation) which captures the use cases that underpin our goal to make these modelling and solving capabilities widely available to the OR community.

3 - Combining Progressive Hedging And Frank-Wolfe To Solve The Lagrangian Dual Of A Multistage Stochastic Integer Program
Natasha Boland, Georgia Institute of Technology, natalia.boland@isye.gatech.edu, Jeffrey Christiansen, Brian Dandurand, Andrew Eberhard, James Luedtke, Jeffrey Linderoth, Fabrichio Oliveira
We present a new primal-dual algorithm for computing the value of the Lagrangian dual of a stochastic mixed-integer program (SMIP) formed by relaxing its nonanticipativity constraints. The algorithm relies on the progressive hedging method, but unlike previous progressive hedging approaches for SMIP, it converges to the optimal Lagrangian dual value. The key improvement is an inner loop of optimized linearization steps, as in the classical Frank-Wolfe method. Numerical results show that the new algorithm outperforms the standard progressive hedging approach.

4 - Invited: High Performance Computing
110A-MCC
HPC in Optimization 1
Invited: High Performance Computing
Invited Session
Chair: Kilbaek Kim, Argonne National Laboratory, 9700 South Cass Avenue, Building 240, Lemont, IL, 60439, United States, kimk@anl.gov
Co-Chair: Geoffrey Malcolm Oxberry, Lawrence Livermore National Laboratory, P. O. Box 808, Livermore, CA, 94551, United States, goxberry@gmail.com
1 - Asynchronous Parallelization Of Decomposition Methods
Kilbaek Kim, Argonne National Laboratory, kimk@anl.gov
We present an approximate and incremental bundle method based on dual decomposition for stochastic mixed-integer programming (SMIP), where the Lagrangian dual function is incrementally updated by approximate subgradients as well as exact ones. We implemented the method in an open source parallel solver D3P, taking advantage of asynchronous communications on HPC cluster using MPI library. We present our computational results on several SMIP problem instances.
2 - Parallel Branch And Bound Revisited
Lluis-Miquel Munguia, Georgia Institute of Technology, lluis.munguia@gatech.edu, Geoffrey Malcolm Oxberry, Deepak Rajan
Branch and Bound (BB&B) is a widely used algorithm for solving Mixed Integer Programs (MIPs). Despite its straightforward parallelization, current BB&B implementations have shown to scale incoherently. In this talk, we propose a new decentralized and lightweight implementation of parallel Branch & Bound for PIPS-SBB, a distributed-memory parallel stochastic MIP solver. In this work, we exploit parallelism at two levels of the optimization process with the objective of increasing parallel efficiency. We present computational results to evaluate the effectiveness of our approach.

3 - Scalable Strategies Exploited by Parallel Nonlinear Solver PIPS-NLP
Nai-Yuan Chiang, United Technology Research Center, chiangn@urtc.utc.com
We present PIPS-NLP, a software library for the solution of large-scale structured nonconvex optimization problems on high-performance computers. We focus on linear algebra parallelization strategies and discuss how such strategies influence the choice of algorithmic frameworks, while all the proposed approaches guarantee global convergence. Small examples using parallel solver PIPS-NLP via AMPL or StructureJuMP are given, to illustrate how to exploit the problem structures. Numerical studies from large-scale security-constrained ACOPF and line-pack dispatch in natural gas networks also demonstrate the robustness and efficiency of PIPS-NLP.

SB21
106B-MCC
Bilevel Programming: Methodology and Applications
Sponsored: Computing
Sponsored Session
Chair: Juan S. Borrero, University of Pittsburgh, 1012 Benedum Hall, Pittsburgh, PA, 15261, United States, jsb81@pitt.edu
Co-Chair: M. Hosein Zare, University of Pittsburgh, 1012 Benedum Hall, Pittsburgh, PA, 15260, United States, moz3@pitt.edu
1 - A Sampling-based Exact Approach For The Bilevel Mixed Integer Programming Problem
Leonardo Lozano, Clemson University, llozano@g.clemson.edu, Cole Smith
We examine bilevel mixed integer programs which are difficult to solve because the leader feasible region is defined in part by optimality conditions governing the follower variables, which are difficult to characterize because of the nonconvexity of the follower problem. We propose an exact finite algorithm for these problems based on an adaptive sampling scheme, and demonstrate how this algorithm can be tailored to accommodate either optimistic or pessimistic assumptions on the follower behavior. Computational experiments demonstrate that our approach outperforms existing algorithms that are tailored to problems in which all functions are assumed to be linear.

2 - On Bilevel Programs With Inexact Follower
M. Hosein Zare, University of Pittsburgh, moz3@pitt.edu
We consider classes of bilevel programs, where the upper-level decision-maker (i.e., the leader) needs to consider the uncertain behavior of the lower-level decision-maker (i.e., the follower). We derive some theoretical properties of the proposed models, and illustrate our results with numerical illustrations.

3 - Reliable Vehicle Sharing Program Network Design
Ran Zhang, University of South Florida, ranzhang@mail.usf.edu, Bo Zeng
This talk develops a bi-level optimization model to achieve a reliable vehicle sharing program network design. A set of numerical study will be presented to demonstrate our design model.

4 - Sequential Max-min Bilevel Programming With Incomplete Information And Learning
Juan S. Borrero, University of Pittsburgh, jsb81@pitt.edu, Oleg A Prokopyev, Denis R. Saure
We consider an adversarial bilevel problem where the leader and follower interact repeatedly. At each period the leader implements an upper-level solution after which the follower reacts by solving the lower-level problem. The leader has incomplete information about the variables, constraints, and data of the follower's problem, and learns about them from observing his reaction to her actions. Given that the leader's objective is to maximize the costs the follower incurs across all periods, we study a set of greedy and robust decision policies that are able to find an optimal solution to the full-information bilevel problem in finite time periods, and moreover, are worst-case optimal.

SB20
106C-MCC
Methods and Applications of Network Sampling
Invited: Tutorial
Invited Session
Chair: Mohammad Al Hasan, Indiana University/Purdue University, Department of Computer Science, Indianapolis, IN, 46202, United States, alhasan@iupui.edu
Network data appears in various domains, including social, communication, and information sciences. Analysis of such data is crucial for making inferences and predictions about these networks, and moreover, for understanding the different processes that drive their evolution. However, a major bottleneck to perform such an analysis is the massive size of real-life networks, which makes modeling and analyzing these networks simply infeasible. Further, many networks, specifically, those that belong to social and communication domains are not visible to the public due to privacy concerns, and other networks, such as the Web, are only accessible via crawling. Therefore, to overcome the above challenges, researchers use network sampling overwhelmingly as a key statistical approach to select a sub-population of interest that can be studied thoroughly. In this tutorial, we aim to cover a diverse collection of methodologies and applications of network sampling. We will base the discussion of network sampling in terms of population of interest (vertices, edges, motifs), and sampling methodologies (such as Metropolis-Hastings, random walk, and importance sampling). We will also present a number of applications of these methods.

SB21
107A-MCC
Applications in Healthcare
Sponsored: Health Applications
Sponsored Session
Chair: Sarah Kadish, Dana-Farber Cancer Institute, 450 Brookline Ave, Boston, MA, 02215, United States, sjkadish@partners.org
1 - Determining The Optimal Schedule For Premixing Chemotherapy Drugs
Donald Richardson, University of Michigan, 2733 1OE Building, 1205 Beal, Ann Arbor, MI, 48109-2117, United States, donalric@umich.edu, Amy Cohn
In collaboration with the University of Michigan Comprehensive Cancer Center, we have developed an optimization-based approach to improve make-ahead policies for chemotherapy drugs for infusion patients. We first present our optimization model. Then we present our proposed user interface to aid our collaborators in interpreting the solutions.

2 - Operations Research Applications At A Comprehensive Cancer Center
Victoria Jordan, University of Texas MD, vsjordan@mdanderson.org
Industrial and systems engineering is an emerging field in healthcare. The University of Texas MD Anderson Cancer Center has Healthcare Systems Engineers working in the Office of Performance Improvement. This session will provide a high level overview of OR applications to improve patient flow and the patient experience, reduce costs, and improve safety. Also presented will be more clinical applications to improve delivery of care and the care itself.

3 - Factors That Predict Discharge Disposition At Admission For Veterans
Nicholas Ballester, Wright State University, 207 Russ Center, 3640 Col Glenn Hwy, Dayton, OH, 45435, United States, ballester.2@wright.edu, Pratik J Parikh
Discharge delays reduce inpatient quality of care and reverberate back through the health care system, tying up valuable resources needed by incoming patients. Discharge disposition, in particular, has a significant effect as different dispositions require vastly different procedures for insurance and transportation coordination. We have developed model to predict discharge disposition upon admission for veterans admitted to a general internal medicine unit. This model considers patient factors known at admission such as demographics, medical history, and living status. Preliminary findings from a trial implementation will also be discussed.
4 - Applications Of Real Time Locating Systems In Ambulatory Oncology
Sarah Kadish, Dana-Farber Cancer Institute, Boston, MA, United States, sarah.kadish@dfci.harvard.edu, Constance Barysawska, Ryan Leib, Avishai Mandelbaum, Petar Momcilocov, Arik Senderovich, Nikolaos Trichakis, Craig Bunnell
Real Time Locating Systems (RTLS) implementations have increased in the healthcare industry despite few studies supporting efficacy. In addition, the potential applications of RTLS as a tool for improving hospital operations management remains relatively unexplored. We sought to measure the improvement in quality of care and patient experience immediately after RTLS implementation. Furthermore, we explored the utility of RTLS in providing unbiased data to improve accuracy for chemotherapy scheduling. Finally, we demonstrate the ability for RTLS to assess impacts of large organizational changes such as the implementation of an Electronic Health Record on patient time in clinic.

■ SB22
107B-MCC
Panel: Challenges of Implementing OR in the Healthcare Industry
Invited: ORInformed Healthcare Policies
Invited Session
Moderator: Michael W Carter, University of Toronto, Toronto, ON, Canada, carter@mie.utoronto.ca
Implementing OR/MS in healthcare poses major challenges to practical researchers. The problems and the corresponding solutions are similar to those in industry and other service industries. So why is it so difficult? This panel brings together a group of researchers who have been successful in overcoming the challenges.
1 - The Challenge of Lean; Working With Health Professionals Who Think O.R. Means Operating Room
Panelist: Martin I. Puterman, University of British Columbia, martin.puterman@sauder.ubc.ca
2 - Developing Good Collaborations And Avoiding Bad Ones
Panelist: Brian T Denton, University Of Michigan, btdenton@umich.edu
3 - The Good, The Bad, And The Ugly Of Publishing Operations Research Work In Medical Journals
Panelist: Sheldon H Jacobson, University Of Illinois, shj@illinois.edu
4 - Struggles In Getting Data For Healthcare Research
Panelist: Amy Cohn, University Of Michigan, amycohn@umich.edu
5 - Moving The Needle In Public Health Decision Making
Panelist: Margaret L. Brandeau, Stanford University, brandeau@stanford.edu

■ SB23
108-MCC
Joint Session MIF/HAS: Modeling and Optimization for Advanced Stage Liver and Kidney Disease Patients
Sponsored: Health Applications
Sponsored Session
Chair: Anahita Khojandi, University of Tennessee Knoxville, 521 John D. Tickel Building, 351 Neyland Drive, Knoxville, TN, 37996, United States, khojandi@utk.edu
Co-Chair: Murat Kurt, Merck Research Labs, 351 N. Summertown Pike, North Wales, PA, 19454, United States, murat.kurt7@gmail.com

1 - Optimal Liver Cancer Surveillance In Hepatitis C Infected Population
Qiushi Chen, Georgia Institute of Technology, Atlanta, GA, United States, qchen6812@gatech.edu, Turjay Ayer, Jagpreet Chhatwal
Liver cancer is the fastest growing cause of cancer deaths in the United States. Although early diagnosis through can improve survival, the optimal surveillance policy remains unknown. We develop a mixed-integer programming-based framework to identify the most cost-effective surveillance policy. Our framework allows a formulation of practical policy structures. Our numerical results find that (1) the optimal surveillance interval should depend on patient's stage of hepatitis C and age, and (2) expanding surveillance to earlier stage of hepatitis C improves the cost-effectiveness of HCC surveillance.

■ SB24
109-MCC
Ecology of Innovation: Sources of Knowledge and Complements
Invited: Strategy Science
Invited Session
Chair: Daniel Levinthal, University of Pennsylvania, Wharton School, Philadelphia, PA, 189, United States, levinthal@wharton.upenn.edu
1 - Intra-firm Spillovers? The Stock And Flow Effects Of Collocation
Evan Rawley, Columbia Business School, New York, NY, United States, erwaley@columbia.edu, Robert Seamans
We study how intra-firm colocation—geographic clustering of establishments owned by the same parent company—influences performance, decomposing colocation effects to learn about the mechanisms behind intra-firm agglomeration. Using Census micro data on the population of U.S. hotels and restaurants 1977-2007, we find that doubling the intensity of intra-firm colocation is associated with a productivity increase of about 2%. Further analyses reveal that a significant component of the productivity gains persist after an establishment ceases to be collocated, suggesting that proximity to other establishments owned by the same parent firm facilitates the transfer of knowledge.
INFORMS Nashville – 2016

2 - Waste Reduction Strategies: Less Is More
Luca Berchicci, Erasmus University, Rotterdam School of Business, Rotterdam, Netherlands, Berchicci@erasmus.edu
Nilanjana Dutt, Will G Mitchell
Manufacturing firms seek to develop and implement techniques to improve production efficiency by obtaining information from various knowledge sources. Examining a greater number of knowledge sources should help firms find a viable solution to improve production efficiency, but it also raises the costs of collecting and using new information, which may ultimately hinder performance. Due to these tradeoffs, a key initial choice is how many knowledge sources to search. Based on U.S. manufacturing facilities that seek to improve production efficiency by reducing their annual toxic waste output, our results indicate that examining one knowledge source is the best approach.

3 - Reload And Relaunch: Strategic Governance Of Platform Ecosystems
Joost Rietveld, Erasmus University, Burgemeester Oudlaan 50, Mandevelle (T) Building, Room 7-41, Rotterdam, 3072AP, Netherlands, rietveld@rsm.nl, Melissa A Schilling, Christiano Bellavitis
Platforms have a number of levers for managing their ecosystems. However, they must use them carefully: how and by whom value is captured is shaped by the dynamics between complementors and the platform itself. We develop a framework of value creation and value capture yielding implications for whether and when platforms should selectively promote complements. We analyze data from seventh generation video games, assessing both how games are selected for promotion, and how promotion affects sales. Platform owners do not promote best in class complements; they invest in underappreciated ones where there is more marginal value to be unlocked, and with whom the platform has greater bargaining power.

4 - Value-Based Outsourcing
Joaquín Poblete, Pontificia Universidad Catolica de Chile, s.s., Chile, joaco.poblete@gmail.com, Jorge Martabiti
Using a value-based approach we analyze make-or-buy choices in settings in which value created by activities depend on the set of activities being performed. We show that when activities are complements, optimal make or buy choices tend to follow a common pattern, i.e., they are all insured or outsourced, whereas firms tend to choose different governance modes when activities are substitutes. We also found that coordination advantages of insourcing are more important when activities are complements, while cost advantages of outsourcing are more important when activities are substitutes.

SB25
110A-MCC
Improving Efficiency of Supply Chains through Scheduling
Invited: Project Management and Scheduling
Invited Session
Chair: Chelliah Srisankaradajah, Texas A&M University, College Station, TX, United States, chelliah@mays.tamu.edu
Co-Chair: Yunxia Peter Zhu, Assistant Professor, Rider University, Sweigart Hall 358, 2083 Lawrenceville Road, Lawrenceville, NJ, 08648, United States, yzhu@rider.edu
1 - Provider Selection Framework For Bundled Payments In Healthcare
Seokjun Youn, Texas A&M University, College Station, TX, United States, syoun@mays.tamu.edu, Anupam Agrawal, Subodha Kumar, Chelliah Srisankaradajah
Well-designed incentive system can lead to the successful operation of bundled payment program. Focusing on provider selection and evaluation problems, we develop a framework that aims to select better providers than existing method while balancing cost reduction, quality of care, and efficiency measures.

2 - A Framework For Analyzing The U. S. Coin Supply Chain
Yiwu Huang, Visiting Assistant Professor, The Pennsylvania State University, State College, PA, United States, yihu201@psu.edu
This is the first study that addresses operational issues within a Coin Supply Chain (CSC) and presents a framework, an optimal/near-optimal operating policy, and a robust planning system for the Federal Reserve System and Depository Institutions to increase their efficiency and effectiveness of coin ordering, producing, packaging, distribution, and inventory management by treating the U.S. CSC as a closed-loop supply chain from both supply and demand-side perspectives.

SB26
110B-MCC
Procurement Auctions
Invited: Auctions
Invited Session
Chair: Martin Bichler, Technische Universitat Munchen, Munich, Germany, bichler@in.tum.de
1 - Trust In Procurement Interactions
Nicolas Fugger, ZEW Mannheim, L7, 1, Mannheim, 68161, Germany, nicolas.fugger@zew.de, Elena Katok
We investigate the observation that auctions in procurement can be detrimental to the buyer-seller relationship. Poor relationship can result in a decrease in trust by the buyer during the sourcing and an increase in opportunistic behavior by the supplier after the sourcing. We consider a setting in which the winning supplier decides on the level of costly quality to provide to the buyer, and compare a standard reverse auction and a buyer-determined reverse auction in the laboratory. We find that buyer-determined auctions result in higher prices but also improve cooperation between the buyer and the selected supplier.

2 - An Optimal Procurement Mechanism With Post-auction Cost-reduction Investigations
Qi (George) Chen, University of Michigan, Ann Arbor, MI, United States, georgege@gemich.edu, Damien Bell, Izak Duenyas
This paper studies the optimal mechanism design problem of a buyer who needs to procure from a pool of qualified suppliers in a setting where she can choose to investigate the suppliers to identify cost-reduction opportunities which reduce their costs after the bids are collected, and then awards the contract. We fully characterize the optimal mechanisms and show that for symmetric suppliers, our mechanisms create ex ante win-win situations for everyone compared to the optimal mechanism without investigations. The win-win situation may break down when suppliers are sufficiently asymmetric, but no supplier has the incentive to unilaterally block investigation.

3 - Linear Pricing In Large-scale Combinatorial Exchanges
Vladimir Fux, Technical University of Munich, vladimir.fux@tum.de, Martin Bichler
Linear and anonymous competitive equilibrium prices are desirable in multi-object auctions, but unfortunately such prices typically do not exist in combinatorial exchanges. We discuss the market design of a large-scale combinatorial exchange for fishery access rights where linear and anonymous prices is a requirement and minor efficiency loss can be tolerated. We analyze the trade-offs of different payment rules relevant for an auction designer, in particular with respect to the welfare loss they incur. Via analytical models and numerical simulations, we show that these losses can be up to 100% in worst-case scenarios, but that these losses are small on average in larger markets.

4 - Equilibrium Bidding Strategies In Ex-post Split-award Auctions With Diseconomies Of Scale
Gian-Marco Kokott, Technical University of Munich, Munich, Germany, gian.marco@dss.in.tum.de, Martin Bichler, Per Paulsen
Ex-post split-award auctions are a wide-spread form of combinatorial procurement auctions. We focus on markets with diseconomies of scale, which is practically relevant and strategically challenging, since bidders have to coordinate on the efficient outcome. We show that the first-price sealed-bid and the Dutch ex-post split-award auction are not strategically equivalent. The first-price sealed-bid format exhibits a coordination problem for bidders, whereas the Dutch has a unique and efficient equilibrium. We also analyze a combination of both formats and compare all three auctions with respect to efficiency and costs. In lab experiments, we find support for the theoretical results.
1 - False Diagnosis And Overtreatment In Services
Senthil Veeraraghavan, University of Pennsylvania, senthilv@wharton.upenn.edu

In many services, consumers must rely on experts to identify the type of service they need. In such service, diagnosis is a crucial step in which the expert identifies the problem and provides the corresponding treatment. The information asymmetry leads to inefficiencies in the form of overtreatment. Overtreatments are expensive but also require more service capacity and time, and thus result in longer delays and higher waiting costs for services. However, we find that such delays act as a natural “fractur cost” and mitigates expert cheating and induce honesty. Experts high capacity utilization are less prone to over-treat.

2 - Conspicuous By Its Absence: Diagnostic Expert Testing Under Uncertainty
Tinglong Dai, Assistant Professor, Johns Hopkins University, 100 International Drive, Baltimore, MD, 21202, United States, dai@jhu.edu, Shubhranshu Singh

Diagnostic experts, such as medical doctors, are crucial for evaluating the state of the world. All diagnostic experts are not equally competent, and even the best experts are imperfect. We model the decision-making process of a diagnostic expert, who is altruistic but concerned about reputation. Our paper presents interesting insights about the expert’s test-ordering behavior primarily driven by reputation concerns.

3 - Incentizing Less-than-Fully-Qualified Providers For Early Diagnosis Of Tuberculosis In India
Sarang Deo, Indian School of Business, sarang.deo@isb.edu
Milind Sohoni, Neha Jha

A major driver of TB epidemic in India is delay in diagnosis by less-than-fully-qualified providers (LTQPs), who are typically the first point of contact for patients. This work is motivated by pilots funded by international donors to provide monetary incentives to LTQPs to induce earlier referral and diagnosis. Using a game-theoretic model, we show that the optimal structure of the incentive referral contract (whether to pay for all referrals or only for confirmed referrals) depends on the quality of diagnosis of the provider. We calibrate our model results using realistic parameter estimates obtained from primary and secondary data sources.

4 - Medical Guideline Making When Litigation Is A Concern: The Role Of Ubiquitous Health Information
Mehmet U Ayvaci, University of Texas-Dallas,
800 W. Campbell Rd. SM33, Richardson, TX, 75080, United States, Mehmet.Ayvaci@utdallas.edu, Yeong In Kim, Srinivasan Raghunathan, Turgay Ayer

We examine the optimal formulation of guidelines in a generic health screening with consideration for the physician’s increased liability risk under ubiquitous health information and information technologies. We find that under the litigation concern, the social planner strategically provides imprecise guidelines with vague recommendations regarding which patients should undergo the test while providing precise guidelines regarding the physician’s decisions based on test results. Strategic vagueness in guidelines balances the trade-off between the reduction of defensive medicine and supply of the health service.

■ SB28
2018-MCC
MSOM Student Paper Competition Finalists – II
Sponsored: Manufacturing & Service Oper Mgmt
Sponsored Session
Chair: Sameer Hasija, Insead, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, sameer.hasija@insead.edu
Co-Chair: Tolga Tetzcan, London Business School, Regent’s Park, London, NW1 4SA, United Kingdom, t.tetzcan@london.edu
Co-Chair: Nicos Savva, London Business School, Regent’s Park, London, NW1 4SA, United Kingdom, n.savva@london.edu

2 - Economies of Scale and Scope in Hospitals
Michael Freeman, University of Cambridge, Cambridge, United Kingdom. mef35@cam.ac.uk

Abstract to come

3 - Online Decision-Making with High-Dimensional Covariates
Hamsa Bastani, Stanford University, Stanford, CA, bayati@stanford.edu

Big data has enabled decision-makers to tailor decisions at the individual-level in a variety of domains such as personalized medicine and online advertising. This involves learning a model of decision rewards conditional on individual-specific covariates. In many practical settings, these covariates are high-dimensional, typically only a small subset of the observed features are predictive of a decision’s success. We formulate this problem as a multi-armed bandit with high-dimensional covariates, and present a new efficient bandit algorithm based on the LASSO estimator. Our regret analysis establishes that our algorithm achieves near-optimal performance in comparison to an oracle that knows all the problem parameters. The key step in our analysis is proving a new oracle inequality that guarantees the convergence of the LASSO estimator despite the non-i.i.d. data induced by the bandit policy. Furthermore, we illustrate the practical relevance of our algorithm by evaluating it on a real-world clinical problem of warfarin dosing.

4 - Real-time Optimization of Personalized Assortments
Negin Golrezaei, USC Marshall School of Business, Los Angeles, CA, golrezae@usc.edu

Abstract to come

■ SB29
202A-MCC
Innovations in the Operations-Marketing Interface
Sponsored: Manufacturing & Service Oper Mgmt
Sponsored Session
Chair: Jose A Guajardo, University of California-Berkeley, Berkeley, CA, United States, jguajardo@berkeley.edu

1 - Does Online Learning Work In Retail?
Serguei Netessine, INSEAD, serguei.netessine@insead.edu
Marshall L Fisher, Santiago Gallino

We partnered with Experticity, a firm that provides online training modules for retail Store Associates, and Dillard’s, a leading department store chain whose more than 50,000 Store Associates had access to the Experticity product training modules. We found that as Store Associates engaged in training over time, their sales rate increased by 1.8 percent for every module taken. We also found that willingness to engage in voluntary training was an indicator of raw talent; those Store Associates who engaged in training were 20 percent more productive prior to any training, and 46 percent more productive after training, than those who took no training.

2 - Business Models In The Sharing Economy: Manufacturing Durable Goods In The Presence Of Peer-to-peer Rental Markets
Zhe Zhang, Carnegie Mellon University, 4800 Forbes Avenue, Pittsburgh, PA, 15213, United States, zhezhang@cmu.edu
Vibhanshu Abhishek, Jose A Guajardo

Business models focusing on providing access to assets rather than on transferring ownership of goods have become an important recent industry trend. Motivated by this trend, this research analyzes the interaction between a manufacturer of durable goods and a peer-to-peer marketplace, characterizing market outcomes under alternative market structures. 
3 - When The Bank Comes To You: Branch Network And Customer Multi-channel Banking Behavior
Vibhanshu Ablishek, CMU, vibes@andrew.cmu.edu
Belwei Li, Dan Geng
Customers today increasingly interact with their banks using digital channels, lifting the necessity for banks to rethink the distribution of physical branches and customer behavior in a multi-channel environment. Using approximately 1.2M anonymized individual-level data from a large commercial bank in US over 6 years, our paper investigates the traditional channel - bank branches - and the impact of its network change (branch opening or closure) on customer multi-channel preferences and other banking behavior.

■ SB30
202B-MCC
Social and Environmental Considerations in Retailing
Sponsored: Manufacturing & Service Oper Mgmt
Sponsored Session
Chair: Xiajun Am Pan, University of Florida, Gainesville, FL, United States, am.pan@warrington.ufl.edu
Co-Chair: Donorthee Honhon, University of Texas at Dallas, Richardson, TX, United States, dorothee.honhon@utdallas.edu
1 - Social Labeling: Leadboard Or Threshold Policy?
Xiajun Am Pan, University of Florida, am.pan@warrington.ufl.edu, Quan Zhong, Asoo Vakharia
Labeling, as a way to certify corporate social performance, is widely adopted in practice. However, little attention has been paid to the endogenous choice of a labeling policy. Should the label be awarded to manufacturers based on absolute performance (threshold policy) or relative performance (leadboard policy)? We address this question through a mechanism design perspective. Our findings are that an impact-motivated third-party organization should confer the label on the best manufacturer provided it meets a threshold. On the other hand, a profit-maximizing retailer should select a certain number of manufacturers who outperform the other in the set without setting a threshold.

2 - The Impact Of Supply Chain Contracts On Inventory Shrinkage: Inference From Packaged Food Products
Min Choi, Arizona State University, mchoi9@asu.edu
Elliott Rabinovich, Timothy Richards
This paper examines the effect of supply chain contracts on inventory shrinkage using a data set from a packaged bakery manufacturer in the U.S. We find that the amount of inventory shrinkage tends to be higher under scan-based (SBT) contracts compared to vendor-managed inventory (VMI) contracts when measured in terms of both explicit and non-explicit shrink. We attribute this effect to retailers' moral hazard under SBT contracts. Our findings highlight a potential loss in efficiency in food supply chains reflected in higher inventory shrinkage under SBT contracts. Our study calls for a careful reexamination of emerging contractual forms in light of their potential impact on inventory waste.

3 - Online Grocery Retail: Revenue Models And Environmental Impact
Elena Belavina, The University of Chicago, ?, chicago, IL, 60616, United States, elena.belavina@chicagobooth.edu
We compare the financial and environmental performance of two revenue models for the online retailing of groceries: the per-order and the subscription model. We find that subscription incentivizes smaller and more frequent orders, which reduces food waste and results in higher retailer revenues. These advantages are countered by greater delivery-related travel and expenses. Subscription leads to lower food waste-related emissions but to higher delivery-related emissions. Geographic and demographic data indicate that the subscription model is almost always environmentally preferable because lower food waste emissions dominate higher delivery emissions.

4 - Incorporating Consumer Attitudes To Minimise Waste And Out-of-stock Situations In Food Retail
Emel Aktas, Senior Lecturer, Cranfield University, Cranfield, United Kingdom, emel.aktas@cranfield.ac.uk
Soorooj Saghir, Zeynep Topaloglu, Tamara van ‘t Wout, Zakiunna Oledinmi, Zahir Irani, Amir Sharif, A. K. Sanmsul Huda
Inventory management of perishable food products is not straightforward since the demand volatility for these products is usually high. Consumer behavior is influenced by many factors, particularly the product availability and the expiry date of the product. Product inventory is to meet the customer demand and due to short shelf life it cannot act as a buffer against demand fluctuations. We study the optimal inventory policies to minimize food waste and stock-out situations based on the expiry dates and consumer preferences. Implications for the environment follow from reduced food waste.

■ SB31
202C-MCC
Empirical Research in Supply Networks
Sponsored: Manufacturing & Service Oper Mgmt, FORM
Sponsored Session
Chair: Vishal Gaur, Cornell University, 321 Sage Hall, Ithaca, NY, 14850, United States, vg77@cornell.edu
Co-Chair: Yasin Alan, Vanderbilt University - Owen Graduate School of Management, 401 21st Avenue South, Nashville, TN, 37203, United States, yasin.alan@owen.vanderbilt.edu
1 - Evolution Of Supply Networks
Nikolay Osadchyi, Emory University, nikolay.osadchyi@emory.edu, Vishal Gaur, Maximilliano Udenio
Using a large panel of firm-level buyer-supplier relationships, we study evolution of supply networks over time.

2 - Inaccurate Inaccurations And Supply Chain Disruptions
William Schmidt, Cornell University, wschmidt@cornell.edu, Mili Mehta
We use supply chain and production data from a division of a Fortune 500 multinational manufacturer to examine the operational performance impact of inaccurate supply chain disruption duration estimates. We find that such inaccuracies can materially increase the cost of the disruption. This effect (1) persists after controlling for the actual length of a disruption and (2) can occur regardless of whether the disruption duration is initially over- or under-estimated. We identify several factors that contribute to the impact of inaccurate estimates.

3 - Using Delay Forecasting To Correct Airline Turn Time Misallocation
Yannis Stamatopoulos, McCombs School of Business, Austin, TX, United States, yannis.stamatos@mccombs.utexas.edu, Jun Li, Carlos Carvalho
Achieving good on time performance (OTP) is a challenging task for airlines. At the center of this challenge is the tradeoff between utilization and resilience. For example, longer turn times increase network resilience by reducing propagated flight delay, but at the same time keep airplanes away from flying and generating revenues. In this work, using proprietary data from a large US airline, we examine how an airline can manage turn times smartly from a network perspective. We find evidence for a potential significant improvement in OTP without hurting revenues.

4 - Shock Propagation In Supply Chain Networks
Jing Wu, University of Chicago, jwu7@chicagobooth.edu
Firms do not exist in isolation but are linked to each other through supply chain relationships. How do firm-level information transmits in the supply chain networks empirically? In this talk, we show both average shock propagation as reflected in stock returns, and extreme shock propagation as reflected in credit default swaps. The results are supported by supply chain theory and also have practical value in investment.

■ SB32
202A-MCC
Scheduling II
Contributed Session
Chair: Mauricio G. C. Resende, Amazon.com, Inc., 2483 Birch Ave N, #512, Seattle, WA, 98109, United States, resende@amazon.com
1 - Online Lazy Bureaucrat Scheduling With A Machine Deadline
Ling Gai, Shanghai University, Shanghai, 201444, China, lgai@shu.edu.cn
The lazy bureaucrat scheduling problem was first introduced by Arkin et al. in 1999. Since then, a number of variants have been addressed. However, very little is known on the online version. In this note we focus on the scenario of online scheduling, in which the jobs arrive over time. The bureaucrat (machine) has a working time interval. Namely, he has a deadline by which all scheduled jobs must be completed. A decision is only based on released jobs without any information on the future. We consider two objective functions of [min-makespan] and [min-time-spent]. Both admit best possible online algorithms with competitive ratio of 1.618.
2 - A Model For Scheduling Practical Lessons And Selecting Teaching Assistants At Universities
Cristian D Palma, Assistant Professor, Universidad del Desarrollo, Avda. Sanhuela 1750, Pedro de Valdivia, Concepcion, 4040418, Chile, cristianpalma@ingenieros.udd.cl, Pablo Gonzalez, Pamela Riffo
Most of the courses at universities includes practical sessions taught by teaching assistants (TAs), which are also students. These sessions are usually scheduled as part of the courses, so the day and time when they are taught are known when students register their courses. Since TAs have to attend their own courses, they apply for teaching only in courses that match their own schedules rather than courses they are good at. We propose a framework in which practical sessions are scheduled after course registration, and show a model that schedules practical sessions and simultaneously selects the TAs for each course. We discuss the advantages of using this approach and present results of its application.

3 - Scheduling Virtual Network Embeddings
Frank Fischer, University of Kassel, Heinrich-Plett-Str. 40, Kassel, 34132, Germany, frank.fischer@mathematik.uni-kassel.de, Andreas Bley
The virtual network embedding problem aims to embed several virtual network (VN) requests, each consisting of several node and connection services that require certain CPU, memory and bandwidth resources, into a shared physical substrate network in such a way that the resources available in the substrate network are not exceeded.

We consider the dynamic version of this problem, where VN requests have time windows and durations specifying when and how long they should be embedded. We discuss several mixed integer and constraint programming approaches for this combined embedding and scheduling problem. Our computational results show that a combination of both techniques performs best.

4 - An Improved Genetic Algorithm For Job-shop Scheduling
Mauricio G. C. Resende, Principal Research Scientist, Amazon.com, Inc., 333 Boren Ave N, Seattle, WA, 98109, United States, resende@amazon.com, Jose F. Goncalves
We present a local search, based on a new neighborhood for the job-shop scheduling problem, and its application within a biased random-key genetic algorithm. Schedules are constructed by decoding the chromosome supplied by the genetic algorithm with a procedure that generates active schedules. After an initial schedule is obtained, a local search heuristic, based on an extension of the 1956 graphical method of Akers, is applied to improve the solution. The new heuristic is tested on a set of 205 standard instances taken from the job-shop scheduling literature and compared with results obtained by other approaches. The new algorithm improved the best-known solution values for 57 instances.

2 - Cloud Based Collaborative Information Sharing In Supply Chains
Cigdem Kochan, Assistant Professor, Ohio Northern University, Dicke College of Business Administration, 525 S Main St, Ada, OH, 45810, United States, cigdem.kochan@gmail.com, David R. Nowicki
This research develops system dynamics models to simulate the effect of cloud based collaborative information sharing in a supply chain. The results suggest that the use of the cloud based information sharing in supply chain reduces inventory levels, reduces actual lead time through demand and inventory visibility, and reduces delivery delays while increasing overall performance of the supply chain.

3 - A Fully Exploratory Reinforcement Learning Algorithm For Solving Semi-Markov Decision Processes
Angelo Encarna, Research Assistant, Missouri University of Science & Technology, Rolla, MO, 65409, United States, amet3b@muast.edu, Abhijit Gosavi, Wulijat Gosavi
We study the development of a fully exploratory Reinforcement Learning (RL) algorithm for solving Semi-Markov Decision Processes (MDPs). Existing RL algorithms, such as R-SMART, for solving SMDPs require gradual decay of exploration. The latter adds a tuning parameter to the algorithm, and indeed its success depends on how the exploration-decay parameter is tuned. Our algorithm uses a “reflective” update that accompanies the main update, based on relative Q-learning, to estimate the average reward without decaying the exploration. Our algorithm delivers encouraging empirical behavior.

4 - A Bounded Actor Critic Algorithm For Reinforcement Learning
Ryan Lawhead, Research Assistant to Dr. Gosavi, Missouri University of Science and Technology, 223 Engineering Management Building, Rolla, MO, 65409, United States, rjlm97@muast.edu, Abhijit Gosavi, Susan Murray
Actor-critic algorithms are amongst the oldest reinforcement learning algorithms that can be used to solve Markov decision processes (MDPs) via simulation. Unfortunately, the values of the “actor” in the classical version of this algorithm get unbounded in practice. In practice, the actor’s values are artificially constrained to obtain solutions. Boltzmann action selection is used for this algorithm in which a temperature is used, but the divergence of the algorithm is guaranteed only when the temperature equals 1. We propose a new actor-critic algorithm in which the actor’s values are bounded even when the temperature is set to 1. Our algorithm delivers encouraging numerical behavior.
4 - Being On The Productivity Frontier: Identifying “Triple Aim Performance” Hospitals
Sriram Venkataraman, University of South Carolina, sriram.venkataraman@moore.sc.edu
Aleda Roth, Anita L Tucker, Jon A Chilingarian
Hospital decision makers may face tradeoffs that make it difficult to achieve relatively high performance simultaneously on cost, clinical quality and patient experience. We empirically examine the association between having high performance on any of the three criteria on the probability of being a U.S. News & World Report honor roll hospital. Surprisingly, we find a significant negative relationship exists between being an honor roll hospital and achieving high performance outcomes on any of the three TAP criteria. Furthermore, we find that the percent of physicians employed by the hospital has a positive and significant effect on being a TAP hospital.

SB35
205A-MCC
Behavioral Models in Service Operations
Sponsored: Manufacturing & Service Oper Mgmt, Service Operations
Sponsored Session
Chair: Guillaume Roels, UCLA, Anderson School of Management, Los Angeles, CA, 90095, United States, groels@anderson.ucla.edu
1 - Pricing With Consumer Optimism And Quality Perception: From Experiment To Theory
Rim Hariss, Massachusetts Institute of Technology, 254Windsor Street, Apt 2L, Cambridge, MA, 02139, United States, rhariss@mit.edu, Georgia Perakis, Wichinpong Sinchaist, Yanchong Zheng
We study how consumers’ optimism about future markdwon and their quality perceptions influence a firm’s optimal markdown pricing strategy. We experimentally elicit the relationship between consumers’ perceived quality of a product and the product’s price information (e.g., initial price, discount, final selling price). We estimate a functional relationship from the data and incorporate this relationship into consumers’ purchase behavior. We then characterize the firm’s optimal policy given that consumers form price-based quality perceptions and may hold inaccurate expectation of the level of future markdwon.

2 - Impact Of Server Behavior On The Performance Of Queuing Systems
Masha Shunko, University of Washington, mshunko@gmail.com
Multi-server single-queue (SQ) systems may outperform multi-server parallel-queue (PQ) systems due to the pooling effect. We model and analyze the impact of human server behaviors (namely, slowdown due to free riding and workload-dependent service rate) on the performance of SQ and PQ systems and derive how large the behavioral impacts should be to outweigh the benefits of pooling.

3 - Pooling Queues With Work Averse Servers
Guillaume Roels, UCLA, groels@anderson.ucla.edu, Mor Armony, Hummy Song
Contrary to the classical theory of operations management, recent case studies in retail, call centers, and healthcare indicate that pooling queues may not necessarily result in less expected work in process. In this paper, we propose that this phenomenon may arise when servers are work averse and have some discretion over their choice of service capacity. We distinguish two types of work aversion, namely workload aversion and busyness aversion, and show that dedicated configurations yield less expected work in process than pooled configurations when servers exhibit high degrees of workload aversion or low degrees of busyness aversion.

SB36
205B-MCC
Incentives and Risk in Supply Chains
Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain
Sponsored Session
Chair: Karan Girotra, INSEAD, Fontainebleau, France, karan.girotra@insead.edu
Co-Chair: Simone Marini, Wharton, Philadelphia, PA, United States, marini@wharton.upenn.edu
1 - Fleet Management For Healthcare Delivery In Africa: Vehicle Ownership And Contracting Models
Sang-Hyun Kim, Associate Professor, Yale University, New Haven, CT, United States, sang.kim@yale.edu, Li Chen, Hau Leung Lee
In this paper we study an innovative healthcare product delivery system that Riders for Health, a non-profit, has implemented in a number of African nations. Health products are delivered to rural areas via motorcycles in difficult transportation conditions, and therefore it is critical to run an effective vehicle maintenance program. Riders for Health experimented with different contractual agreements with government agencies. We build a model based on reliability theory and contract theory that captures the essence of the problem that Riders faced, and discuss managerial insights that the model predicts.

2 - Learning (or Not) From Precursors To Disasters
Heikki Peura, Imperial College, London, United Kingdom, hpeura@london.edu, Nitin Bakshi
Disasters are invariably preceded by more frequent precursor events. These events embed valuable information about the likelihood of the root cause of a disaster, and thereby facilitate risk assessment. But to learn from precursors, a managing firm typically relies on the reports of a contractor, who is often also responsible for mitigating the occurrence of these incidents. We show how firms may fail to learn from precursor events due to the resulting interpersonal problems of moral hazard (on risk mitigation) and hidden information (on reporting precursors).

3 - Supply Disruptions And Optimal Network Structures
Kostas Bimpikis, Stanford, kostasb@stanford.edu, Ozan Candogan, Shayan Ehsani
We study multi-tier supply chain networks in the presence of disruption risk. Firms compete in one of K production stages and prices of intermediate goods are set so that markets clear. We characterize equilibrium prices, profits, and sourcing decisions and explore how they are affected by the network structure. Also, we identify the network structures that maximize aggregate profits, welfare, and consumer surplus. Interestingly, these networks can be ranked in terms of how “balanced” the supply chain is. Finally, we consider endogenous chain formation and argue that it leads to inefficiencies both in terms of the number of firms that enter and in terms of the structure of the resulting networks.

SB37
205C-MCC
Supply Chain Topics
Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain
Sponsored Session
Chair: Robert Bray, Kellogg School of Management, 830 Hinman Ave. Apt. 25, Evanston, IL, 60202, United States, robertbray@gmail.com
1 - Buyer Intermediation In Supplier Finance
Tunay Tuncu, Professor, University of Maryland, College Park, MD, 20910, United States, tuncan@rhsmith.umd.edu, Weiming Zhu
We analyze the role and the efficiency of buyer intermediation in supplier financing (BIF). We theoretically demonstrate that BIF can significantly improve the supply chain surplus over traditional financing. Using data from a large Chinese online retailer, we estimate model parameters, empirically verify the theory, and predict efficiency gains.

2 - Shock Spillover And Financial Response In Supply Chain Networks: Evidence From Firm-Level Data
Andrew Wu, Assistant Professor of Tech, Operations, Finance, Ross School of Business, University of Michigan, Ann Arbor, MI, United States, andydiwu@umich.edu, Jun Li
Using machine learning methods on firm-level textual disclosures, this research studies the propagation of firms-specific production shocks through supply chain relationships, and the stock market reactions to such propagated shocks.
3 - Unbundling Of Ancillary Service: How Does Price Discrimination Of Main Product Matter?
Yao Cui, Cornell University, Ithaca, NY, United States, yao.cui@cornell.edu, Izhak Duenyas, Ozge Sahin
We consider a setting where the firm sells a main and an ancillary service. We study how the firm’s ability to charge discriminatory main service prices affects the decision of whether to separately charge for the ancillary service, both for the firm and for the industry.

4 - Centralized Vs. Decentralized Platform Markets
Daniela Saban, Stanford GSB, dbs2131@columbia.edu, Yash Kamoria
We consider a two-sided matching market with search frictions, and study the impact of the matching technology and platform design on the efficiency of the marketplace in serving its users. We find that a few different designs may be optimal in different settings, with the best choice of design depending crucially on the agents’ selectivity — likelihood that a potential match on the opposite side of the market will be acceptable — and their cost of search —cost of discovering the value of a potential match.

SB38
206A-MCC
Innovation: Choices and Constraints
Invited: New Product Development
Invited Session
Chair: Pascale Crama, Singapore Management University, Singapore, Singapore, pcrama@smu.edu.sg
1 - The Role Of Form In Product Evolution: An Analysis Of Styles
Tian Chan, Emory University, Atlanta, GA, 3, United States, tianheong.chan@itsc.emory.edu, Jurgen Mihm, Manuel Sosa
Styles are groupings of product designs of similar form. We leverage on a recently introduced database of styles among the more than $350,000 US design patents granted from 1977 through 2010 to study how styles evolve over time. We study and theorize how the interactions between design, technology, and organizations lead to the emergence, growth, and decline of styles. We discuss the implications of our results in furthering the understanding of how products evolve.

2 - Implementing Corporate Entrepreneurship With Contests
Lakshminarayana Nittala, University of California San Diego, La Jolla, CA, 92037, United States, linnitala@ucsd.edu, Sanjiv Erat, Viswanathan Krishnan
We analyze the use of Innovation contests by firms as processes to implement corporate entrepreneurship. The cost benefit analysis of such internal contests brings forth interesting insights on the relation between the institutional features and profitability of such contests.

3 - Contracts With Reciprocal Buyout Options
Pascale Crama, Singapore Management University, pcrama@smu.edu.sg, Niyazi Taner T
Joint research and development (R&D) allows firms to combine complementary capabilities, but is difficult to organize in the face of uncertainties surrounding the future product and skills needed to bring it to market. We analyze how contracts with reciprocal buyout options can help to organize joint R&D to mutual advantage when the parties to the contract can invest in capability-building.

SB39
207A-MCC
Mean Field Models and Economic Applications
Sponsored: Applied Probability
Sponsored Session
Chair: Ramesh Johari, Stanford University, Stanford, CA, United States, ramesh.johari@stanford.edu
1 - Mean Field Models For Economic Applications
Ramesh Johari, Stanford University, ramesh.johari@stanford.edu
This session will survey the use of mean field methods for analysis of strategic interactions in dynamic markets. Dynamic markets can be viewed as a significant special class of dynamic stochastic games; these are generally difficult to analyze, and these difficulties are only exacerbated when the number of players is large. We will discuss the use of large system asymptotics to simplify equilibrium characterization and market design. A significant emphasis will be on discussion of open applied directions for such methods. It will not be assumed that attendees are experts in dynamic games or economic modeling; the goal is to introduce applied probabilists to an exciting area of application.

SB40
207B-MCC
Applications of Data Envelopment Analysis
Invited: Data Envelopment Analysis
Invited Session
Chair: Daiki Wakayama, Komazawa University, 1-23-1-2409 komazawa, Setagaya-ku, Tokyo, 154-8525, Japan, dwakayam@komazawa-u.ac.jp
1 - Transmission Congestion And Eco-technology Innovation In U.S. Electric Power Industry Measured by DEA Environmental Assessment
Daiki Wakayama, Komazawa University, Tokyo, 3510021, Japan, dwakayam@komazawa-u.ac.jp, Mika Gotto, Toshiyuki Sueyoshi
This study discusses a new use of DEA environmental assessment to measure a possible occurrence of congestion in U.S. coal-fired power plants. The congestion is classified into two categories: Undesirable Congestion (UC, indicating a transmission limit) and Desirable Congestion (DC, indicating eco-technology innovation). The identification of UC is important to avoid a cost increase and a shortage of electricity, while investigating of DC can be effectively used to reduce the amount of air pollution. This study finds that UC may occur on most of power plants. In contract, DC may occur on a limited number of power plants.

2 - Study Of Capital Requirement And Bank Operating Efficiency
Yang Li, National University of Kaohsiung Kaohsiung, yangli@nuk.edu.tw
Following the 2008 financial tsunami, the Bank of International Settlements proposed Basel III in 2010, in which banks need to raise their capital adequacy ratio in order to make them sound and safe. This study employs the two-stage bootstrapped truncated regression model, proposed by Simar and Wilson (2007), and takes into account undesirable outputs to investigate how the increases in core, tier I, and total capital adequacy ratios influence the efficiency of Chinese commercial banks. The data set is obtained from Bankscope for the period 2012-2014. Empirical results are consistent with the schedule and intention set by Basel III.

3 - Statistical Measure Of Goodness On Quantitative Models Of Efficiency And Effectiveness
Abbas Attarwala, University of Waterloo, Waterloo, ON, Canada, aattarwa@uwwaterloo.ca, Stanko Dimitrov, Amer Obeidi
We propose a statistical measure of goodness on quantitative models of efficiency and effectiveness. Our measure is used in a financial setting based on the Efficient Market Hypothesis. Using information criterion we find the best fit model in a family of functions. The goodness of fit of a model is traded against the number of parameters required to achieve this approximation. We apply the developed statistical measure on four models using two case studies of U.S and Indian bank data.

4 - The Group And Individual Evaluation Using Fuzzy DEA
Hiroshi Morita, Osaka University, Suita, Japan, morita@ist.osaka-u.ac.jp, Rui Dai, Minghao Chen
We use the fuzzy DEA to evaluate the performance based on the evaluators’ scores, which come from the evaluation questionnaire and considered as fuzzy DMUs. We suppose the situation of teachers’ evaluation by students’ score. The fuzzy DEA model is used to analyze the group evaluation of the performance effectiveness. The DEA model is firstly used to analyze the scores for every DMU, where the evaluators’ ambiguity or bias may bring the fuzziness of DMU. It also compares the group evaluation and individual evaluation on efficiencies. This approach is more objective and fair by avoiding the effect of the directly counting scores which is easily affected by negative or positive attitude of evaluators.
a approach.
goal-based investment model that only requires the input of wealth, income, and
detailed financial situation through online platform. Therefore, we propose a
目标-based investment model that only requires the input of wealth, income, and
consumption goals with priorities via multi-stage stochastic programming
approach.

2 - How to Train Your Lawyer
Ephrat Bitton, Future Advisor, ephratb@gmail.com
For better or worse, Robo Advisors operate in a highly regulated industry. Folks
may roll their eyes at the mention of compliance, but it is a crucial process for
ensuring that we protect the end client. As a mathematician at FutureAdvisor,
one of my greater challenges is adequately describing to our compliance officer
how to manage portfolios using optimization. MILP can be immensely powerful
for solving complex decision problems, but it is notoriously difficult to pinpoint
the reasons for different outcomes. This talk follows my story on automating
portfolio management, ensuring the quality of our results, and finally, explaining
how it all works to someone who reads legal settlements for fun.

3 - Pricing And Hedging Guaranteed Minimum Withdrawal Benefit
With High Water Mark Benefit Base
Peiqi Wang, Princeton University, Princeton, NJ, United States, peqiw@princeton.edu, Patrick Cheridito
We consider pricing and hedging of Guaranteed Minimum Withdrawal Benefit
(GMBW) rider on a variable annuity (VA) contract. We price the VA+GMBW
contract by considering the optimal withdrawal strategy of the policyholder. We
show that policyholder's payoff resulting from the optimal withdrawal strategy
corresponds to the super-replication cost of the contract and we provide a
hedging strategy. Our numerical results show that it is sometimes optimal for the
policyholder to aggressively withdraw and ruin the account. Further analysis on
the numerical results suggests how the insurer should determine the fee structure
and minimal deposit requirement.

4 - About Holistic Robo-advice Engine
Dan Dibartolomeo, Northfield Information, dan@northfield.com
Robo-advisors aim to attract non-high-net-worth individual investors by
significantly lowering the entry barrier to professional wealth management industry.
Unfortunately, existing schemes of robo-advisors have not been sophisticated enough to provide fully personalized investment advice. However,
its surely is challenging to ask clients, who might lack financial literacy, to provide
their detailed financial situation through online platform. Therefore, we propose a
goal-based investment model that only requires the input of wealth, income, and
consumption goals with priorities via multi-stage stochastic programming
approach.

SB43
Systems Engineering and Decision Analysis
Sponsored: Decision Analysis
Sponsored Session
Chair: Robert F Bordley, PMP, MBA, Booz Allen Hamilton, Troy, MI,
United States, bordley_robert@bah.com

1 - Value-focused Thinking For Engineering Resilient Systems
Greg Parnell, University of Arkansas, gparnell@uark.edu
DoD's requirements analysis identifies Key Performance Parameters to meet the
system goals. The acquisition documents identify the thresholds and objectives for
each parameter that are supported by mission analysis that considers mission
needs, technical maturity, affordability, and schedule. Multiple objective decision
analysis and Value-Focused Thinking can provide a mathematical framework for
evaluating the resilience of systems in mission scenarios under uncertainty and
the adaptability of the platform to future missions.

2 - The Systems Engineering Approach To Setting Design Targets
Robert Bordley, Booz Allen Hamilton, bordley_robert@bah.com
Systems engineering is a value-focused process aimed at defining feasible
component-level design targets for a system which, when designed and assembled,
will best meet the needs of system stakeholders. To reach this goal, systems
engineering first defines targets at the system level, then at the subsystem
level, the assembly level etc down to the component level. At each level,
informal trade-offs are made about what is most appealing to stakeholders given
beliefs about what is technically possible. Making these tradeoffs involves
specifying alternative solutions, investigating each solution and constructing an
optimal hybrid of the solutions.

3 - A Bayesian Method For Selecting Elite Varieties Of Soybean
Jack Kloebner, Kromite, LLC, 82 Nelson Drive, Churchville, PA,
18966, United States, jkloebner@kromite.com, Joseph Byrum,
Tracy Doubler, Greg Doonan, Craig Davis, Peiranz Zhao
In agriculture RD, a new variety's genetic contribution to higher yield is difficult
to separate from factors of soil, insects, weather, or agronomic practices. Varieties
are grown at multiple locations, downselecting over 4 years. Syngenta developed a
generalized method which helps breeders find the genetic winner using
Bayesian Updating. The increased accuracy leads to better decision-making and
higher yield.
1 - Missing Data Inference With Application To The Home Mortgage Disclosure Act
Andrew Porter, Office of the Comptroller of the Currency, Washington, DC, United States, andrew.porter@occ.treas.gov
Tong-yob Nam
The Home Mortgage Disclosure Act (HMDA) mandates financial institutions to report protected class information such as race and ethnicity for each mortgage applicant when available. However, a significant proportion of these data is missing which impairs regulatory ability to determine whether a financial institution provided fair access to its mortgage products. We use a multimodal logit with spatial data analysis coupled with multiple imputation methodology to infer the missing HMDA data and mitigate the effect of model uncertainty. Our empirical analysis concerns varied institutions with different levels of missing protected class data including a large bank and a non-bank lender.

2 - Prudential Policies And Their Impact On Credit In The United States
Paul Calen, FRB of Philadelphia, paul.calen@phil.frb.org
We analyze impacts on bank lending of two supervisory policies. We find that banks reduced their share of jumbo mortgage originations following the stress test in 2011, but not in later years when they were better capitalized. We find little initial impact of the 2013 Leveraged Lending Guidance, but follow-up FAQs issued late in 2014 marked a significant drop in leveraged lending. Thus, measurable risk and capital appear to have a more immediate impact on lending. Model governance can still have compliance implications—exemplified by banks failing the stress tests on qualitative grounds. Our findings for the 2013 Guidance and FAQ suggest that clarity of regulatory communications also play a role.

3 - Forecast Combination Of Machine Learning Models With Application To Camels Early-warning Systems
Lewis Gaul, Office of the Comptroller of the Currency, lewis.gaul@occ.treas.gov
This paper uses forecast combination methods to predict future CAMELS bank ratings assigned by the Office of the Comptroller of the Currency. We use several individual algorithms and statistical models to forecast future CAMELS ratings with information on lagged financial statement ratios and macroeconomic variables. We then analyze whether combinations of multiple forecasts provide more accurate out-of-sample forecasts of future CAMELS ratings than any individual forecast model. Results indicate that the out-of-sample forecast performance of most individual models varies over time, and that combinations of forecasts generally perform better than any individual model.

1 - Defensibility - A New Concept In Risk Analysis
Vicki Bier, University of Wisconsin-Madison, vicki.bier@wisc.edu
Alexander Gutfreund, Ziyanq Lu
We define a system as defensible if modest investment of resources can significantly improve the outcome to the defender. After quantifying defensibility, we use empirical examples and stylized examples to show that some systems that appear highly vulnerable are actually highly defensible.

2 - Using The Concept Of Multidimensional System Resilience In Decision And Risk Analysis
Dante Gama Dessave, Stevens Institute of Technology, dgamades@stevens.edu, Jose Emmanuel Ramirez-Marquez
Resilience is generally understood as the ability of an entity to recover from an external disruptive event. Systems such as cities, face the challenge of each of their subsystems being vulnerable to multiple threats. This work analyzes the compilation of subsystem and multiple measurements in order to have a more accurate description of system resilience. The object of this work is to introduce the use of this multidimensional system resilience model in the disciplines of decision and risk analysis, showing how it allows creating more comprehensive and intuitive tools for decision makers.

3 - Behavioral Experiments On Deterrence
Richard John, USC, richardj@usc.edu
When evaluating potential countermeasures, emphasis is often placed on interdiction over deterrence because the impact of interdiction focused countermeasures is easier to identify and quantify compared to the impact of countermeasures designed to deter. Resource allocation decision often focus on measures of interdiction enhancement only, even though the involve countermeasures are expected to improve both interdiction and deterrence. I will focus on innovative methods to characterize and quantify the deterrent effects of countermeasures. I will also include methods and findings drawn from decision and risk analysis, game theory, and behavioral research on deterrence.

4 - A Robust Optimization Approach For Electric Power Grid Protection
Alberto Costa, NUS, Singapore, Singapore, isealc@nus.edu.sg
Alberto Costa, Future Resilient Systems (FRS) - ETH Zurich, Singapore, Singapore, isealc@nus.edu.sg
We study the problem of the optimal allocation of protection resources in an electric power grid with the aim of maximizing its robustness against attacks to the lines. This problem can be seen as a game between two players, i.e., the system operator and the attacker. Given a budget for protecting the lines and a performance threshold, i.e., the maximum value of load shed tolerated by the system operator, the attacker wins the game if the load shed after the attack is above the threshold. We propose an algorithm to find the allocation of the system operator’s budget to the lines of the grid which maximizes the amount of budget needed by the attacker to win the game.

1 - Matching Markets With Search Frictions
Nicholas A. Arnott, Stanford University, narnosti@stanford.edu
Ozan Candogan, University of Chicago, 7449 9th Street, Unit 472, Durham, NC, 27705-1084, United States, ozan.candogan@chicagobooth.edu
Kostas Bimpikis
We consider a model in which sellers compete by posting prices and buyers visit sellers sequentially. We show that there is a unique equilibrium outcome, which is constrained efficient. We then study the consequences of reducing search costs. This benefits buyers, but may either increase or decrease seller revenue. If there are sufficiently many buyers, sellers benefit from lower search costs. Otherwise, the effect on seller revenue depends on the shape of the distribution of buyer values. If it is heavy-tailed (has a decreasing hazard rate), then sellers benefit from lower search costs. If it is light-tailed (has an increasing hazard rate), then seller revenue falls as search becomes easier.

2 - Dynamic Mechanisms With Martingale Utilities
Santiago Balirse, Duke University, sbb43@duke.edu, Valah Mirokni, Renato Paes Leme
We study the dynamic mechanism design problem of a seller who repeatedly sells independent items to a buyer with private values under two practically relevant revenue constraints: (i) a periodic individual rationality constraint, which limits the mechanism to charge at most the buyer’s value in each period and (ii) a martingale utility constraint, which imposes that from the perspective of the buyer, the next item’s expected utility is equal to the present one’s. Our main contribution is the design of a dynamic auction that asymptotically achieves full extraction of buyer surplus as agents become more patient.

3 - Ridesharing Networks
Ozan Candogan, University of Chicago, 7449 9th Street, Unit 472, Durham, NC, 27705-1084, United States, ozan.candogan@chicagobooth.edu, Daniela Saban, Konstantinos Bimpikis
We consider the problem faced by a revenue optimizing ride-sharing platform, which must decide on how to price the rides as well as how to compensate the drivers. These decisions will impact both the entry of customers and the actions of the drivers. We study the impact that the underlying network structure has on the pricing strategy.
4 - Tractable Equilibria For Sponsored Search With Budget Optimizing Bidders
Dragos Florin Ciocan, INSEAD, florin.ciocan@insead.edu, Krishnamurthy Iyer

We examine a model of sponsored search markets where bidders strategically choose their budgets and bids, while the ad network can throttle bidders to optimize its own revenues. We show the equilibria in this market take a simple form and that for these equilibria the network’s optimal throttling policy is greedy.

SB47
200C-MCC
New Topics in Revenue Management and Pricing
Sponsored: Revenue Management & Pricing
Sponsored Session
Chair: So Yeon Chun, McDonough School of Business, Georgetown University, Washington, DC, United States, sc1286@georgetown.edu

1 - Worker Poaching In A Supply Chain: Enemy From Within?
Gad Allon, Northwestern University, g-allon@kellogg.northwestern.edu, Achal Bassamboo, Evan Barlow

Poaching workers has become a universal practice. We explore worker poaching between firms linked in a supply chain. We show that the classical intuition from labor economics is insufficient in explaining poaching between supply chain partners. We also show how and under what conditions worker poaching can actually improve supply chain performance. Finally, we show how the equilibrium identity of the supply chain bottleneck depends on the interaction between hiring, poaching, and productivity.

2 - The Revenue Impact Of Dynamic Pricing Policies In Major League Baseball Ticket Sales
Joseph Xu, University of Pennsylvania, Philadelphia, PA, United States, jiaxju@wharton.upenn.edu, Senthil Veeraraghavan, Peter Fader

We study RM implementation of multiproduct dynamic pricing by a Major League Baseball franchise for their single game tickets. We develop a comprehensive customer choice model to calibrate and design a dynamic pricing policy for the franchise. Our model also incorporates external factors that drive consumer valuation of sports tickets, such as the effect of the home team’s on-field performance and the effect of overall attendance level. Our counterfactuals show potential revenue improvement of up to 15% through the effective use of dynamic pricing. We also find that a properly calibrated fixed pricing policy can achieve similar levels of performance as the optimal dynamic pricing policy.

3 - Designing Rewards-based Crowdfunding Campaigns For Strategic Contributors
Soupidta Chakraborty, Duke University, Durham, NC, 27708, United States, sc390@duke.edu, Robert Sinnwey

We study a model of rewards crowdfunding with the all or nothing funding mechanism. The creator of a crowdfunding campaign sets a target funding level and the campaign is successful only if the funding it receives meets this target. A creator can have two possibly competing objectives: maximize the likelihood of success and maximize the expected total funding. The creators incur a transaction cost while pledging to a campaign. As a result, they behave strategically and decide whether to pledge at the beginning or to wait till the target is met. We analyze how a creator, who encounters such strategic behavior, can achieve her objectives by optimally using the operational parameters of her campaign.

4 - Setting The Optimal Value Of Loyalty Points
So Yeon Chun, McDonough School of Business, Georgetown University, sc1286@georgetown.edu, Dan Andrei Iancu, Nikolaos Trichakis

A loyalty program introduces a new currency—the points—through which customers transact with a firm. We study the problem of optimally setting the monetary value of points, i.e., pricing in this new currency, in a multi-period setting. We first show that point pricing is different from cash pricing primarily due to the way points are accounted for, as liabilities on the firm’s balance sheet, and then we characterize the optimal cash and point pricing policies.

SB48
210-MCC
Social Media Analytics for Businesses
Invited: Social Media Analytics
Invited Session
Chair: Panagiotis Adamopoulos, New York University, School of Business, New York, NY, 11111, United States, padamopo@stern.nyu.edu

1 - Monetizing Sharing Traffic Through Incentive Design: Evidence From A Randomized Field Experiment
Tianshu Sun, University of Southern California, 3330 Van Munching Hall, Los Angeles, CA, 20742, United States, tianshu.sun@gmail.com, Siva Viswanathan, Elena Zhelavsky

Using a large-scale randomized field experiment, we examine whether and how firms can engage customers involved in online social sharing, through the design of novel incentive mechanisms. We find evidence that incentive design has a significant impact on both sender’s purchase and referrals, but in a different ways. Specifically, compared to the senders who receive non-shareable promotional code, senders who receives shareable code are less likely to make purchases themselves, but much more likely to make further referrals. We further leverage variation in incentive design to untangle three motives underlying the sender’s sharing-self-regarding, other-regarding, group-regarding motive.

2 - Realizing The Activation Potential Of Online Communities
Marios Kokkodis, Boston College, kokkodis@bc.edu

In this work we present a data-driven stochastic framework that identifies which users and when are more likely to become heavy contributors in an online community.

3 - Word Of Mouth Vs. Word Of Health Inspectors: Evidence From Restaurant Reviews
Chenhui Guo, University of Arizona, 1130 E Helen St, McClelland Hall 430, Tucson, AZ, 85721, United States, chguo@email.arizona.edu, Paulo B Goes, Mingleng Lin

Prior to purchase, consumers are naturally exposed to multiple sources of quality information. We study whether and how consumer word of mouth of restaurants—both volume and valence—is influenced by co-presence of information from health inspectors. We build a simple analytical model and conduct an empirical study using data from a leading consumer review site, showing that the availability of official information has a significant dampening effect on the volume of reviews generated by customers. Moreover, the effect on valence is significantly positive, with a very small magnitude.

4 - The Role Of Dimensionality Reduction In Binary Classification For Social Network Data
Jessica Clark, New York University, jclark@stern.nyu.edu, Foster Provost

Dimensionality reduction is regarded as a key part of the predictive analytics process. We take a design-science approach to analyzing the role of dimensionality reduction via matrix factorization for binary classification using large, sparse social network data. The experiments in this work (which span a variety of data sets, modeling techniques, and DR methods) find that DR at best provides little advantage in terms of classification performance, and at worst can significantly negatively impact performance. The results emphasize the need for caution when utilizing DR in predictive modeling, which should serve as a guideline for applied data science researchers and industry practitioners.

SB49
211-MCC
Case Competition II
Sponsored: Education (INFORMS)
Sponsored Session
Chair: Palanippan Krishnan, University of Delaware, Newark, DE, United States, bab@udel.edu

1 - Dynamic In-Game advertising: Managing Complex High-Stakes Operations
Alan Scheller-Wolf, Carnegie Mellon University, Pittsburgh, PA, United States, awolf@andrew.cmu.edu, John Turner

Dynamic in-game advertising is an advanced form of advertising in which ads are displayed on electronic billboards, stadium walls, or in other visually appealing spots within the 3D worlds of video games. This case teaches students not only about the economics of online advertising and how to solve complex multi-objective ad planning problems using goal programming, but also covers broader modeling concepts, practical modeling considerations, and discusses relevant strategic issues from the fast-growing and fast-changing online advertising industry.
2 - Shipment Consolidation And Dispatching Problem At Ekol Logistics
Sinem Tokcaer, zmir University of Economics, Izmir, Turkey, sinem.tokcaer@iue.edu.tr, Ozgur Ozpeynirci, Muhittin H. Demir, Irem Celik

The case considers international freight forwarding operations in Ekol Logistics of Turkey; a leading international logistics company. Less-than-truckload orders are routed either directly to destination, or through a cross dock. Currently, the consolidation and dispatching plan is done manually. The case has two phases: first, students analyze the cost structure to determine the total cost for a given plan and suggest a better one. The second phase involves the construction of the mathematical programming formulation to identify an optimal plan. Students are also required to identify alternative feasible routes to be fed into the formulation, in search for an improved optimal plan.

3 - Inventory Optimization For Rent The Runway
Vincent Slough, Cornell University, Ithaca, NY, United States, vslaugh@cornell.edu, Sridhar Tayur

The choice of how many rental dresses to procure in advance of each fashion season plays a critical role in the success of Rent The Runway, an online high-fashion dress rental business. The case leads students through this inventory optimization decision for a single dress style using both queuing and Monte Carlo simulation models implemented in a spreadsheet. Students are encouraged to consider the strengths and weaknesses of each modeling approach and how to incorporate additional model features such as nonstationary demand and the random loss of rental units.

4 - The Safe Birth Clinic
Milind Dawande, The University of Texas at Dallas, Richardson, TX, United States, milind@utdallas.edu, Tim Huh, Ganesh Janakiram, Mahesh Najarajan, Yang Bo

The effective utilization of capacity is an important operational goal that managers strive to achieve. Most textbooks use the following simple “bottleneck formula” to calculate process capacity: the capacity of each resource is first calculated by examining that resource in isolation; process capacity is then taken as the smallest (bottleneck) among the capacities of the resources. The main goal of this case is to alert students that, for processes in which activities share resources, the use of the bottleneck formula brings the potential danger of reaching incorrect conclusions about process capacity and may eventually lead to erroneous decisions with significant financial impact.

- Shipment Consolidation And Dispatching Problem At Ekol Logistics

- Inventory Optimization For Rent The Runway

- The Safe Birth Clinic

- Online Overbooking Strategies In Outpatient Specialty Clinics With No-shows And Advance Cancellations
Shannon Harris, Ohio State University, harris.2572@osu.edu, Jerrold H May, Luis G Vargas

Patient behavior, such as no-shows and cancellations, can lead to issues that heighten outpatient clinic access issues. In this paper, we develop strategies to determine if and when to overbook patients, over a finite horizon, in an online scheduling environment. We incorporate clinic parameters, no-shows, and cancellations to inform the overbooking decisions. We find that the optimal overbooking strategies are a function of both no-shows and cancellations, and that a clinic can, under certain conditions, achieve a greater service reward by overbooking patients than it can by not overbooking. Our work is motivated, in part, by our observations of scheduling at a VH specialty clinic.

- Modeling For The Equitable And Effective Distribution Of Food Donations Under Stochastic Capacities
Irem Sengul Orgut, Quality Analytics Project Manager, Lenovo, Raleigh, NC, United States, isengul@ncsu.edu, Julie Ivy, Reha Uzsoy

Food insecurity is an increasing threat to people’s health status and quality of life. In partnership with the Food Bank of Central and Eastern North Carolina, which distributes donated food to a 34-county service area, our objective is to achieve equitable and effective food distribution among the population at risk for hunger. Counties’ capacities are the main source of uncertainty in this system as they constrain the total food distribution due to the need to distribute food equitably. We develop stochastic models for optimal food distribution and prove structural results. We illustrate our results and perform an extensive numerical study using historical data from our collaborating food bank.
2 - The Role Of Surge Pricing On A Service Platform With Self-scheduling Capacity
Kaitlin Daniels, Assistant Professor, Olin Business School, Washington University in St. Louis, St Louis, MO, United States, k.daniels@wustl.edu
Platforms like Uber use dynamic pricing policies to manage a workforce of “self-scheduling” providers who decide for themselves how often to work. We show that the optimal dynamic pricing policy substantially increases the platform’s profit relative to contracts with a fixed price or fixed wage (or both) and although surge pricing (which pays providers a fixed percentage of a dynamic price) is not optimal, it generally achieves near optimal profit. Furthermore, we find that providers and consumers are generally better off with surge pricing because providers are better utilized and consumers benefit both from lower prices during normal demand and expanded access to service during peak demand.

3 - Team Leadership And Performance: Combining The Roles Of Direction And Participation
Morvarid Rahmani, Georgia Institute of Technology, 800 West Peachtree Street, NW, Atlanta, GA, 30308-1149, United States, morvarid.rahmani@scheller.gatech.edu, Uday Karmankar, Guillaume Roels
One of the challenges that project team leaders face is how to combine their roles as individual contributors and managers. In this paper, we propose a model of team leadership and study how a contributor leader should adjust her managing effort over time and with respect to the project characteristics (e.g., team members' incentives and team size).

4 - Sole Inventor Vs Team Of Inventors: What’s Best?
Tian Chan, Emory University, Atlanta, GA, United States, tianhoeng.chan@isnacad.edu, Jurgen Mieth, Manuel Sosa
Should a team of inventors outperform individual inventors in creating groundbreaking innovations? The empirical evidence that examines into scientific papers and technology patents (representing millions of inventive work) suggests that the answer is an unqualified “yes”. However, in this work we use design patent data to show that “teams are better than individuals” is not true in the context of design innovation. While so, we find that collaboration yields future dividends—designers who has collaborated extensively in the past but currently operates alone outperforms either teams or sole designers. We discuss the implications of our results in the organization of innovative work.

5 - Impact Of Future Wind Power Scenarios On The Distributionally Robust Operation And Cost Of Reserves
Bita Anali, Post Doctoral Scholar, Ira A. Fulton Schools of Engineering, Arizona State University, Tempe, AZ, 85287-9309, United States, Bita.Anali@asu.edu, Anna Scaglione
The increasing share of renewable energy and its intermittency have led to new challenges in modeling and optimization of power system operations. In this work, we present the distributionally robust extension of multistage stochastic optimization of reserves operations under stochastic wind power generation. In this setting, the reference probability model is a scenario tree based on the direct quantization of wind power trajectories. Constructing the alternative scenario trees in the epilon-neighborhood of the reference tree forms the ambiguity set P, wherein an iterative algorithm determines the minmax solution and identifies the worst case probability model.

2 - The Quest For Zero-carbon Supply Chain: An Onsite Generation Approach
Tongdan Jin, Texas State University, tjin7@txstate.edu
Is it feasible to deploy a zero emission production-logistics system using intermittent renewable energy? If so, how to design such eco-friendly supply chain system in a distributed generation environment? In this talk we present a wind- and solar-based onsite generation system to achieve carbon-neutral performance for a multi-facility production-distribution network with affordable cost.
3 - Robust Transmission Planning Under Uncertain Generation Investment And Retirement  
Lizi Wang, Iowa State University, lzwang@iastate.edu, Bokan Chen

We present a new robust optimization model for transmission planning. This model considers the addition of new renewable generation and the retirement of existing generation capacity as sources of uncertainty. It incorporates for each transmission plan the worst scenario that would result in the highest investment and operational cost, and identifies the most robust transmission plan with the least costly worst case scenario. We demonstrate this approach with a case study on the WECC 240-bus test system. Results will be illustrated with novel quantification and visualization techniques.

4 - Data-driven Stochastic Unit Commitment For Integrating Wind Generation  
Chao Yue Zhao, Oklahoma State University, chao_yue.zhao@okstate.edu

In this talk, we propose a data-driven risk-averse stochastic unit commitment model, where risk aversion stems from the worst-case probability distribution of the renewable energy generation amount, and develop the corresponding solution methods to solve the problem. Given a set of historical data, our proposed approach constructs a confidence set for the distributions of the uncertain parameters using statistical inference and solves the corresponding risk-averse stochastic unit commitment problem. The computational results numerically show how the risk-averse stochastic unit commitment problem converges to the risk-neutral one, which indicates the value of data.

4 - Profits And Efficiency Of A Mobile Platform  
Ruiling Wang, University of Science and Technology of China, Helei, China, ruiling@mail.ustc.edu.cn, Qinglong Gou, Yonghua Ji

A mobile platform serves as a multi-sided market which connects users, app developers and advertisers. Different from the traditional multi-sided market, the cross-side network effects between different groups are different. It makes the decision process on advertising investments of platform owners and app developers more challenging. We develop a dynamic model, capturing these impacts, to offer suggestions on their advertisement strategy. We found that platform owners should offer app developers incentives according to the size of their user base or their advertising expenditure. We also investigate the impact of different kinds of incentive on the system efficiency.

SB56

Music Row 4- Omni

Analytical Models in E-business
Sponsored: E-Business
Sponsored Session
Chair: Yonghua Ji, University of Alberta, School of Business, Edmonton, AB, T6G2R6, Canada, yji@ualberta.ca

1 - Allowing Privacy Threshold In Mobile Platform Competition  
Zixuan Meng, University of Washington, zxmeng@uw.edu

Smartphones are increasingly necessary for everyday life and consumers find it important to prevent from privacy violations through Apps on mobiles. Android and iOS, two of the most popular App platforms, are different in App privacy levels. iOS, known to have a higher privacy level, chooses to make privacy requirement public. Using vertical differentiation model, we find that when market is fully covered, publicizing privacy threshold motivates both firms lowering privacy level. This helps both firms generate more profit by hurting consumers. This finding contradicts with common belief and calls for awareness of potential harm from a policy that seems protective to consumers.

2 - How Much To Open, How Fast To Fix And Develop? Impacts Of Openness On Software Development And Maintenance  
Rakesh R Mallipeddi, Texas A&M University, College Station, TX, 77840, United States, smallipedi@mae.tamu.edu, Emre Muzaffer Demirezen, Ram Gopal, Subodha Kumar

Proprietary software vendors have recently begun to emulate the open source software community in opening up part of their software. We analyze the impacts of software openness in the context of resource allocation between bug fixing and new version development, an important operations issue that many software vendors face in light of prevalence of software defects. We formulate optimal control models to examine the effects of making the software code open (fully or partially) on the overall quality of the software and the development efforts of its next version.

3 - Crowdfunding Mechanism Design And Its Effect On Fundraising  
Aravinda Garimella, University of Washington, ararinda.garimella@gmail.com

Our study examines how entrepreneurs’ choices of Funding Type and Rewards Types jointly impact the outcome of crowdfunding campaigns. We begin by providing a conceptual framework that distinguishes between Mechanism and Non-Mechanism aspects of campaign design. We then focus on two mechanisms at play in Reward-Based Crowdfunding platforms. First, entrepreneurs may opt for one of two Funding Types, Fixed Funding or Flexible Funding. Second, entrepreneurs are also heterogeneous in the mix of Reward Types they choose to offer to their backers. Using a rich data set of daily funding information on Indiegogo, we study how these two mechanisms influence funding outcomes and trajectories.

4 - Profit-sharing Or Target-with-bonus? A Behavioral Investigation  
Kay-Yut Chen, University of Texas at Arlington, UT, Arlington, TX, 1, United States, kychen@uta.edu, Shant Li, Ying Rong

We experimentally study the profit sharing and the target-with-bonus mechanism in a setting with a principal setting the parameters of the mechanism, and an agent choosing his effort level (moral hazard) and managing a news vendor store. We find the presence of fairness concerns under both mechanism, and the principal yields higher profit under target-with-bonus mechanism. A behavioral model is constructed to explain the findings.
1 - Optimal Transmission Line Switching Under Geometric Disturbances

Mowen Lu, Clemson University, Industrial Engineering Department, 801 7th St. Apt 21B, Los Alamos, NM, 87544, United States, mlu879@clemson.edu, Russell Bent, Scott Backhaus, Harsha Nagarajan, Emre Yamanlig

Geomagnetically-induced current (GIC) flows induced by geomagnetic disturbances (GMDs) can cause transformer hotspot heating and reactive power losses that can severely impact power grid reliability. We present an optimal transmission line switching model for a power grid experiencing a GMD. We show how convex quadratic relaxations and improved bilinear function relaxations can be used to obtain tight lower bounds. A case study based on a modified single area of the IEEE RTS-96 system demonstrates our model's operating decisions with respect to GMD direction.

2 - Management Of Electric Vehicles Participation In Smart Grids For Demand Response

Nasim Nezamoddini, Ms., State University of New York - Binghamton, 222 Main Street, Apt 1, Binghamton, NY, 13905, United States, nasim.nezam@gmail.com

Electric vehicles (EVs) are potential distributed energy resources that support both the grid-to-vehicle and vehicle-to-grid modes in the smart grid. Their participation in the time-based and incentive-based demand response (DR) programs helps improve the stability and reduce the potential risks to the grid. This research proposes a novel stochastic model from the Independent System Operator's perspective for risk management and participation planning of EVs in the smart grid for DR. The effectiveness of the model in response to various settings such as the area type (residential, commercial, and industrial), the EV penetration level, and the risk level has been investigated.

3 - A Computationally Efficient Branch-and-cut Method For Robust Unit Commitment

Narges Kazemzadeh, Iowa State University, 3004 black engineering, Ames, IA, 50011-2164, United States, narges.kazemzadeh@gmail.com, Sarah M Ryan

Unit commitment seeks the most cost effective generator commitment decisions to meet net load while satisfying operational constraints. Robust optimization is a widely studied approach for optimizing under uncertainty in the load less variable generation. We adopt a branch-and-cut approach to solve a Renders decomposition for the robust formulation with different forms of uncertainty sets. Its improved efficiency relative to the naive Renders algorithm is demonstrated with numerical experiments.

4 - Modeling And Computation Of Reliable Grid Expansion

Bo Zeng, University of Pittsburgh, Department of Industrial Engineering, Pittsburgh, PA, 15260, United States, bzeng@pitt.edu, Hossein Haghighat

Different from existing capacity expansion models, we consider the non-cooperative market clearing results in bilevel capacity expansion scheme. Numerical results will be presented to demonstrate this novel scheme in practice.

5 - Interdependencies In The Communications And Electrical Networks

Alberto J Lamadrid, Assistant Professor, Lehigh University, 621 Taylor Street, R451, Bethlehem, PA, 18015-3120, United States, ajlamadrid@ieee.org, Basel Almajlab, Lawrence V. Snyder, Rick Blum, Shalinee Kishore

Managing an electric grid in a reliable and economic manner requires collecting information for grid operators. Part of this information is collected through sensors and a supervisory control and data acquisition (SCADA) system, as well as from data provided by market players in the market clearing process. Therefore, the operation of the system requires three interdependent networks: the electric grid, the communication network, and the control network. This paper presents a model that explicitly connects these three networks, considering the probabilistic nature of possible disruptions and changes in any of the networks.
Node models are responsible for capturing the propagation of traffic dynamics through networks (e.g., spillback dynamics). Holding-free solutions for node models are formally defined. Flow maximization is only a sufficient condition for holding-free solutions. A greedy algorithm is shown to produce holding-free solutions while also respecting the invariance principle. Staging movements through nodes in a manner that prevents conflicting flows from proceeding through the nodes simultaneously is shown to simplify the node models considerably and promote unique solutions.

Advances in Railway Research

Sponsored: Railway Applications
Sponsored Session
Chair: Shanith Marie Spanton, CSX, 31 West Adams Street, Apt 607, Jacksonville, FL, 32202, United States, shaniths@gmail.com

1 - CSX Line-of-Road Simulation
Yu Wang, CSX, Jacksonville, FL, United States, yu_wang@csx.com
Jagadish Jampani, Raya Rahn

CSX Line-of-road simulation model implements a heuristic algorithm which can efficiently generate a meet-and-pass plan to dispatch trains through a division in a conflict-free manner. In order to accurately capture the speed variation, a data mining module was implemented to predict the speed of any train during its trip based on selected attributes of the train at that time. The model has been validated and used for multiple case studies such as impact of train profile change, sub-division capacity analysis, and curfew planning.

2 - Crew Caller Districting With Consideration Of Workload Balance And Geographic Compactness
Siyang Xie, U of Illinois at Urbana-Champaign, Urbana, IL, United States, sxie1@illinois.edu, Yanfeng Ouyang, Kamalesh Somani
Railroads companies everyday receive a large amount of customer calls. These calls are handled by the crew callers distributed in various crew calling desks. Each of these desk is in charge of the calls from a particular region. To improve service quality and save costs, the region assigned to each desk is designed to be compact and the workload of desks are balanced. We formulate the problem as a network-flow based graph partitioning model and design a specialized heuristic to effectively solve the model. We demonstrate the feasibility of our methodology by applying it to the CSX’s call center design problem.

3 - Scheduling Preventive Grinding For Railway Maintenance
Masoumeh Tashimi, Operations Research Manager, CSX Transportation, Jacksonville, FL, United States, masoumeh_tashimi@csx.com, Kamalesh Somani, Siyang Xie, Yanfeng Ouyang
Railway is the one of the most valuable assets at railway industries. Periodic grinding has been used to protect railway from deterioration and to prolong the life of existing rail infrastructure. Rail grinding smooths the rail to minimize the impact of rail wear, fatigue, and defects. The grinding schedule is usually determined manually on required frequencies. It is desirable to both maximize the total track miles smoothed by grinding, and also minimize the grinder’s total travel distance. In this study, we propose a variant of Vehicle Routing Problem with Time Window to create the grinders’ target frequencies at CSX Transportation.

4 - Scheduling Training Activities For Engineers And Conductors
Grigory Pastukhov, CSX, grigoriypas@gmail.com
CSX Transportation constantly hires engineers and conductors to operate trains. In order to make sure that these people are qualified to fulfill their duties, they have to complete extensive training program. We present fully automated scheduling system that creates detailed training plan for each trainee in the system for the whole duration of training.

SB62

Cumberland 4- Omni
Aviation Applications Section: Best Student Presentation Competition II
Sponsored: Aviation Applications
Sponsored Session
Chair: Lavenya Marla, University of Illinois, 216E Transportation Building, 104 S. Mathews Ave., Urbana, IL, 61801, United States, lavenyam@illinois.edu

SB63

Cumberland 5- Omni
Alternative Fuel Vehicles and Sustainable Transportation
Sponsored: TSL, Urban Transportation
Sponsored Session
Chair: Jee Eun Kang, University at Buffalo, 409 Bell Hall, Buffalo, NY, 14260, United States, jeecunta@buffalo.edu
Co-Chair: Changhyun Kwon, University of South Florida, 4202 E. Fowler Ave. ENH118, Tampa, FL, 33620, United States, chkwon@usf.edu

1 - Economic Analysis On Adopting Strategies Of Electric Vehicles For Urban Parcel Delivery Industry
Nan Ding, University at Buffalo, Nanding@buffalo.edu, Changhyun Kwon, Rajan Batta
Most existing works of electric vehicles (EVs) address travel distance cost of EVs as the only objective and implement the strategy of replacing an entire fleet of conventional vehicles (CVs) with EVs. Few works consider other costs of EVs or alternative strategy. To fill this gap, this work conducts economic analysis of four different strategies of adopting EVs. The objective of all strategies is to minimize the total cost including distance cost, ownership cost, energy cost, as well as infrastructure and maintenance cost for both EVs and/or CVs. These strategies are implemented and solved by heuristics. Secondly, simulation analysis is conducted under various uncertainties for comparison.

2 - Incorporating Demand Dynamics In Multi Period Capacitated Recharging Location Planning For Electric Vehicles
Anpeng Zhang, University at Buffalo, Buffalo, NY, United States, anpengzh@buffalo.edu, Jee Eun Kang, Changhyun Kwon
We develop a multi-period capacitated flow refueling location problem for electric vehicles (EVs) as EV market responds to the charging infrastructure. We present two market dynamics (sensitive to path specific and general charging opportunities) with two objective of charging location problem (maximizing flow coverage and maximizing electric vehicle demand). A case study on US Northeastern network is presented.

3 - Long-term Planning Of Inter-city Battery Electric Vehicle Fast Charging Stations For The State Of California
Fei Xie, Oak Ridge National Laboratory, Knoxville, TN, United States, xiefei@ornl.gov, Changzheng Liu, Shengyin Li, Yongxi Huang, Zhenhong Lin
This study focuses on the long-term planning of battery electric vehicle (BEV) inter-city fast charging stations for the state of California in response to the increasing market share of BEVs. Genetic algorithm will be used to solve this large scale problem. We will investigate the trade-off between the high investment cost in the BEV infrastructure and the growing BEV intercity travel demand with higher BEV fleet size.

4 - Inter-city Network Of Refueling Stations For Plug-in Electric Vehicles
Mehrnaz Ghamami, Assistant Professor, Michigan State University, 428 S. Shaw Lane, Room 3502, East Lansing, MI, 48824, United States, ghamamim@msu.edu
This study aims at finding the optimum location of charging stations in an intercity network of roads, considering multiple routes and multiple OD pairs on each route. It also captures the optimal routes for various classes of vehicles considering not only refueling time, but also travel time, subject to change by link flows, along the routes. It is worth noting that the location of charging stations affects the route selection of electric vehicle users and the route selection affects the energy consumption, traffic on road, and the optimum location of charging stations as a result. Thus, this study considers these independent variables.
1 - A Navy Weapon Selection Throughout Fitradeoff
Adiel Teixeira De Almeida Filho, Assistant Professor, Universidade Federal de Pernambuco, Recife, Brazil, adieltaf@cseid.org.br

This work presents a multiple criteria decision model for selecting a weapon to be incorporated in a navy ship using the Fitradeoff method. A numerical application is presented based on realistic data with regard to the real problem faced by a Brazilian Navy.

2 - A Multicriteria Model For Supplier Selection Based On A Multilinear Utility Function
Felipe Macedo de Morais Pinto, Universidade Federal de Pernambuco, felipe_mmp94@hotmail.com, Adiel Teixeira De Almeida Filho

This work presents an MCDM model based on a multilinear utility function for selecting a maintenance service supplier. Depending on the context, maintenance activities may need to consider other criteria besides cost, which are detailed in the reference Multicriteria and Multiobjective Models for Risk, Reliability and Maintenance Decision Analysis.

3 - Computing Interval Weights For Incomplete Pairwise Comparison Matrices Of Large Dimension – A Weak Consistency Based Approach
Jana Krejci, PhD Student, University of Trento, Italy, Jana.krejci@unitn.it
Jana Krejci, PhD Student, University of Bayreuth, Universitat str. 30, Bayreuth, D-95440, Germany, jana.krejci@unitn.it, Vera Jandova, Jan Stoklasa, Michele Fedrizzi

We present a novel interactive algorithm for large-dimensional pairwise-comparison problems based on the sequential optimal choice of the pairwise comparisons (PCs) to be provided by the decision maker and the concept of weak consistency. The proposed solution significantly reduces the number of needed PCs by providing sets of feasible values for all missing PCs after each input of a new PC. Interval weights of objects covering all possible weakly consistent completions of the incomplete PCMs are then computed from the resulting incomplete weakly consistent PCM. The algorithm is capable of reducing the number of PCs required in PC matrices of dimension 15 and greater by more than 60% on average.

2 - Towards Improved Education For Students Of Low Socioeconomic Status: Learning Analytics Of Massive Open Online Courses (MOOCs)
Sang Pil Han, Arizona State University, Main Campus, PO Box 874606, Office:BA 301D, Tempe, AZ, 85287-4606, United States, sangpill78@gmail.com, Mi Hyun Lee, Sungkoo Kim, SungHo Park

Although the new era of free, online learning unfolds, the claim of ‘education for all’ appears to be overshadowed by the concern over the unequal use of Massive Open Online Courses (MOOCs). MOOCs may not be a viable solution to students across all levels of socioeconomic status (SES). Using learner outcome and demographic data at a MOOC, we examine the effectiveness of two intervention strategies to improve engagements among low SES learners: (1) course verification which allows learners to earn an official credit later and (2) mobile media which enable learners to attend MOOCs anytime/anywhere. From the findings, we draw implications that can help expand access to education to everyone through MOOCs.
3 - Efficient Multi-fidelity Decision Making For Dynamic Data Driven Application Systems
Jie Xu, George Mason University, jxu13@gmu.edu
Chun-Hung Chen, Edward Huang
Dynamic data driven application systems enable real-time simulation-based decision making. However, existing simulation optimization algorithms lack the computational efficiency required for real-time decision making. In this paper, we present a Bayesian framework that makes use of data and models of multiple fidelity levels to achieve the computational efficiency necessary for decision support in the context of dynamic data driven application systems.

4 - Dynamic Data Driven Modeling Of Nanoparticle Self-assembly Processes
Xin Li, Florida State University, 2525 Pottsdam St, Building A, Suite A231, Tallahassee, FL, 32310, United States, x112d@my.fsu.edu; Chihwoo Park, Yu Ding, Tao Liu
We present a dynamic data-driven modeling strategy, capable of tracking and predicting the transient dynamics of nanoparticle production processes. The proposed methodology is built upon two emerging multi-resolution instruments. The methodology regularly triggers cheap low resolution measurements while triggering expensive high resolution measurements when model predictions fail. The proposed strategy would provide crucial clues to understand nanoparticle productions as well as powerful insights to control the production of nanoparticles for yielding desirable morphology.

**SB68**
Mockingbird 4- Omni
Advanced Maintenance Modeling
Sponsored: Quality, Statistics and Reliability
Sponsored Session
Chair: Yisha Xiang, Lamar University, Beaumont, TX, United States, yxiang@lamar.edu
Co-Chair: David W Coit, Rutgers University, Piscataway, NJ, United States, coit@rci.rutgers.edu
1 - Reordering Of Spare Parts Experiencing Two Phase On-shelf Deterioration
Haifao Liao, University of Arkansas, liao@uarbox.edu
We study maintenance and inventory policies for a system carrying spare parts that experience two-phase on-shelf deterioration. Based on the parts' degradation states, we introduce two different replacement strategies for the spare consumption, i.e., the Degraded-First strategy and the New-First strategy.

2 - A Model Of System Limiting Availability Under Imperfect Maintenance
Suzan Alaswad, Zayed University, suzan.alaswad@zu.ac.ae
Charles Richard Cassidy, Edward A Pohl
In this paper, we explore the impact of Kijima Type II imperfect repair model on equipment availability. Our specific interest is in the system steady-state availability. Since the derivation of a closed form expression for the limiting availability is extremely difficult, we use simulation modeling and analysis to estimate the system limiting availability. Next, we develop a meta-model to convert the system reliability and maintainability parameters into the coefficients of the limiting availability estimate without the simulation effort. Lastly, we identify an optimal age-based preventive maintenance policy that maximizes the system's steady-state availability.

3 - Predictive Maintenance For A Multi-unit System
Yisha Xiang, Lamar University, yxiang@lamar.edu
Zhicheng Zhu, David W Coit
Preventive maintenance has been extensively studied. Time-based PM and condition-based maintenance (CBM) are two major approaches for PM. However, time-based PM is often associated with high occurrence of system breakdowns, and CBM might incur more-than-necessary inspections. Recently, predictive maintenance has become popular since it aims to pinpoint when a failure is about to occur and prolong the operational time. However, only a few predictive models consider a multi-unit system. In this paper, we develop an opportunistic predictive maintenance structure for a multi-unit system. Numerical examples are provided to illustrate the proposed predictive maintenance policy.

4 - Reliability Of System With Clusters Of Dependent Degrading Components
Sanling Song, Rutgers University, Busch Campus, Core Building Room 201, Piscataway, NJ, 08854, United States, sanling@scarletmail.rutgers.edu; David W Coit, Qianmei Feng, Yisha Xiang
A reliability model is developed for complex multi-component system with each component subject to multiple failure processes. Degradation paths for certain components are stochastically dependent with clusters of dependent components. Gamma process is used to model the stochastic process of component deterioration. In this new model, two failure processes within each component are dependent due to simultaneous shared exposure to shock process. Furthermore, degradation paths among certain components are considered to be dependent. Components sharing dependent degradation can be determined by the MLE of model parameters.

**SB69**
Old Hickory- Omni
Panel Discussion: Internet of Things (IoT) Data Analytics
Sponsored: CPMS, The Practice Section
Sponsored Session
Moderator: Robin Lougee, IBM Research, IBM TJ Watson Research Center, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States, rlougee@us.ibm.com
1 - Panel Discussion: Internet of Things (IoT) Data Analytics
Robin Lougee, IBM Research, IBM TJ Watson Research Center, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States, rlougee@us.ibm.com
What are the opportunities and challenges for analytics and operations research when virtually every machine that operates in every market and sector can be connected to the internet? Thought leaders who create IoT technologies, systems, and application solutions will share their experiences, delineate the substance from the hype, and engage in a lively discussion of the most needed areas of future research.

2 - Panelist
Doug Meiser, The Kroger Co., 11450 Grooms Road, Cincinnati, OH, 45242, United States, doug.meiser@kroger.com

3 - Panelist
Srinivas Bollapragada, GE Global Research Center, 1 Research Circle, K1-5a50a, Niskayuna, NY, 12309, United States, bollapragada@research.ge.com

4 - Panelist
Ihsan Sehgal, IBM, 3039 E Cornwallis Road, Research Triangle Park, NY, 27709, United States, rlougee@us.ibm.com

5 - Panelist
Joseph Byrum, Syngenta, 913 31st Street, West Des Moines, IA, 50265, United States, joseph.byrum@syngenta.com

**SB70**
Acoustic- Omni
Transportation, Freight II
Contributed Session
Chair: Samaneh Shiri, Research Assistant, University of South Carolina, 101 pickens st. Apt. G2, Columbia, SC, 29205, United States, shiri@email.sc.edu
1 - Commodity-based Econometric Empty Trip Models
Carlos Alberto Gonzalez-Calderon, Research Associate, Rensselaer Polytechnic Institute, 425 7th st. Apt 5, Troy, NY, 12180, United States, gonzicae@rpi.edu; Jose Holguin-Veras, Ivan Dario Sanchez-Diaz, Ivan Sarmiento, Johanna Amaya
This paper estimates econometric models of empty trips of different commodities and vehicle types. In doing this, panel models with time-dependent parameters and fixed effects are used to assess how parameters change over time considering different commodities, and to detect the presence of time effects not captured by the other parameters. The performing of the formulation for the different commodities is tested in Colombia.

1 - On the Unique Features Of On-demand Peer-to-Peer Logistics Systems
Jennifer A Pazour, Assistant Professor, Rensselaer Polytechnic Institute, 110 8th street, CII 5217, Troy, NY, 12180, United States, pazouj@rpi.edu
On-demand peer-to-peer logistics systems use a business model for the movement and storage of goods that matches independent supply resources (warehouse space, truck space, delivery services) to demand requests on demand. These systems are part of the growing sharing economy and gig economy. We identify the unique features of these systems, comparing and contrasting them with traditional logistics systems. By mapping the characteristics to supply chain principles, we identify challenges with designing and operating, as well as using
these systems for the movement and storage of goods.

2 - The Impact Of U. S. Chassis Supply Models On Drayage Productivity
Samaneh Shiri, Research Assistant, University of South Carolina, 101 pickens st., Apt. G2, Columbia, SC, 29205, United States, shiri@mail.sc.edu, Nathan Huynh
The U.S. container chassis supply market is changing and new models are emerging recently. Supply chain stakeholders such as drayage companies could be affected by evolving models. To study this effect on drayage operation productivity, drayage problem is formulated as an extension of the multiple traveling salesman problem with time window. The proposed solution method is based on tabu search.

■ SB71
Electric- Omni
Transportation, Public II
Contributed Session

1 - The Simultaneous Vehicle Scheduling And Passenger Service Problem With Flexible Dwell Times
Allan Larsen, Associate Professor, Technical University of Denmark, DTU, Building 115 Room 003, Lynghby, DK-2800, Denmark, alar@dtu.dk, Joao F Fonseca, Evelien van der Hurk, Roberto Roberti, Stefan Ropke
In the SVSP-FDT the original timetables of the trips can be changed (i.e., shifted and stretched) in order to minimize a new objective function that aims at minimizing the operational costs plus the waiting times of the passengers at transfer points. The SVSP-FDT establishes the possibility of changing trips’ dwell times at important transfer points based on expected passenger flows. A compact mixed integer linear formulation of the SVSP-FDT capable a solving small instances as well as a meta-heuristic approach to solve medium/large instances are presented. The proposed solution methods are tested on a set of real-life instances from the greater Copenhagen area.

2 - A Static Repositioning Problem With Two Commodities For Bike-sharing Systems
Tiantian Zhu, Nanyang Technological University, 50 Nanyang Avenue, Singapore, 639798, Singapore, zhuht0003@e.ntu.edu.sg, Xiaofeng Nie
In order to handle the issue of static repositioning for bike-sharing systems, a novel integer optimization model is formulated, defining repositioning actions as transferring both bikes and lockers. To handle larger scale cases, a new clustering-first route-second heuristic is proposed. Based on a set of modified instances from the literature, the heuristic is tested to show its efficiency.

3 - Impact Of Carpool Lane Availability And Traffic Conditions On Peer-to-peer Ridesharing Demand
Sara Masoud, University of Arizona, 1300 E Fort Lowell Road, #A214, Tucson, AZ, 85719, United States, sara.masoud@email.arizona.edu, Neda Masoud, Young-Jun Son
This research examines the impact of carpool lane availability and traffic conditions on ridesharing demand using an agent-based simulation model. The proposed work uses a many-to-one ride-matching algorithm in which each rider can travel by means of transferring between multiple drivers’ vehicles. A ride-matching algorithm is embedded in the agent-based microscopic traffic simulation software AnyLogic®. Trip tables derived from a real travel demand data set of Los Angeles, California have been used to calibrate the simulation model. The results of this research will shed light on the types of urban settings that are more receptive towards ridesharing services.

■ SB72
Bass- Omni
Supply Chain Mgt II
Contributed Session
Chair: Mojtaba Mahdavi, PhD Student, University of Auckland, 12 Grafton Road, Auckland, New Zealand, m.mahdavi@auckland.ac.nz

1 - Optimal Procurement Design For A National Brand Supplier In The Presence Of Store Brand Competition
Xiang Fang, Associate Professor, University of Wisconsin-Milwaukee, 3202 North Maryland Avenue, Milwaukee, WI, 53211, United States, fangx@uwm.edu, Xinyan Cao
We consider a supply chain consisting of a national brand supplier and a retailer which intends to develop its own store brand. We develop a game-theoretic framework to analyze the strategic interaction between the two players in the presence of asymmetric information.

2 - Optimizing Array Of Shipping Cartons For Ecom DCS
Manjeet Singh, Research Manager, DHL Supply Chain, 570 Polaris Parkway, Westerville, OH, 43082, United States, manjeet.singh@dhl.com
Dimensional weight charges previously restricted to large packages are now applied to all packages. This has a large impact on Ecom DCs, we found that even in a small piece pick and pack operation on an average over 50% of shipments are now subjected to dimensional weight. Therefore, optimizing the array of shipping cartons can have a huge impact in combating dimensional weight charges. This study puts a special focus on large shipments, which are subjected to more severe charges. Additionally, it also makes recommendations on when to utilize made to order packaging.

3 - How To Design Effective Supply Chain Strategies Based On The Product And Demand Characteristics
Mojtaba Mahdavi, PhD Student, University of Auckland, 12 Grafton Road, Auckland, New Zealand, m.mahdavi@auckland.ac.nz, Tava Olsen
This paper analyzes how different characteristics of product and demand impact the capacity of supply chain strategies for efficiency and responsiveness. In our modeling work, we particularly discuss the impact of product life cycle, demand variability, contribution margin, and stock-out rate on both inventory and lead-time decisions.

■ SB79
Legends G- Omni
JFIG Paper Competition II
Sponsored: Junior Faculty JFIG

Sponsored Session
Chair: Andrew Schaefer, Rice University, 6100 Main Street - MS 134, Houston, TX, 77005, United States, andrew.schaefer@rice.edu

1 - JFIG Paper Competition II
Andrew Schaefer, Rice University, 6100 Main Street - MS 134, Houston, TX, 77005, United States, andrew.schaefer@rice.edu
The 2016 JFIG paper competition features paper submissions from a diverse array of talented junior faculty members. The prize committee evaluated submissions based on the importance of the topic, appropriateness of the approach, and significance of the contribution. After careful review, the prize committee selected a group of finalists to present their research in one of the two JFIG sessions. For information on the finalists and their papers, please refer to the online program.

2 - Simple Bayesian Algorithms For Identifying The Best Arm In A Multi-armed Bandit
Daniel Russo, Northwestern University, Evanston, IL, Dan.Joseph.Russo@gmail.com
This talk considers the optimal adaptive allocation of measurement effort for identifying the best among a finite set of options or designs. An experimenter sequentially chooses designs to measure and observes noisy signals of their quality with the goal of confidently identifying the best design after a small number of measurements. I propose three simple Bayesian algorithms for adaptively allocating measurement effort. Each is shown to have strong performance in numerical experiments, and a unified analysis establishes each satisfies a strong asymptotic optimality property.

3 - Recovering Statistical Guarantees Via The Empirical Robust Optimization
Henry Lam, the University of Michigan, khlam@umich.edu
We investigate the use of distributionally robust optimization (DRO) in recovering the statistical guarantees provided by the best benchmark that is in line with the central limit theorem, for the feasibility of expected value constraints. We show that the divergence ball, suitably empirically defined, and with its size calibrated by the quantile of a chi-square process excursion, amounts to such guarantees. The construction of this ball deviates from the standard mechanism of DRO in that the ball can have low, or even zero probability of covering the true distribution. Rather its performance is explained by connecting the dual of the DRO with a generalization of the empirical likelihood method.

4 - Staffing to Stabilize the Tail Probability of Delay in Service Systems with Time-Varying Demand
Yunan Liu, North Carolina State University, Raleigh, NC, yliu48@ncsu.edu
Abstract to come.
1 - A Lagrangian Relaxation Approach For A Multi-product Stochastic Production Planning Problem
Reha Uzsoy, North Carolina State University, Dept. of Industrial & Systems Engg, 300 Daniels Hall Camps Box 7906, Raleigh, NC, 27695-7906, United States, ruzsoy@ncsu.edu, Ankit Bansal, Karl Kempf
We model a single-stage multi item capacitated production-inventory system with stochastic demand. We present a chance-constrained production planning model that considers forewarning, which is employed using Lagrangian relaxation. Computation results show that the proposed approach outperforms previous myopic capacity allocation procedures.

2 - Order Scheduling For A Class Of Electronic Ceramic Manufacturers In Make To Order Environments
Zhongshun Shi, Peking University, Haidian Chengfu Road 298, Founder Building Room 512, Beijing, 100871, China, zhongshun@pku.edu.cn, Hongjiang Gao, Leyuan Shi
Motivated by the applications for a class of electronic ceramic manufacturers, we study the order scheduling on sintering operations in make-to-order environments, where competing furnaces are modeled as batch processing machines. The order consists of multiple types of jobs with specific demand quantity. We consider the total weighted order completion time as objective function and prove the problem is strongly NP-hard. Efficient heuristics with worst-case analysis and asymptotic performance analysis are also developed. Numerical results demonstrate that the proposed heuristics can give near-optimal solutions for different production scenarios.

3 - A Lagrangian Approach For Coordinating Capacity Negotiations In A Semiconductor Firm
Reha Uzsoy, North Carolina State University, Dept. of Industrial & Systems Engg, 300 Daniels Hall Camps Box 7906, Raleigh, NC, 27695-7906, United States, ruzsoy@ncsu.edu, Ankit Bansal, Karl Kempf
We model the negotiations between a product development organization and a production organization for access to manufacturing capacity for product development activities in the semiconductor industry. We develop a negotiation framework based on Lagrangian decomposition that maximizes overall firm contribution subject to the resource constraints of both organizations. The approach aims to achieve coordinated decisions between the two organizations, and provides a benchmark for alternative models of negotiations.

4 - Modeling And Solution For Supply Chain Scheduling In Cold Rolling
Shengnan Zhao, PhD Candidate, Northeastern University, Shenyang, China, zhao6shengnan_nceu@163.com, Lixin Tang, Qingxin Guo
This paper studies a supply chain scheduling problem which is derived from steel production. The problem is to make coil schedules with the aim of balancing the capacity of each production line, and minimizing the total setup cost. To describe the problem, we formulate a MILP model with consideration of practical technological requirements. Then we develop an improved discrete differential evolution (DE) algorithm to solve it. The computational experiments show that the proposed DE algorithm outperforms the compared DE algorithms for solving this problem. In addition, the proposed algorithm is also competitive in comparison with the commercial optimization solver CPLEX.

5 - Analysis Of The Barriers To Implement Additive Manufacturing Technology In The Indian Automotive Sector: A Fuzzy-ISM Approach
Gourav Dwivedi, Doctoral Student, Indian Institute of Management, Indian Institute of Management, IIM Road, Off Sitapur Road, Lucknow, 226013, India, fpm14013@iiml.ac.in, Rajiv K Srivastava, Sunit K Srivastava
This paper analyzes the interaction among barriers to implement additive manufacturing (AM) technology in the Indian automotive sector. We use Fuzzy-Interpretive Structural Modeling (Fuzzy-ISM) method to derive hierarchy and direction and to measure the strength of relations among these barriers. Dominant barriers are identified using this approach. The findings may be useful for managers to develop suitable mitigation strategies. This study contributes to AM literature by the structured presentation of the barriers.
3 - Load Forecasting Using Support Vector Machine With Optimized Parameters
Oluwemi A. Omitaomu, Oak Ridge National Laboratory, omitaomuo@ornl.gov

Load forecasting is central to most of the energy transaction decisions in power systems planning and energy markets. Until now, most approaches for forecasting energy demand rely on monthly electrical consumption data. The emergence of smart meters is changing the data landscape for electric utility companies, and creating opportunities for utility companies to collect and analyze energy consumption data at a much finer temporal resolution. To enhance the estimation of energy demand at the household and network levels, we present an on-line accurate support vector regression technique that uses optimized regression parameters for forecasting real-time energy demand using smart meters data.

4 - Catch Me If You Can: Detecting Pickpocket Suspects From Large-scale Transit Records
Chuanren Liu, Drexel University, chuanren.liu@drexel.edu

Massive data collected by automated fare collection (AFC) systems provide opportunities for studying both personal traveling behaviors and collective mobility patterns in the urban area. We creatively leverage such data for identifying thieves in the public transit systems. We develop a thief active tracking system that identifies pickpocket suspects based on their daily transit records. We first extract a number of features from each passenger's daily activities in the transit systems. Then, we exploit a combination of outlier detection and classification models to identify thieves, who exhibit abnormal traveling behaviors.

■ SC02
101B-MCC
Quality and Statistical Decision Making in Health Care Applications
Sponsored: Data Mining
Sponsored Session
Chair: Cao Xiao, University of Washington, 3900 Northeast Stevens Way, MEB, Seattle, WA, 98195, United States, xciao@uw.edu
Co-Chair: Shuai Huang, University of Washington, Seattle, WA, United States, shuilai@uw.edu
1 - Modeling And Analysis Of The Waiting Time Of Rapid Response Process In Acute Care
Nan Chen, Tsinghua University, Room 615, Shunde Building, Tsinghua University, Haidian District, Beijing, 100084, China, chenn618@gmail.com, Xiaolei Xie, Li Zheng

Improving the efficiency of rapid response process in acute care plays a significant role to ensure patient safety. We develop an analytical method to evaluate the waiting time and its variability. We discussed the structural properties and continuous improvement by adding care providers. A bottleneck indicator is introduced and a simple approximation formula is obtained. Case study is introduced to illustrated the application of the method.

2 - Modeling And Prediction Of The Mental Health Conditions Of Web Users
Qingpeng Zhang, City University of Hong Kong, 1, Hong Kong, brianzq@gmail.com

The digital footprints of Web users left on the Web presents important proxies of their health conditions. In this research, we propose novel machine learning algorithms to model and predict the mental health conditions of Web users based on their online activities on social media. The preliminary results show the potential of using the open source social media data to infer the mental health conditions of people, and help health providers make better decisions.

3 - Learning Semantics Behind Health Status Disclosure On Twitter
Zhijun Yin, Vanderbilt University, Nashville, TN, 37203, United States, zhijun.yin@vanderbilt.edu, Bradley Malin

User generated content in social media is increasingly acknowledged as a rich resource for research into health problems. We in this talk present a framework to investigate how semantics are related with disclosure routines for 34 health issues. Our findings show that health issues related with family members, high medical cost and social support (e.g., Alzheimer’s Disease, cancer, and Down syndrome) lead to tweets that are more likely to disclose another individual's health status, while tweets with more benign health issues (e.g., allergy, arthritis, and bronchitis) with biological processes (e.g., health and ingestion) and negative emotions are more likely to contain self-disclosures.

■ SC03
101C-MCC
Doing Good with Good OR I
Invited Session
Chair: Karen Smilowitz, Northwestern University, 2145 Sheridan Road RM D239, Evanston, IL, 60208, United States, ksmilowitz@northwestern.edu
1 - The Operational Challenges Of Sharing-Economies: An Optimal Re-balancing Mechanism For The Bike-Sharing Industry
Pantelis Loupos, Department of Operations Management, Kellogg School of Management, Northwestern University, Evanston, IL 60208, Can Urgun

Bike-sharing programs have been gathering momentum, but their expansion poses operational challenges. We propose a novel solution to the bike re-balancing problem, that is centered around the actions of the riders instead of utilizing trucks for re-balancing. Our findings indicate great promise, whose adoption by bike sharing operators could have a positive impact on the industry.

2 - The Humanitarian Pickup And Distribution Problem
Ohad Eisenhandler, Department of Industrial Engineering, Tel Aviv University, Tel Aviv, Israel, ohadeis@gmail.com, Michal Tzur

We address the logistic challenges of food banks, which collect donated food from suppliers and distribute it to welfare agencies. We model the problem as a routing – resource allocation problem. Motivated by the activity of Israeli and American organizations, we introduce an innovative objective function, which balances equity and effectiveness in this operation, and propose exact and heuristic solution methods.

3 - Data Analytics For Optimal Detection Of Metastatic Prostate Cancer
Christine Barnett, Department of Industrial & Operations Engineering, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI 48109, cbarnett@umich.edu, Selin Merdan

We used data-analytics approaches to develop, calibrate, and validate predictive models to help urologists make prostate cancer staging decisions. These models were used to design guidelines that weigh the benefits and harms of radiological imaging. The Michigan Urological Surgery Improvement Collaborative implemented these guidelines which miss less than 1% of metastatic cancers while reducing unnecessary imaging by more than 40%.

■ SC04
101D-MGC
Gas-Power Market Integration
Sponsored: Energy, Natural Res & the Environment, Energy I Electricity
Sponsored Session
Chair: Robert Brooks, President, RBAC Inc, 14930 Ventura Blvd. Ste. 210, Sherman Oaks, CA, 91403, United States, rebrooks@rbac.com
1 - Analysis Of Gas / Electric Integration And Coordination In The Eastern Interconnection Of The United States And Canada
Sara Wilmer, Levitan & Associates, Inc., swilmer@levitan.com

Levitan & Associates has conducted recent analyses of gas-electric integration and coordination on behalf of the Eastern Interconnection Planning Collaborative and the Department of Energy. These analyses examined whether future electric sector demand for natural gas will be able to be accommodated by the available natural gas infrastructure as renewable penetration expands and coal-fired resources are retired. This case study will describe the modeling tools and integrated modeling framework used to conduct the work, and challenges faced both in the representation of real-world gas and electric systems in the selected modeling tools and in the integration of the different modeling tools.
Environmental regulations in the energy sector paired with a tsunami of shale gas have changed power and natural gas market operations. The shift in regional gas supply is driving infrastructure changes. Lower renewable costs are impacting capacity decisions and affecting reliability requirement decisions. Electricity demand has gone through a paradigm shift as steps taken to improve energy efficiency are realized, changing views on how to model future growth. In this environment, having tools to evaluate the impact of changes in both the electricity and gas markets andpass detailed information between the models is essential to understanding how each assumption impacts both markets.

The results show consistent impacts of optimization models with a range of levels of sophistication, including DC optimal interconnection are optimized based on several variants of a 300-bus framework to quantify the impact of the Clean Power Plan on both power and efficiency are realized, changing views on how to model future growth. In this context, this talk presents various approaches to solve the transmission expansion planning problem under generation expansion uncertainty. In particular, we compare robust and stochastic methods, and discuss about their suitability to properly balance benefits of economies of scale against risks of stranded assets.

Benefits of transmission network planning significantly depend on deployment patterns of electricity generation that are characterized by severe uncertainty. In this context, this talk presents various approaches to solve the transmission expansion planning problem under generation expansion uncertainty. In particular, we compare robust and stochastic methods, and discuss about their suitability to properly balance benefits of economies of scale against risks of stranded assets.

In this work a recently developed mathematical formulation has been applied with traditional stochastic programming methods in the context of electric infrastructure expansion planning. While the adaptation formulation structure resembles that of a generic stochastic program it deviates from the temporal conventions of traditional expansion planning formulations. Structural comparisons and simulations are investigated to better understand differences in the methods.

2 - Value Of Model Sophistication On Transmission Expansion Planning
Qingyu Xu, Johns Hopkins University, Baltimore, MD, 21218, United States, qxu29@jhu.edu, Saamrat Kasina, Benjamin Field Hobb
A set of transmission expansion plans for the western North America interconnection are optimized based on several variants of a 300-bus co-optimization model with a range of levels of sophistication, including DC optimal power flow, unit commitment and stochastic planning. The economic benefits of increasing model realism are estimated. The results show consistent impacts of sophistication upon transmission and generation investments, with load flow representations mattering most.
3 - Data Mining For Result Prediction In Sports
Kyuhan Lee, Seoul National University, Seoul, Korea, Republic of, kyuhanlee019@gmail.com
Insoo Park, Buil Mooy Kim
The expansion of sports betting has extensively contributed to the increase of public interest on sports result prediction. In academia, as statistical data respecting sports games are readily accessible, abounding research has been conducted regarding the subject. In this paper, unlike the past studies focusing on limited types of data, we use a comprehensive set of data, including statistical data as well as text data, to enhance the accuracy of sports result prediction. We expect that our prediction model produces a preferable outcome comparing to the models of previous research.

4 - Predicting Users’ Continuous Participation In Online Health Virtual Community: Demographic And Content Cues
Yanyan Shang, Dakota State University, Madison, SD, United States, yshang@pluto.dsu.edu, Jun Liu, Iljoo Kim
Online health community (OHC) is a platform where people with similar health conditions gather virtually to ask questions, share experiences, provide support, and exchange healthcare knowledge. To be effective, the OHCs have to maintain active continuance participation from their users. The purpose of this study is to identify the factors that affect the users’ continuance participation. Specifically, we attempt to use data analytics techniques to identify the demographic and content cues that affect the users’ continuance participation. The findings of our research help community managers deploy various strategies to encourage the continuance participation of different types of members.

4 - Allocating Countermeasures To Defend Water Distribution Systems Against Terrorist Attack
Jacob Monroe, North Carolina State University, Raleigh, NC, United States, jmonroe@ncsu.edu
Elizabeth Ramsey, Emily Zeichman Berglund
An agent-based model is developed to simulate the attack and defense of a water distribution system to analyze security resource allocation strategies for protecting against chemical contamination events. A single period attacker-defender game is simulated, in which an attacker seeks to contaminate a system node, and a group of defenders seek to minimize the public health impact from attack. Terrorist decisions are simulated using a multi-attribute utility function. The utility manager assigns personnel and security equipment to nodes using one of three security resource allocation strategies.

SC08
103A-MCC
Undergraduate OR Prize - II
Invited: Undergraduate Operations Research Prize
Invited Session
Chair: Pavithra Harsha, IBM Research, 1101 Kitchawan Road, Room 34-225, Yorktown Heights, NY, 10598, United States, pharsha@us.ibm.com
1 - Hot Sales Logistics Optimization For ET
Ba ak Erman, Bilkeni University, Ankara, Turkey, basakerman@gmail.com
Zeynep Yaprap Be lk, Deniz Berlin Karaöko, Umut Midüro Lu, Yektah Jehat Misrakli, Egehan Yanik
ET is one of the leading food manufacturer in Turkey. Additional to standard distribution system, ET has a local distribution system that enables trucks to visit smaller retailers and pursue hot sales. The aim of the project is to increase the efficiency of hot sales where demand by the retailers are better satisfied. The delivery route is divided into two: route from the main depot, which is far from customers, to the customers, and the route between customers. This project aims to maximize the utility of time spend in routes by assigning customers to trucks and identifying depot locations.

2 - Regularized Linear Regression via Robust Optimization Lens
Hari Bandi, Massachusetts Institute of Technology, Cambridge, MA, United States, hbandi@mit.edu, Garud Iyengar, Vineet Goyal
There has been research in recent years to understand why regularized linear regression methods work well in the presence of noise. This problem has been approached by establishing relationship between robust optimization and regularized linear regression methods. In this work, we seek to understand the same for general loss functions used widely in Statistics, Machine Learning and Econometrics literature and we propose principled approaches to select regularization functions in order to optimally balance the bias-variance trade-off in regularized regression.

3 - On Comprehensive Mass Spectrometry Data Analysis For Quality Assessment Of Biological Samples
Sameer Manchanda, Purdue University, West Lafayette, IL, United States, Mikaela Meyer, Nan Kong, Qianqian Li, Yan Li
Mass spectrometers have become promising instruments to acquire proteomic information, creating a need for a data analysis platform for classification of mass spectra and identification of important biomarkers. To meet this need, we present a comprehensive pattern recognition platform for spectrum preprocessing and classification. In a case study, the platform achieves higher than 90% sensitivity and specificity in distinguishing rat blood samples stored for different amounts of time and derives fingerprint patterns of serum proteins that are strongly associated with the sample classification.

3 - Feed-in Tariffs Vs. Renewable Portfolio Standards: The Effect Of Market Power
Duan Zhang, University of California Santa Cruz, Santa Cruz, CA, United States, dzhang33@ucsc.edu, Yilu Chen, Makoto Tanaka
The performance-based standard under the US federal Clean Power Plan relies on trading the emission rate credits (ERCs), which represent the equivalent MWh of energy generated or saved with zero associated CO2 emissions, to equating marginal abatement costs across generating units. We show theoretically the equivalence between the ERCs and the traditional mass-based trading when states are subject to their own performance-based standards. We also identity the conditions under which the ineffectiveness of the performance-based standard might arise, leading to a divergence of permit prices across states. A numerical 3-node model was built to illustrate our findings.

3 - Allocating Countermeasures To Defend Water Distribution Systems Against Terrorist Attack
Yilu Chen, University of California Santa Cruz, yilushchen@ucsc.edu, Afzal Siddiqui, Makoto Tanaka
The federal Clean Power Plan (CPP) stipulates a state-specific performance-based CO2 standard and offers considerable flexibility to the states in achieving the target. We analyze the tradable performance standards and related mass-based standard when they are subject to imperfect competition by formulating them either as a complementarity problem or a mathematical program with equilibrium constraints (MPEC). The MPEC is solved as mixed integer problems with a binary expansion. We show that while the cross-subsidy inherent in the performance-based standard that might effectively reduce power prices, it could in inflate energy demand, thereby rendering permits scarce.
1 - Relative Clique Relaxations In Complex Networks

As “communities,” which can be rigorously characterized using graph-theoretic concepts. In this presentation, we will focus on so-called relative clique relaxation models, which are obtained by relaxing certain metrics that attain their maximum possible values on a clique: edge density, minimum vertex degree, and vertex connectivity. We will discuss optimization problems of identifying such clusters in networks, as well as related asymptotic results on phase transitions in random graphs.

2 - Robust Network Clusters With Small-world Property

We will discuss theory and computational practice, and attempt to relate our work to earlier results by Renegar and Barvink. Joint work (Gonzalo Munoz, Chen Chen and Daniel Bienstock).

3 - Detecting Essential Proteins Using A Novel Star Centrality Metric

If you have a simple, undirected graph, the Independent Union of Cliques (IUC) problem is to find the maximum subset of vertices, in which every connected component is a clique. It is known that this problem can be formulated on 3-uniform hypergraphs as the maximum weak independent set. We propose the estimates for IUC problem based on different SDP relaxations, extending the Lovász estimate for the maximum stable set. The comparison of different approaches is also presented.

4 - Estimating The Maximum IUC Using SDP Relaxations

Joint work (Gonzalo Munoz, Osaka University, Osaka, Japan, and Daniel Bienstock).

We present ongoing work on solving polynomial optimization problems using linear and convex relaxations based on a number of ideas, including separation from the set of rank-1 psd matrices, and, in particular, the method of approximate representation of continuous variables as weighted sums of binary variables. We will present our current work as well as future directions. This is a joint work (Gonzalo Munoz, Chen Chen and Daniel Bienstock).

SC11

104A-MCC

Dense Clusters in Network Optimization

We present a flexible iterative framework to approximately solve robust convex optimization problems. Our results are based on weighted regret online convex optimization and online saddle point problems. A key distinguishing feature of our approach from prior literature is that it requires access to only cheap first-order oracles for each constraint individually and does simple online updates in each iteration while maintaining the same convergence rate. For strongly convex functions, we also establish a new improved iteration complexity. As a result, our approach becomes much more scalable and hence preferable in large-scale applications from machine learning and statistics domains.

3 - New And Old Results On Polynomial Optimization

We present ongoing work on solving polynomial optimization problems using linear and convex relaxations based on a number of ideas, including separation from the set of rank-1 psd matrices, and, in particular, the method of approximate representation of continuous variables as weighted sums of binary variables. We will discuss theory and computational practice, and attempt to relate our work to earlier results by Renegar and Barvink. Joint work (Gonzalo Munoz, Chen Chen and Daniel Bienstock).
2 - Balancing Weather Risk And Crop Yield For Soybean Variety Selection
Ling Tong, University of Iowa, Iowa City, IA, United States, ling-tong@uiowa.edu, Bhupesh Shetty, Samuel Burer

We propose an optimization-based method to assist a farmer’s choice of soybean varieties to plant in order to maximize expected yield while also managing risk, where the primary uncertainty faced by the farmer is due to seasonal weather patterns. By solving a sequence of MIPs, we calculate the efficient frontier between the two competing objectives of maximizing expected yield and guaranteed yield over all possible season types. The coefficients of the MIPs are estimated using a multiple-linear-regression model and a Bayesian updating scheme applied to the training and evaluation data. Using the efficient frontier, the farmer may choose an optimal solution that fits his/her risk-budget profile.

3 - Decision Assist Tool For Seed Variety To Provide Best Yield In Known Soil And Uncertain Future Weather Conditions
Mehul Bansal, Robert Bosch Engineering and Business Solutions, Bengaluru, Karnataka, India, Mehul.Bansal@in.bosch.com
Nataraj Vusrirka

The gap between agriculture produce and demand is ever increasing due to growing world population. There is an urgent need for utilizing all possible methods and technology solutions to bridge this gap. One of the key challenges to increase the agricultural produce is the ability to take right decisions under uncertain climate and weather conditions. In this paper we discuss a method to provide decision assist to the farmer on the best variety of soybean seed to be sown at the start of a season. In order to optimize the yield under uncertain conditions, we use a combination of crop yield modeling, weather forecasting and portfolio optimization techniques to suggest best combination of soybean variety. The data used in this method is the historical soybean produce data and the corresponding soil and weather conditions under which the yield was produced, day-wise weather data (temperature, precipitation and solar radiation) at farm sites from 2008 to 2014. We recommend planting the following varieties with the given percentages at site 2290 for year 2016: (i) 10% of Variety V107, (ii) 35% of Variety V179, (iii) 10% of Variety V189, (iv) 10% of Variety V193, and (v) 35% of Variety V46.

■ SC15

104E-MGC
Optimization and Learning in Biomedical Applications
Invited: Modeling and Methodologies in Big Data
Invited Session
Chair: Mengdi Wang, Princeton University, NY, United States, mengdi@princeton.edu

1 - Latent Graphical Models For Mixed Data
Yang Ning, Princeton University, Princeton, NJ, United States, yning@exchange.princeton.edu, Juan Qin, Han Liu, Hui Zou

Graphical models are commonly used tools for modeling multivariate random variables. While there exist many convenient multivariate distributions such as Gaussian distribution for continuous data, mixed data with the presence of discrete variables or a combination of both continuous and discrete variables poses new challenges in statistical modeling. In this talk, we propose a semiparametric model named latent Gaussian copula model for binary and mixed data.

2 - Hierarchical Knowledge-gradient With Stochastic Binary Feedbacks With An Application In Personalized Health Care
Yinglei Wang, Princeton University, Princeton, NJ, United States, yinglei@cs.princeton.edu, Warren B. Powell

Motivated by personalized health care problems, we consider the problem of sequentially making decisions that are rewarded by “successes” and “failures” which can be predicted through an unknown relationship that depends on a partially controllable vector of attributes for each instance. The learner takes an active role in selecting samples from the instance pool. The goal is to maximize the probability of success. Our problem is motivated by healthcare applications where the highly sparsity makes learning difficult. With the adaptation of an online boosting framework, we develop a knowledge-gradient (KG) policy to guide the experiment by maximizing the expected value of information.

3 - Approximate Newton-type Methods With Cubic Regularization
Saeed Ghadimi, Princeton University, Princeton, NJ, United States, sghadimi@princeton.edu, Tong Zhang, Han Liu

In this talk, we consider a class of second order methods for solving convex optimization problems. In particular, we propose Newton-type methods with cubic regularization when hessian of the objective function is not completely available. Convergence analysis of these methods under different conditions like stochastic setting are also presented.
We present a clustering-based preconditioning strategy for stochastic programs within an interior-point framework on distributed memory machines. This approach is unique in that the scenario clustering is applied at the linear solver level, not at the outer NLP level, allowing for scenario clusters to change from iteration to iteration. This approach allows one to build a small and sparse preconditioner with fewer clusters, and then solve the full KKT system in parallel using GMRES. We also describe the features of our implementation in C++, demonstrate that high scenario compression rates of up to 94% can be obtained, and that speedups of an order of magnitude are achievable.

2 - Optimization Driven Scenario Grouping

Kevin C Ryan, Georgia Institute of Technology, Atlanta, GA, United States, kryan31@gatech.edu, Shabbir Ahmed, Santanu Subbas Dey, Deepak Rajan

Scenario decomposition algorithms for stochastic programs compute bounds by dualizing all nonanticipativity constraints and solving individual scenario problems. We develop an optimization problem that selects a set of nonanticipativity constraints to re-enforce, placing scenarios into 'groups'. We show that the proposed grouping problem is NP-hard in general, identify a polynomially solvable case, and present a mixed integer programming formulation. Its effectiveness is demonstrated on a set of standard test instances for two-stage 0-1 stochastic programs. The idea is extended to propose a finitely convergent algorithm for two-stage stochastic programs with a finite feasible region.

3 - MIDAS: A Mixed Integer Dynamic Approximation Scheme

Andy Philpott, University of Auckland, Auckland, New Zealand, a.philpott@auckland.ac.nz, Faisal Wahid, Frederic Bonnans

Mixed Integer Dynamic Approximation Scheme (MIDAS) is a sampling-based algorithm for solving finite-horizon stochastic dynamic programs with monotonic Bellman functions. MIDAS approximates these value functions using step functions, leading to stage problems that are mixed integer programs. We provide a general description of MIDAS, and illustrate it on some instances of revenue maximization problems for hydroelectricity generators.

4 - Nested Decomposition Of Multistage Stochastic Integer Programs With Binary State Variables

Jikai Zou, Georgia Institute of Technology, Atlanta, GA, United States, jikai.zou@gatech.edu, Shabbir Ahmed, Andy Sun

We propose a valid nested decomposition algorithm for multistage stochastic integer programming problems where the state variables are binary. We prove finite convergence of the algorithm as long as the cuts satisfy some sufficient conditions. We discuss the use of well-known Brønders' and integer optimality cuts within this algorithm, and introduce new cuts derived from a reformulation of the problem where local copies of state variables are introduced. We propose a stochastic variant of this algorithm and prove its finite convergence with probability one. Numerical experiment on a large-scale generation expansion planning problem will be presented.

2 - A two-stage stochastic program with joint-chance constraints for a hybrid wind-conventional generator system

Bismark Singh, The University of Texas at Austin, Austin, TX, bismark.singh@utexas.edu, David Morton, Surya Santoso

We consider an application of a two-stage joint chance constrained stochastic program with recourse to power generation. As a first stage decision we propose an hour-by-hour firm energy output to the system operator. The conventional generator serves as a recourse option which can be used if the uncertain wind output is not large enough. We seek to ensure that with high probability our promised energy output is met by this generator and wind combination. We computationally investigate this joint-chance constrained model with recourse, using data from Texas.

3 - An integer L-shaped approach to a stochastic program with endogenous uncertainty and chance-constrained recourse

Gabriel Lopez Zeneros, Assistant Professor, University of North Carolina at Charlotte, 9201 University City Blvd., Cameron Hall 242, Charlotte, NC, 28223, United States, gzenaros@uncc.edu, Oleg A. Prokopyev, Deepak Rajan

We present a stochastic integer program with chance-constrained recourse for the surgery scheduling and one-time rescheduling problem. Our goal is to provide an approach for creating initial surgery schedules that afford agility in day-of-surgery rescheduling so as to minimize the total expected operating-room underutilization under probabilistic overutilization constraints. We use the integer L-shaped method to iteratively refine the initial surgery schedule to enable subsequent rescheduling of surgeries under the scenarios the initial schedule induces.

4 - Solving 0-1 semidefinite programs for distributionally robust allocation of surgery blocks

Yiling Zhang, University of Michigan, Ann Arbor, MI, United States, yziling@umich.edu, Siqian Shen, Ayca Erdogan

We consider surgery allocation in operating rooms (ORs) under random surgery durations. We minimize the cost of opening ORs and surgery assignments, while restricting OR overuse risk via a distributionally robust (DR) chance constraint, built on a moment-based ambiguous set. Following the conic duality, the DR chance-constrained model is equivalent to a 0-1 semidefinite program, solved by a cutting-plane algorithm. Alternatively, we optimize a less conservative 0-1 second-order conic program approximation. We test outpatient treatment instances, and compare different approaches.

3 - Tight formulations for value-at-risk minimization problems

Konstantin Pavlikov, University of Florida, Gainesville, FL, 32611, United States, kpa@ufl.edu, Alexander Veremyev, Eduardo Pasiliao

The problem of minimization of Value-at-Risk via MIP formulations with big M constants is considered. Special emphasis is put to setting the tightest big M for every scenario where it should be positive. We show that the problem of setting the tightest possible M is equivalent to solving another instance of VaR minimization problem. Moreover, we propose a specialized branch-and-bound algorithm to solve the problem that dynamically updates big M during its execution. Computational experiments are provided and discussed.

4 - Updates to PIPS-SBB: Distributed-memory Structure-aware Presolve and Cut Generation

Geoffrey Malcolm Oxberry, Lawrence Livermore National Laboratory, Livermore, CA, United States, goxberry@gmail.com

Deterministic equivalent formulations of stochastic MILPs from applications such as unit commitment (UC) can exceed available memory on a single workstation. To overcome this issue, we have developed PIPS-SBB, a distributed-memory parallel stochastic MILP solver based on the distributed-memory parallel stochastic LP solver PIPS-S. Our initial work focused on implementing a distributed-memory B&B algorithm that parallelizes LP solves. To further improve performance, we discuss implementing structure-aware variants of presolve methods and cuts, and how these methods improve performance. Based on these results, we discuss a path forward to solving larger UC problem instances.
1 - Models And Algorithms For Maximum Proportional Flow Problems With Semicontinuous Restrictions
Robert Mark Curry, Clemson University, Clemson, SC, United States, rmcurry@g.clemson.edu, Cole Smith
We consider a variation of the multi-source, multi-sink maximum flow problem in which flow must emanate from the source nodes according to a prescribed rate, while flow arrives to the sink nodes at another given rate. Additionally, we restrict flow variables to be semicontinuous, in which the flow must either be 0 or no less than some lower bound. We call this problem the semicontinuous maximum proportional flow problem (SC-MFPF) since the amount of outgoing flow must leave the source nodes and arrive at the sink nodes according to a given proportional pattern. To solve the SC-MFPF, we decompose the formulation and employ a Branch-and-Price algorithm.

2 - Enumeration Algorithms For Infrastructure Resilience Analysis
W. Matthew Carlyle, Naval Postgraduate School, mcarlyle@nps.edu, David Alderson
We propose a functional definition of infrastructure resilience based on parametric analysis of two-stage (attacker-defender) and three-stage (defender-attacker-defender) models that require enumeration of a potentially enormous number of optimization problems. We present computational techniques that use bounding arguments to significantly limit the enumeration while still providing useful measures of infrastructure resilience and support the use of faster heuristic algorithms for the most difficult of these problems.

3 - Faster Algorithms For The Time-cost-tradeoff Problem And Minimum Cost K-flow Problems With A New All-min-Cuts Procedure
Dorit S. Hochbaum, University of California, Berkeley, Berkeley, CA, United States, hochbaum@ieor.berkeley.edu
We explore surprising links between the time-cost-tradeoff (TCT) problem in project management and the minimum cost flow problem (MCF) leading to faster algorithms for both problems. The algorithm relies on a new procedure all-min-cuts procedure, which for a given maximum flow, is capable of generating all minimum cuts of equal value very efficiently. This results in faster strongly polynomial algorithms for unit capacity MCF; the K-MCF problem and uniform costs TCT and match the complexity of the fastest algorithm for the assignment problem.

2 - Generating And Solving The Large Scale AC-security Constrained Optimal Power Flow Problems In Parallel
Feng Qiang, Argonne National Laboratory, Lemont, IL, 60439, United States, fjiang@anl.gov, Cosmin G. Petra, Joseph A. Huchette, Miles Lubin, Mihai Anitescu
In this talk, we present an integrated approach for the modelling and solution of the AC-SCOPF problems using StructureMP, a newly developed parallel extension of JuMP for modelling large scale optimization problems in Julia and PIPS optimizer solver for HPC platforms. We will present a thorough study of the the parallel performance of StructureMP and PIPS for large scale AC-SCOPF instances on hundreds of nodes.

3 - ParaXpress: A Massively Parallelized MIP Solver Designed To Run On The Largest Supercomputers
Yuji Shinano, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, shinano@zib.de, Timo Berthold, Stefan Heinz
The Ubiquity Generator (UG) is a framework for the external parallelization of MIP solvers. It was used to develop ParaXpress, a distributed memory, massively parallel version of the open-source solver SCIP that runs on up to 80,000 cores in parallel. In this talk, we introduce ParaXpress, for which one of the fastest commercial MIP solvers, the FICO Xpress-Optimizer, has been parallelized by UG. Combining the internal shared-memory parallelization of Xpress and the external parallelization of UG, we aim at a new order of magnitude for supercomputer core-usage in MIP solving.

SC20
106B-MCC
Novel Dimension Reduction Techniques for High Dimensional Data Using Information Complexity
Invited: Tutorial
Invited Session
Chair: Hamparsum Bozdag, University of Tennessee-Knoxville, Oper and Mgmt Sci, Knoxville, TN, 37996, United States, bozdag@utk.edu
1 - Novel Dimension Reduction Techniques For High Dimensional Data Using Information Complexity
Hamparsum Bozdag, University of Tennessee-Knoxville, Oper and Mgmt Sci, Knoxville, TN, 37996, United States, bozdag@utk.edu, Esra Pamukcu
This tutorial introduces and develops two computationally feasible intelligent feature extraction techniques that addresses the potentially daunting statistical and combinatorial problems. First part of the tutorial employs a three-way hybrid between: Probabilistic Principal Component Analysis (PPCA) to reduce the dimensionality of the dependent variables; Multivariate regression (MVR) models that account for misspecification of the distributional assumption to determine a predictive operating model for glass composition for automobiles; and uses the genetic algorithm (GA) as the optimizer along with the misspecification-resistant form of Bozdag’s iCOMP as the fitness function. Second part of the tutorial is devoted to dimension reduction via a novel Adaptive Elastic Net (AEN) regression model to reduce the dimension of a Japanese stock index called TOPIX as the response to build a best predictive model when we have “large p, small n” problem. Our results show the remarkable dimension reduction in both of these real-life examples of wide datasets, which demonstrates the versatility and the utility of the two proposed novel statistical data modeling techniques.

SC21
106B-MCC
Novel Dimension Reduction Techniques for High Dimensional Data Using Information Complexity
Invited: Tutorial
Invited Session
Chair: Hamparsum Bozdag, University of Tennessee-Knoxville, Oper and Mgmt Sci, Knoxville, TN, 37996, United States, bozdag@utk.edu
1 - Novel Dimension Reduction Techniques For High Dimensional Data Using Information Complexity
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INFORMS Nashville – 2016
3 - Social Desirability Bias In Self-reported Compliance With Hand-hygiene Regulations
Reidar Hagtvedt, University of Alberta School of Business, 2-43 Business Building, Edmonton, AB, T6G 2R6, Canada, hagtvedt@ualberta.ca, Kenneth L. Schultz, Sarah Forgie
We posit Social Desirability Bias (SDB) as an explanation for why self-reported compliance with hand-hygiene (HH) regulations is so much higher than observed compliance. SDB breaks down into self-deception and image management. Using data gathered at a large teaching hospital over six years, we first show that in spite of the two measures being nearly uncorrelated, respondents do know something of their own compliance rate, and secondly, that image-management is a greater effect than self-deception.

4 - Reducing Surgical-site Infections For Coronary Artery Bypass Graft Patients
Eva Lee, Georgia Tech, evakylee@isye.gatech.edu
This is joint with Grady Health Systems. A system-approach is designed to reduce surgical site infection (SSI) which takes into account the inter-dependency of preoperative, intraoperative and postoperative processes. A decision tree model and a simulation-optimization model are developed to identify critical infection factors. Changes involve pre-op sterilization, nasal cleaning, hair-clipping, and optimized antibiotics prophylaxis timing and dosage. E-alerts are also implemented for compliance. The hospital realized a drop of 65% in SSI (from 23% to 8%) in the first six months. It achieved zero percentage thereafter and sustained that rate for 18 months.

SC22
107B-MCC
Joint Panel Session: ORHP/HAS/MSOM-Hlth: Challenges and Lessons Learned from Influencing National Policy Change in Organ Transplant
Invited: ORInformed Healthcare Policies
Invited Session
Moderator: Sanjay Mehrotra, Northwestern University, 2145 Sheridan, Evanston, IL, 60208, United States, mehra@northwestern.edu
1 - Challenges And Lessons Learned From Influencing National Policy Change In Organ Transplant
Sanjay Mehrotra, Northwestern, mehra@northwestern.edu
Policy changes are being debated nationally to reduce disparity and improve efficiency in organ allocation. These issues are contentious within the transplant community as such policy changes impact patient lives lost and finances at the regional and national level. Operations research models have been used to help arrive at recommendations in the past, but get questioned. This session will focus on lessons learned from the transplant community that would be helpful for policy related research in other areas of work in healthcare. The panelists have worked closely with the transplant community as joint researchers, advisors and reviewers of proposed changes.

2 - Panelist
Andrew J Schaefer, Rice University, andrew.schaefer@rice.edu

3 - Panelist
Sommer Gentry, US Naval Academy, gentry@usna.edu

4 - Panelist
Baris Ata, Northwestern University, a, Evanston, IL, 1, United States, baris.ata@chicagobooth.edu

5 - Panelist
Tim L. Pruett, American Society of Transplant Surgeons (ASTS), Arlington, VA, 22202, United States, tlpruett@umn.edu

6 - Panelist
Yolanda Becker, United Network of Organ Sharing (UNOS), Chicago, IL, United States, ybecker@surgery.bsd.uchicago.edu

SC23
108-MCC
Risk Management in Global Food Supply Chains
Sponsored: Health Applications
Sponsored Session
Chair: Retsef Levi, MIT, 100 Main Street, Building E62-562, Cambridge, MA, 02142, United States, retsef@mit.edu
1 - A Data-Driven Approach To Managing Food Safety In Global Supply Chains
Amine Anoun, Massachusetts Institute of Technology, aminen@mit.edu
Economically motivated adulteration poses a serious threat to public health. Prevention is achieved by sampling food shipments. However, the sampling resources are limited. In an effort to mitigate risk in the shipping supply chains, we develop a data-driven approach to identify risky manufacturers. We obtained over 850,000 shipment records of shrimp to the US from the FDA. We determine structural features of shipping supply chains that correlate with risk of adulteration, at the global scale and in China. We use a Bayesian approach to model both the risk of adulteration, and the sampling procedure of the FDA, and show that our model predicts high risk manufacturers with high accuracy.

2 - Economically Motivated Adulteration In Agriculture Supply Chains
Somiya Singhvi, Massachusetts Institute of Technology, Cambridge, MA, United States, ssinghvi@mit.edu, Retsef Levi, Yanchen Zheng
We study how dispersion and quality uncertainty affect adulteration risk in agriculture supply chains. Our model captures the effects of testing accuracy and traceability on adulteration decisions by suppliers. We characterize conditions under which adulteration risk increases with dispersion or quality uncertainty. Further, we also analyze quality assurance policies for manufacturers in the presence of a risk threshold.

SC24
109-MCC
Dynamics of Competition
Invited: Strategy Science
Invited Session
Chair: Daniel Levinthal, Wharton School, University of Pennsylvania, Philadelphia, PA, 19104, United States, dle@wharton.upenn.edu
1 - Changes In Persistence Of Performance Over Time
Claudine Gartenberg, New York University, Stern Business School, New York, NY, 1, United States, cgenten@stern.nyu.edu
Victor Bennett
One of the central puzzles of strategy is the persistence of superior performance. About a decade ago a stream of research emerged looking at changing persistence over time and finding a trend toward a new “age of temporary advantage”. We extend the time series from these analyses and introduce new tools from the literatures on social mobility and economic growth. We find that the trend reversed itself and the beginning of the 21st century has been characterized by increasing persistence of superior performance. This trend is not due to changes in industry composition or newly public listings. Instead we report this reversal both within and across industries and primarily within established firms.
2 - Markets For Technology And The Technological Trajectories Of Entrepreneurial Startups
Mahka Moeen, University of North Carolina, Chapel Hill, NC, 03, United States, mahka_moeen@kenan-flagler.unc.edu
Seth Carnahan

This paper focuses on how entrepreneurial startups shape their opportunity set for participation in the market for technology, by pursuing investments that increase their attractiveness as a technology seller. Because startups in technological proximity to a technology buyer may be considered favorable technology sellers, we suggest that investment by potential buyers in a technical domain is likely to spur investments by startups in the same or proximate domains. We further examine the moderating effects of the direction of scientific progress, commercial applicability, and density of the buyer's alliance portfolio. The empirical context is plant biotechnology field experiments.

3 - The Entrepreneurial Process: Evidence From A Nationally Representative Survey
Aaron Chatterji, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708, United States, ronnie@duke.edu, Victor Bennett

Using data from a newly national representative survey of Americans, we document patterns in the process of firm entry via entrepreneurship. Only 1/3 of our respondents have even considered starting a business, motivated in the vast majority of cases by non-pecuniary concerns rather than the pursuit of significant market opportunities. Fewer than half of those who considered starting a business take even the lowest cost steps, like searching the Internet for potential competitors or speaking with a friend. This surprising lack of progress is evident in comparison to nationally representative evidence on job search activities.

4 - Venture Capital Investment Strategies Under Financing Constraints: Evidence From The 2008 Financial Crisis
Annamaria Conti, Georgia Institute of Technology, Atlanta, GA, 30332, United States, annamariaconti@scheller.gatech.edu
Stuart Graham, Nishant Dass

Employing the 2008 financial crisis as an empirical setting, we examine the investment strategies of venture capitalists (VCs) in response to liquidity supply shocks. While predictably VCs reduce investment, we show that VCs reposition by increasing their share of, and per-round funding to, startups operating in the VCs' core sectors. These effects are driven by more-experienced VCs, and are strongest in early-stage portfolio startups. Consistently, we find superior ex-post performance among crisis-funded portfolio startups operating in more-experienced VCs' core sectors. Our findings point to more-experienced VCs possessing information advantages, especially in their core sectors.

**SC26**

**110B-MCC**

Latest Developments in Scheduling Research

Invited: Project Management and Scheduling

Invited Session

Chair: Zhi-Long Chen, Professor, University of Maryland, Van Munching Hall, College Park, MD, 20742, United States, zchen@rhsmith.umd.edu

1 - A Polyhedral Study Of The Physician Scheduling Problem With Equalization Constraints
Pelin Daci-Kurt, Lightning Bolt Solutions, South San Francisco, CA, United States, pelin@lightning-bolt.com, Minjiao Zhang

We study a physician scheduling problem in which the goal is to minimize the penalties associated with different requirements over a finite horizon. The problem is divided and solved in two phases according to penalty values. We focus on a relaxation including assignment demand and equalization constraints. We present a class of valid inequalities, and report preliminary computational experiments with them in a branch-and-cut algorithm on our client data sets.

2 - Models For Workforce Scheduling In A Union Shop
John Mittenthal, The University of Alabama, Tuscaloosa, AL, 35487, United States, jmittenthal@cha.ua.edu, Minjiao Zhang

We develop an assignment problem model for worker to job assignments that deviates as little as possible from a shift supervisor's allocation of these workers. These deviations occur due to worker absences. In addition to validating the model over four weeks of data, we investigate a number of what-if questions.

3 - An Integrated Production Scheduling And Outbound Vehicle Routing Problem
Kunpeng Li, Huazhong University of Science and Technology, likp@hust.edu.cn

In this integrated production scheduling and vehicle routing problem, there is a single machine for production and limited vehicles with capacity constraints for transportation. The objective is to determine the decisions about production scheduling, transportation batching and vehicle routing, to minimize the maximum order delivery time. Based on an optimal property for production scheduling and transportation batching, backward and forward batching methods are developed, which are embedded into an improved genetic algorithm. The results show that the genetic algorithm can provide high quality solutions, compared with a two-stage algorithm and a published genetic algorithm.

4 - Integrated Production, Inventory And Distribution Problems
Zhi-Long Chen, University of Maryland, zchen@rhsmith.umd.edu, Feng Li, Lixin Tang

We consider several integrated production, inventory and delivery problems that arise in practical settings where customer orders have pre-specified delivery time windows and are first processed in a plant and then delivered to the customers by transporters that have fixed delivery departure times. The objective is to find an integrated schedule for processing the orders, keeping finished orders in inventory if necessary, and delivering them to the customers such that the total inventory and delivery cost is minimum. We study complexity and propose algorithms for various problems. For the two most general problems, we propose combined column generation and tabu search heuristic algorithms.

**Invited Auctions**

Invited Session

Chair: Sasa Pecek, Duke University, 100 Fuqua Drive, Durham, NC, 27708-0120, United States, pecek@duke.edu

1 - Stable Matchings With Proportionality Constraints
Thanh Nguyen, Purdue University, nguye161@purdue.edu, Rakesh Vinay Vohra

In designing two sided markets, a stable matching is often desired to satisfy certain additional side constraints. Current literature has mainly focused on constraints where the relevant “right hand sides” are absolute numbers specified a-priori, before agents on the “proposing” side make their participation decisions. There is a danger, then, of over constraining the problem. It is sometimes more natural to express the relevant constraints as proportions. We develop a framework to obtain stable matchings that almost satisfy floor and ceilling proportional side constraints. Our results are based on a generalization of Scarf’s lemma, which is of independent interest.

2 - Budget-constrained Procurement
Alexandre Belloni, Duke University, abn@duke.edu, Giuseppe Lopomo, Leslie Marx, Roberto Steri

We consider a setting where a buyer procures up to D units of a homogeneous good (e.g. a medical drug) but needs to satisfy a hard budget constraint of spending at most B in total payments. Furthermore, the buyer faces suppliers with privately known costs. We characterize the optimal procurement mechanism as well as new simple mechanisms (which are at least as good as the second price auction with reservation price) that are easy to implement via a sequential auction. In particular we highlight how the budget constraint fundamentally alters the structure of the optimal mechanism.

3 - Robust Bidding Policies
Sasa Pecek, Duke University, pecek@duke.edu

We study the best-response decision problem of an auction bidder who wants to maximize her worst-case payoff, while facing uncertainty about rivals’ objectives and bids. The information about rivals is modeled via an uncertainty set consisting of all possible realizations of rivals’ bids. Maximizing the bidder’s worst-case payoff over this set yields robust bidding policies that do not depend on distributional assumptions. Robust bidding policies are constructed for several multi-item auction formats, depending on how supply (homogeneous or heterogeneous items) and demand (unit-demand or multiple-demand bidders) is handled.
3 - Reference Points In Replacement Purchases

Mahdi Mahmoudzadeh, Georgia Institute of Technology, mahdi.mzh@scheller.gatech.edu

We study reference-points in replacement purchases, trade-ins and upgrades, wherein customers replace their in-use product with its newer version. Through an experimental study, we find that with trade-ins, irrespective of the new version's innovation level, the secondary market price is the reference-point. With upgrades, however, depending on the innovation level and the manufacturer's decision on co-production of successive versions, the new version's price, the current selling price the old version, or the original price of the old version is the reference-point. We also find that the manufacturer can always frame a replacement purchase to induce the same reference-point as in buy-backs.

4 - Rewarding Service And Serving Rewards: Strategic Complications To Order Management

Somak Paul, Doctoral Student, The Ohio State University, 600 Fisher Hall, 2100 Neil Avenue, Columbus, OH, 43202, United States, Paul.865@osu.edu, Nathan C. Craig, Elliot Bendoly

We conduct laboratory experiments to identify how order complexities including strategic-level factor relating to demand management affect the ordering behavior of those in purchasing management roles and thus induce variation in upstream operations. We further investigate how the backorder and surplus cost structure moderates the relationship between the service-dependent demand and order variation. We finally recommend strategic directions for the purchasing manager and suggest personality traits to look for while choosing purchasing managers.

SC28

Empirical Research in Operations Management

Sponsored: Manufacturing & Service Oper Mgmt
Sponsored Session
Chair: Nathan C. Craig, Ohio State University, 630 Fisher Hall 2100 Neil Avenue, Columbus, OH, 43201, United States, craig.186@osu.edu

1 - Dynamic Optimization Of Multichannel Advertising Campaigns In An Online Advertising Supply Chain

Changseung Yoo, The University of Texas at Austin, Austin, TX, United States, cyoo@utexas.edu, Anitesh Barua, Genaro Gutierrez

We examine channel structures and pricing models in an online advertising supply chain using a proprietary dataset. The supply chain consists of two channels - a network and an exchange - from which an ad agency buys advertising inventory and sells them to an advertiser. We design a nonlinear Kalman filter to estimate an extension of the Sethi advertising model and derive the optimal closed-loop strategies for the advertising agency. We then compare them to the approximate solutions based on the Nerlove-Arrow model and derive managerial insights. Our analyses furnish strong support for the synergy effects between the channel structures due to strategic complementarities between the channels.

2 - Variability In Labor Schedules: Effects On Store Performance And Employee Turnover

Hyun Seok Lee, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, Hyunseok_Lee@kenan-flagler.unc.edu, Saravanan Kesavan, Camelia Kuhnlen

Millions of employees face work schedules that are changed frequently by firms trying to match labor to demand. Prior work has shown that unstable schedules have negative consequences on worker life quality. Here, using detailed personnel records from the retail industry, we find that variability in labor schedule negatively affects store performance metrics such as sales, number of transactions, and employee turnover.
2 - Optimal Monitoring In Collateralized Lending
Dan Andrei Iancu, Stanford University, Stanford, CA, United States, daniIan@stanford.edu, Nikolaos Trichakis, Do Young Yoon Collateralized lending agreements critically rely on the lender's ability to monitor the value of a borrower's pledged assets, and to decide when these are sufficient to cover the outstanding loan. To further complicate matters, lenders often have to take such decisions under limited information concerning the assets' future value. Our work focuses on the problem of choosing a monitoring and liquidation policy for a lender when a finite number of monitoring times are possible during the life of the loan. We develop a robust optimization model and provide characterizations for the optimal choices involved.

2 - Financial Pooling In A Supply Chain
Alex Song Yang, London Business School, London, United Kingdom, sayang@london.edu, Ming Hu, Qu Qian Trade credit is common in supply contracts. We find the embedded stretch option of trade credit (i.e., buyers paying suppliers after the agreed due date) allows supply chain partners to pool their liquidity. As such, even as the supplier's financing costs are strictly higher than the buyer's, the buyer may still demand for trade credit. In addition, trade credit is more efficient when the supplier's cost for collecting trade credit is low (e.g., when the retailer trusts the supplier), when the supplier's financing cost is high when facing liquidity shocks, or when the buyer has a more diversified supplier portfolio. Finally, reverse factoring further enhances this pooling benefit.

3 - Effective Donor Fund Allocation For Health Product Procurement
Iva Petrova Rashkova, Washington University in St Louis, irashkova@wustl.edu, Jeremie Gallien Motivated by Global Fund grant recipients, we study the procurement of health products subject to an uncertain funding schedule. Such schedule includes either periodic lump-sum disbursements or per-unit subsidy agreements, or both. The objective is to minimize expected health costs in the presence of random demand and lost sales inventory dynamics. We design near-optimal financing mechanisms for the allocation of donor funds, characterize their theoretical and computational performance, and discuss managerial insights.

1 - Integrated Pricing And Production Scheduling Under Make-to-order Strategy
Guohua Wan, Professor, Shanghai Jiao Tong University, 1954 Huashan Road, Antai College of Economics and Management, Shanghai, 200030, China, zhaowenhui@sjtu.edu.cn, Qing Yue, Zhi-Long Chen we consider a joint pricing and production scheduling problem where the manufacturing firm produces a number of customized products from a base product. At the beginning of each period in a planning horizon, the firm sets the price of the base product as well as the prices for the customized products, and processes the accepted orders on a single production line, so as to maximize the total profit of the orders over the planning horizon. Three specific problems with different order acceptance and processing modes are studied, and computational complexity and solution algorithms are presented.

1 - Are Patients Patient? The Role Of Time To Appointment On Patient Flow
Diwis S KC, Emory University, diwas.kc@emory.edu
We examine the effect of wait to appointment on patient flow - specifically, on a patient's decision to schedule an appointment and arrive for that session. Contrary to previously-reported findings, our results suggest that some wait can be beneficial for reducing no-shows.

2 - Product Complexity, Network Position, And Product Innovation
Yingchao Lan, PhD Candidate, The Ohio State University, 2100 Neil Avenue, Fisher Hall 252C, Columbus, OH, 43210, United States, lan.63@osu.edu, John Gray, Aravind Chandrasekaran, Brett Massimino Despite a consensus that a firm's extended product development network plays a critical role in its innovation performance, empirical evidence linking network position, product complexity, and product innovation performance is scarce. We provide a longitudinal study employing secondary data to investigate these relationships.

3 - Managerial Attention, Reminders And The Energy Efficiency Gap
Enno Siemens, University of Wisconsin-Madison, esiemens@wisc.edu, Suvrat Dhanokar Reminders have been shown to at the individual level increase adherence to medical prescriptions and savings goals. We demonstrate that reminders also help to increase environmental project implementation at the organizational level. Using data from a state technical assistance program, we also demonstrate the contextual effects that make reminders more effective.

4 - Does Learning From Inspections Affect Environmental Performance? - Evidence From Unconventional Oil And Gas Wells
Suresh Muthulingam, The Pennsylvania State University, State College, PA, United States, suresh@psu.edu, Vidyu Mani Manufacturing firms increasingly face environmental inspections that determine whether their operations comply with environmental regulations. We investigate how firms learn from their own inspection experiences as well as from the experiences of other firms. We identify the characteristics of the inspection experience that enable firms to improve their environmental performance.

2 - Optimal Course Scheduling For United States Air Force Academy Cadets
Christopher D. Richards, Colorado School of Mines, Golden, CO, United States, capt.soup@gmail.com The United States Air Force Academy spends months scheduling approximately 1,500 courses and 4,000 cadets. By building alternatives based on department preferences, we develop an integer program to generate course and cadet schedules which fulfill registration, department and institution needs. Specifically, we observe enrollment and staffing limits, military time requirements, and athletic commitments. Efficient formulation and solution methods including heuristics provide quick turnaround for an iterative process between departments and the registrar. Easily resolving scheduling conflicts ensures all cadets meet crucial commissioning deadlines.
3 - Minimizing The Total Number Of Late Multi-task Jobs On Identical Machines
Hairong Zhao, Purdue University Calumet, 2200 169 Street, Hammond, IN, 46323, United States, hairong@pnw.edu
Lingxiang Li, Haibing Li
We consider scheduling multi-task jobs on identical machines in parallel. Each job consists of one or more tasks that can be processed by any machine. The tasks of a job can be processed concurrently. Preemptions are not allowed. Each job has a release date and a due date. The completion time of a job is the time when all of its tasks have been completed. We focus on the problem of minimizing the number of late jobs. We show that while some special cases are solvable, the general problem is NP-hard and admits no constant approximation algorithm unless P=NP. We then present a framework of a general algorithm for the problem and derive from it six heuristic whose performance is evaluated by experimental results.

4 - An Improvement In NSGA II For Resource Constrained Project Scheduling Problem
Fikri Kucuksayagil, Iowa State University, 610 Siquaw Creek Drive, Unit 18, Ames, IA, 50010, United States, ikseven@iastate.edu
Resource constrained project scheduling problem has been extensively studied. For multi-objective form of this problem, since finding an optimum solution is nearly impossible, several metaheuristic methods have been proposed and implemented. Non-dominated sorting genetic algorithm (NSGA II) has been one of the most effective algorithms in this respect. In this study, we develop a hybrid simulated annealing / NSGA II algorithm to find more diverse and better quality results. The results show that our algorithm visits more solutions in the solution space.

5 - Production Scheduling Of Jobs With Fixed Processing Property On Parallel Machines
Sangoh Shim, Hanbat National University, Dept of Business Administration, Deokmyung-Dong, Daejeon, 305-719, Korea, Republic of, mizar0110@gmail.com
One of the important things for smart factory is an intelligent production scheduling, how to schedule jobs effectively and efficiently. This problem is for scheduling jobs on parallel machines with the fixed processing property in which a group of specific jobs can be processed on the predetermined machine. Usually, even thought parallel machines can process various types of jobs, fixed processing are preferred not to deteriorate products' quality. Also, in this problem, when changing process of different groups of jobs, operations for changing type of groups, called as setup, are necessary. To minimize makespan of jobs, several heuristic algorithms are devised.

3 - Flexible High Density Puzzle Storage System
Ehsan Shirazi, West Virginia University, 1204, Van Voorhis Road, Unit B, Morgantown, WV, 26505, United States, ehsirazi@mix.wvu.edu
A puzzle-based storage system has been introduced to replenish and retrieve items from the top and bottom of a highly dense storage system. Each cell of the puzzle storage is considered as a grid. Each grid is able to store an item and or to move items in the south direction. We describe a high density storage system that can retrieve and replenish items from all sides. A puzzle storage with this characteristic is a lot more flexible than what has been introduced before. We will illustrate how this puzzle storage scheme affects replenish and retrieve time based on different network policies, distributions of replenishing and retrieving items, and number of free spaces on the puzzle network.

4 - The Use Of Simulation For Evaluating Forecast Models
Sanjeeva Naranpanawe, Sr Analytical Consultant, SAS Institute, 100 SAS Campus Drive, Cary, NC, 27513, United States, sanjeeva.naranpanawe@sas.com
The normal process of evaluating forecast models are by fitting the model using historical data, evaluating using holdout samples to select the model. However, this single point evaluation of forecast accuracy may not be good at predicting how the model is going to perform in the future. This presentation examines how simulation can be used to evaluate different forecast models.

5 - Adaptive-spline For Integer-order Simulation Optimization
Prasanna Kumar Ragavan, Virginia Tech, Durham Hall, Blacksburg, VA, 24061, United States, rpkumar@vt.edu
Raghur Pasupathy, Michael Taaffe
We present Adaptive-SPLINE to solve simulation optimization (SO) problems where the decision variables are integer-ordered, and the objective function can only be estimated through “noisy” observations from a simulation. Adaptive-SPLINE iterates between a line search and an enumeration procedure, and adaptively determines sampling effort by trading-off stochastic error with structural error. We will discuss consistency and finite-time performance.

SC33
201B-MCC
Simulation and Optimization III
Contributed Session
Chair: Prasanna Kumar Ragavan, Virginia Tech, Durham Hall, Blacksburg, VA, 24061, United States, rpkumar@vt.edu
1 - Managing Escalations: Equipment Failure And Response Capacity Allocation
Marc Christiaan Jansen, PhD Candidate, Cambridge Judge Business School, Downing College, Regent Street, Cambridge, CB2 1DQ, United Kingdom, mj32@cam.ac.uk
Nektarios Oraipoulos, Daniel Ralph
Failure of medical equipment represents a cause of downtime for hospitals and may lead to life-threatening circumstances for patients. At the onset of such failure, the scale of the disruption is typically unknown. This paper examines how contracting decisions between a maintenance service provider and multiple clients can enable efficient allocation of response capacity under imperfect and asymmetric information on the true nature of the disruption.
2 - Illusion Of Control In Resource Allocation Decision Making
Howard Charles Ralph, Visiting Assistant Professor, Western Carolina University, 201 Edgemont Avenue, Liberty, SC, 29657-1110, United States, r_1111@hotmail.com
Resource allocation decisions drive the managerial function of control and are basic to business school curricula. Decision problems, deterministic or probabilistic, seek to equip future managers with mathematical tools for optimized solutions, and flexibility to operate under uncertainty. But, “illusion of control” or cognitive biases giving the decision-maker unwarranted confidence, interferes with learning. An exercise has inexperienced decision-makers prioritize a set of realistic allocation problems and explores recorded rationales for features of illusion of control biases.

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SC34
204-MCC
Joint Session HAS/MSOM-HC: Analytics in Drug Development
General Session
Chair: Elisa Frances Long, UCLA Anderson School of Management, Los Angeles, CA, United States, elisa.long@anderson.ucla.edu
1 - Continuity In Gatekeepers: Quantifying The Impact Of Care Fragmentation
Vishal Ahuja, SMU Cox School of Business, vahuja@smu.edu
Bradley R Staats,
Care coordination is increasingly being recognized as a critical aspect of overall patient care. We attempt to establish a quantitative measure of care coordination and study its impact on patient health outcomes. Further, we investigate the mechanism by which coordination affects these outcomes. We use data on patients with diabetes, a chronic condition.
2 - Flexible FDA Approval Thresholds: A Dynamic Programming Approach
Taylor Corcoran, University of California-Los Angeles, taylor.corcoran.1@anderson.ucla.edu, Elisa Frances Long, Fernanda Bravo
Current FDA approval standards require drug companies to demonstrate the efficacy of their product by presenting statistically significant results from clinical trials. Traditionally, this significance level is set to 0.05 or 0.01, but this choice ignores the complexity of the drug approval process. In particular, the current approval threshold does not incorporate the severity and prevalence of the disease being treated, the level of research and development taking place, and the quantity of existing drugs available for the disease. We develop a continuous time dynamic programming model to study how the optimal significance level should depend on characteristics of the drug pipeline.
4 - A Comparison Between The Robust Risk-aware And Risk-seeking Managers In R&D Portfolio Management
Aurelie Thiele, Associate Professor, Southern Methodist University, Dallas, TX, United States, aurelie@alum.mit.edu
Shuyl Wang

We analyze via simulation two mathematical modeling frameworks that reflect different managerial attitudes toward upside risk in R&D portfolio selection. The manager seeks to allocate a development budget between low-risk, low-reward projects, called incremental projects, and high-risk, high-reward projects, called innovative projects. We study the differences in strategy and portfolio's risk profile that arise between a risk-aware manager, who takes upside risk because he has to for the long-term competitive advantage of his company, and a risk-seeking manager, who will take as big a bet as allowed by the model.

3 - Is The FDA Too Conservative Or Too Aggressive?: A Bayesian Decision Analysis Of Clinical Trial Design
Andrew W Lo, Charles E. and Susan T. Harris Professor, MIT, 100 Main Street, EG2-618, Cambridge, MA, 02142, United States, alo-admin@mit.edu, Andrew W Lo, Charles E. and Susan T. Harris Professor, MIT, 32 Vassar Street, Cambridge, MA, 02139, United States, alo-admin@mit.edu, Leah Isakov, Vahid Montazerhodjat

We explore the application of Bayesian decision analysis (BDA) to minimize the expected cost of drug approval, where the relative costs of Type I and Type II errors are calibrated using burden of disease data. For terminal illnesses with no existing therapies such as pancreatic cancer, the standard Type I error threshold of 2.5% is substantially more conservative than the BDA-optimal threshold of 23.9% to 27.8%. We compute BDA-optimal sizes for 25 of the most lethal diseases and show how a BDA-informed approval process can incorporate all stakeholders' views in a systematic, transparent, internally consistent, and repeatable manner.

4 - Increasing Retail Sales Via Improved Store Staffing: An Empirical Study With Implemented Results
Santiago Gallino, Dartmouth College, santiago.gallino@tuck.dartmouth.edu, Marshall L Fisher, Serguei Netessine

We analyzed 30 months of a retailer's history on store-month sales and potential sales drivers to measure the impact of store selling staff level on revenue. We identified a third of the stores where our analysis indicated that increasing staffing would increase sales. The retailer confirmed this finding via a 16 store test which showed that a 10% increase in staff sales resulted in a 9.9% sales increase, and was highly profitable. The retailer is now implementing our finding in other stores.

1 - Inventory Management With Censored Demand Data: The Adversarial Case
Michail Markakis, Universitat Pompeu Fabra, mihalis.markakis@upf.edu

We consider a repeated newsvendor problem where the demand distribution is unknown ex ante and has to be learned from sales/censored data. To shed light to scenarios where the demand may be non-stationary, e.g., exhibiting trends or seasonality, we model the problem as a game between the inventory manager and an oblivious opponent, who prior to the game decides a sequence of demands for the different periods arbitrarily. We propose randomized inventory management policies that perform well with respect to the regret criterion, i.e., the difference between a policy's cumulative cost and the cumulative cost of the best fixed action/ordering decision in hindsight, for any given demand sequence.

2 - Optimizing Local Content Requirements Under Technology Gaps
Shiliang Cui, Georgetown University, shiliang.cui@georgetown.edu, Lauren Xiaojuan Lu

We study the optimal Local Content Requirements (LCR) and innovation policies of a developing economy in which a foreign Original Equipment Manufacturer (OEM) produces and sells a final product. We find that the domestic component supply base becomes more cost efficient, surprisingly, the OEM's profit could decrease.

3 - Take-rate Crowdsourcing Contracts
Yun Zhou, University of Toronto, Toronto, ON, Canada, yzhou.jy@gmail.com, Ming Hu

Motivated by the surge pricing strategy by the ridesharing platforms, we consider the pricing problem in a two-sided market. The total amount of supply is an increasing function of the wage and the amount of demand depends on the price. We model supply and demand uncertainty by a number of different scenarios, and show that the take-rate price contract is optimal for maximizing the platform's profit or the total utility of the platform and the supply side when only the market size is scenario dependent. In more general cases, we derive performance bounds for the take-rate contract.

1 - Consumer Choice Under Rational Irritation And Implications For Assortment Planning
Tamer Boyaci, ESMT Berlin, Berlin, 10178, Germany, Tamer.Boyaci@esmt.org, Frank Huettner, Yalcin Akca

We study the choice behavior of rationally inattentive customers who optimally acquire information about available options with ex-ante uncertain values through potentially different channels with different costs. Customers trade-off the benefits of better information obtained by asking questions with the associated cost. We quantify acquired information and its cost through a novel function based on conditional mutual information. We solve the consumer's choice problem and analytically characterize the resulting optimal choice behavior. We illustrate some properties of the choice behavior and discuss implications for assortment planning.

3 - Self-policing In A Supply Chain Under Threat Of Public Disclosure
Sang-Hyun Kim, Associate Professor, Yale University, New Haven, CT, United States, sang.kim@yale.edu, Saed Alizamir

We study incentive dynamics among supply chain members and an external stakeholder (e.g., NGO) that impact environmental performance. A buyer inspects a supplier's production in its supply chain to detect and correct environmental compliance violations. The buyer's primary motive is to deter the NGO from discovering the violation first and publicize it, from which the buyer incurs a reputational penalty. The buyer and the NGO engage in a game to competitively set their inspection intensities, which influence the supplier's decision to restore compliance. Together, the actions made by all parties determine the environmental outcome and social welfare.

2 - Impact Of Grocery Store Density And Market Structure On Food Waste
Elena Belavina, University of Chicago Booth School of Business, elena.belavina@chicago Booth.edu

Food waste is one of the major contributors of greenhouse gas emissions. If food waste was a country, it would be third largest polluter shortly after US and China. About $1 trillion dollars of food is wasted every year, which is equivalent to 1% of GDP globally. This study explores the impact of store density and market structure on consumer food waste.

205A-MCC
Frontiers of Supply Chain Research
Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain Sponsord Session
Chair: Karen Zheng, MIT Sloan School of Management, Cambridge, MA, 02142, yanchang@mit.edu

1 - Dual Co-product Technologies: Implications For Process Development And Adoption
Brian Tomlin, Tuck School of Business, brian.tomlin@tuck.dartmouth.edu, Ying-Ju Chen, Yinmin Wang

Many industries operate technologies in which multiple outputs (co-products) are jointly produced. Three important attributes of a co-product technology are its production cost, its overall yield, and its co-product split. Process development often wrestles with an inherent trade-off: improvement in one attribute comes at the expense of another. In this talk, we first explore production and pricing decisions for a firm with two technologies and then use this foundation to examine implications for process development and process adoption.

2 - Increasing Retail Sales Via Improved Store Staffing: An Empirical Study With Implemented Results
Santiago Gallino, Dartmouth College, santiago.gallino@tuck.dartmouth.edu, Marshall L Fisher, Serguei Netessine

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2 - Optimizing Local Content Requirements Under Technology Gaps
Shiliang Cui, Georgetown University, shiliang.cui@georgetown.edu, Lauren Xiaojuan Lu

We study the optimal Local Content Requirements (LCR) and innovation policies of a developing economy in which a foreign Original Equipment Manufacturer (OEM) produces and sells a final product. We find that the domestic component supply base becomes more cost efficient, surprisingly, the OEM's profit could decrease.

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We identify the key drivers, market heterogeneity and production cost, for the controversy and provide managerial and political implications. Interestingly, the innovator can be better off with a strong competitor when market inequality is low or the competitor is strong enough.

SC39

Market Microstructure and Optimal Trading
Sponsored: Applied Probability
Sponsored Session
Chair: Costis Maglaras, Columbia University, New York, NY, United States, c.maglaras@columbia.edu
Co-Chair: Ciamac Cyrus Moallemi, Columbia University, New York, NY, United States, ciamac@gsb.columbia.edu

1 - Trading The Close — Market Impact And Optimal Execution
Costis Maglaras, Columbia University, c.maglaras@columbia.edu

We develop a tractable model to estimate portfolio liquidity costs through a multi-dimensional generalization of the optimal execution model of Almgren and Chriss. Our model allows for the trading of standardized liquid bundles of assets (e.g., ETFs or indices). We show that in a “large universe” asymptotic limit, where the correlations across a large number of assets arise from relatively few underlying common factors, the liquidity cost of a portfolio is essentially driven by its idiosyncratic risk. Moreover, the additional benefit of trading standardized bundles is roughly equivalent to increasing the liquidity of individual assets.

2 - Portfolio Liquidity Estimation And Optimal Execution
Kai Yuan, Columbia University, kyuana17@g牀.columbia.edu

We study dynamic assortment decisions of a firm learning about consumer tastes by observing sales. Each period, the firm offers an assortment to maximize expected total profits over a finite horizon given its beliefs on consumer tastes. The consumer then chooses a product that maximizes their utility and the firm updates its beliefs on consumer tastes after having observed sales. We model consumer tastes as locations on a Hotelling line and develop a nonparametric Bayesian learning model using Polya tree priors. We derive upper bounds on the firm’s total profit based on information relaxations and study the performance of various heuristic policies with respect to these upper bounds.

3 - Learning Consumer Tastes From Dynamic Assortments: A Nonparametric Bayesian Model
Catan Ulu, Georgetown University, cu50@georgetown.edu

We study dynamic assortment decisions of a firm learning about consumer tastes by observing sales. Each period, the firm offers an assortment to maximize expected total profits over a finite horizon given its beliefs on consumer tastes. The consumer then chooses a product that maximizes their utility and the firm updates its beliefs on consumer tastes after having observed sales. We model consumer tastes as locations on a Hotelling line and develop a nonparametric Bayesian learning model using Polya tree priors. We derive upper bounds on the firm’s total profit based on information relaxations and study the performance of various heuristic policies with respect to these upper bounds.

4 - The Price Of Flexibility
Hoda Bidkhori, Swanson School of Engineering, University of Pittsburgh, Pittsburgh, PA, United States, bidkhori@pitt.edu
Dimitris Bertsimas, Albert Dunung

Process flexibility is a popular operations strategy that has been employed in many industries to help firms respond to uncertainty in product demand. Additional flexibility comes at a cost that firms must balance against the reduction of risk it can provide. We reduce the price of flexibility by taking an optimization approach to the process flexibility design problem. Unlike many approaches in the literature, we consider systems that may have nonhomogeneous parameters and unbalanced capacity and demand. We formulate the problem as a robust adaptive optimization model, and propose a computationally tractable method for solving this model using standard integer optimization software.

SC38

Collaborative New Product Development
Sponsored: New Product Development
Sponsored Session
Chair: Niyazi Taneri, Singapore University of Technology and Design, Singapore, Singapore, na, Singapore, niyazitianeri@sutd.edu.sg

1 - The Role Of Operations In Alliances For New Product Development
Niyazi Taneri, Singapore University of Technology and Design, niyazitianeri@sutd.edu.sg, Arnoud De Meyer

We review the role of operations in joint ventures and joint product development alliances (where both parties exert joint efforts) and sequential alliances (where, for the most part, the partner takes over going forward). We test these hypotheses through the analysis of a dataset of over 2000 biopharmaceutical alliances.

2 - Optimal Sequential Investments In Product Development With Exogenous Technologies And Learning
Shantanu Bhattacharya, Singapore Management University, shantanub@smu.edu.sg, Stylianos Kavadias, Sameer Hasija

We determine the optimal investments for a firm when the product development opportunities come over from two distinct exogenous technologies. Upfront investment in a product platform from a technology that is currently available gives higher returns from opportunities based on the platform technology in the future, due to the associated learning effects. We formulate the resource allocation problem and characterize the optimal development investments that determine the firm product development roadmap. We show that the firm’s optimal resource investment in platform development has a nuanced relationship with the relative speed of arrival of the new technology.

3 - Business Model For Technology-intensive Supply Chains
Junghee Lee, University of California, San Diego, junghee.lee@rady.ucsd.edu
Krishnan Vish, Hydok Shin

In technology licensing, controversy has swirled among firms and policymakers about royalty base choice between subsystem and full system. We study the impact of royalty base on inventor’s business model decisions from R&D investment to manufacturing integration in Technology Intensive Supply Chain.
2 - Dea Computation For The Big Data – A Proactive Approach  
Wen-Chih Chen, National Chiao Tung University, Hsinchu, Taiwan, wenchih@faculty.nctu.edu.tw, Yueh-Shan Chen  
This talk presents a computation strategy to determine the DEA efficiencies of a massive data set. The strategy proactively searches for the references of a data point under evaluation by solving small-size linear programs (LPs). The size of each individual LP solved is controlled within a guarantee upper bound. The approach does not rely on the data density, and can improve the computational performance significantly.

3 - Segmented Concave Least Squares: An Automatic Classification Method With An Application To The Analysis Of The Room Rates Of Hotels In Finland  
Abolfazl Keshvari, Aalto University School of Business, Helsinki, Finland, abolfazl.keshvari@aalto.fi  
In this paper, segmented concave least squares estimator is introduced. It estimates a piecewise linear concave function, wherein the number of linear segments (k) is pre-specified. Two extreme cases of this problem are ordinary least squares (k=1) and concave least squares (k=∞, the number of observations). The estimator is used to analyze the room rates of hotels in Finland and to classify them into three groups based on their pricing strategies.

4 - Long Term Risk: A Martingale Approach  
Likuan Qin, Northwestern University, Evanston, IL, 60208, United States, likuan.qin@gmail.com  
This paper extends the long-term factorization of the stochastic discount factor introduced and studied by Alvarez and Jermann (2005) in discrete time ergodic environments and by Hansen and Scheinkman (2009) and Hansen (2012) in Markovian environments to general semimartingale environments. The transitory component discounts at the stochastic rate of return on the long bond and is factorized into discounting at the long-term yield and a positive semimartingale that extends the principal eigenfunction of Hansen and Scheinkman (2009) to the semimartingale setting. The permanent component is a martingale that accomplishes a change of probabilities to the long forward measure, the limit of T-forward measures. The change of probabilities from the data generating to the long forward measure absorbs the long-term risk-return trade-off and interprets the latter as the long-term risk-neutral measure.
Pearson distributions and others. Applications in fish biology and hydrology show how metabolos enable unprecedented insight into CDF data. A decision analysis application shows metabolos aided a decision that would have been made wrongly based on traditional discrete methods.

3 - Reexamining The Viability Of Scoring Rules
Zachary Smith, The University of Texas at Austin, zack.smith@utexas.edu, J. Eric Bickel

There are a number of widely used proper scoring rules used to elicit and rank expert opinions. However, not all rules have the property of being additive, in the sense that the score for marginal distributions and joint distributions are comparable. Scoring rules without this property are sensitive to the presentation of information as well as the information itself. We characterize scoring rules that are additive, and consider practical implications for some commonly-used rules.

1 - Optimal Use And Replenishment Of Substitutable Raw Materials
In Non-Stationary Capacitated Systems With Dynamic Price
Izak Duenyas, University of Michigan-Ann Arbor, duenyas@umich.edu

We consider a make-to-order setting where a firm can use either of two kinds of materials (or their mixture) to produce an end product using a shared production line with stochastic capacity. The materials are substitutable but one has a higher conversion rate and the other is cheaper, and their availability is uncertain. We show that a Use-down-to/Balancing Production Policy and modified Order-up-to Ordering Policy is optimal. Although the optimal policy is hard to compute using brute-force due to curse of dimensionality, we use its structure to develop an algorithm that solves for it efficiently. We also conduct sensitivity analysis of the optimal policy and find counter intuitive results.

2 - A Squared-coefficient-of-variation Rule For Learning And Earning
N. Bora Keskin, Duke University, Durham, NC, United States, bora.keskin@duke.edu

Consider a price-setting firm that sells products over a continuous time horizon. The firm is uncertain about the sensitivity of demand to price changes and updates its prior belief on an unobservable sensitivity parameter by observing demand responses. We derive and solve a PDE to show how the value of learning should be projected onto prices in an optimal fashion.
3 - Dynamic Pricing With Stochastic Reference Price Effects
Xin Chen, UIUC, xinchen@illinois.edu, Zhenyu Hu, Yuhan Zhang

We study a dynamic pricing problem of a firm facing stochastic reference price effect. Randomness is incorporated in the formation of reference prices to capture exogenous factors that affect consumers’ memory processes. We derive an explicit expression for the optimal pricing strategy which allows us to obtain the distribution of the steady state reference price. We compare the expected steady state reference price to the steady state reference price in a deterministic model and we find that the former one is always higher. A transformation technique is presented to show how one can extend the analysis to higher dimensional problems in which consumers have heterogeneous reference prices.

4 - Hidden City Travel And Its Impact On Airfare: The Case With Competing Airlines
Jaelynn Oh, University of Utah, jaelynn.oh@business.utah.edu
Tim Hu

We study the impact of hidden-city ticketing on airfare pricing in a setting where two airlines compete on a hub-and-spoke flight network.

**SC47**

209C-MCC

**New Topics in Revenue Management**

Sponsored: Revenue Management & Pricing

**Sponsored Session**

Chair: Stefanus Jasin, University of Michigan, Ann Arbor, MI, United States, sjasin@umich.edu

1 - Managing Dynamic Mobile Push Advertisements At Alibaba

Van Anh Truong, Columbia IEOR, vt2196@columbia.edu

In recent years, e-commerce companies are seeing an increasing amount of transactions completed via mobile platforms, such as apps in iOS and Android systems. In China, the e-commerce market share of a mobile app developed by Alibaba Group, which has been installed on several hundred million devices, is rapidly replacing that of traditional e-commerce markets hosted on webpages. We study the problem of managing the allocation of push notifications sent to users by this app which recommends products tailored to every user.

2 - Efficient Algorithms For Dynamic Pricing Problem With Reference Price Effect

Zhenyu Hu, National University of Singapore (NUS), bizhu@nus.edu.sg

We analyze a dynamic pricing model in which demand at each period depends on not only the current price but also past prices through reference prices. A unique feature but also a significant challenge in this model is the asymmetry in reference price effect which implies the underlying optimization problem is non-smooth and no standard optimization methods can be applied. We identify a few key structural properties of the problem, which enable us to develop strongly polynomial time algorithms to compute the optimal prices for several plausible settings. We further conduct numerical experiments to study the optimal price path and demonstrate the value of dynamic pricing when demands are seasonal.

3 - Optimal Stopping And Worker Selection In Crowdsourcing: An Adaptive Sequential Probability Ratio Test Framework

Xi Chen, Stern, NYU, xchen3@stern.nyu.edu

In this talk, we propose an adaptive sequential probability ratio test (Ada-SPRT) that obtains the optimal experiment selection rule, stopping time and final decision rule under a single Bayesian decision framework. Our motivating application comes from binary labeling tasks in crowdsourcing, where the requestor needs to simultaneously decide which worker to choose to provide the label and when to stop collecting labels to save for budget. We characterize the structure of the optimal adaptive sequential design that minimizes the Bayes risk through log-likelihood ratio statistic and develop dynamic programming based algorithms for both non-truncated and truncated tests.

4 - Dynamic Joint Pricing And Order Fulfillment For E-commerce Retailers

Yanzhe Lei, University of Michigan, Ann Arbor, MI, United States, leij2@umich.edu, Stefanus Jasin, Amitabh Sinha

We consider a dynamic joint pricing and order fulfillment optimization problem in the e-commerce retailing context, where a retailer sells a catalog of products to customers from different locations and fulfills orders through multiple fulfillment centers. The objective is to maximize the total expected profits, defined as revenues minus shipping costs. We propose two heuristics that are easily implementable, and show both theoretically and numerically their good performances compared to reasonable benchmarks.

**SC48**

210C-MCC

**Social Media in Marketing and Talent Management**

General Session

Chair: Fujie Jin, Indiana University, 1309 East Tenth Street, Suite 4100, Bloomington, IN, 47405, United States, jinljufe@wharton.upenn.edu

1 - Social Media Marketing In Product Harm Crisis

Shu He, University of Connecticut, shuhe@uconn.edu

We conceptualize the dual roles of a firm’s social media strategy—offensive and defensive marketing strategies—and study how non-focal firms adjust these two components of strategy in response to a product-harm crisis. We use daily social media activity of 56 major airlines on Twitter around the time of an airplane crash to study how non-focal airlines harness these two functions before and after the crisis. We find that a non-focal airline increases its defensive marketing effort but decrease its offensive marketing effort after the crash. The adjustment of offensive marketing decrease is significantly attenuated by whether the non-focal airline directly competes with the focal airline.

2 - Influence Of Social Media On Flash Sales: An Empirical Analysis

Karthik Kannan, Georgia Tech, karthikbabu.nk@scheller.gatech.edu, Jeffrey Hu, Sridhar Narasimhan

The emergence of e-commerce platforms has democratized both the production and consumption of goods and services. While anyone can offer their services through these platforms, sellers with little brand recognition have to overcome high search cost faced by prospective buyers in order to succeed in these markets. We study two mechanisms - flash sales and social media - used by sellers to promote their products by collecting sales and social media data from 24,446 products sold in a popular e-commerce platform.

3 - Does Reputation Management On Social Media Boost Career? Evidence From The Market For Executives

Yanzhen Chen, University of Texas at Austin, Austin, TX, United States, yanzhen@utexas.edu, Huaxia Rui, Andrew Whinston

Our paper studies the impact of reputation management (RM) on executives’ careers gathering evidence from their Twitter usage. Our structural model, which is based on a Two-Sided Matching Model, is able to exploit the characteristics of all of the candidates so as to identify separate RM’s influences in bargaining power as well as sorting during the hiring process. The results show that in the recruiting process of CEO and CMO markets, both out-/underperformed applicants benefit from RM. However, in compensation bargaining, RM is profitable only for outperformed candidates. RM can help more than 40% of CEOs and may increase their compensation by more than $10 million per year.

4 - Gravity In Open Source Software Production

Xuan Ye, New York University, New York City, NY, United States, xye@stern.nyu.edu, Prasanna Tambe

Using data on over 2 million hourly contributions contributed over eight years to GitHub.com, this paper investigates how the geographic organization of contributors influences open source production in corporate sponsored projects. Specifically, we test the extent to which time zones play a role in open source software production. We find strong evidence of such a bias in open source software production. Concentration of contributors within the same time zone is correlated with greater contribution levels, and this is robust to user fixed-effects.

**SC49**

211C-MCC

**Social, Political, and Economic Applications of Social Media Analysis**

Invited: Social Media Analytics

**Invited Session**

Chair: Amanda Andrei, MITRE Corporation, 7515 Colshire Dr, Mclean, VA, 22102, United States, aandre@mitre.org

1 - Characterizing Traffic Accident Detection Through Twitter And Open Data

Jared Mowery, MITRE Corporation, jmowery@mitre.org

Several recent studies have shown that Twitter can be used to detect traffic disruptions with high precision. This study builds on those results by incorporating open data including real-time traffic speed sensor measurements and weather data, measuring the recall of traffic accident detection against New York City police records, and by characterizing the probability of detection as a function of the severity of the accident.
To our knowledge, there exist no metrics describing the system capacity across delivery. Considering essential constraints (e.g., budget uncertainty, and environmental conditions at the field), we design a heuristic to identify the optimal fleet sizing and mission fulfillment over time. The objective of our model is to minimize the social cost.

3 - Models And Metrics To Assess Humanitarian Response Capacity
Jason Acimovic, Penn State University, acimovic@psu.edu
The race to meet vital needs following sudden onset disasters leads response organizations to establish stockpiles of inventory that can be deployed immediately. Even though the value of one organization's stock deployment is contingent on others' decisions, decision makers lack evidence regarding sector capacity to assess the marginal contribution (positive or negative) of their action. To our knowledge, there exist no metrics describing the system capacity across many agents to respond to disasters. To address this gap, our analytical approach yields new humanitarian logistics metrics based on stochastic optimization models.
1 - Analyzing The Predictive Power Of Early Warning Systems

Nasibeh Azadeh-Fard, Visiting Professor, Rochester Institute of Technology, Industrial and Systems Engineering Department, Rochester, NY, 14623, United States, azadefard@gmail.com, Navid Ghaforzadegan, Jaime Camilo

Early warning systems have been widely used in healthcare to predict adverse outcomes. The prediction power of early warning systems, however, is an empirical question. The objective of this study is to assess the predictive power of early warning systems and prognostic risk indicators in predicting different outcomes in health such as mortality, disease diagnosis, adverse outcomes, care intensity, and survival.

2 - Reverse Bullwhip Effect In Pricing In Retail Industry

Ziaul Haq Adnan, University of North Carolina at Charlotte, Charlotte, NC, United States, zadnan@uncc.edu
Ertunga Ozeklan

Bullwhip effect in pricing refers to the amplified variability of prices. If the variability is amplified towards downstream (upstream), we refer to it as reverse (forward) bullwhip effect in pricing. In this paper, we consider both simultaneous and sequential (e.g. wholesale and retail leading) game structures. We show analytical results and parametric examples for concave, linear, and convex demand functions. We conclude that forward bullwhip effect in pricing occurs for all concave and linear demand functions, and reverse bullwhip effect in pricing occurs for some convex demand function. The rate of amplification of variability in prices varies for different game structure.

3 - A Simulation Approach To Plan DesignV&V Activities For The New Product Reliability Improvement

Mohammad Sadeq Mobin, Western New England University, 1215 Wilbraham Road, Springfield, MA, 01119, United States, m337076@wne.edu*, Zhaojun Li, Mohammad Dehghaninimohammadabadi

Product failure modes, their effects, and a set of verification and validation (V&V) activities are outputs of conducting the design failure modes and effect analysis (DFMEA) in the early stages of developing a new product. A robust method for planning V&V activities is needed to mitigate all critical design failure modes by considering cost and timeframe constraints. In this paper, an integrated simulation-DEA (Data Envelopment Analysis) model is proposed to provide the efficient product design V&V activities’ plans by considering the uncertainty of V&V process parameters.

4 - Design Of Coordinating Contracts In Volume Discount Group Purchasing

Abdollah Mohammadi, University of North Carolina - Charlotte, 532 Lex Dr., Charlotte, NC, 28262, United States, amoham17@uncc.edu, Ertunga Ozeklan

This study investigates supply chain coordination using contracts in the context of group purchasing (GP), where there is a supplier, a GP agent and multiple customers. In GP the underlying contract between a supplier and the GP agent is quantity discount, while between the agent and the customers it can be a different type of contract. In this study, we specifically investigate revenue sharing or buyback contracts and discuss how and when they coordinate and align objectives of all members of the supply chain.

[SC53] Music Row 1: Omni
Advances in Research Exploring the Link between Learning and Innovation
Sponsored: Technology, Innovation Management & Entrepreneurship
Sponsored Session
Chair: Onesun Steve Yoo, University College London, One Canada Square, London, E14 SAB, United Kingdom, o.yoo@ucl.ac.uk

1 - Design Of Resource Competitions For R&D Projects
Pascale Crama, Singapore Management University, pascale@crama@smu.edu.sg

Academic research is funded by governments as well as by university administered research funds (UARF) at research universities. Government funding is based on arm’s length, competitive peer reviews of project proposals, whereas UARF funding is more relationship-based. We evaluate the impact of these two funding sources and their differing funding rules on the novelty of the projects being funded and social welfare creation. Our research points to the importance of an appropriate design of the two-stage funding system to increase social welfare.

2 - Staged Ideation In Crowdsourced Problem Solving
Nlaim Kaushik, University College London, uceikau@ucl.ac.uk
Crowdsourcing innovation platforms are increasingly gaining traction and are being used by firms to tap into the wisdom of crowds to generate ideas and to solve problems. Some such platforms are based on a multi-staged ideation paradigm where ideas are elicited from the user community for an open problem. A few ideas are selected for further refinement which involves updating the idea based on feedback from the user community. Refined ideas are subsequently evaluated and a subset is chosen for winning. Using a novel dataset from a crowdsourcing innovation platform, we investigate factors that affect the selection of an idea into the refinement stage and further into the winning stage.

3 - Research And Development Competition With Spillovers And Uncertain Completion Times
Wenxin Xu, University of Illinois at Urbana-Champaign, wxu9@illinois.edu
Dharma Kwon, Jovan Grabovac

We examine a game-theoretic model of two firms that are competitively engaged in R&D projects and address two questions: (1) What is the impact of natural spillover upon innovative firms’ payoffs? (2) Does an innovative firm have an incentive to unilaterally increase the spillover to its competitor? To answer these questions, we investigate the impact of natural spillover on R&D investment strategies when the R&D completion times are uncertain and either firm can receive spillover from the other. We characterize the Nash equilibrium of the model and find that natural spillover may or may not diminish the profit of the more efficient firm.

4 - A Theoretical Analysis Of The Lean Startup’s Agile Product Development Process
Onesun Steve Yoo, University College London, onesun.yoo@ucl.ac.uk, Tingliang Huang, Kenan Arifoğlu

We provide a theoretical foundation for the lean startup’s agile product development process. It helps us better understand why lean start-up works, and also predict when it does not work. We discuss the implications of our results to research and practice.

[SC54] Music Row 2: Omni
Mathematical Modeling and Data Analytics in the Service Industry
Sponsored: Service Science
Sponsored Session
Chair: Mohammad Sadegh Mobin, Western New England University, 1215 Wilbraham Road, WNE university, Springfield, MA, 01119, United States, m337076@wne.edu
Co-Chair: Zhaojun Li, Western New England University, 1215, Wilbraham Road, WNE University, Springfield, MA, 01119, United States, zhtaojun.li@wne.edu

1 - Analyzing The Predictive Power Of Early Warning Systems In Healthcare
Nasibeh Azadeh-Fard, Visiting Professor, Rochester Institute of Technology, Industrial and Systems Engineering Department, Rochester, NY, 14623, United States, azadefard@gmail.com, Navid Ghaforzadegan, Jaime Camilo

Early warning systems have been widely used in healthcare to predict adverse outcomes. The prediction power of early warning systems, however, is an empirical question. The objective of this study is to assess the predictive power of early warning systems and prognostic risk indicators in predicting different outcomes in health such as mortality, disease diagnosis, adverse outcomes, care intensity, and survival.

Emerging Topics in Service Operations
Sponsored: Service Science
Sponsored Session
Chair: Mike Pinedo, NYU, NYU, NYC, NY, 10012, United States, mpinedo@stern.nyu.edu
Co-Chair: Yuqian Xu, NYU, NYU Stern School of Business, NYC, NY, 10012, United States, yxu@stern.nyu.edu

1 - Vertical Opaque Selling Under Demand Uncertainty
Rachel Chen, UC Davis, rachen@ucdavis.edu

This paper studies opaque selling with vertically differentiated products when demand is uncertain. The quality of the product a consumer receives depends on the realization of the random demand. We show that it is more profitable to offer an opaque product of the vertically differentiated products than to offer a transparent product line.

2 - When Prospect Theory Meets Consumer Choice Models
Ruxian Wang, Johns Hopkins Carey Business School, Baltimore, MD, 21202, United States, ruxian.wang@jhu.edu

According to prospect theory, when the price is higher or lower than a reference point, customers perceive a utility loss or gain. We incorporate the extra utility changes into popular choice models. An empirical study shows that the new choice models can better characterize customer choice behavior.
3 - Price Formation And Efficiency In Ride Sharing Services
Yi Xu, University of Maryland, yxu@rhsmith.umd.edu, Liu Ming, Tunay Tunca, Weiming Zhu
Using data obtained from a leading company, we construct a structural model to estimate price formation in ride-sharing services based on operational characteristics such as the number of consumers and the utilization of drivers. Further, we conduct counterfactual analysis to examine efficiency and welfare implications.

4 - When Do Financial Firms Relocate? A Stochastic View
Michael Pinedo, New York University Stern School of Business, 44 West 4th St. KMCB-152, New York, NY, United States, mpinedo@stern.nyu.edu, Yuqian Xu, Jingqiu Zhu
We consider a financial firm makes the relocation decision based on two perspectives: i) higher expected utility in relocation, and ii) higher probability in achieving certain utility. In this paper, we use the hiring lead time which is a random variable to capture the difficulty in hiring, and thus how this factor impact the relocation. The model captures the uncertainty and variation in employee capability as well as the uncertainty in their willingness to relocate.

**SC56**
Music Row 4- Omni
Crowdsourcing and Sharing Economy
Sponsored: EBusiness
Sponsored Session
Chair: Wei Chen, University of Arizona, 1130 East Helen Street McClelland Hall 430, Tucson, AZ, 85721-0001, United States, weichen@email.arizona.edu

1 - Do Ride Sharing Services Affect Traffic Congestion?
Yili Hong, Arizona State University, Tempe, AZ, United States, ykhong1@asu.edu, Ziru Li, Zhongzhi Zhang
Sharing economy, which leverages information technology to re distribute unused or underutilized assets to people who are willing to pay for the services, has tremendous potential to contribute to the sharing economy. In this research, we investigate how Uber affects traffic congestion in the urban areas of the United States. Findings from this research provide evidence on the potential effect of ride sharing services in the transportation industry, contributing to the understanding of the sharing economy and government policy decisions.

2 - Room Sharing Economy And Destination Tourism
Wei Chen, University of Arizona, 3750 E Via Palomita, Apt 23103, Tucson, AZ, 85718, United States, weichen@email.arizona.edu, Lijia Xie
While significant debate has surrounded the entry of room-sharing services, limited empirical work uncovers the impact of such services to traveler activity, particularly, tourism flow and satisfaction at local destinations. We exploit a set of natural experiments, the entry of two major room-sharing services, Tujia.com and Xiaozhu.com, into markets of China between 2011 and 2015. The study underscores the connection of peer-to-peer accommodation availability to relocation of traveler spending, extended stays and improved experience which are critical to the local tourism industry gains. Important implications of theory, practice, and policy making will be provided.

3 - The Role Of Syndication In Democratizing Capital Flow In Online Equity-crowdfunding
Qiang Gao, City University of New York, New York, NY, 85719, United States, qiangg@email.arizona.edu, Mingfeng Lin
Equity crowdfunding provides opportunities for startups to raise funds from a large number of online potential investors. However, the issue of information asymmetry not only remains as the major barrier for financing these early stage companies but is actually exacerbated by the "virtual" nature of these marketplaces. This paper examines whether syndication, a group of investors who collaborate to pool resources and share risks, in online equity crowdfunding, can alleviate this issue and democratize the access to capital and investment opportunities. We further investigate the drivers for the formation of such syndicates.

4 - “Release Early, Release Often”? The Impact Of Release Frequency In Open-source Software Co-creation
Wei Chen, University of Arizona, weichen@email.arizona.edu
Yeh Krishna, Kevin Zhu
A central virtue of OSS is the contributions from the communities, yet our knowledge on how to coordinate and maximize the benefit of such contributions for market success is limited. In this paper, we uniquely formalize, analyze, and validate the impact of product release frequency as a coordinating mechanism in the adoption of open-source products. We build a dynamic structural model to characterize the optimal release strategy from the project owner’s perspective. The theoretical and empirical results have important implications for managing technology-enabled collaboration in open-source communities and for research on open-source software, open innovation, and software adoption.
3 - Essential Aspects Of Power System Resource Planning In Developing Community Of Microgrid
Aida Khayatian, PhD Student, University of Houston, 4722 Memorial Drive, Eng. Building, Room 282, Coral Gables, FL, 33146, United States, akhayatian@uh.edu, Masoud Barati, Gino J Lim
This paper addresses Microgrid expansion planning problem which helps Community Microgrid companies to decide whether or not they invest on Microgrid installation in a competitive electricity market. Integrated resource planning, demand-side management, environmental issues, the competitiveness of power investors, energy efficiency, rural electrification, future load growth and possible power outage in the face of uncertainty and reliability are challenges faced by power system planners. This paper develops a model and policy for Microgrid expansion planning in a competitive electricity market under uncertainty by considering these challenges.

4 - Technology-push, Demand-pull, And Strategic R&D Investment
Benjamin D. Leibowitz, Assistant Professor, University of Texas at Austin, 204 E. Dean Keeton St., Stop C2200, Austin, TX, 78712, United States, leibowitzc@gmail.com
A bilevel modeling framework is constructed to determine the optimal combination of technology-push and demand-pull interventions for a given technology policy application. The inner agents are profit-maximizing firms who solve a two-stage stochastic decision problem with product and process R&D investments. The outer agent is a welfare-maximizing policymaker. Findings illustrate how the optimal technology policy combination varies with the primary motivation for innovating and the relative strengths of three important market failures (incomplete appropriability of R&D, a negative production externality, and imperfect competition).

2 - Game Theoretic Approach For Load-shifting In The Smart Grid With Storage Capacity
Murat Erkok, Associate Professor, University of Miami, 1251 Memorial Drive, Eng. Building, Room 282, Coral Gables, FL, 33146, United States, merkok@miami.edu, Izyad Al-Ahmadi
We study the load-shifting problem within the context of smart grid demand response for an electricity market composed of a single energy provider and multiple consumers. We consider the case where the energy provider has the option of installing and managing client storage devices at consumer sites. The provider acts as the leader and decides on price discounts and storage decisions across a finite time horizon. The consumers, acting as followers, respond by deciding if and how they shift their consumption from their nominal demand. We investigate the joint impact of price discounts and storage option on player incentives and peak-to-average ratios.

1 - Understanding The Integration Of Freight Supply Chain By Integrating Pairwise Decision Mechanism
Dapeng Zhang, Hyperloop Tech Inc., dapeng@hyperlooptech.com
This paper develops an innovative econometric model to understand joint response. The first part explains the matching process in a many-to-one matching structure; The second part characterizes the joint decision making process of mutually-selected decision makers. The two parts are integrated by recognizing their dependency that is essentially a sample selection process: a joint response is only observed for matched decision makers. The proposed model is estimated using a Bayesian Markov-Chain Monte-Carlo approach. The likelihood functions and posterior distributions are derived and followed by simulation studies to test parameter recovery capability.
Flow demands are given, and they route through the network based on available transportation networks of service vehicles (e.g., trucks). For links with active work zones, the available capacity of that link is reduced. The origin-destination flow demands are given, and they route through the network based on available capacities on the links to achieve the total minimum cost. The goal is to schedule the work zones so that all maintenance work can be completed before a given completion date while the total flow cost over the project period is minimized. An innovative randomized fix-and-optimize heuristic was developed to solve the problem with much better efficiency than commercial solvers like CPLEX.

3 - Optimal Deployment Of Autonomous Vehicle Lanes With Endogenous Market Penetration
Zhihui Chen, University of Florida, 1, Gainesville, FL, 32603, Lihui Zhang, Yalifeng Yin, Fang He
This paper first models the evolution of autonomous vehicle (AV) market penetration on a multimodal transportation network that includes conventional vehicles (CVs) and AVs. A time-dependent mathematical approach is then proposed to optimize the deployment plan of AV lanes such that the social cost is minimized. The AV lanes are exclusive lanes for AVs, and the deployment plan will dictate when and where, and how many AV lanes to be deployed.

4 - Road Extension Prioritization And Scheduling Problem
Mersedeh Tativerdi, University of Maryland, College Park, Washington, DC, 20009, United States, mercedeh@umd.edu, David Rey, Saeed AsadiBagloee
Budget scarcity as well as limited resources in road construction may have a significant toll on the completion of the projects. Therefore it is of highest importance to arrive at a knowledge-based decision support system for projects prioritization and scheduling. We represent this problem as a bi-level program where the objective function maximizes the return of projects’ completion defined as the total savings derived from traffic improvement. The interconnections among the projects as well as prerequisites requirements are imposed using mixed integer constraints. An efficient solution algorithm is developed based on an outer approximation approach.

5 - A Branch And Price Algorithm For The Work-zone Scheduling Problem
David Rey, University of New South Wales, School of Civil and Environmental Engineering, Sydney, Australia, d.rey@unsw.edu.au, Hillel Bar-Gera, Vinyak Dixit, S. Travis Waller
We address the work-zone scheduling problem which consists in finding the optimal schedule for the coordination of road occupancy projects in a transport network over a planning period. Road works and maintenance operations which require partial or total road closures over a period of time may considerably impact network performance and result in significant delays. In addition, the effects of conducting multi-work-zone projects simultaneously may be non-additive, hence increasing the difficulty to anticipate congestion effects. We present a new branch and price algorithm for the work-zone scheduling problem which relies on the enumeration of work-zone project combinations.

### SC62
Cumberland 4- Omni
Aviation Applications Section: Best Student Presentation Competition III
Sponsored: Aviation Applications
Sponsored Session
Chair: Lavanya Marla, University of Illinois, 216l Transportation Building, 104 S. Mathews Ave., Urbana, IL, 61801, United States, lavanyam@illinois.edu

Entrants for the Best Student Paper Presentation competition will be presenting their papers.

### SC63
Cumberland 5- Omni
Network Design and Maintenance in Transportation
Sponsored: TSL, Intelligent Transportation Systems (ITS)
Sponsored Session
Chair: David Rey, UNSW Australia, School of Civil and Environmental Engineering, UNSW, 2072, Australia, d.rey@unsw.edu.au

1 - Scheduling Work Zones In Networks Of Service Vehicles
Denan Peng, Arizona State University, 699 South Mill Avenue, Tempe, AZ, 85281, United States, dening.peng@asu.edu, Pitu B Mirchandani

A mixed integer linear programming model is developed to schedule work zones in transportation networks of service vehicles (e.g., trucks). For links with active work zones, the available capacity of that link is reduced. The origin-destination flow demands are given, and they route through the network based on available capacities on the links to achieve the total minimum cost. The goal is to schedule the work zones so that all maintenance work can be completed before a given completion date while the total flow cost over the project period is minimized. An innovative randomized fix-and-optimize heuristic was developed to solve the problem with much better efficiency than commercial solvers like CPLEX.
2 - A General Approximation Method For Bicriteria Minimization Problems
Stefan Ruzika, Department of Mathematics/Natural Sciences University of Koblenz-Landau Universitätstrasse 1 56070 Koblenz (Germany), ruzika@uni-koblenz.de

We present a general technique for approximating bicriteria minimization problems with positive-valued, polynomially computable objective functions. Given $0 < \varepsilon \leq 1$ and a polynomial-time -approximation algorithm for the corresponding weighted sum problem, we show how to obtain a bicriteria $\varepsilon$-approximation algorithm for the budget-constrained problem whose running time is polynomial in the encoding length of the input and linear in $1/\varepsilon$. Moreover, we show that our method can be extended to compute an $(1+2/\varepsilon)$-approximation Pareto curve under the same assumptions.

3 - Bicriteria Analysis Of The Fixed-charge Network Flow Problem - Separating Fixed Costs And Flow Costs
Michael Stilagnay, University of Wuertperal, Wuertperal, Germany, stiglagnay@math.uni-wuertperal.de

The fixed-charge network flow problem is an inherently biobjective optimization problem: Minimize fixed (design) costs and minimize flow costs. In its classical form the sum of these two objectives is minimized which corresponds to the weighted-sum scalarization of the associated biobjective problem. However, design costs and flow costs are not directly comparable, since design costs occur once, while flow costs are due periodically. In this talk we present heuristic and exact solution approaches based on the two-phase method and ranking algorithms.

4 - Multi-objective Optimization Of Coupled Systems
George Fadel, Mechanical Engineering Department Fluor Daniel Engineering Building Clemson University, Clemson SC 29634 USA, lgeorge@clemson.edu

An engineering problem consists of two multi-objective problems that must be coordinated. The top level focuses on the optimal placement of components under the hood of a car, with design variables which specify the location of the various non-convex components in a non-convex volume, and non-overlap constraints. Then, the optimization of shape and size of a battery pack that is one of the components placed under the hood is conducted. We show how the two problems can be assigned to separate teams, and their optimizations can be coordinated, enabling the chief designer to allow the sub-problem or the upper level design team to be driving the solution.

SC66
Mockingbird 2- Omni

Additive Manufacturing
Sponsored: Quality, Statistics and Reliability
Sponsored Session
Chair: Prahalad Krishna Rao, Assistant Professor, Binghamton University, P.O. Box 6000, Binghamton, NY, 13902-6000, United States, prao@binghamton.edu

1 - Accelerated Process Optimization For Laser-based Additive Manufacturing By Leveraging Similar Prior Studies
Amir M Aboutalebi, Mississippi State University, Industrial & Systems Engineering Department, Mississippi State University, MS, 39762, United States, a1a1869@msstate.edu, Linkan Bian Manufacturing parts with target properties and quality in Laser-Based Additive Manufactured (LBAM) parts is crucial towards enhancing the “trustworthiness” of this emerging technology. We propose a novel process optimization method by directly utilizing experimental data from previous studies as the initial experimental data to guide the sequential optimization experiments of the current study. We conduct a real-world case study that optimizes the relative density of parts manufactured using a Selective Laser Melting system. A combination of optimal process parameters is achieved within 5 experiments.

2 - Online Detection For Cyber Attacked Additive Manufactured Parts By Real-time Sensing And Analysis
Cheneng Liu, Virginia Tech, Blacksburg, VA, 24061, United States, lcheneng@vt.edu, Tomilayo Komolade, Zhenyu Kong, Jaime Camelio Cyber security of additive manufacturing (AM) is important for some critical applications such as defense industry. This work focuses on the online detection of attacked AM parts by real-time sensing using network analysis based data fusion techniques. Using the effective features extracted from multiple sensor data, the discrepancy between normal and attacked AM parts can be detected effectively. The case study show that the proposed method can successfully detect the attacked parts, but does not cause false alarm for the sample normal part.

3 - Laplacian Eigen Compressive Sensing For Dimensional Integrity Classification In Additive Manufacturing
Prahhalad Rao, Binghamton University, prahalad.k.rao@gmail.com

This work relates the effect of parameters, namely, infill and extrusion temperature in fused filament fabrication (FFF) additive manufacturing (AM) process on pre-selected geometric dimensioning and tolerancing (GD&T) features. Next, a method is proposed to classify the part quality in terms of the geometric integrity using minimal number of laser-scanned point cloud data. The proposed method combines spectral graph theory with compressive sensing, as a means of supervised classification of part geometric integrity.

Sharing economy has empowered consumers to communicate their needs with one another and thus has helped them to assume the role of both suppliers and producers seamlessly. In this paper, using a natural experiment set up and a novel dataset, we analyze how Airbnb has impacted the traditional way of conducting the hotel business. We study if the hotels have responded to the increasing number of Airbnbs by increasing their quality and whether this response varies across different types of hotels. We analyze the hotel industry’s response across different dimensions in quality by not only considering star ratings, but also user sentiments and latent quality expressed in textual content of reviews.

Property’s Image Aesthetic Quality On Demand At Airbnb
Shunyuan Zhang, Carnegie Mellon University, Pittsburgh, PA, United States, shunyuan@andrew.cmu.edu

Dokyun Lee, Param Vir Singh, Kannan Srinivasan Sharing economy platforms such as Airbnb are challenged with product quality uncertainty. To solve the issues, Airbnb has implemented strategies such as professionally taking high quality photos for hosts and calling them verified. This paper studies the impact of having verified photos. To assess the aesthetic quality of images, we use machine learning techniques. Employing Difference-in-Difference method we find rooms with verified photos are on average 9% more frequently booked. We separate the effect of photo verification from photo quality and find an extra $2,435 in yearly earnings brought by high photo quality. We find asymmetric spillover effects across rooms in the same neighborhood.
SC67

Decision Analysis Approaches and Predictive Modeling to Managing Uncertainty in Manufacturing and Service Systems Design & Operations

**Sponsored: Quality, Statistics and Reliability**

**Sponsored Session**

Chair: Zhenny Kong, Virginia Tech, 1145 Perry Street, Blacksburg, VA, 24060, United States, zkong@vt.edu

- **1 - Self-organizing Network For Variable Clustering And Predictive Modeling**
  
  Hui Yang, Penn State University, huy25@engr.psu.edu

  Rapid advancement of sensing and information technology brings the big data, which presents a gold mine of the 21st century to advance knowledge discovery. However, big data also brings the challenging problem of data-driven decision making. In particular, it is common that a large number of variables (or predictors, features) underlie the big data. Complex interdependence structures among variables challenge the traditional framework of predictive modeling. This paper presents a new methodology of self-organizing network for variable clustering and predictive modeling.

- **2 - Forecasting Of Weather-driven Damage In A Distribution System Of Electric Power**
  
  Zhiguo Li, IBM, hardthinking@gmail.com

  Electric utilities spend a large amount of resources and budget on managing unplanned outages, the majority of which are driven by weather. A major ongoing effort is to improve their emergency preparedness process, in order to reduce outage time, reduce repair costs, and improve customer satisfaction. This paper proposes a method for forecasting the number of damages of different types that will result from a weather event in a power distribution system. The proposed method overcomes practical issues with sparsity of historical damage records, and its performance is evaluated on real utility data. This work is the core of an approach called Outage Prediction and Response Optimization.

- **3 - Prognostics Of Surgical Site Infections Using Dynamic Health Data**
  
  Yan Jin, University of Washington - Seattle, yanjin@uw.edu, Shuai Huang

  Surgical Site Infection (SSI) is a national priority in healthcare research. To achieve better SSI risk prediction models, there have been emerging mobile health (mHealth) apps that can closely monitor the patients and generate continuous measurements of many weight-related variables and other evolving clinical variables. Since existing predictive models of SSI have quite limited capacity to utilize the evolving clinical data, we develop the corresponding solution to improve these mHealth tools with decision-making capabilities for SSI prediction. We derive efficient algorithms and demonstrate the advantage of our new predictive model on a real-world dataset.

- **4 - Spatiotemporal Model With Dirichlet Process Mixing For Nonnormal And Nonstationary Data**
  
  Jia Liu, Virginia Tech, jliu@vt.edu

  In real-life, sensor data often violate assumptions of normality and stationarity required by many prevalent statistical methods. In order to acquire accurate prediction and interpolation by sensor data, a nonparametric spatiotemporal model is proposed, which takes non-normality and non-stationarity of data into account. In this model, spatial correlation is captured by Dirichlet process mixture model using particle filter. Moreover, temporal correlation is incorporated into this model by using recurrent Dirichlet process. This model can be used in various fields with data exhibiting non-normality and non-stationarity to achieve accurate interpolation and prediction.

SC68

Panel Discussion: Funding Opportunities

**Sponsored: Quality, Statistics and Reliability**

**Sponsored Session**

Moderator: Abhishek K Shrivastava, Florida State University, Tallahassee, FL, United States, ashrivastava@fsu.edu

Co-Chair: Hui Wang, FSU, TBD, TBD, FL, 00000, United States, hwang10@fsu.edu

- **1 - Panel Discussion On Funding Opportunities**
  
  Abhishek Shrivastava, Florida State University, FAMU-FSU College of Engineering, Tallahassee, FL, 32310, United States, ashrivastava@fsu.edu

In this panel, program officers from NSF will discuss funding opportunities in their programs. The panelists are Dr. Joanne Culbertson, Dr. David Mendonca, Dr. Jon Leland and Dr. Alexandra Medina-Borja-Borja

SC70

Transportation, Freight III

**Contributed Session**

Chair: Carlos Alberto Gonzalez-Calderon, Rensselaer Polytechnic Institute, 4 25th St, Apt 5, Troy, NY, 12180, United States, gonzac@rpi.edu

1 - A Multi-commodity Intermodal Traffic Assignment Between Rail And Truck

Lokesh Kumar Kalahasthi, Rensselaer Polytechnic Institute, 22 College Ave, Troy, NY, 12180, United States, kalahhi@rpi.edu

The goal of the paper is to obtain an optimization model that gives a freight traffic assignment on a combined network of road and rail; that could be used to assess the freight modal split including vehicle types and intermodal transfers. Authors of this paper have conducted In-Depth-Interviews (IDI) with shippers, carriers and receivers regarding the factors influencing their modal choice. The challenge is to incorporate the findings from these IDIs into a mathematical model. Major findings include commodity type, backhaul, shipment limit, transfer time, reliability in transit time restrictions. The model also incorporates the variation in the rail pricing based on origin and destination.

2 - Reliable Routing Of Multicommodity Road-rail Intermodal Freight Under Uncertainty

M. Majbah Uddin, University of South Carolina, 300 Main Street, Civil and Environmental Engineering, Columbia, SC, 29208, United States, muddin@cec.sc.edu, Nathan Huyin

A reliable routing model for multimmodity shipments on a road-rail intermodal freight transport network, where network elements are subject to uncertainty, is proposed. A stochastic mixed integer program is formulated which minimizes not only operational costs but also penalty cost associated with unsatisfied demand. This study provides a novel distribution-free approach to ensure probabilistic guarantees on the resulting routing plan. Case study on a small network reveals the key characteristics of the proposed model.

3 - Shipment Consolidation And Dispatching With Cross-docks

Sinem Tokcaer, Izmir University of Economics, Pevzi Calmakin Mh, Sakarya Cd No:136, Izmir, 35330, Turkey, sinem.tokcaer@ieu.edu.tr, Ahmet Camci, Ozgur Ozpeynirci

Freight forwarders dealing with long haul transportation establish their own consolidation systems in order to reduce costs by economies of scale and efficient use of owned or rented vehicles. Such consolidation systems usually include cross-docking terminals to provide additional services and reduce the travelling time of the vehicles. We propose a shipment consolidation and dispatching problem with cross-docks, and develop a mathematical programming model. The model suggests the consolidation and transportation plans. We propose lower and upper bounds, develop a Variable Neighborhood Search algorithm, and test the performances of develop methods on randomly generated instances.

4 - Freight Trip Generation (FTG), Freight Generation (FG) And Service Trip Attraction (STA) In New York City (NYC) And Capital Region

Joa nne Culbertson, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA, 22230, United States, jculbert@nsf.gov

This paper presents a thorough analyses and econometric models explaining the Freight Trip Generation (FTG), Freight Generation (FG) and Service Trip Attraction (STA) in the New York City and Capital Region. The team conducted a detailed survey including the number of deliveries (received), shipments (sent), type of cargo, weight of shipment, industry, sector, type, who transports the cargo (vendor or receiver). This study serves as a tool for transportation planners in understanding the freight patterns in urban areas.
Contribution Session

Chair: Mehdi Zamani, The University of Arizona, 7415 S Seneca Ridge Dr, McLean, VA, 22102, United States, zamani@email.arizona.edu

1 - Developing an Integrated Approach to Optimize Vehicle And Driver Scheduling Problem With Equilibrium Constraint

Bisheng He, Southwest Jiaotong University, 111#, 1st Section, Northern 2nd Ring Road, Chengdu, 610031, China, bishenghe@home.swjtu.cn, Xiaobo Liu, Gengyuan Lu, Qingwei Jin

We optimized vehicle and driver scheduling problem considering equilibrium constraint to maintain their equal workload. An integer programming model was established and solved by integrating a heuristic algorithm and a commercial solver. Comparison results indicated that this method could effectively improve the scheduling efficiency and equilibrium based on a real world case from Ji’nan Transit Company.

2 - How Tight Capacity Constraints Involve Bounded Rationality And How To Consider Bounded Rationality In Designing Dynamic Capacitated Transit Service Network

Jiangao Liu, Arizona State University, 2062 S Hammond Drive, Apt 205, Tempe, AZ, 85282, United States, jliu215@asu.edu, Xuesong Zhou

This talk will discuss how tight capacity constraints involve bounded rationality and how to address bounded rational decision rules of travelers in a dynamic transit service network with tight capacity constraints. Within a space-time network, we propose an agent-based single-level integer linear programming model, which can be further decomposed as two efficiently solvable subproblems through Lagrangian decomposition.

3 - Study On The Taxi Fleet Of Electric Vehicles With Battery Swapping

Lei Li, Zhejiang University, 866 Yuhangtang Rd, West Lake District, Hangzhou, 310058, China, lieli.simon@gmail.com, Qıngweitın

In this paper, we consider a company is using electric vehicles with battery swapping to satisfy the urban taxi traveling demand. We construct a choice model based on the utility of the taxi drivers which reflects the adoption model of electric taxi vehicles. Based on the adoption model, the company is trying to maximize its profit based on the optimal decisions of battery capacity and service price. We set up a revenue model to find these optimal decisions and consider the impacts of technology advancements. We also extend this model to a mixed case in which the swapping stations serves both taxis and private vehicles.

4 - Pricing Analysis And Optimization Of Mobility On Demand Service

Hao Zhou, Research Scientist, Ford Motor Company, 2101 Village Road, Dearborn, MI, 48124, United States, haozhou@umich.edu

Mobility On Demand (MoD) is a new transportation system that allows users to make on-demand ride requests using devices such as smartphones. The MoD back-end service tries to dynamically schedule these requests to maximize ride-sharing while minimizing waiting time. This research tries to analyze 1) under what conditions such MoD systems can be functioning efficiently, and 2) what would be the right pricing scheme for this kind of MoD system.

5 - An Integrated Priority Optimization And Intelligent Traffic Signal Control Model

Mehdi Zamani, The University of Arizona, 7415 S Seneca Ridge Dr, McLean, VA, 22102, United States, zamani@email.arizona.edu, Govind Vadakpat

In this research, an integrated priority and adaptive signal control model is developed that can intelligently consider connected vehicles and priority eligible vehicles at both intersection level and section level in a low connected vehicles penetration rate environment. Fundamentals of shockwave theory and queue estimation techniques are used in the mathematical model. Standard traffic control methods including coordinated actuated operation are taken in to consideration. The study also conducts a sensitivity analysis on the Dedicated Short Range Communication (DSRC) by virtually extending the range.
3 - Allocation Of Medical Interventions In Outbreak Control: The Case Of Ebola Virus
Farzad Farhadi, Roger Williams University, 1 Old Ferry Road, Bristol, RI 02809, United States, ffarhadi@rwu.edu
The outbreak of Ebola in 2014 in western Africa is one of the fastest and deadliest outbreaks in history of viral diseases, causing a reported 28 thousand suspected cases and over 11 thousand deaths, according to WHO, leading to over 70% fatality rate. Further outbreaks of the disease may occur in the future and fast and effective containment strategies to control the spread is vital. In this study a model for efficient allocation of medical interventions for outbreak containment is presented.

5 - Cyclic Physician Scheduling Using Goal Programming
Hamoud Sultan Bin Obaid, PhD Student, University of Oklahoma, 1027 E Brooks St., Apt E, Norman, OK, 73071, United States, hsbinobaid@gmail.com, Theodore B Trafalis
A two-phase approach to construct a three-month schedule for physicians at an outpatient clinic is proposed. The goal of the proposed model is to minimize the variability of clinic and surgery sessions over the three-month period and utilize resources. From mathematical point of view, the goal is to reduce the complexity of solving this problem. The data used in this problem is obtained from King Khaled Eye Specialist Hospital in Saudi Arabia.

SC86

Gibson Board Room-Omni
Manufacturing III
Contributed Session
Chair: Zahra Sedighi Maman, Auburn University, Auburn, AL, 36849, United States, zzm0016@auburn.edu
1 - Minimum Cost Allocation Of Quality Improvement Targets: The Effects Of Forgetting And Knowledge Decay
Didun Peng, Purdue University, 610 Purdue Mall, West Lafayette, IN, 47906, United States, peng67@purdue.edu
WeiJia Wang, Robert Plante, Jen Tang
This paper incorporates knowledge depreciation in two dimensions of learning: forgetting in autonomous learning and induced learning. We first present a comprehensive quality cost progress function to account for both learning and forgetting effects, where the forgetting effects are imbedded in the progress function components of accumulated production and induced learning. Within the context that a manufacturer allocates quality improvement targets to its suppliers, an optimization model is developed to allocate induced learning activities that minimize the total system cost. A numerical example of an internal supplier process is used to demonstrate the model.

2 - Sustainability and Changeability In Manufacturing System
Shima Ghanie, University of Minnesota -Duluth, 105 Voss Kovach Hall, 1305 Ordean Court, Duluth, MN, 55812, United States, ghanie009@d.umn.edu, Tarek Al Gedawy
Changeable Manufacturing Systems (CMS) are designed to quickly adapt to changing market requirements by transition from a configuration to the next. Not only is the reconfiguration cost dependent on degree of system convertibility and scalability, but also dependent on what time of the year during which it is performed, since energy pricing changes within and between seasons. This paper presents a new linear mixed integer mathematical model to maximize sustainability of CMS on the tactical level. It is solved by CPLEX solver in GAMS software to analyze influence of volatile energy pricing and variable demand on system convertibility and scalability which can affect layout configuration selection.

3 - Printing The Future: Using Analytics To Advance Additive Manufacturing
Sarah Powers, Oak Ridge National Laboratory, One Bethel Valley Rd., P.O. Box 2008, Oak Ridge, TN, 37831, United States, powersss@ornl.gov
Recent advances in additive manufacturing have led to many success stories of large 3D printed objects and leave the industry poised for rapid growth. This work describes a multi-approach approach for data discovery, engaging multiple analytic tools as well as a framework to ingest and house the data itself in an effort to identify areas for process improvement and promote the potential for advanced defect detection.

4 - A Short Note On The Effect Of Sample Size On The Estimation Error In Cp
Zahra Sedighi Maman, Auburn University, Auburn, AL, 36849, United States, zzm0016@auburn.edu, William Murphy, Saeed Maghooloo, Fatemeh Haj-Ahmad, Fadel Megahed
Process Capability indices such as Cp are used extensively in manufacturing industries. In practice the parameter for calculating Cp is rarely known and is frequently replaced with estimates from an in-control reference sample. This study explores the optimal sample size required, with some practical tools to achieve a desired error of estimation using absolute percentage error of different Cp estimates.

Sunday, 3:10PM - 4:00PM

■ Keynote
Davidson Ballroom A-MCC
Optimizing the Kiel Canal – Online Routing of Bidirectional Traffic
Keynote Session
Michael Trick, IFORS President, Carnegie Mellon University, Pittsburgh, PA 15213-3890, trick@cmu.edu
1 - Optimizing The Kiel Canal – Online Routing Of Bidirectional Traffic
Rolf H Mohring, Beijing Institute of Scientific and Engineering Computing, Beijing, China, rolf.mohring@me.com
We introduce, discuss, and solve a hard practical optimization problem that deals with routing bidirectional traffic on the Kiel Canal, which is the world’s busiest artificial waterway with more passages than the Panama and Suez Canal together. The problem arises from scarce resources (sidings) that are the only locations where large ships can pass each other in opposing directions. This requires decisions on who should wait for whom (scheduling), in which siding to wait (packing) and when and how far to steer a ship between sidings (routing), and all this for online arriving ships at both sides of the canal. The lecture is based on joint work with Elisabeth Lukebeke and Marco Lukebeke.

■ Keynote
Davidson Ballroom B-MCC
Creating the Exascale Ecosystem for Science
Invited: Plenary, Keynote
Invited Session
Bogdan Bichescu, The University of Tennessee, Knoxville, TN 37996-0525, bbichescu@utk.edu
1 - Creating The Exascale Ecosystem For Science
Jeff Nichols, Oakridge National Laboratory, Oak Ridge, TN, United States, malonelt@ornl.gov
The way we tackle grand challenge science questions at the national scale has changed over the past two decades with the advent of both modeling and simulation (M&S) and “big data” becoming more recognized and supported discovery paradigms. In fact, most large scientific problems today are solved as integrated solutions of experiment, theory, M& S, and data analytics. The past several decades of high performance computing have focused on delivering compute intensive systems and their performance measured by how fast they can accomplish a simple matrix multiply (e.g., high performance linpack). Today’s complex workflows require not only compute intensive capabilities, but also capabilities that target data analytics approaches such as deep learning, graph analytics, or map reduce. In this talk I will describe several scientific areas that require an integrated approach and discuss the ecosystem [ORNL’s Leadership Computing Facility (OLCF) and its Compute and Data Environment for Science (CADES)] that we have created. We continue to invest in the evolution of this ecosystem to enable successful delivery of important scientific solutions across a broad range of disciplines.
SD02

101A-MCC

Interpretable Machine Learning in Social Science
Sponsored: Data Mining
Sponsored Session
Chair: Tong Wang, MIT, Cambridge, MA, United States, tongwang@mit.edu

1 - Interpretable Decision Sets: A Joint Framework For Description And Prediction
Himabindu Lakkaraju, Stanford University, himal@cs.stanford.edu

One of the most important obstacles to deploying predictive models is the fact that humans do not understand and trust them. In this talk, I will present interpretable decision sets, a framework for building predictive models that are highly accurate, yet also highly interpretable. We formalize decision set learning via an objective function that simultaneously optimizes for accuracy, conciseness, and meaningfulness of the rules. We prove that our objective is a non-monotone submodular function, and efficiently optimize it with a 2/5 approximation guarantee. Our experiments demonstrate that interpretable decision sets help humans understand their data better than other interpretable models.

Sunday, 4:30PM - 6:00PM

SD02

101B-MCC

Data Analytics and Modeling for Medical Prognosis and Decision Making
Sponsored: Data Mining
Sponsored Session
Chair: Shouyi Wang, University of Texas-Arlington, Arlington, TX, United States, shouyiw@uta.edu

1 - Diagnosis Of Posttraumatic Stress Disorder Using Functional Near Infrared Spectroscopy (fNIRS) signals And Data Mining Techniques
Rahil Hosseini, University of Texas at Arlington, rahilsadat.hosseini@uta.edu

In this paper we extract various feature groups from FNIRS records that are from the experiment about digits memorizing and recalling; it includes three phases in each trial: encode, maintain and recall; we showed the discovered patterns between two classes for some selected features. Specifically the results show that the last phase which is when the subject tries to recall the digits, is the most significant part and with extracted features from Statistics, Autocorrelation and SVDNorm, it is enough for highly accurate classification. We discuss a new proposed feature derived from SVD (Singular Value Decomposition) of raw data in channels. It demonstrated promising results in classification. Third contribution is comparison of feature selection methods to reduce the dimension of the feature matrix. We compare the performance through number of selection and sensitivity and specificity and their average. The proposed method includes Mutual Information (MI) guided sparse models that outperform the existing features selection techniques. The existing models are “minimum Redundancy and Maximum Relevancy” (mRMR), and “Sparse Group Lasso” (SGL). We propose “Mutual Information and Least Absolute Selection and Shrinkage Operator” (MILASSO) “Mutual Information Sparse Group Lasso” (MISGL). All these techniques are applied to classify PTSD veterans and healthy controls using “Support Vector Machines” (SVM). Last contribution is finding the Region of Interest (ROI), we conclude that two specific areas on brain are the most significant ones which are directly related to memorizing.

2 - Pattern Classification And Analysis Of Memory Processing In Depression Using Eeg Signals
Kin Ming Puk, University of Texas at Arlington, bookbook089@gmail.com

An automatic, EEG-based approach of diagnosing depression with regard to its effect on memory is presented. EEG signals are extracted from 15 depressed subjects and 12 normal subjects during experimental tasks of reading and rehearsal. After pre-processing noisy EEG signals, seven groups of mathematical features are extracted and classification with SVM is conducted under a five-fold cross-validation, with accuracy of up to 70% - 100%. The contribution of this paper lies in illustrating the usefulness of the classification framework in facilitating the analysis and visualization of the difference of EEG signals between depressed and control subjects in memory processing.
3 - Discriminating Parkinson’s Disease (pd) Using Functional Connectivity And Brain Network Analysis
Shouyi Wang, University of Texas at Arlington, shouyiw@uta.edu
In this study, we explored the use of functional connectivity patterns in fMRI data to classify subjects on the basis of Parkinson's disease. We explore various brain networks and features. We partition our fMRI data in 5 filtered frequency ranges. We use a proximal support vector machine paired with a minimum-redundancy and maximum-relevance feature selection method on each frequency range. We use a majority voting ensemble classification method on the results of the proximal support vector machine classification results. Our results indicate that the ensemble method is effective compared to a single broad frequency range, and that Bonferroni correction may enhance classification results.

2 - Optimal Planning Of Green Infrastructure Placement Under Precipitation Uncertainty
Masoud Barah, University of Tennessee, mbarah@vols.utk.edu, Anahita Khojandi, Xueping Li, Jon Hathaway
Green Infrastructures (GIs) are low cost, low regret strategies that can dramatically contribute to stormwater management. We develop a multi-objective stochastic programming model to determine the optimal placement of GIs across a set of candidate locations in a watershed to minimize the excess runoff under short-term and medium-term precipitation uncertainties. We calibrate the model using precipitation projections and stormwater system’s hydrologic responses to them. We obtain the optimal GI placement for a watershed and perform sensitivity and robustness analyses to provide insights.

Sponsored: Energy, Natural Res & the Environment I Electricity

3 - Optimal Placement Of Green Infrastructure Under Uncertainty
Anahita Khojandi, University of Tennessee, 603 W Main St., Apt 801, Knoxville, TN, 37902, United States, anahitakhojandi@gmail.com, Mohit Shukla, Xueping Li, Mohammad Ramshani
Despite the environmental and societal benefits of Green Infrastructure (GI), they are mostly planned and established in response to an existing problem rather than being actively incorporated into the early stages of urban planning. In this paper, we present a stochastic model that would allow urban planners to incorporate uncertainties in population and climate predictions, land use and budgetary constraints and the ‘connectivity’ between GIs into the decision making process of GI placement on a county or city scale land area. The proposed approach is tested on data from a real county to evaluate its utility.

SD06
102B-MCC
Joint Session DM/Al: Predictive Analytics in Data Science
Sponsored: Data Mining
Sponsored Session
Chair: Xi Wang, University of Iowa, 5210 John Pappajohn Business Building, Iowa City, IA, 52242-1000, xi-wang-1@uiowa.edu

1 - Link Prediction In Multi-relational Networks For Online Health Communities
Xi Wang, The University of Iowa, xi-wang-1@uiowa.edu
Kang Zhao
Online Health Communities (OHCs) are a popular resource for those with health problems to exchange information and support. Users often interact via multiple communication channels, such as online discussions, blogs, and private messages. Connections among users via different channels form a multi-relational social network. Using data from a smoking cessation network, this study aims to predict links between users in one sub-network based on information from other sub-networks. Our findings regarding the formation will inform the development and ongoing management of online health communities.
2 - Purchase Prediction Based On Multilevel Association Rule Mining
Xinxue Qu, College of Business, Iowa State University, Ames, IA, 50010, United States, qxinxue@iastate.edu, Zhengrui Jiang

Recommendation systems are one of the most widely deployed applications in e-commerce. The goal of this study is to improve existing association-rule-based methods to increase the quality of product recommendations. There are two important factors in our method. First, due to the huge number of products in stores, market basket data is often sparse. Second, competing products are often highly substitutable, and consumers may be open to alternatives. The method we propose infers the level of similarity/substitutability between pairs of products from product category information. Experimental results show multilevel association rules can lead to a higher accuracy of purchase predictions.

3 - Risk Information Disclosure And Project Success Rate
Yang Pan, University of Maryland, ypan@rsmith.umd.edu

Since information asymmetry between funders and creators is a critical issue in crowdfunding platform, many policies are introduced to improve the information transparency and make markets more efficient. One of the mechanisms is mandatory disclosure imposed by platform. We aim to understand how disclosed risk information has an effect on project outcomes. We study this question on a popular crowdfunding site requiring project creators disclose potential risk information about projects. We analyze the detail content of the disclosed risk information with text mining techniques and test the association between self-disclosed risk information and successful rate of crowdfunding projects.

■ SD10
103C-MCC
INFORMS Prize
Invited: INFORMS Prize Invited Session
Chair: Julia Morrison, Marriott International, Department 51/974.18, Bethesda, MD, 20817, United States, julia.e.morrison@marriott.com
1 - 2016 INFORMS Prize Presentation by General Motors
Michael Harbaugh, General Motors, Warren, MI, United States, michael.harbaugh@gm.com, Robert Inman, Pelling Wu-Smith, Yilu Zhang

General Motors, 2016 INFORMS Prize Winner, will survey its sustained application of analytics. Highlights will include Vehicle Health Management: using advanced analytics to predict failure of certain automotive systems before customers are affected. Optimizing New Vehicle Inventory: determining first how much, and second what mix of vehicles to hold in dealer inventory, and Revenue Management for Vehicle Component and Packaging: leveraging customer preferences to package and price vehicle content that will sell best.

■ SD11
104A-MCC
Network Optimization
Sponsored: Optimization, Network Optimization Sponsored Session
Chair: Alexander Nikolaev, Assistant Professor, University at Buffalo, 312 Bell Hall, Buffalo, NY, 14260, United States, anikolae@buffalo.edu
1 - Optimal Seed Activation Scheduling For Influence Maximization In Social Networks
Mohammadreza Samadi, Operations Research Consultant, American Airlines, Fort Worth, TX, United States, Mohammadreza.Samadi@aa.com, Alexander Nikolaev, Rakesh Nagi

Influence maximization problem selects a set of influential nodes, called seeds, in a social network to spread the influence over the network maximally. We critique the basic assumption of influence maximization problem in the literature on controlling cascades only through the early starters and present Seed Activation Scheduling Problem (SASP) in two-level networks. The SAPS is a sequential seed selection problem that results in optimal budget allocation over the campaign time horizon. The problem is modeled as a mixed-integer program for blogger-centric marketing campaigns and an efficient heuristic algorithm is presented using column generation method.

2 - From Local To Global Connections: A New Random Graph Model To Explain The Structural Properties Of Real-world Networks
Rakesh Nagi, U of Illinois at Urbana-Champaign, Department of Industrial & Enterprise Systems, 117 Transportation Building, MC-238, Urbana, IL, 61801, United States, nagi@illinois.edu, Sushant Khopkar, Alexander Nikolaev

Online Social Network (OSN) data are hard to interpret. Many OSN users have lots of connections, easily surpassing 150 – the Dunbar number. We present a random graph formation model that explains social tie formation by bridging the gap between the Watts-Strogatz and scale free networks. It shows how the information about “talented” individuals may propagate from their friends towards the masses, with a power law in degree emerging via the mechanism fundamentally different from preferential attachment (PA): while PA assumes full visibility, our model relies on local information exchanges. We report and interpret the model parameter estimates for several real-world networks.

3 - Constrained Sparse Optimization For Tensor Based Modeling Of Student Learning In Collaborative Environments
Alireza Farasat, University at Buffalo, afarasat@buffalo.edu

Educational systems have witnessed a substantial transition from traditional educational methods mainly using text books, lectures, etc. to newly developed systems which are artificial intelligence-based systems personally tailored to the learners. In this study, a constrained sparse tensor-based factorization approach is proposed for modeling of student learning in collaborative environments. The main challenge of modeling students learning is the fact that learning occurs over time therefor. We develop a probabilistic, constrained based approach to the tensor factorization model which enables capturing the underlying dynamics of student learning over time.

4 - Generalized Cascade Model And Seed Bounds For Disease Spread In Social Networks
Araash Ghayoori, U of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, ghayoor2@illinois.edu, Rakesh Nagi

In this talk, we introduce a new diffusion model for social networks, which generalizes most of the previously introduced diffusion models. We establish its relevance in disease spread (epidemiology) as well as viral marketing. An upper bound on the size of the influential set (“seed” set of nodes that if become infected, will eventually result in making the entire network becoming infected) is also obtained for a special case of this model. We show this bound to be tight by providing a simple algorithm that outputs an influential set with size nearly equal to this upper bound.

■ SD12
104B-MCC
Convexification Techniques in Integer Programming
Sponsored: Optimization, Integer and Discrete Optimization Sponsored Session
Chair: Sercan Yildiz, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States, sylidiz@email.unc.edu
1 - Sparse Pseudoinverses Via LP And SDP Relaxations Of Moore-Penrose
Jon Lee, University of Michigan, jonxlee@umich.edu
Pseudoinverses are ubiquitous tools for handling over- and under-determined systems of equations. For computational efficiency and also in the context of identifying Gaussian models having a sparse precision matrix, sparse pseudoinverses are desirable. Recently, sparse left and right pseudoinverses were introduced, using $1$-norm minimization and linear programming. We introduce new sparse pseudoinverses by developing tractable convex relaxations of the wellknown Moore-Penrose properties. In the end, we have several new sparse pseudoinverses that can be calculated via linear and semi-definite programming.

2 - Optimal Trust Topology Design By Mixed Integer Conic Optimization
Tamas Terlaky, Lehigh University, terlaky@lehigh.edu, Mohammad Shahabsaf, Ali Mohammad-Nezhad, Luis F Zuluaga

We present novel models, including Mixed Integer Linear Optimization (MILO) and Mixed Integer Second Order Cone Optimization (MISOICO) models, for Trust Topology Design Optimization. We discuss how classes of non-convex models can be reformulated as MILO and MISOICO models. We present our approach to solve the MISOICO models through adding Disjunctive Conic Cuts in a BCC framework. Additionally, we present an efficient line search method developed to solve the original non-convex model. Preliminary computational results indicate the effectiveness of our novel approaches.
3 - Low-complexity Relaxations And Convex Hulls Of Disjunctions On The Positive Semidefinite Cone And General Regular Cones Serkan Yildiz, Postdoctoral Researcher, Statistical and Applied Mathematical Sciences Institute, Durham, NC, United States, syildiz@email.unc.edu, Fatma Kilinc-Karzan

This talk concerns two-term disjunctions on a regular cone K. The resulting disjunctive sets provide fundamental non-convex relaxations for mixed-integer conic programs. We develop a family of structured convex inequalities which together characterize the closed convex hull of such a set in the original space. Under certain conditions on the choice of disjunction, a single inequality from this family is enough for a closed convex hull description. In the case where K is the positive semidefinite cone, we show that these inequalities can be represented in conic form for a class of elementary disjunctions. For more general disjunctions, we present tight conic relaxations.

SD13

104C-MCC

New Algorithms for Global Optimization and MINLP I

Chaired: Optimization, Global Optimization
Sponsored Session
Chair: John W Chinneck, Carleton University, Ottawa, ON, Canada, chinneck@scce.carleton.ca

1 - Nonlinear Objective Decomposition By Binary Decision Diagrams
David Bergman, University of Connecticut, david.bergman@business.uconn.edu, Andre Augusto Cire

In recent years the use of decision diagrams for discrete optimization has grown in popularity, with a focus on linear integer optimization. In this talk, an expansion to nonlinear objective functions will be discussed. The work proposes the use of decision diagrams to model the objective function, which are then linked together through a network flow linearization. Experimental results on problems arising in revenue management, portfolio optimization, and healthcare exhibit orders-of-magnitude improvement in solution times compared with state-of-the-art nonlinear solvers.

2 - Identifying And Exploiting Special Features In Mixed Integer Nonlinear Programs
Linus E Schrage, LINDO Systems, Inc., linus.schrage@chicago booth.edu

Most MINLP problems have the following features to varying degrees: convexity, linearity, conic representability, common expressions, monotonicity, decomposability, and symmetry. We describe methods for identifying these features and performance improvements possible by exploiting these features.

3 - A Fast Heuristic For Global Optimization
John Chinneck, Carleton University, chinneck@scce.carleton.ca, Mubashsharul Shafique

Our CCGO multistart heuristic trades off some accuracy to gain speed. It generally finds good quality solutions quickly. The main steps are a scatter of initial points, rapid movement towards feasibility via Constraint Consensus, clustering, simple point improvement, and local solver launch. Much of the work is done concurrently. Recent work improves the initial point scatter to provide better exploration of useful areas of the variable space. Our results are very promising in comparison to several existing global optimizers, especially for larger nonconvex models.

4 - A Dantzig-Wolfe Decomposition With Nonlinear Subproblems For Recursive Circle Packing
Ambros Gleixner, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, gleixner@zib.de, Stephen John Maher, Benjamin Müller, Joao Pedro Pedroso

A large fraction of the total costs in tube industry arises from delivery inside rectangular containers. The problem of minimizing the number of containers to transport a set of different tubes can be modeled as a nonconvex MINLP: the recursive circle packing problem (RCP), which is practically unsolvable for any state-of-the-art MINLP solver. We present a branch-and-price algorithm that handles recursiveness in the master problem and solves nonconvex MINLPs for column generation. Our computational results using the MINLP solver SCIP that show this algorithm solves small-sized instances to proven optimality and produces better solutions than the best known heuristic for larger RCP instances.
4 - Sparse Convex Regression
Nisanth Mundru, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, nmundru@mit.edu, Dimitris Bertsimas

Given data (xi, yi) (d+1), i=1,..., n, the problem of convex regression finds a convex function f : \mathbb{R} \rightarrow \mathbb{R} that minimizes the error \sum_{i} |y_i - f(x_i)|. We propose a cutting plane algorithm that scales to (n, d) = (10^4, 10^2) in minutes and (n, d) = (10^5, 10^2) in hours. Sparse convex regression finds the best k out of d features, and solves for the optimal convex function on that subset. Using Mixed integer optimization methods and first order convex optimization based heuristics, we extend our algorithm to model sparsity and solve the problem to provable optimality for (n, d, k) = (10^4, 10^2, 10) in minutes.

■ SD16
105A-MCC
Buffered Probability of Exceedance and Applications
Sponsored: Optimization, Optimization Under Uncertainty
Sponsored Session
Chair: Matthew Norton, University of Florida, 355 Tigert Hall, Gainesville, 32611, United States, mdnorton@ufl.edu

1 - Buffered Probability Of Exceedance And Applications To Machine Learning
Matthew Norton, University of Florida, mdnorton@ufl.edu

We present a new characterization of uncertainty, called Buffered Probability of Exceedance (bPOE), specifically addressing its application to machine learning. Using ideas from Robust Optimization, we show that Robust bPOE minimization provides a highly flexible framework for binary classification which encompasses support vector machines (SVMs), including SVM variants which utilize Robust Optimization and various convex/non-convex regularization schemes. While also providing a more concrete interpretation for various SVM formulations, the proposed framework reveals a fundamental connection between many regularization schemes and Robust Optimization principles.

2 - Buffered Probability Of Exceedance: Methodology And Applications
Stan Uryasev, University of Florida, uryasev@ufl.edu

This paper investigates a new probabilistic characteristic called buffered probability of exceedance (bPOE). With bPOE, it is possible to count outcomes similar to a threshold value, rather than only outcomes exceeding the threshold. To be more precise, bPOE counts tail outcomes averaging to some specific threshold value. bPOE can be considered as an important supplement to POE. We will discuss the Cash Matching problem for a Portfolio of Bonds. We minimize bPOE that assets exceed liabilities.

3 - Smoothed Buffered Probability of Exceedance: A New Class of Probability-like Uncertainty Measures
Alexander Mafusavol, University of Florida, mafusavol@ufl.edu

Buffered probability of exceedance (bPOE) is a risk-averse alternative to probability of exceedance and cumulative distribution function. Minimization of bPOE is reduced to convex programming or even LP for a wide class of problems. However, being a non-smooth function, bPOE is not always well suited for gradient optimization. In addition, bPOE reverses the curve of CVaR values, while another family of risk measures might be preferable in a given application. This paper introduces a new class of smooth probability-like uncertainty measures, which are based on bPOE. Dual representations and other mathematical properties, along with advantages in optimization, are studied.

4 - Approximation Of A Distribution With A Finite Mixture Of Some Other Distributions Using Cvr Norm
Giorgi Pertaia, University of Florida, Gainesville, FL, United States, georgepertaia@gmail.com

CVR norm is applied to approximate a distribution with a finite mixture of some other distributions. A finite mixture is a weighted sum of simple distributions (such as normal or triangular). Despite the simplicity of underlying distributions, the finite mixture can model a wide variety of distributions with heavy tails. Classical approach of fitting the mixture relies on Maximum Likelihood estimation, which, in general, leads to a nonconvex optimization problem (with many local minima where the optimization algorithms might get trapped). In contrast, procedures using CVR norm minimization lead to convex programming, which can be reduced to linear programming problems.

■ SD17
105B-MCC
Polyhedral Methods in Integer Programming under Uncertainty
Sponsored: Optimization, Optimization Under Uncertainty
Sponsored Session
Chair: Weijun Xie, Georgia Institute of Technology, 225 North Ave, Atlanta, GA, 30332, United States, wxie33@gatech.edu

1 - Decomposition Methods For Solving Distributionally Robust Two-stage Stochastic Integer Programs
Sanjay Mehrotra, Northwestern University, mehra@northwestern.edu, Manish Bansal, Kuo-Ling Huang

We present a cutting surface L-shaped method for solving 2-stage distributionally robust mixed integer programs. We show the finite convergence of the algorithm under suitable conditions. Wasserstein and moment based uncertainty sets are considered. Numerical results will be presented that demonstrate the performance of our approach and illustrate its ability to perform distributional sensitivity analysis.

2 - An Integer Programming Approach For Two-sided Chance-constrained Programs
Xiao Liu, The Ohio State University, liu.273@osu.edu, Simge Kucukyavuz, Fatma Kilinc-Karzan

We study two-sided chance-constrained programs with a finite probability space. We reformulate this class of problems as a mixed-integer program. We study the key substructure of the reformulation and propose valid inequalities that define the convex hull of this substructure. Finally, we propose polynomial optimization and separation algorithms for the optimization problem over this substructure.

3 - Polyhedral Approach To Online Bipartite Matching
Alfredo Torrico, Georgia Institute of Technology, Atlanta, GA, United States, atorricc@gatech.edu, Alejandro Torriello, Shabbir Ahmed

We study the i.i.d. online bipartite matching problem, a dynamic version of the classical model where one side of the bipartition is fixed and known in advance, while nodes from the other side appear one at a time as i.i.d. realizations of a uniform distribution, and must immediately be matched or discarded. We consider various relaxations of the polyhedral set of achievable matching probabilities, introduce valid inequalities, and discuss when they are facet-defining. Several of these relaxations correspond to ranking policies and their time-dependent generalizations.

4 - On Risk Averse Submodular Minimization
Weijun Xie, Georgia Institute of Technology, Atlanta, GA, United States, wxie33@gatech.edu, Shabbir Ahmed

This paper studies a risk averse submodular minimization problem (RASMSP) under a knapsack constraint. Many problems can be reformulated as RASMSP (e.g., chance constrained problems, mean-risk models, optimization with conditional-value-at-risk, etc.) Approximation algorithms are proposed for RASMSP by rounding an optimal solution to a suitable convex relaxation. We also propose new valid inequalities by partitioning binary variables into groups, and their separation.

■ SD18
109A-MGC
Marketing VI
Contributed Session
Chair: Gary Chao, Kutztown University, 888 Kingston Ln, Breinigsville, PA, 18031, United States, chao@kutztown.edu

1 - Product Life Cycle Among Different Generations
Gary Chao, Kutztown University, PO Box 730, Department of Business Administration, Kutztown, PA, 19530, United States, chao@kutztown.edu, Maxwell Hsu

The launch of a new product needs a larger commitment in time, money, and managerial resources. The new product introduction requires careful planning to ensure the expected market success of a new product. We would like to study how frequently and when an automaker introduced the new models, how an automaker designed their product line, what factors influence the diffusion. We attempt to fit longitudinal data across brands to Baseline model and examine the generation change within the same model from different automakers in order to identify the factors influencing car sales.
Parallel Computing for Optimization and Data Analysis
Sponsored: Computing
Sponsored Session
Chair: Jonathan Eckstein, Rutgers University, Rutgers University, Piscataway, NJ, 08854, United States, jeckstei@rci.rutgers.edu
1 - The Rectangular Maximum Agreement Problem And Its Data Analysis Applications
Ai Kagawa, Rutgers University, ai.kagawa@gmail.com
The NP-hard rectangular maximum agreement (RMA) problem finds a "box" that best discriminates between two weighted datasets. Its data analysis applications include boosting classification methods and boosted regularized regression. We describe a specialized parallel branch-and-bound method for RMA.
2 - Object-parallel Solution Of Lasso Problems
Gyorgy Matyasfalvi, Rutgers University, 100 Rockafeller Road, Piscataway, NJ, 08854, United States, matyasfalvi@gmail.com
Jonathan Eckstein
We describe an "object-parallel" C++ approach to implementing first-order optimization methods. As an example application, we solve large-scale Lasso problems on a distributed-memory supercomputer with the spectral projected gradient (SPG) method. We can efficiently accommodate highly unbalanced sparsity patterns.
3 - Asynchronous ADMM-like Optimization Algorithms
Jonathan Eckstein, Rutgers University, jeckstei@rci.rutgers.edu
Drawing on some recent work on asynchronous decomposition methods for monotone inclusions, this talk develops a class of parallel convex optimization algorithms that resembles the alternating direction method of multipliers (ADMM) but operates asynchronously. Unlike prior work on asynchronous variants of the ADMM, the new algorithm's convergence theory does not rely on either restrictive assumptions on the problem instance or on random invocation of subproblems. Instead, it needs only a basic "fairness" restriction that there be some upper bound on the ratio of the longest and shortest possible subproblem solution times. Stochastic programming applications may also be discussed.

A Unified Framework for Optimization under Uncertainty
Invited: Tutorial
Invited Session
Chair: Warren B Powell, Princeton University, 230 Sherrerd Hall, Dept of Operations Research and Financial Eng, Princeton, NJ, 08544, United States, powell@princeton.edu
1 - A Unified Framework For Optimization under Uncertainty
Warren B Powell, Princeton University, 230 Sherrerd Hall, Dept Of Operations Research And Financial Eng, Princeton, NJ, 08544, United States, powell@princeton.edu
Stochastic optimization, also known as optimization under uncertainty, is studied by over a dozen communities, often (but not always) with different notational systems and styles, typically motivated by different problem classes (or sometimes different research questions) which often lead to different algorithmic strategies. This resulting "jungle of stochastic optimization" has produced a highly fragmented set of research communities which complicates the sharing of ideas. This tutorial unifies the modeling of a wide range of problems, from dynamic programming to stochastic programming to multiarmed bandits problems to optimal control, in a common mathematical framework that is centered on the search for policies. We then identify two fundamental strategies for finding effective policies, which leads to four fundamental classes of policies which span every field of research in stochastic optimization.

Healthcare, General
Contributed Session
Chair: Julie Lynn Hammett, Texas A&M University, 301 Holleman Dr E, Apt 728, College Station, TX, 77840, United States, jhammett@tamu.edu
1 - Analysis Of Physician Productivity In Emergency Departments
Krista Foster, University of Pittsburgh, Mervis Hall, Roberto Clemente Drive, Pittsburgh, PA, 15260, United States, kmf88@pitt.edu, Jennifer S Shang
We present our analysis of a cohort of U.S. emergency departments. We use visit-level data to analyze hospital processes and develop models for physician productivity.
2 - A Review And Extension Of Clinically Significant, Automated Estimation Of End Systolic And End Diastolic Volumes In Cardiac MRIs
Michael Kim, Booz Allen Hamilton, 3930 Valley Ridge Drive, Fairfax, VA, 22033, United States, mikeskim@gmail.com
We review the winning methods in Kaggle’s Second Annual Data Science Bowl. The top three algorithms automatically measure endystolic and enddiastolic volumes in cardiac MRIs using data from more than 1000 patients. The results were found to be clinically significant. An analysis of the winning solutions is presented with a focus on extension through ensembling and transfer learning. In particular, we architect a machine learning pipeline to extend the top algorithms to the case of cancer detection given a time series of prostate MRIs.
3 - The Risks Of Risk Adjusted Mortality Rates And A Proposed Alternative Measure
Thomas Raymond Sexton, Professor, Stony Brook University, 317 Harriman Hall, Stony Brook, NY, 11794-3775, United States, Thomas.Sexton@StonyBrook.edu, Christine Pliocco
We consider the widespread use of the risk-adjusted mortality rate (RAMR) to evaluate hospital performance. We demonstrate that the RAMR, as currently employed, has significant methodological flaws. We propose an alternative to the RAMR that is based on standard statistical theory and methods. Applying our measure yields a more complete and accurate evaluation of hospitals.
4 - Effects Of Artificial Agents Based Ordering On The Supply Chain Of Perishables
Harshal Lowalekar, Assistant Professor, Indian Institute of Management-Indore, Prabandh Shikhari, Rau-Pithampur Road, Indore, 453381, India, lwisterschelle@gmail.com, Raghu Santhanam, Ajay Vinze
We develop a blood bank game which contains a mix of human and computer based hospital blood banks who order blood at regular intervals from a regional bank. The objective of all the agents is to minimize their total inventory costs. The computer agents use a near-optimum policy to determine their order sizes. We show that presence of a large number of computer based agents in the supply chain leads to a systematic increase in the order sizes of the hospital banks which leads to a severe perceived blood shortage in the region. The performance of the supply chain worsens when the computer agents have the capability to learn from their past performance.
5 - Remote Patient Monitoring System Framework: A User Perspective
Julie Lynn Hammett, Texas A&M University, 301 Holleman Dr E, Apt 728, College Station, TX, 77840, United States, jhammett@tamu.edu, Michelle M. Alvarado, Mark Alan Lawley
Healthcare providers are facing an increasing number of patients requiring long-term care, introducing new challenges to providing fast and affordable care. We present ongoing research to create a framework for the design, development, and implementation of remote patient monitoring (RPM) for chronic care. We highlight the stakeholder needs, system requirements and component interdependencies. We describe RPM’s need for automated solutions that support clinical decisions and deliver interventions. This technology must be interchangeable to suit the varied needs and characteristics of many patients. We show that these solutions can improve chronic care management.
1 - Pre-positioning Emergency Relief Items Before A Typhoon With An Uncertain Trajectory
Joline Uichanco, University of Michigan, Ross School of Business, jolineu@umich.edu

We describe a collaborative work with the Philippine government on a pre-positioning model in preparation for an oncoming typhoon. Pre-positioning relief aid before a typhoon is challenging due to the uncertainties in locations and quantities of future demand. We develop a prediction model for the number of affected population by fitting a dataset of typhoon effects to a hierarchical linear model. Our model reveals a significant relationship between wind speed and affected population. We propose a bi-objective stochastic pre-positioning model which balances fairness and effectiveness of the pre-positioning strategy.

2 - Ecuador Earthquake Relief Support: Observations From Fieldwork Research
Johanna Amaya, Rensselaer Polytechnic Institute, Troy, NY, United States, amayaj@rpi.edu, Johanna Amaya, Iowa State University, Ames, IA, 50011, United States, amayaj@rpi.edu, Cintia Perez Siguenza, Jose Holguin-Veras

This talk presents an overview of the disaster response logistics that took place after the earthquake in Ecuador. The talk discusses the preliminary results of the fieldwork research conducted by the authors in the aftermath of the disaster.

3 - Objectives’ Mismatch In Humanitarian Operations: The Role Of Earmarking
Laura Turriini, Kuehne Logistics University, laura.turriini@the-klu.org, Maria Besiou

Effectiveness of humanitarian programs depends both on the donors’ willingness to support the program and on the program implementation by the international humanitarian organization (IHO). Donors provide with the aim of reaching as more beneficiaries as possible. IHOs also have the same objective, but face constraints on how funds. A big constraint comes from the donors themselves, who often earmark their funding. In this paper, we analyze the donors’ and IHOs’ decision-making in an effort to shed more light on how decisions for earmarking are taken. The aim is to give recommendations to the IHOs on how to align donors’ objectives to theirs.

4 - Willingness-to-pay Models On Post-disaster Environments
Diana Ramirez-Rios, Research Assistant, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, ramird2@rpi.edu, Jose Holguin-Veras, Johanna Amaya, Trlice Marie Encarnacion, Shaligram Pokharel, Victor Cantillo, Luuk Wassenhove

This paper introduces an economic valuation for the level of anxiety of an individual under deprivation conditions as anxiety is well-known measure of psychological distress in a community. More specifically, this research estimated the willingness-to-pay for water of individuals who have been affected by disasters, under different scenarios of deprivation and expectation. The level of anxiety is measured by the effect that the expected time to normality introduces to WTP and results indicate that that as the time to recover increases, the level of suffering increases. 

3 - Equitable Scheduling Of Resident Shifts
Hernan Abelo, George Washington University, abeledo@gwu.edu, Anthony Coudert

Creating shift schedules for resident physicians is a notoriously difficult task that is typically done manually by the chief residents. Shift assignments need to observe a large number of rules while populating a complex schedule structure. A key goal is that the schedule be perceived as fair by all residents. We present an integer programming model used to schedule anesthesiology residents at the George Washington University Hospital. The fairness objective is addressed through a joint system proposed by the residents.

4 - Re-scheduling Of Physicians In Case Of Unexpected Absences
Andreas Fugener, University of Cologne, andreas.fugener@uni-koeln.de, Christopher Gross, Jens Brunner

Scheduling physicians is a complex task as legal requirements, levels of qualification, and preferences for different working hours should be considered. Unplanned absences, e.g. due to illness, additionally drive the complexity. In this study, we discuss an approach to deal with the following trade-off: Changes to the existing plan should be kept as small as possible. However, an updated plan should still meet the requirements regarding work regulation, qualifications needed, and employee preferences. We present a mixed-integer programming model to create updated plans following absences of scheduled personnel and apply it to real-life data from a German university hospital.

2 - Neonatal Physician Scheduling At The University Of Tennessee Medical Center
Charles E Noon, University of Tennessee-Knoxville, Knoxville, TN, United States, cnoon@utk.edu, Melissa R Bowers, Wei Wu, Kirk Bass

The default approach for scheduling hospital coverage is to distribute the various types of shifts equally among the covering physicians. This “equality” approach ignores that each physician works his/her fair share of overnight, weekends, etc. We present a new model that incorporates individual shift-type preference so that each physician attains a schedule that is equivalent or superior to his/her “equality” schedule. We formulate and solve the model as a mixed integer program. We demonstrate its benefits by using the approach to schedule hospital coverage for a neonatology group.

4 - Locked In? Noncompete Enforceability And The Mobility And Earnings Of High-tech Workers
Jin Woo Chang, University of Michigan, Ann Arbor, MI, United States, jinwooch@umich.edu, Natarajan Balasubramanian, Mariko Sakakibara, Jagadeesh Sivadasan, Evan Starr

We use matched employer-employee data from 30 U.S. states to examine how the enforceability of noncompete contracts affects the length of job spells and the level of wages. Exploiting inter-state variation in the degree of enforceability and controlling for worker-, job-, and state-level characteristics, we find that a unit standard deviation increase in enforceability is associated with a 3.6% increase in the length of job-spells for high-wage workers in technology industries. We also find persistent wage suppressing effects that last throughout their employment history. Together, these are consistent with noncompetes reducing the bargaining power of employees relative to their employers.

2 - On A Firm’s Optimal Response To Pressure For Gender Pay Equity
David Ross, University of Florida, 55, Gainesville, FL, 32611, United States, David.Ross@warrington.ufl.edu

We present a theory of how a firm would respond to pressure for gender pay equity by strategically distributing raises and adjusting its organizational structure. Using mathematical reasoning, simulations, and data from a real employer, we show that (a) employees in low-paying jobs and whose job-related traits typify men at the firm are most likely to get raises; (b) counterintuitively, some men will get raises and giving raises to certain women would increase the pay gap; (c) a firm can reduce the gender pay gap as measured by a much larger percentage than the overall increase in pay to women at the firm; and (d) “ghettoizing” women in select jobs can help a firm reduce its pay gap.
Managing Uncertainties in Projects

1 - Zooming In On The Innovator's Bias Within Organizations
Fábio Silva, Erasmus University Rotterdam, Rotterdam School of Management, fsting@rsn.nl, Christoph Fuchs, Maik Schickel
Firms in competitive industries strive for process innovations, and one source of such ideas is the firm's workforce. In the selection process, firms rely on input from ideating employees - input that might contain systematic errors (biases) and/or unsystematic errors (noise). We study such errors by analyzing the process innovation ideas contributed by an automotive manufacturer. Our data set is unique in that it includes information on idea generation, employee evaluation, standardized value calculation, selection, and implementation. Overall, our findings contribute to a more differentiated yet theoretically coherent understanding of the innovator's bias in organizations.

2 - To Better Manage Risks In New Product Development Portfolio Selection – Be Risk Neutral?
Janne Kettunen, Assistant Professor, The George Washington University, 2201 G Street, NW, Washington, DC, 20052, United States, jkettune@gwu.edu, Shivraj Kanungo
We investigate trade-offs between risk and return in multi-period new product development (NPD) portfolio selection problems, where new development projects become periodically available. Our analytical and computational results show that, paradoxically, a risk-neutral NPD portfolio selection approach provides higher return and lower risk than a risk-averse selection approach. This result can explain why leading innovators tend to employ a risk-neutral NPD selection approach. The risk of the NPD portfolio can be mitigated by (i) reviewing portfolios more frequently and (ii) increasing the proportion of derivative products instead of platform products.

3 - Project Portfolio Selection – A Behavioral Study
Sebastian Schifflers, Technical University of Munich, Munich, 80333, Germany, sebastian.schifflers@wti.tum.de, Thomas Fliedner, Rainer Kollisch
Choosing the right set of projects is a key driver of success and failure in new product development. We conducted experimental studies based on the knapsack problem to address the question which decision rules individuals apply to select a portfolio as well as how cognitive limitations influence their selection. Grounded in portfolio selection practice, we investigate subjects' adherence to four heuristics. Decision making is partially explained by adherence to two simple rules, but problem complexity limits the application of such rules as subjects apply a local search. Furthermore, decision maker prefer projects with low risk resulting in portfolios with few high risk high impact projects.

4 - Initiating Supplier New Product Development Projects: A Behavioral Investigation
David Wuttke, EBS University, Wiesbaden, Germany, david.wuttke@ebs.de, Karen Donohue, Enno Siemsen
Using a combination of analytical models and laboratory experiments, we study the effectiveness of buyer contract mechanisms, including breach penalties and profit sharing, on incentivizing product innovation at the supplier level. Our results provide insight into how the mechanisms can be altered to better account for supplier-specific behavior.

Empirical Research in Finance and Operations

1 - Optimal Timing Of Inventory Decisions Under Price Uncertainty
Nikolay Osadchy, Emory University, nikolay.osadchy@emory.edu, Vishal Gaur, Sridhar Seshadri, Marty Subrahmanyam
We study the problem of optimal inventory order timing when the selling price and demand are random and their forecasts improve with time. We show that the optimal timing of inventory ordering decision follows a simple threshold policy in the price variable with a possible option of non-purchasing, and is independent of the demand. Given this policy structure, we evaluate the benefits of timing flexibility using the best pre-committed order timing policy as the benchmark.

2 - Wisdom Of Crowds: Forecasting Using Prediction Markets
Roemeng Cui, Kelley School of Business, Indiana University, Bloomington, IN, 47401, United States, cuir@indiana.edu, Achal Baslambo, Antonio Moreno-Garcia
Prediction markets are virtual markets created to aggregate predictions from the crowd. We examine data from a public prediction market and internal prediction markets run at three corporations. We study the efficiency of these markets in extracting information from participants. We show that the distribution forecasts, such as sales and commodity prices predictions, generated by the crowds are perfectly calibrated. In addition, we run a field experiment to study drivers of forecast accuracy.

3 - Linking Operational Performance To Financial Distress In The U.S. Airline Industry
Yasin Alan, Vanderbilt University, Nashville, TN, United States, yasin.alan@owen.vanderbilt.edu, Michael A Lapre
We study the impact of four areas of operational performance - revenue management, operational efficiency, service quality and operational complexity - on financial distress in the U.S. airline industry using quarterly data from 1988 through 2013. Our findings suggest that operational metrics convey useful information regarding future financial distress even after controlling for financial ratios that predict bankruptcies.
There is abundant evidence that operational disruptions are damaging to firm value. This depends not only on characteristics of the firm and its supply chain but also the level of operational transparency with investors. While the former has been widely studied, little is known about the implications of operational transparency. We examine this issue by taking advantage of an exogenous regulatory shock. A well-defined set of firms was excluded from fully complying with the new rules, creating a natural quasi-experiment which we exploit. Our research suggests that credible transparency with investors can alleviate over 50% of the loss in market value from operational disruption announcements.

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**4 - Operational Transparency With Investors**

William Schmidt, Cornell University, ws366@cornell.edu, Ananth Raman

Distributed energy resources (DERs), including distributed generation, storage, and demand response, create new options for the provision of electricity services. Employing a new MILP formulation of the electricity capacity planning problem, this work evaluates the value of DERs and how they compete with conventional resources. Tradeoffs between "locational benefits" of DERs—e.g., loss mitigation, network capacity deferral, constraint mitigation—and economies of scale are considered, and cases where DERs are economically attractive contributors to a least-cost system mix are presented.

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Sponsored Session

2 - Cancelling Distance-driven Online Scheduling be Better Than Order-driven?
KeLin Luo, Xi’an Jiaotong University, Xianning West Road 29, Xi’an, 710049, China, luokelin@stu.xjtu.edu.cn

Scheduling IV
Contributed Session

3 - A Dynamic Lot Sizing Based Discounted Cash Flow Model Considering Working Capital Requirement Financing Costs
Thomaz G Yeung, Associate Professor, Ecole des Mines de Nantes, 4 rue Alfred Kastler BP 20722, La Chantrerie, Nantes, 44307, France, thomas.yeung@mines-nantes.fr, Yuan Bian, David Lemoine, Nathalie Bostel-Dejaz, Jean-Laurent Viviani, Vincent Hovaleque

1 - An Improved Algorithm On Two-stage Scheduling With An Outsourcing Option
Kangbok Lee, City University of New York, York College, 94-20 Guy R Brewer Boulevard, Queens, NY, 11431, United States, kangbok.lee3@gmail.com, Xiaojuan Jiang, An Zhang, Yong Chen, Guangting Chen

We consider a two-stage scheduling problem with an outsourcing option where each operation can be outsourced. The objective is to minimize the sum of the makespan and the total outsourcing cost where the outsourcing cost of an operation is the product of the operation’s processing time and the unit processing time cost of that stage. There was a study on Greedy algorithm with regard to the worst-case analysis. In this work, by reanalyzing the Greedy algorithm, we derive the tight worst-case performance ratio and proposed a new approximation algorithm with a better worst case performance ratio.

2 - Can Distance-driven Online Scheduling Be Better Than Order-driven?
KeLin Luo, Xi’an Jiaotong University, Xianning West Road 29, Xi’an, 710049, China, luokelin@stu.xjtu.edu.cn

Taxi arrangement, instance delivery, and intra-city express has been considered as a dispensable part of everyday life. The orders appear in real-time and in a certain area. The serving net is established by summarizing the order’s properties. In this work, by reanalyzing the Greedy algorithm, we derive the tight worst-case performance ratio and proposed a new approximation algorithm with a better worst case performance ratio.

3 - An Algorithmic Evaluation
Kangbok Lee, City University of New York, York College, Queens, NY, 11431, United States, kangbok.lee3@gmail.com, Xiaojuan Jiang, An Zhang, Yong Chen, Guangting Chen

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INFORMS Nashville – 2016

SD33

203B-MCC
Recent Advances in Simulation
Sponsored: Simulation
Sponsored Session
Chair: Jing Dong, Northwestern University, Evanston, IL, United States, jing.dong@northwestern.edu
Co-Chair: Jose Blanchet, Columbia University, New York, NY, United States, jose.blanchet@gmail.com

1 - On Calibrating Statistical Distances
Huajie Qian, University of Michigan, 2302 St Francis Drive, Apt B118, Ann Arbor, MI, 48104, United States, hjqian@umich.edu
Henry Lam

We present a general framework to calibrate the statistical distance dictating the size of the uncertainty sets for distributionally robust optimization used in stochastic or simulation optimizations under uncertainty. We discuss the implications on the statistical guarantees of the resulting objective values and feasibility. We also compare these guarantees to sample average approximation.

2 - Multi-resolution Gaussian Markov Random Fields For Discrete Optimization Via Simulation
Eunhye Song, Northwestern University, Evanston, IL, United States, EunhyeSong2016@u.northwestern.edu
Barry L. Nelson, Jeremy C Stam

The Gaussian Markov Improvement Algorithm (GMIA), an optimization via simulation algorithm based on Gaussian Markov random fields (GMRF), has computational advantages in solving problems on a large discrete solution space. We extend GMIA to a multiresolution algorithm (MR-GMIA) to solve even larger problems. The solution space is divided into regions; each region becomes a "solution" in a region-level GMRF while solutions within each region are represented by a solution-level GMRF. Using complete expected improvement, MR-GMIA guides the search toward promising regions and promising solutions within the selected regions with global inference about the optimality gap for termination.

3 - Unbiased Monte Carlo Computations For Optimization And Functions Of Expectation
Yanan Pei, Columbia University, yp2342@columbia.edu

We present general principles for the design and analysis of unbiased Monte Carlo estimators for quantities such as functions of expectations. Our estimators possess finite work-normalized variance under mild regularity conditions. We apply our estimator to various settings of interest, such as optimal value estimation in the context of Sample Average Approximations, unbiased estimators for particle filters and conditional expectations.

4 - Estimation In The Tail Of The Gaussian Copula
Raghu Pasupathy, Purdue University, West Lafayette, IN, 47907, United States, pasupath@purdue.edu

We present ecoNORTA for efficient constrained random vector generation within the Gaussian and NORTA contexts. We propose three importance-sampling estimators for such settings, the first of which actively exploits knowledge of the local structure of the feasible region around a dominating point to achieve bounded relative error. The second and third estimators, for use in settings where information about the constraint set is not readily available, do not exhibit bounded relative error but are shown to achieve a slightly weaker form of efficiency. Numerical results on various example problems show promise.

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SD34

204-MCC
Joint Session HAS/MSOM-HC: Models and Analytics in Healthcare Operations
Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations
Sponsored Session
Chair: Joel Goh, Harvard Business School, Boston, MA, United States, jgoh@hbs.edu

1 - Accurate Prediction Of Case Duration
Aminhossein Meisami, University of Michigan, Ann Arbor, MI, United States, meisami@umich.edu, Nick Kastango, Christopher Thomas Borum Stromblad, Mark P Van Oven

The primary goal of this study is to analyze the abundant data available prior to surgery and leverage this information to produce accurate case length predictions via novel statistical learning methodologies. We will be working with a rich database from Memorial Sloan Kettering Cancer Center to identify the essential features in defining case duration variability. The research also focuses on reducing the uncertainties and variations imposed by rare events that may arise in various procedures during a case.

2 - Admission Of Long Stay Patients In A Busy Pediatric ICU
Fernanda Bravo, Assistant Professor, UCLA Anderson School of Management, Los Angeles, CA, United States, fernanda.bravo@anderson.ucla.edu, Michael McManus

This work studies admission policies for complex patients in the ICU of a large pediatric academic hospital. There are four different patient types: medical, emergency, surgical, and transfers. Within these, long-stay-patients use a large amount of resources and limit the access to the unit. The ICU must always remain available for emergencies before accommodating elective admissions. As a result, many children are queued for complex surgeries and medical workups. We study policies to decide when to admit an long-stay-patient depending on the current ICU status, and future patients’ arrivals.

3 - Scheduling Work In Radiology
Maria R. Ibanez, Harvard Business School, mibanez@hbs.edu

Using detailed data on millions of radiological studies interpreted by physicians, we study the drivers of speed and quality of the interpretation, and identify implications for scheduling and allocation of work across workers.

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SD35

205A-MCC
Strategic Queuing
Sponsored: Manufacturing & Service Oper Mgmt, Service Operations
Sponsored Session
Chair: Laurens Debo, Dartmouth College, Tuck School of Business, Hanover, NH, 03755, United States, Laurens.G.Debo@tuck.dartmouth.edu

Co-Chair: Luyi Yang, University of Chicago, Booth School of Business, Chicago, IL, 60637, United States, luyi.yang@chicagobooth.edu

1 - Queueing With Strategic Balking And System Design
Yichen Tu, University of North Carolina, Chapel Hill, NC, United States, yichen1@live.unc.edu, Nur Sunar, Serhan Ziya

We analyze a queueing system where customers decide whether to join or balk the system depending on the expected benefit they receive by joining a system. In this setting, we characterize the optimal choice of system design from the perspective of a social welfare optimizer. We also conduct numerical studies to shed light on the benefit of different system design choices.

2 - Risk/return Trade-off In Queues With A Nonlinear Waiting Cost Function
Hossein Aboee-Mehrizi, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada, haboueeemehrizi@uwaterloo.ca, Ata G Zare, Renata Konrad

We consider an M/M/1 queueing system and assume that each customer receives a value by getting served and suffers from a waiting cost. To analyze customers’ behavior, we consider the risk/return trade-off and a nonlinear waiting cost function. Customers are impatient and have a mixed attitude with respect to the risk. Before reaching a certain point in time, customers are risk-seeking, but after that they become risk-averse. We assume that customers follow a joint balking and abandonment strategy. We fully characterize the equilibrium joint balking and abandonment strategy and show that three types of equilibria may exist: global, myopic, and farsighted.

3 - Optimal Information Disclosure In M/M/1 Queues
Shiliang Cui, Georgetown University, 544 Rafik B. Hariri Building, 37th & O Streets, NW, Washington, DC, 20057, United States, shiliang.cg@georgetown.edu, Jinting Wang

Queue length is a very important parameter for customers to make a joining decision or not. We study optimal information disclosure policies in M/M/1 queues.

4 - Want Priority Access? Refer Your Friend To Move Up In Line
Luyi Yang, University of Chicago, lyang6@chicagobooth.edu, Laurens G Debo

This paper studies the referral priority program, an emerging business practice adopted by a growing number of technology companies that manage a waitlist of customers. The program enables existing customers on the waitlist to gain priority access if they successfully bring in new customers. We find that the effectiveness of this novel mechanism as a marketing tool for customer acquisition and an operational approach for waitlist management depends crucially on the base arrival rate of the system. Referrals may not be generated when the base arrival rate is either too high or too low. Even when customer refer, the program could backfire (i.e., reduces the system throughput and customer welfare).
Economics of Operations Management
Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain
Sponsored Session
Chair: Kenan Arifoglu, UCL, London, United Kingdom, k.arifoglu@ucl.ac.uk

1 - Money-back Guarantees When Physical And On-line Retailers Compete
Hang Ren, University College London, hang.ren.13@ucl.ac.uk
Tingliang Huang, Ying-Ju Chen, Christopher S Tang
We study the pricing and product return policies when physical and on-line stores compete. We find that the on-line store offers money-back guarantees when its salvage advantage outweighs total return hassle. Interestingly, better service quality may hurt the on-line store. When consumers can showroom, i.e., buying online after trying the product offline, the on-line store should offer hassle-free money-back guarantee. Moreover, the showrooming behavior may benefit the physical store while hurting the online store.

2 - Licensing Contracts In Conspicuous Markets
Prateek Raj, University College London, p.raj.12@ucl.ac.uk, Kenan Arifoglu
We study licensing decision of a brand owning firm that sells its primary product to conspicuous customers who value the brand exclusivity, and also licenses its brand name to a licensing firm. We compare efficiency of fixed-fee, royalty and mixed contracts and also explore the role of licensing under competition.

3 - Selling New Products Through Consumer Learning
Yulei Huang, University of Bath, y.huang@bath.ac.uk, Billal Gokpinar, Christopher S Tang, Onesun Steve You
Due to uncertain valuation of a new product, consumers often seek to learn more about the product before making purchasing decisions. In general, consumers can learn from the firm directly, from making an individual effort to learn, or from other consumers indirectly (through social learning). In this paper, we present a unified framework of consumer learning in the context of rational and heterogeneous consumers. Our goal is to examine, from the firm's perspective, when and why (i) investing in firm-induced learning can be superior to variable pricing, (ii) subsidizing individual learning can be beneficial, and (iii) investing in social learning (e.g., online forums) can be harmful.

4 - Is Reshoring Better Than Offshoring Under Offshore Supply Dependence?
Hui Bin, University of North Carolina, Chapel Hill, NC, United States, Bin_hu@unc.edu, Li Chen
We investigate offshore supply dependence's impact on the offshoring-reshoring comparison. We find that offshore supply dependence may hamper a reshoring manufacturer's responsiveness to demand information updates, such that reshoring may yield lower profits than offshoring in many cases, including when reshoring has no direct cost disadvantages. We then show that offshore supply dependence also affects how customs duties and shipping costs influence the offshoring-reshoring profit comparison. We further identify common-component designs as an approach to mitigate reshoring firms' offshore supply dependence and help promote reshoring in its presence.

Value Chain Transformations for Sustainability
Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations
Sponsored Session
Chair: Dan Andrei Iancu, Stanford University, 655 Knight Way, Stanford, CA, 94305, United States, dani@stanford.edu
Co-Chair: Joann de Zegher, Stanford University, Y2E2 Suite 226, Stanford, CA, 94305, United States, jdezegher@stanford.edu

1 - Retail Clusters In Developing Countries
Xuying Zhao, University of Notre Dame, Xuying.Zhao.29@nd.edu, Hong Guo, Chao Ding, Jing-Sheng Jeanette Song
A retail cluster refers to a collection of horizontally differentiated retailers of a particular business sector located in close proximity. Retail clusters are commonly seen in developing countries. In this paper, we develop a game-theoretic model to explore why the retail cluster phenomenon is so popular in developing countries and how the governments in these countries can foster retail clusters and leverage them to improve social welfare.

2 - Achieving Sustainability Commitments In Commodity Supply Chains
Joann Françoise de Zegher, Stanford University, Stanford, CA, United States, jdezegher@stanford.edu, Hau Leung Lee, Dan Andrei Iancu, Erica Plambeck
How can downstream companies in commodity supply chains incentivize small producers to mitigate deforestation while also improving farmer welfare? Motivated by field research in the palm oil industry, we propose an incentive based on early payments. The dynamics of this incentive are distinct from a price premium incentive, due to characteristics of small-farmer cash flow needs upstream and large uncertainties in borrowing abilities of different supply chain tiers. We build a theoretical model to analyze this setting and ground our analysis through empirical work in the complex palm oil supply chain originating in Indonesia.

3 - Effective Medical Surplus Recovery
Can Zhang, Georgia Institute of Technology, Atlanta, GA, 30309, United States, c.zhang2012@gatech.edu, Atalay Atasu, Beril I. Toktay, Wee Meng Yeo
We analyze a Medical Surplus Recovery Organization (MSRO) that recovers and manages reusable medical products to fulfill the needs of under-served healthcare facilities in developing countries. Using a game theoretic analysis, we identify loss of effectiveness caused by competition among recipients in a recipient-driven model implemented by the MSRO. We then present operational mechanisms that can improve the MSRO's total value provision and we numerically validate our results using real life data.

Innovations in Production and Disruption Management
Sponsored: Manufacturing & Service Oper Mgmt
Sponsored Session
Chair: Yufei Huang, University of Bath, y.huang@bath.ac.uk, Dan Andrei Iancu, Erica Plambeck

1 - Risk Aversion And Joint Problem Solving: Experimental Evidence
Marc Christian Jansen, Cambridge Judge Business School, Downing College, Regent Street, Cambridge, CB2 1DQ, United Kingdom, mcj32@cam.ac.uk, Nektarios Oraipoulos, Niyazi Taneri
We examine the effect of risk aversion on collaborative problem solving between two partners. We design an experiment that measures subjects' risk aversion and allocates subjects to treatments accordingly. We show that subjects perform relatively well in sharing the risk between them, but underperform relatively to the optimal investments levels.

2 - Strategic Positioning In Global Entrepreneurship Ecosystems
Hwipark Park, Postdoctoral Fellow, Georgia Institute of Technology, Atlanta, GA, 30332, United States, hwipark@gatech.edu, Rahul Basole, Raul Chao
Strategic positioning is particularly critical for entrepreneurial ventures, which face a difficult trade-off in balancing legitimacy through similarity versus innovativeness through differentiation. Using a computational approach based on data mining, text analytics, and network visualization, we seek to gain an understanding of the structure of strategic positioning of nearly 60,000 companies in 35 global entrepreneurial ecosystems.

3 - Won't Leave You At The Altar: Designing Alternative Mechanisms For Startup Supply Chain Development
Emre Guzelis, Boston University, bguzelsu@bu.edu, Brad Lee, Nitin Gogekar
Startup supply chain development spans two stages, early experimentation without revenue followed by production scale-up and revenue generation. Early experimentation involves single sourcing with another startup, where production offers dual sourcing opportunity. We explore alternative mechanisms for startup supplier alignment across both stages using a game theoretic framework.

4 - Optimal Supplier Allocation In Collaborative Product Development With Competing Internal Teams
Svenja Sommer, HEC Paris, 1, Rue de la Liberation, Jouy-en-Josas, France, sommers@hec.fr, Timofey Shalpagnet, Christian Van Delft
To reduce the uncertainty inherent in development, manufacturers sometimes deploy competing internal teams, each working on a different technology or design. Often this development takes place in collaboration with key suppliers. We explore how manufacturers should allocate suppliers (with different capabilities) to these teams, considering the impact on supplier efforts.
1 - Optimal Routing To Remote Queues
Yun Li, NC State University, Raleigh, NC, United States,
yliu48@ncsu.edu, Shuangchi He, Yao Yu
We develop optimal routing policies for remote queueing systems, in which each arrival, after being routed to join one of several single-server queues in parallel, will experience a pre-arrival delay. Motivated by service systems in which system state (e.g., queue length and waiting time) is available for routing decisions, we intend to use pre-arrival delays to model commute times of arrivals, such as patients’ transportation times before arriving at clinics and data packets’ transmission times to web servers. In order to minimize the delay, we propose a state-dependent probabilistic routing policy.

2 - Complete Resource Pooling In Open Shop Networks
Shuangchi He, National University of Singapore, Singapore, heshuangchi@nus.edu.sg, Gideon Weiss, Hanqin Zhang
In an open shop network, each customer needs to go through all stations once, but the order of visiting each station is irrelevant. Can this flexibility in service order give us an edge in reducing customer waiting times? In this paper, we consider an open shop network consisting of two stations. We find routing and sequencing policies that are asymptotically optimal when the open shop network is operated in heavy traffic. We prove that under the obtained scheduling policies, customer waiting times in an open shop network are asymptotically close to the waiting times in a GI/GI/2 queue with the same traffic intensity.

3 - Stein Method And Moderate Deviations For Steady-state Diffusion Approximations
Jim Dai, Cornell University, jds694@cornell.edu, Fang Xiao
Service levels such as no more 5% of callers have to wait 3 minutes longer are common performance measures for many service systems. We will use the Erlang-C system to explain how Stein method can be used to develop moderate deviations bounds for steady-state diffusion approximations of these performance measures. This is the joint work with Xiao Fang at NUS and Chinese University of Hong Kong.

4 - Optimal Service Rate And Admission Control For A Queue
Levent Kocaga, Yeshiva University, kocaga@yu.edu
We study the joint service rate and admission control problem for a multi-server service system modeled as a G/M/N+GI queue. We consider the infinite horizon discounted cost criterion as well as the infinite horizon average cost criterion where costs are associated with customer waiting, customer abandonment, and service rate control. Instead of solving the potentially intractable original queueing control problem, we solve an approximating diffusion control problem (DCP) and show that the optimal control is of threshold and feedback type. We utilize the solution to the DCP to construct a control policy for the original queueing control problem.

2 - The Value Of Aggregated Information Sharing In Supply Chains
Vladimir Kourtis, Yeshiva University Symms School of Business, New York, NY, vladimir.kourtis@yu.edu
We study a two-stage supply chain where the retailer’s order is the aggregate of two stationary ARMA processes. We determine when there is value to sharing the individual processes and when there is additional value to sharing the shocks. We also determine the supplier’s mean squared forecast error under no sharing, process sharing, and shock sharing. We find instances where process sharing has no value which are not present in earlier literature.

3 - Coordination Of The Supply Chain With Quality Improvement And Customer Returns
Xinghao Yan, Western University, London, ON, Canada. Contact: xyan@ivey.uwo.ca
We study a supply chain with both quality improvement and customer returns. We analyze the retailer’s incentive for refund price and the supplier’s incentive for quality improvement. We also design coordinating contracts for the supply chain, which is influenced by several factors: contract format, profit negotiation, and first-mover right.

2 - Simulating Risk Measures
Steven Kou, National University of Singapore, matsteve@nus.edu.sg
Risk measures, such as value-at-risk and expected shortfall, are widely used in risk management. We propose a simple general framework, allowing dependent samples, to compute these risk measures via simulation. The framework consists of two steps: In the C-step, we control the relative error in the simulation by computing the necessary sample size needed for simulation, using a newly derived asymptotic expansion of the relative errors for dependent samples; in the S-step, the risk measures are computed by using sorting algorithms. Numerical experiments indicate that the algorithm is efficient even at the 0.001 quantile level. This is a joint work with Wei Jiang.

2 - Valuation Of Path-dependent Equity And Credit Derivatives
Ning Cai, Hong Kong University of Science & Technology, Jinhua Road, Hefei, 230026, China, songyd@ustc.edu.cn
We study the pricing problems of path-dependent equity and credit derivatives within a general hybrid equity-credit framework, i.e., under generalized jump to default extended exponential Levy models with local volatilities. More precisely, under this general model, we propose a unified approach to pricing various equity derivatives and credit derivatives, including defaultable corporate bonds, European options, barrier options, CDS, and EDs. Numerical results indicate that our pricing methods are accurate, efficient, and easy to implement. This is joint work with Haohong Lin from HKUST.

3 - A Unified Framework For Options Pricing Under Regime Switching Models
Yingda Song, University of Science and Technology of China, Hefei, China, songyd@ustc.edu.cn
Regime changes are prevalent in the financial markets, yet it is challenging to price options in presence of regime switching. In this talk, we provide a unified framework for pricing options under a wide class of regime switching models. Based on our framework, we study the effects of regime switching on the prices and hedge parameters of various types of options, as well as the yield spread of a structural credit model.
SATISFACTION with their decisions and lives.

Decision-making. We recommend schools, colleges, and universities to offer more empirical evidence that proactive cognitive skills can be trained in a course on decision-making. We recommend schools, colleges, and universities to offer more courses on decision-making to enhance student’s proactive cognitive skills and satisfaction with their decisions and lives.

Further, we provide empirical evidence that proactive cognitive skills can be trained in a course on decision-making. We recommend schools, colleges, and universities to offer more courses on decision-making to enhance student’s proactive cognitive skills and satisfaction with their decisions and lives.

In several situations, analysts are not able to assign a unique distributions to the inputs of a computer code. Especially when alternative opinions are received by experts, analysts may combine alternative assessments using a mixture. The removal of the unique distribution assumption creates several issues in global sensitivity analysis, which we address systematically in this work.

The projected impacts of climate change often include untenable implications for many infrastructure systems. Planners and policy makers seek the best possible sources of climate change projections and information to assist their decision making needs. However, the dominance of climate science oriented toward mitigation of greenhouse gas emission questions leads to a disorientation of research focused on adaption to climate change impacts. A break from “impact analysis” methods is needed, and a climate informed decision analysis is proposed in response. The question of use of probabilities, in particular, is analyzed.

The risk of terrorism is of great concern to many countries and significant resources are spent to counter this threat. A better understanding of the motivation of terrorists and their reasons for selecting certain modes and targets of attack can help improve the decisions to allocate resources in the fight against terrorism. We develop methods using principles of decision analysis and value-focused thinking to identify, structure, and compare objectives of terrorists. We use our methods to predict the key decision makers in the Pentagon with a sound basis for fighting the terrorist groups.

The Proactive Decision Making scale, which is based on the concepts of value-focused thinking and decision quality, measures proactive personality traits and cognitive skills in decision-making. We show that proactive cognitive skills can explain up to 36% of life satisfaction, i.e., proactive decision makers are more satisfied with their decisions and with their lives. Furthermore, we provide empirical evidence that proactive cognitive skills can be trained in a course on decision-making. We recommend schools, colleges, and universities to offer more courses on decision-making to enhance student’s proactive cognitive skills and satisfaction with their decisions and lives.

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3 - Path-dependent And Randomized Strategies In Barberis’ Casino Gambling Model

Xunyu Zhou, Columbia University, Manhattan, New York City, NY, United States, x22574@columbia.edu

We consider the dynamic casino gambling model initially proposed by Barberis (2012) and study the optimal stopping strategy of a pre-committing gambler with cumulative prospect theory (CPT) preferences. We illustrate how the strategies computed in Barberis (2012) can be strictly improved by reviewing the betting history or by tossing an independent coin, and we explain that the improvement generated by using randomized strategies results from the lack of quasi-convexity of CPT preferences. Moreover, we show that any path-dependent strategy is equivalent to a randomization of path-independent strategies.

4 - Optimal Exit Time From Casino Gambling: Strategies Of Pre-committed And Naïve Gamblers

Xuedong He, Chinese University of Hong Kong, xdehe@sc.cuhk.edu.hk

We study the strategies of a pre-committed gambler, who commits her future selves to the strategy she sets up today, and of a naïve gambler, who fails to do so and thus keeps changing plans at every time. We identify conditions under which the pre-committed gambler, asymptotically, adopts a stop-loss strategy, exhibits the behavior of disposition effect, or does not exit. When the utility function is piece-wise power and the probability weighting functions are concave power, we derive the optimal strategy of the pre-committed gambler in closed-form whenever it exists. Finally, we study the actual behavior of the naïve gambler and highlight its marked differences from that of the pre-committed gambler.

SD46

200B-MCC

Revenue Management: From Theory to Practice

Sponsored: Revenue Management & Pricing
Sponsored Session
Chair: Georgia Perakis, Massachusetts Institute of Technology, Cambridge, MA, United States, georgia@mit.edu

1 - The Role Of Vendor Funds In Promotion Planning

Lennart Baardman, MIT, Cambridge, MA, United States, Georgia Perakis, Kiri Venkata Panchamgam

Vendor funds are integral to promotion planning. Vendor funds are trade deals in which manufacturers offer discounts to retailers, encouraging them to promote their products, while demanding pass-through to the customers. We model the problem of selecting vendor funds to maximize profit while taking into account the impact on promotional pricing as a GIP. First, we use a strategic model to analyze the optimal strategies of both the manufacturer and the retailer. Additionally, to solve the tactical problem, we use Lagrangian relaxation to propose an approximation algorithm with analytical performance guarantees. Finally, computational results show near-optimal practical performance.

2 - Revenue Management For The Shipping Industry Under Limited Foresight

Max Biggs, Massachusetts Institute of Technology, Cambridge, MA, United States, maxbiggs@mit.edu, Georgia Perakis

We study a scenario where a shipping company has limited foresight into cargo availability in future periods. It is possible that a high valued cargo may discharge in unpromising region with scarce or low valued cargoes, thus jeopardizing profit in subsequent time periods. We model this situation using a finite horizon Markov Decision Process and present a ranking algorithm which solves optimally in polynomial time. We also explore fast heuristics, and test these algorithms on a simulation that uses real shipping data to evaluate their performance in a practical setting. We also show extensions for uncertain shipping rates.

3 - Submodular Batch Scheduling

Daniel Chen, MIT, Cambridge, MA, United States, dchen@mit.edu, Retsef Levi, Georgia Perakis

Consider an online retailer shipping out orders from a warehouse. Multi-item orders take up capacity in a holding area until all items are picked. This holding area is often the cause of bottlenecks, so we formulate the submodular batch scheduling problem to maximize throughput. We wish to schedule jobs in batches to minimize the sum of job completion times. The processing time of each batch is given by a submodular cost function, and the completion time of each job is given by the completion time of the batch. We show this problem is strongly NP-hard, but propose several practical methods, including a $4$-approximation algorithm.

4 - The Periodic Joint Replenishment Problem Is Strongly NP-hard

Tamar Cohen, MIT, ticohen@mit.edu, Liron Yedidsion

The Joint Replenishment Problem (JRP) deals with the prospect of saving resources through coordinated replenishments in order to achieve substantial cost savings. In the JRP it is required to schedule the replenishment times of numerous commodities in order to supply a constant demand per commodity. In this research we answer a long-standing open question regarding the computational complexity the periodic JRP. This problem received a lot of attention over the years and many heuristic and approximation algorithms were suggested. However, in spite of the vast effort, the complexity of the problem remained unresolved. In this research, we provide a proof that the problem is indeed strongly NP-hard.
2 - Unlocking Your 80%: Unearthing New Insights With Text Analytics
Christina Engelhardt, SAS Institute, Christina.Engelhardt@sas.com
How can your organization harness the staggering volumes of textual data coming from social & online media and your own proprietary systems? Join us as we explore some of the challenges and exciting opportunities these rich, yet complex, data sources provide us. Session topics include: • Why you should consider incorporating text analytics into your data science, research, and operational work streams• How to align technology, data sources, and the various text methods with your use case and objectives• Examples of how leading organizations are leveraging Text Analytics

3 - Hierarchical Machine Learning Approach To Detecting Anomalous Behavior In Online Social Media Forums
Naveen Kumar, University of Memphis, Memphis, TN, 38152, United States, nkumar7@memphis.edu, Deepak Venugopal, Robin Poston
The detection of anomalous behavior in online social media is a challenging problem due to complex interactions between several user characteristics such as review veracity, velocity, volume, and variety. We propose a novel two stage hierarchical machine learning approach that increases the likelihood of detecting anomalies by analyzing different actions of individual users and then characterizing their collective behavior. Specifically, we model user characteristics as univariate/multivariate distributions and then combine these distributions using mixture models to obtain a unified view of a user's behavior. We apply our approach to real-world reviews and obtain promising results.

4 - Trade-offs In Digital Advertising: Modeling And Measuring Advertising Effectiveness And Annoyance Dynamics
Vilma Todri, New York University, vtodri@stern.nyu.edu
Anindya Ghose, Param Vir Singh
This study captures the trade-offs between effective and annoying digital advertising exposures. A hidden Markov model (HMM) is proposed that allows us to investigate the extent to which display advertising has an enduring impact on consumers’ purchase decision and whether display advertising can stimulate annoyance to consumers; we provide a conceptual framework for understanding whether persistent digital display advertising exposures constitute a mechanism of annoyance. We also study the structural dynamics of the effective and annoying display advertising effects by allowing the corresponding effects to be contingent on the latent state of the funnel path consumers reside.

5 - Social Influence And Changing Circumstances In The Creation, Maintenance, And Disruption Of Habits In Global Health Behavior
Christos Nicolaides, Massachusetts Institute of Technology, chrisnic@mit.edu
In this research I analyze a unique, granular dataset of individual-level exercise data from more than 10 million users worldwide for about seven years to (a) measure the regularity of exercise behavior, (b) identify factors that predict a behavior continuing, (c) compare social influence in running for individuals with and without running habits, and (d) estimate the consequences of common disruptions to circumstances cues for habitual behaviors. I use modern causal inference techniques to address central questions in the psychology of habits with applications to interventions — especially social interventions — to influence exercise behavior and adoption of consumer exercise products.

5 - The Dynamics Of Queueing Transience With Dynamic Rates
William A Massey, Professor, ORFE Department, Sherrerd Hall, Princeton University, Princeton, NJ, 08544, United States, wmassey@princeton.edu
In this talk we will explore the applications of time varying queues to problems in urban transportation. We show how Bill Massey’s fundamental contributions to queueing theory and applied probability can be applied to smart parking systems, bike sharing and car sharing services.

6 - The Dynamics Of Queueing Transience With Dynamic Rates
William A Massey, Professor, ORFE Department, Sherrerd Hall, Princeton University, Princeton, NJ, 08544, United States, wmassey@princeton.edu
Inspiried by communication and healthcare services, this talk summarizes the methods developed with many collaborators over the decades to understand the transient behavior of dynamic rate queues. This analysis is needed when confronted with the dynamic parameters found in time-inhomogeneous Markovian queueing models. The static equilibrium analysis for the steady state of constant rate queues no longer applies.

Constants summarizing the transient behavior for these steady state systems yield to the natural substitute of deterministic dynamical systems. We can then approximate the optimal behavior of these queues by controlling this related family of ordinary differential equations.
1 - Estimating Disease Burden Of A Potential H7N9 Pandemic Influenza Outbreak In The United States

Walter Silva Sotillo, USF, silvasotillo@mail.usf.edu

Recent emergence of H7N9 influenza virus in China resulted in 571 laboratory-confirmed cases of human infections causing 212 deaths (37% fatality rate). Researchers have developed early estimates of some of the epidemiological parameters to characterize H7N9 virus in China. We use data from recent reports, an agent-based simulation model and stratified sampling to estimate disease burden of a potential H7N9 pandemic outbreak in the United States.

2 - Using The HIV Optimization And Prevention Economics (HOPE) Model For Evaluating HIV Interventions In The United States

Emine Yaylali, Centers for Disease Control and Prevention, wq3@cdc.gov, Paul Farnham, Stephanie Sansom, Katherine A. Hicks, Amanda Honeycutt, Emily Tucker

The HOPE model is a detailed, dynamic compartmental model of HIV disease progression and transmission in the United States. We parameterized and calibrated the model to closely match the population of people living with HIV between 2006 and 2010, to project HIV transmission into the future. The population was stratified by age, sex, circumcision status, race/ethnicity, transmission group, and risk level. Outcomes included HIV incidence, prevalence, and care status. We employed the HOPE model to evaluate the cost-effectiveness of HIV interventions and explore HIV prevention policy questions.

3 - Access-to-Medicines (ATM) Vaccine Supply Chain Design: Astakeholder Framework

Nico Vandaele, KU Leuven, Naamsestraat 69, Leuven, 3000, Belgium, nico.vandaele@kuleuven.be

Catherine Jenny Decouttere, Mauro Bernuzzi, Stef Lemmens

Supply chains supportive of ATM, like vaccine supply chains, impose considerable additional challenges on the supply chain design process. We embed the modeling in a broader stakeholder based framework, which will substantially enhance the societal and human impact of the ATM supply chain service delivery. Our approach contains stakeholder mapping and system delineation, key performance indicator development, scenario generation including modelling, scenario ranking and final design selection.

4 - A Methodology For Parameterization Of State-transitions For Cancer Progression In Populations With Limited Longitudinal Cancer Database

Chaithra Gopalappa, University of Massachusetts, Amherst, chaitra@umass.edu, Carel Pretorius, Jeremy Lauer

Economic analyses of cancer screening strategies specific to populations in low and middle income countries (LMICs) are limited. Barriers include absence of cancer progression models parameterized specific to these populations. This study addresses this gap.

2 - Identifying Optimal Multi-state Collaborations For Reducing Co2 Emissions By Co-firing Biomass In Coal-burning Power Plants

Ronald McGarvey, University of Missouri, Columbia, MO, rmcgarvey@missouri.edu, Francisco X Aguilar

EPA has recently proposed a rule that aims to achieve a total US carbon emission reduction of 32 percent below 2005 levels by 2030. An increase in co-firing woody biomass with coal is one approach electricity providers could take towards achieving these reductions. We develop a mixed integer linear programming model to identify min-cost approaches for reducing carbon emissions via biomass co-firing subject to spatially-explicit biomass availability constraints, utilizing a robust optimization approach to address uncertainties in power plant modification costs and emission rates. We apply this model to a set of 18 states in the northern US to identify optimal sets of multi-state collaborations.
4 - How Cost Reduction And Change Of Technology Significantly Changed The Demand Of A Product. Case Story Based On Daily Demand Data From 2012-2016
Eric Bentzen, Copenhagen Business School, eb.om@cbs.dk
Senior leadership can influence a direct report through incentives and communication. Financial incentives are credible and precisely specified, but offer limited flexibility, whereas communication is flexible, but lacks precision and must be deemed credible to affect a direct report’s actions. We study senior leadership who seeks to add an initiative to their portfolio. Early on, its potential to create value is not well-understood, however, senior leadership eventually obtains knowledge on its potential which they may communicate to their direct report.

SD54
Music Row 2 - Omni
Simulation of Healthcare Service Systems
Sponsored: Service Science
Sponsored Session
Chair: Wai Kin Chan, Rensselaer Polytechnic Institute, 110 8th St., CI 5015, ESE Dept., RPI, Troy, NY, 12180, United States, chansw@rpi.edu
1 - Optimizing Hospital Service Levels Via Resource Allocation
Weiwei Chen, Assistant Professor, Rutgers University, 1 Washington Park, Newark, NJ, 07901, United States, wchen@business.rutgers.edu, Siyao Gao, Hainan Guo
This talk introduces a resource allocation problem typically encountered in hospitals. Service levels in a hospital will vary as the resources are allocated differently. These performance measures can be evaluated via simulation. We aim to find the optimal allocation that maximizes one service level while satisfying the other service level requirements. Such an optimization is subject to random noises in simulation and the limit on computing budget to run simulation. To this end, we formulate the problem as a simulation optimization problem, and derive the corresponding optimal computing budget allocation policy.
2 - Simulation Of Infectious Disease Propagation
Susan M Sanchez, Professor, Naval Postgraduate School, Monterey, CA, 93950, United States, ssanchez@nps.edu, Paul J. Sanchez
We explore the behavior of a new stochastic model of infectious disease propagation. The model tracks individual outcomes, but without creating connectivity graphs for all members of the population. Accordingly, it is readily scalable to large populations, while preserving the impact of variability during the critical early stages of an outbreak. Initial explorations show behaviors similar to the observed course of historical outbreaks: while many outbreaks fizzle out quickly, some flare into more widespread epidemics. Such results may better inform decision makers about risk.
3 - Association Between Staff Behavior And Patient Experience Of Care In Acute-care Hospitals
Eduardo Perez, Assistant Professor, Texas State University, San Marcos, TX, United States, eduardop@txstate.edu
David P. Dzubay, Anthony Stahl
This research proposes a new framework to assess the performance of hospitals across multiple domains of patients’ experiences. We examine whether key systemic characteristics of hospitals are associated with a better experience for patients. In particular, we investigated the effects of nurses and hospitalists activities on patients’ ratings of their care. A case study is presented that considers data from the intensive care units from multiple hospitals in Central Texas.
4 - Simulating The Size Distribution Of Hospital Service Systems
Wai Kin Chan, Rensselaer Polytechnic Institute, 110 8th St., CI 5015, ESE Dept., RPI, Troy, NY, 12180, United States, chansw@rpi.edu, Baojun Gao, Nancy Deng
This talk introduces an agent-based simulation model for simulating the growth process of a hospital service system. In this model, hospitals grow or reduce their size to react to (and compete for) patient demand. Patients, as another type of agents in the model, select a hospital to visit based on multiple factors. The objective of the agent-based model is to understand what factors influence the growth of hospitals in a way that the hospital size distribution converges to the size distribution consistent with the actual size distribution observed in a real hospital size dataset.

SD55
Music Row 3: Omni
Modeling and Simulation of Education as a Complex System
Sponsored: Service Science
Sponsored Session
Chair: Maryam Alsadat Andalib, PhD Student, Virginia Tech, 1185 Perry Street, 536F Whittemore Hall, Blacksburg, VA, 24061, United States, maryam7@vt.edu
1 - Cross-sectional Surveys: Inferring Total Time In State Using Only Elapsed Time-to-date
Richard C Larson, Massachusetts Institute of Technology, rclarson@mit.edu
We survey populations whose members are in a temporary state, asking time already spent in the temporary state. Leveraging longevity bias, we derive distributions of total time spent in the state for: random & fixed times of surveying, random & fixed times of entering the state, and sampling only those who have already spent some minimal specified time in the state.
2 - Exploring The United States Behavioral And Social Science Research (BSSR) Workforce Through Dynamic Modeling
Julie Maurer, Ohio State University, maurer.99@osu.edu
The behavioral and social sciences research (BSSR) workforce in the United States is a segment of the STEM researcher workforce that is of growing concern. There is considerable interest in the health of the BSSR workforce as demonstrated by a recent Executive Order (EO 13707, 2015) recognizing the value of such research in informing effective policy creation. Given its complexity and the challenges of understanding the heterogeneity of its scientists, a hybrid model (combining system dynamics and agent based approaches) is developed in this study to explore and better understand the complex dynamics of the supply and demand in the BSSR workforce and the effects of various policy interventions.
3 - Different Modes Of Scientific Progress In HIV/AIDS
Arash Baghaii Lakhe, Virginia Tech, arash@vt.edu
Navid Ghaffarzadegan
There is a variation in research focus of scientific communities from different countries on various aspects of HIV/AIDS disease. In this research, we are employing topic finding methods to distinguish different trends of HIV/AIDS research over the past two decades. Our data includes the abstracts of more than 200,000 papers published over this period on HIV/AIDS. We then show differences of focus on HIV research in different countries and investigate the underlying reasons for such variation.
4 - Modeling And Analysis Of The Leaking Pipeline: Diversity In The United States Higher Education
Maryam Alsadat Andalib, Virginia Tech, Blacksburg, VA, United States, maryam7@vt.edu, Navid Ghaffarzadegan
Moving towards an equitable education system provides underrepresented groups with equal educational and economic opportunities. Many studies have attempted to identify the important causes of the existing gender and ethnicity gaps in higher education and the policy leverages with the goal of increasing equity. But the body of research investigating the effectiveness of different policy leverages is methodologically narrow. In this research, we specifically aim at identifying the important causes of disparities in the US higher education, and introduce policies to improve education equity as well as long term achievements of underrepresented minorities through a system dynamics approach.

SD56
Music Row 4: Omni
Health & IT
Sponsored: EBusiness
Sponsored Session
Chair: Laura Brandimarte, University of Arizona, Tucson, AZ, United States, lbrandimarte@email.arizona.edu
1 - There's An App For That: Addressing The Handoff Problem In Healthcare Using Mobile
Idris Adjerid, Notre Dame University, iadjerid@nd.edu
Corey M Angst, Ralph Gross
Healthcare and mobile technologies seem like a natural union with the potential for considerable value to providers and patients. With this in mind, we study a novel mobile application designed to address the handoff problem between the Emergency Department and inpatient units. Leveraging data on more than 145,000 Emergency Department visit over 4.5 years alongside detailed logs of app usage, we find that use of the app reduced patient length of stays in the ED by 4-6%, effectively eliminating the additional time that an admitted patient spends in the ED.
2 - CPOE Adoption Impacts On Medicare Reimbursements
Hilal Atasoy, Temple University, hilal atasoy@temple.edu

Computerized Physician Order Entry (CPOE) systems allow physicians to seamlessly enter information in patient records compared to paper-based records, potentially leading to higher quality of care. On the other hand, the ease of capturing information into electronic medical records can be deliberately used by hospitals to inflate their reimbursement requests from Medicare by overstating the complexity of patients’ diagnoses. We study the relationship between CPOE adoption and reported patient complexity of hospitals. We find that, on average, the adoption of CPOE systems is associated with an increase in the case mix index. This increase is significantly higher among for-profit hospitals.

3 - Not What The Doctor Ordered: Physician Mobility And Technology Adoption
Brad N Greenwood, Temple University, brad.n.greenwood@gmail.com, Corey M Angst, Kartik Krishnamurthy

In this work we investigate the relationship between EMR implementation and physician mobility. Strikingly, although significant anecdotal evidence would suggest that EMR implementation is associated with an exodus of physicians, we find that this reaction is strongly moderated by hospital characteristics, physician characteristics, and the type of EMR implemented.

4 - Detecting Anomalous Patterns Of Care Using Health Insurance Claims
Sriram Somanchi, University of Notre Dame, 344 Mendoza College of Business, Notre Dame, IN, 46556, United States, somanchi.1@nd.edu, Edward McDowall

Patient care data using health insurance claims can be used to improve clinical practice by analyzing patterns across patients and providing actionable insights. Our goal in this project is to analyze complex patient care data in order to identify interesting patterns in patient care that have led to anomalous health outcomes. Specifically, we detect treatments in the outpatient patient care that have significantly deviated from the regular treatment process and have affected health outcomes either negatively or positively. This can further help both in terms of improving patient health and reducing health care costs.

■ SD58

Music Row 6- Omni
Joint Session BOM/RMP: Consumer Behavior In Pricing and Loyalty
Sponsored: Behavioral Operations Management
Sponsored Session
Chair: Anton Ovchinikov, Queen’s School of Business, Kingston, ON, Canada, ao37@queensu.ca

1 - Impact Of Tiered Incentives On Behavior: Case Of The Airline Loyalty Programs
Tong Guo, University of Michigan, 701 Tappan Street, Ann Arbor, MI, 48109, United States, tongguo@umich.edu, A. Yesim Orhun

This paper explores the impact of status incentives provided by a major U.S. airline on the purchasing behavior of its frequent flyer program members. We leverage a database of complete transaction histories of more than six million members to study within-person changes in the distribution of price and route characteristics of tickets purchased from the airline as members progress towards a status goal. We present novel empirical manifestations of increased customer loyalty on market outcomes.

2 - Stockpile Or Redeem: How Do Consumers Value Loyalty Program Points
So Yeon Chun, McDonough School of Business, Georgetown University, sc1286@georgetown.edu, Rebecca Hamilton

Loyalty programs are designed to reward customers for buying more or buying more frequently from a firm. Typically, customers earn points for their purchases, which can then be exchanged for additional products and services. In a sense, these loyalty program points function as a currency that consumers can spend (redeem) on a purchase instead of money. We conduct a series of behavioral lab experiments to examine differences in the way customers think about loyalty points as compared to money, and how they choose whether to make a purchase with cash or points.

3 - Which Customers Are More Valuable In A Dynamic Pricing Situation?
Jue Wang, Queen’s School of Business, Kingston, ON, Canada, jw171@queensu.ca, A. Yesim Orhun, Anton Ovchinikov

We consider a firm that dynamically price its inventory and examine whether customers who purchase at higher prices indeed add higher marginal value to the firm. We present modeling and computational results which are calibrated on a unique data set from a major travel firm.

4 - Strategic Consumers, Revenue Management And The Design Of Loyalty Programs
Anton Ovchinikov, Queen’s School of Business, ao37@queensu.ca, So Yeon Chun

Several major firms recently switched their loyalty programs from quantity/mileage-based toward spending-based. We study the impact of this switch on firm’s profit and consumer surplus. We present a novel model of strategic consumers’ response to firm’s pricing and loyalty program decisions, incorporate such response into the firm’s pricing and loyalty program design problem, compare several plausible loyalty-program designs, and discuss managerial implications.

■ SD58

Music Row 6- Omni
Energy IV
Contributed Session
Chair: Byungkwon Park, Ph.D student, University of Wisconsin - Madison, 202 N Eau Claire Avenue, # 314, Madison, WI, 53705, United States, bpark52@wisc.edu

1 - Two-stage Multi-agent Stochastic Optimization In Power Systems
Shasha Wang, Clemson University, 107 Wyeth LN, Central, SC, 29630, United States, shashaw@g.clemson.edu

Harsha Gangamanavar, Sandra D Ekisio glu, Scott J. Mason
We present a two-stage stochastic optimization framework for a multi-agent system in which the global objective function incorporates individual agents’ objective functions. Our approach applies to the problem of managing energy in microgrids that contain integrated renewable energy resources. A sequential sampling-based, stochastic approach—stochastic decomposition—is used to analyze the problem. Computational experiments are conducted and demonstrate the effectiveness of our proposed methodology using real world case study data.

2 - Analysis Of Co2 Emission Performance And Abatement Potential For Municipal Industrial Sectors In Jiangsu, China
Jie Zhang, Hohai University, Nanjing, China, zhangjie_jie@126.com, Jigan Wang, Zhenxing Xing

As the main source of CO2 emissions in China, industrial sector has been faced with the tremendous pressure of reducing emissions. Based on the analysis of SMB-Undesirable model, GIS visualization method, kernel density estimation and industrial abatement model, we find that there exists a significant spatial inequality of CO2 emission performance across various regions in Jiangsu, the largest CO2 emitter in China, but the regional disparity has been narrowing during our study period. Additionally, average annual industrial CO2 emission reductions in Jiangsu can attain 15654.00 (10 thousand tons), accounting for 28.2% of its average annual actual emissions.

3 - Production Intermittence In Spot Electricity Markets
Olivier Massol, IFF School, 228-232 Avenue Napoleon Bonaparte, Rue-Malmaison, 92852, France, olivier.massol@iffen.fr, Albert Banal-Estandal, Augusto Ruperez-Micola

This paper analyses the influence of production intermittence on spot markets. We use both game theory concepts and an agent-based simulation approach derived from the Camerer and Ili (1999) behavioral model. Controlling for costs, we find that intermittent technologies yield lower prices when incumbents have individual market power, but higher when they do not have it. This happens when firms are risk-neutral and risk-averse, and also under different intermittence and ownership configurations. Replacing high-cost assets with low-cost ones results in higher prices than letting them co-exist.

4 - A Sparse Tableau Analysis Formulation For The Security-constrained Optimal Power Flow
Byungkwon Park, PhD Student, University of Wisconsin-Madison, 202 N Eau Claire Avenue, # 314, Madison, WI, 53705, United States, bpark52@wisc.edu, Christopher DeMarco

The nonlinear security-constrained optimal power flow (sCOOPF) is computationally challenging, with difficulties in obtaining even feasible points due to the nonconvexity of power flow equations and the large dimension when many contingencies are considered. As illustrated in literature on semidefinite programming for OPF, a well-chosen formulation can yield better solutions, more efficiently. To this end, this work considers a range of sCOOPF problems in new sparse tableau formulations that explicitly maintain port curvatures and voltages of all grid elements, and examines computational time and quality of solutions with different nonlinear solvers.
1 - Throughput Analysis For Horizontal Traffic Queues under Safety Constraints
Mohammad Motie, University of Southern California, CA 90007, USA, motieisha@usc.edu
We consider horizontal traffic queues (HTQ), where vehicle arrival and departure locations are sampled from spatial distributions. We consider first and second order car following models that guarantee no collision. HTQ is a state-dependent queueing system, where the service rate depends on the configuration of vehicles. We combine queueing-theoretic and dynamical systems tools, to provide novel insights into the service rate dynamics and busy period distribution for HTQ. These tools are used to compute bounds on throughput, which closely match simulations. Our throughput analysis illustrates the interplay between car-following behavior, road geometry, and arrival and departure statistics.

2 - Lost Demand And Redistribution In Bike Sharing Systems
Konstantina Mellou, Massachusetts Institute of Technology, Cambridge, MA, United States, kmellou@mit.edu, Patrick Jaillet
Spatial imbalances in bike sharing systems often lead to unavailability of resources (bikes or docks) and, as a result, lost customer demand. Our goal is to model redistribution operations that will allow the company to improve its level of service. An optimization approach is used, combined with decomposition and heuristics, and the performance of our methods is evaluated with tests on real datasets. Lost customer demand, which is often not considered since it cannot be registered in the system data, is also taken into account.

3 - A Destination-based Algorithm For User Equilibrium With Recourse Using Split Proportions
Tarun Rambha, University of Texas, Austin, TX, 6, United States, tarun.1988@utexas.edu, Stephen Boyles, Avinash Unnikrishnan
When travelers receive en route information and select routing policies that minimize expected cost, user equilibrium with recourse models can help predict the resulting network state. We propose a new destination-based algorithm to solve such models using link proportions and compare its performance with existing methods.

4 - Optimal Patrol Planning For Urban Parking Enforcement Considering Driver's Parking Behavior
Chao lei, University of Illinois at Urbana-Champaign, 2063 S. Orchard St. Apt A, Urbana, IL, 61801, United States, lei8785@gmail.com
In the aim of designing an effective parking patrolling scheme for the parking enforcement agency, we propose a bi-level optimization approach to help the agency determine the patrolling schedule and routing plan in the upper level while considering the drivers' parking payment decisions in the lower level. Both a mixed-integer formulation and a continuum approximation (CA) model are developed. The numerical study shows that, due to its advantage in computational performance, the CA approach provides a good alternative to handle the large scale problems.

2 - Put Bluetooth Data In A Good Use: A Case Study In Tucson, Arizona
Shu Yang, University of Arizona, shuyang@email.arizona.edu, Yao-Jan Wu
A Bluetooth based traffic data collection and analysis system is developed and integrated into the regional transportation district network system. Fully utilizing the Bluetooth-based data requires comprehensive data quality assurance, including data decomposition, imputation, and outlier detection. A case study is conducted in Tucson to demonstrate a one-stop solution for Bluetooth-based traffic performance measurement.

3 - Developing A Simulation Model Of A Tram Network By Using Historical RFID Data
Yong-Hong Kuo, The Chinese University of Hong Kong, Hong Kong, Hong Kong, yhkuo@cuhk.edu.hk, Janny M. Y. Leung, David S.W. Lai, Henry K.F. Cheung, Joshua Hiew
In this talk, we will present a real-world application that utilizes historical RFID data for the development of a simulation model of a tram network. The historical data about the tram locations are used to model the travel times of trams at different times of the day. Our simulation model allows the tram company to examine the impacts of different tram schedules on the service requirements and other performance measures.

4 - Accident Impacts on Traffic Mobility In Concern Of Network Features
Chenshuo Sun, Tsinghua University, Haidian District, Beijing, 100084, China, scs14@mails.tsinghua.edu.cn
It is hypothesized that there may be associations between intersection's accident-impact proneness and its location, as well as accident impacts and its origin. To substantiate such hypothesis, four topological measurements are assigned to intersections. Then, accident impacts specified in four aspects are quantified from both macroscopic and microscopic perspective. This study employs one macro-level model and three micro-level models. The results prove that intersection's accident-impact proneness is closely related to the network features of its location, also accident's infectiousness, network damage and delay are closely related to the network features of its origination.
2 - Customized Offers In Airline Revenue Management
Michael Wittmann, Massachusetts Institute of Technology, Cambridge, MA, United States, wittman@mit.edu

I propose an approach for decoupling the customized offer generation problem from the well-studied airline revenue management (RM) problem. After generating a baseline assortment of fare products and observing a passenger’s characteristics, an airline can choose to customize that offer by either adjusting the products in the assortment or changing the offered prices for those products. For implementation, heuristics are developed that are compatible with the airline RM methods and systems currently in use at large airlines.

3 - Optimization Models For Speed Control In Air Traffic Management
James Jones, University of Maryland, College Park, MD, United States, jonesjc@umd.edu

We propose four sets of models that use speed control to enhance the level of coordination by FAA managers at the tactical and pre-tactical level to account for the uncertainty at the time of planning. The first approach, assumes control of all airborne flights 500 nm from the destination airport while assuming no control over flights originating less than 500 nm. The second assumes control over all flights. In the third and fourth approach we propose enhancements for equitably rationing airport access to carriers and new GDP control procedures and flight operator planning models.

4 - Modeling In Air Transportation: Cargo Loading And Itinerary Choice
Virginie Lurkin, University of Liege, Liege, Belgium, vlurkin@ulg.ac.be

We examine two problems as part of this presentation. The first is a cargo loading problem. The aim is to load a set of containers and pallets into a cargo aircraft that serves multiple airports. Our work is the first to model cargo transport as a series of trips consisting of several legs at the end of which pickup and delivery operations might occur. The second problem we examine involves the estimation of itinerary choice models that include price variables and correct for price endogeneity using a control function that uses several types of instrumental variables.

SD63
Cumberland 5- Omni
Dynamic Routing and Logistics
Sponsored: TSL, Freight Transportation & Logistics
Sponsored Session
Chair: Nicholas Kullman, University of Washington, Seattle, WA, United States, n kullman@uw.edu

1 - Dynamic Pickup And Delivery Problem With Transfers
Afonso H. Sampaio, Eindhoven University of Technology, Eindhoven, Netherlands, A.H.Sampaio.Oliveira@tue.nl, Lucas Petrus Veeleturf, Tom Van Woensel

We consider the Dynamic Pickup and Delivery Problem with Transfers (d-PDP-T) in which a set of transportation requests arrive in real-time and must be assigned to a fleet of vehicles. Unlike most variants of the PDP, the pairing constraint is not hard in the d-PDP-T and requests can be transferred from one vehicle to another at transship locations. Our research focus is to address the operational issues and to evaluate costs/benefits when such transfers are introduced in a dynamic environment. It is especially relevant for transportation companies that provide on-demand services and that need to plan several service requests per day. We discuss some preliminary modelling and solution approaches.

2 - Anticipatory Preemptive Depot Revisits For A Dynamic Same-day Delivery Problem
Dirk Mattfeld, TU Braunschweig, Braunschweig, Germany, d.mattfeld@tu-bs.de, Martin Wolf Ulmer, Barrett Thomas

We consider a single-vehicle stochastic and dynamic one-to-many pickup and delivery problem (SDPD) motivated by a same-day delivery application. An uncapacitated vehicle delivers goods from a depot to customers during a shift. Dynamic customer orders occur stochastically within the shift. Before serving these orders, the vehicle revisits the depot to pick up the according goods. Since the shift is limited, not every order can be assigned to the vehicle. Objective is to maximize the number of assigned orders. For the SDPD, we present an anticipatory preemptive depot revisit policy (APDR) based on approximate value iteration. We show how APDR significantly increases the number of assignments.

3 - Electric Vehicle Routing With Mid-route Recharging And Uncertain Charging Station Availability
Nicholas Kullman, University of Washington, nkullman@uw.edu, Justin Goodson, Jorge E. Mendez

We consider the problem of routing a single electric vehicle (EV) and allow for mid-route recharging at stations with uncertain availability. The uncertainty in charging station availability complicates the planning of mid-route recharging, which is necessitated by EVs’ restricted driving ranges, longer recharging times for EVs compound this difficulty. We present a stochastic dynamic programming approach to route planning that hedges against these uncertainties.

4 - Joint Capacity Logistics And Inventory Control Of Mobile Modular Production Systems
Satya Sarvani Malladi, Georgia Institute of Technology, ms@gatech.edu, Alan Erera, Chelsea C White III

Mobile modular production systems enable better response to spatial and temporal variations in demand. How should the logistics of such systems be planned taking into account uncertainty of demand? We try to evaluate value added by mobile production through several approaches.

SD64
Cumberland 6- Omni
Evolutionary Bilevel Multi-criterion Optimization Methods and Applications
Sponsored: Multiple Criteria Decision Making
Sponsored Session
Chair: Kalyanmoy Deb, Professor, Michigan State University, 428 S. Shaw Lane, 2120 EB, Michigan State University, East Lansing, MI, 48824, United States, kdeb@cgr.msu.edu

1 - Impacts Of Climate Uncertainty On A Bilevel Optimization Framework For Targeting Agricultural Conservation Policy
Morih Ostain, Lewis and Clark College, mbostain@lclark.edu

We characterize the problem of spatially targeting agricultural conservation practices to improve water quality as a multiobjective bilevel optimization problem, integrating a biophysical model of the watershed with an economic production model to estimate policy costs. Weather is an important driver of water quality and agricultural production. We solve for the Pareto frontier for water and production objectives under changing climate conditions, based on a range of leading climate projections. We use the solution values to assess the robustness of policy targets to climate uncertainty.

2 - Solving Optimistic Bilevel Programs By Iteratively Approximating Lower Level Optimal Value Function
Pekka Malo, Aalto University School of Business, pekka.malo@aalto.fi, Kalyanmoy Deb, Ankur Sinha

The difficulties in bilevel programming arise primarily from the nested structure of the problem. In this paper, we propose a metamodeling based solution strategy that attempts to iteratively approximate the optimal lower level value function.

3 - Optimal Allocation Of Restoration Practices Using Indexes For Stream Health
Brad Barnhart, U.S. EPA ORD/NHEERL/WD/E2B, bradleybarnhart@gmail.com

The optimal placement of agricultural and urban (i.e., green infrastructure) management practices in order to achieve both economic and environmental objectives is a commonly posed problem. However, the majority of studies seek to optimize objectives related to intermediary environmental outputs (e.g., N and P nutrient loading, stream temperature, sediment concentrations) and do not address impacts on overall indexes of stream health. Therefore, we investigate on how best to include indexes within a bi-level optimization framework to better characterize objectives when targeting management practices.

4 - Robust And Reliability-based Bi-level Multi-criterion Optimization
Zhichao Lu, Michigan State University, mike1990@gmail.com

Practical optimization and decision making problems involve uncertainties in decision variables and parameters. In this talk, we shall suggest robust and reliability based methods for bilevel problems using evolutionary methods. Results on two practical methods will be presented.
SD65

Mockingbird 1 - Omni

Analytical Models
Sponsored: Information Systems
Sponsored Session
Chair: Zhe Zhang, University of Texas Dallas, University of Texas Dallas, Richardson, TX, 75080, United States, zx2145430@utdallas.edu

1 - Altruism or Shrewd Business? Implications Of Technology Openness on Platform Innovations And Competition
Hongyan Xu, Chongqing University, School of Economics & Business Admin, Chongqing, 400030, China, xuhongyan@cqu.edu.cn, He Huang, Geoffrey Parker, Yinliang Tan

There is a growing number of platforms that commit to open their technologies. In contrast to the previous literature focusing on the network effect, our study reveals a novel explanation on why firms are willing to open their technologies. The main intuition is due to the fact that technology openness can alleviate the unwarranted innovation competition caused by the uncertainty belonging to technology closeness. We also discuss the impact of technology openness on individual and total innovations and illustrate that this intuition is robust under several extended models.

2 - Share Your Health Information And Help Me Save Your Life: Effects Of His Use On Healthcare Outcomes – An Empirical Investigation
Emre Demirezen, School of Management, Binghamton University, Binghamton, NY, United States, edemirezen@binghamton.edu

Eunho Park, Ramkumar Janakiraman, Subodha Kumar

In the last decade, the U.S. government has been aggressively promoting the use of electronic health records and the establishment of regional healthcare information exchanges (HIEs). HIEs facilitate the exchange of electronic health information among healthcare practitioners that is considered to be beneficial for the society. However, the real benefits of HIEs are not well understood. Hence, we work with an HIE provider based in the state of New York to investigate the benefits of HIEs.

3 - Platform Integration In The Age Of The Internet Of Things
Burecu Tan, Tulane University, btan@tulane.edu, Edward G Anderson, Geoffrey Parker

Many two-sided platforms (e.g., eBay, Google, iOS, Android, Twitter, Amazon) provide development tools, such as software development kits (SDKs) and application programming interfaces (APIs), to facilitate third party content development. While crucial to platform success, these tools are costly to create. We develop an analytic model to explore the key trade-offs behind investment in development tools and how that investment coordinates with pricing decisions in a two-sided market. We model these decisions under various scenarios including monopoly and competitive platforms as well as symmetric and asymmetric platforms.

4 - Interoperability, Organization Form And Cooperative Games In Public Safety Networks
Barrie R Nault, University of Calgary, naultu@ucalgary.ca
Hong Guo, Yijing Liu

We analyze tradeoffs in the provision of public safety networks when network assets are distributed across districts, causing a district to value network assets in other districts as well as in its own district. Modeling centralized and decentralized organization forms we incorporate interoperability among distributed network assets. We find that the optimal/equilibrium interoperability increases in the cross-district spillovers from network assets. We show that the districts’ incentive to adopt centralized provision depends on the sharing rule for the cost of interoperability effort, and we find that certain sharing rules have a corresponding cooperative game analogue.

SD67

Mockingbird 3 - Omni

Foundations of Accuracy for Additive Manufacturing
Sponsored: Quality, Statistics and Reliability
Sponsored Session
Chair: Qiang Huang, University of Southern California, Los Angeles, CA, United States, qiang.huang@usc.edu
Co-Chair: Arman Sabbaghi, Purdue University, West Lafayette, IN, United States, sabbaghi@purdue.edu

1 - Deformation Model Transfer Via Equivalent Effects Of Lurking Variables In Additive Manufacturing
Arman Sabbaghi, Assistant Professor, Purdue University, 150 N. University Street, West Lafayette, IN, 47907, United States, sabbaghi@purdue.edu, Qiang Huang

The transfer of a deformation model across different settings of lurking variables in additive manufacturing is addressed with a novel framework that fuses the Rubin causal model with the effect equivalence concept. Model transfer in this general framework is formulated through the total equivalent amount of the lurking variables in terms of a base factor with respect to a key model feature. The weakest sufficient condition on the data-generating and assignment mechanisms in a new setting is identified that permits inference for its total equivalent amount with respect to the mean. Bayesian methodology for modeling the total equivalent amount are developed under this condition.

2 - Implications Of Assuming Incorrect Model Equivalence For Additive Manufacturing
Matthew Plumlee, University of Michigan, mplumlee@umich.edu

Additive manufacturing control is often limited by the few number of homogeneous parts produced. Thus purely data-driven approaches can fail to give anything but large uncertainty quantification bounds for producing a new part. One solution to this problem is to let additive manufacturing systems to learn from each other by assuming that they could produce exactly the same resulting parts. In this talk, some preliminary results are used to explain the potential ramifications of assuming that a model for one additive manufacturing system can produce similar results as another system under a specialized design plan.

3 - Prescriptive Analytics For Understanding Of Out-of-plane Deformation In Additive Manufacturing
Yuan Jin, University of Southern California, Los Angeles, CA, 90089, United States, yuanjin@usc.edu, Joe Qin, Qiang Huang

Geometric accuracy control is crucial to fulfill the promise of additive manufacturing (AM). We have been establishing a generic methodology to represent, predict and compensate 3D deformation of AM built products. Built upon our previous study, this work aims at 1) developing a prescriptive approach to understand the out-of-plane deformation due to complex inter-layer interactions; 2) establishing a Bayesian approach to infer the predictive deformation model for out-of-plane complex shapes. Experiments are conducted to validate the prescriptive model.

4 - Shape Deviation Modeling For Additive Manufacturing With Different Process Parameters
Longwei Cheng, HKUST, lchengk@connect.ust.hk

Reducing the dimensional error of the fabricated products is a critical quality issue for the wide application of additive manufacturing (AM) technologies in industry. Process parameters in fabrication significantly affect the shape deviation of products. In this work, we establish an in-plane shape deviation prediction scheme that predicts the final shapes of products with the information of both process parameters and 2D input shapes. The corresponding shape error compensation strategy is derived, which greatly improves the dimensional accuracy of products. The methodology is validated through experimental studies of fused deposition modeling (FDM) process.

SD66

Mockingbird 2 - Omni

2016 QSR Best Student Paper Competition
Sponsored: Quality, Statistics and Reliability
Sponsored Session
Chair: Chiwwoo Park, chiwwoo.park@eng.fsu.edu

1 - 2016 QSR Best Student Paper Competition
Chiwwoo Park, Florida State University, chiwwoo.park@eng.fsu.edu

Best Student Paper Award recognizes excellence among QSR student members. Four finalists for the Best Student Paper Award will make presentations. The winner will be announced at the QSR business meeting during the conference.
show the effectiveness of the proposed method.

1 - High Dimensional Process Monitoring Using Sparse Principal Component Analysis
Mohammad Nahban, Georgia Institute of Technology, nahban@gatech.edu, Jianjun Shi

Dimension reduction techniques, such as PCA and PLS, have been used for process monitoring in statistical process control. However, in high dimensional settings they suffer from inconsistency and interpretability issues. Sparse principal component analysis (SPCA) has been shown to be more consistent in these settings. Due to its sparse nature, it allows for better interpretation. This article proposes a monitoring and diagnostics scheme utilizing SPCA to reduce the dimensionality of the data while improving interpretability. The method is effective under certain stipulations on the spatial structure of the data streams. The proposed method is validated through simulation and a case study.

2 - Monitoring Low-e Glass Manufacturing Using Optical Profiles
Qian Wu, Texas A&M University, College Station, TX, 77840, United States, hi_qianwu@tamu.edu, Li Zeng

In this study we develop a method for process monitoring using optical profiles collected from low-e glass products. The proposed method uses a piecewise polynomial mixed-effect model to characterize the complex shape of optical profiles and a T2 control chart to monitor the estimated random effects for change detection. We investigate a potential problem caused by high correlations of random effects in implementing this method and propose a remedy based on regression transformation for this issue. A case study will be shown, indicating the proposed method fits the real optical profiles and performs well in process monitoring.

3 - Remaining Useful Life Prediction in Populations With Heterogeneity
Raed Kontar, University of Wisconsin - Madison, Madison, WI, United States, alkontar@wisc.edu

Degradation signal data used for prognosis are often imbalanced as most units are reliable and only few tend to fail at early stages of their life cycle. Such imbalanced data may hinder accurate remaining useful life (RUL) prediction especially in terms of detecting pre-mature failures as early as possible. In this paper, we propose a degradation signal-based RUL prediction method to address the imbalance issue in the data. The proposed method introduces a mixture prior distribution to capture the characteristics of different groups within the same population and provides an efficient and effective online prediction method for the in-service unit under monitoring.

4 - Statistical Monitoring And Fault Diagnosis Of Vibration Signal Based On Wavelet Transform
Wei Fan, City University of Hong Kong, Kowloon, Hong Kong, weifan8-ctmy.cityu.edu.hk, Qiang Zhou

To effectively monitor and detect the early fault of rolling bearing, a wavelet-based statistical process control method is proposed and studied. The vibration signal is decomposed by orthonormal wavelet transform. The generalized likelihood ratio test is taken into consideration to detect the shift of the wavelet coefficients. To increase the detection power of the small shift, the proposed control chart takes the exponentially weighted moving average of the logarithm of the likelihood ratio. Both the simulation studies and the experimental cases show the effectiveness of the proposed method.
5 - Prioritizing Hepatitis C Treatment in U.S. Prisons
Turgay Ayer, Georgia Tech, Atlanta, GA, Boston, MA, ayer@isye.gatech.edu, Anthony Bonifonte, Can Zhang, Anne Spaulding, Jagdeep Chhatwal

High prevalence of HCV in prisons offers a unique opportunity to control the HCV epidemic. Newest HCV treatments drugs are effective but providing treatment is outrageously expensive. We propose a restless bandit modeling framework to support hepatitis C treatment prioritization decisions in U.S. prisons. From the interpretation of this closed-form expression, we anticipate the performance of Whittle’s index would degrade as the treatment increases. Using a detailed agent-based simulation model, we show our proposed policy can significantly improve overall health outcomes compared with the current practice. Our results shed light on issues in hepatitis C prioritization: 1) considering remaining sentence length and injection drug use (IDU) status and liver health state in prioritization decisions can lead to a performance improvement; 2) when linkage-to-care rate outside prison is small while treatment capacity in prison system is relatively large, patients with shorter remaining sentence lengths should be prioritized; and 3) for patients with advanced liver disease, IDUs should not be prioritized unless their reinfection is very well controlled.

4 - Using Regression Tree Models To Improve Freeway Incident Duration Prediction A Comprehensive Case Study In Maryland Region
Xuechi Zhang, Graduate Research Assistant, University of Maryland, 0147C Engineering Lab Building, College Park, MD, 20740, United States, zhangxc90@gmail.com, Ali Haghani, Yeming Hao

Timely and accurate prediction of freeway incident duration is not only useful for providing travelers with re-routing strategies, but can also reduce their in-vehicle anxiety. This research proposes several regression tree based models to improve the incident duration prediction accuracy by fusing heterogeneous information, i.e., incident information, weather and traffic conditions. A comprehensive case study with real-world data in Maryland Region was conducted to evaluate and demonstrate the proposed models. Further, practical implications from the case study were given.

■ SD70
Acoustic- Omni Transportation, General Contributed Session

1 - Solving The Privately Owned Automated Vehicles Assignment Problem
Theresia van Essen, Delft University of Technology, Mekelweg 4, Delft, 2628 CD, Netherlands, j.t.vanessen@tudelft.nl, Goncalo Correia

We propose a new model to study how replacing privately owned non-automated vehicles with shared automated ones affects travel time, congestion and parking demand in an urban area. As automated vehicles will reduce the value of travel time, it is expected that travel time will increase. In addition, congestion is on the one hand expected to increase because of the empty trips, and on the other hand expected to decrease because of a reduction in the number of vehicles on the road. Parking demand is expected to decrease as the utilization of the vehicles will increase. The model is applied to a case study based on the city of Delft, the Netherlands.

2 - Developing Interrelated Airport Facilities under Uncertainty: A Network Flow Formulation
Yanshuo Sun, University of Maryland, 1173 Glenn Martin Hall, College Park, MD, 20742, United States, yssun@umd.edu, Paul Schönfeld

Interactions between user flows and facilities are quite complex in an airport system. Thus, capacity expansion decisions for these facilities are largely interrelated. A network flow formulation is proposed for coordinating such development decisions so that a balanced capacity configuration is likely to be obtained. The nonlinear congestion effect, which is common in most airport facilities, is considered and uncertainties in demand and aircraft mix are also included. The stochastic mixed integer nonlinear program is reduced to a deterministic mixed integer program and thus solved.

3 - From Trend Spotting To Trend Setting: Modeling The Impact Of Major Technological And Infrastructural Changes On Travel Demand
Feras El Zarwi, PhD Candidate, University of California at Berkeley, 2100 Channing Way, Apt 415, Berkeley, CA, 94704, United States, feraselzarwi@gmail.com

Transformative mobility will revolutionize travel and activity behavior but we should be cautious with how the future is going to play out. This research project proposes a methodological framework tailored to address impacts of technological innovation to understand and predict long-range trends in travel behavior. We integrate hidden Markov and discrete choice models to predict long-range trends in travel behavior as a result of adopting new services. The model is estimated on a longitudinal travel diary dataset from Santiago, Chile. The proposed quantitative methods are critical in assessing how policies/strategies can influence trends of travel behavior to guide transformative mobility.
5 - Probability Analysis Of The Severity Of Train Derailments Using Copula Models
Emmanuel Martey, University of Delaware, 302 DuPont Hall, Newark, DE, 19716, United States, emmartey@udel.edu,
Nii Attoh-Okin

In spite of their relatively low occurrence, train derailments have been a major concern due to their high consequence. Derailment severity may depend on various factors such as speed, accident cause and residual train length. It is important to know the dependencies between these variables in order to better understand how to reduce derailment severity. This paper presents the copula approach as a technique for modeling dependencies between the various variables. Copulas link arbitrary marginal distributions to form a joint multivariate distribution with a particular dependence structure. Copulas are suitable for modeling multivariate data with non-normality, tail dependence or skewness.

■ SD72
Bass-Omni
Supply Chain Mgt IV
Contributed Session
Chair: Shabnam Rezapour, University of Oklahoma,
2248 Houston Ave. apt 2, Norman, OK, 73071, United States, shabnam_rezapoor@yahoo.com

1 - Upstream Supplier And Downstream Customer Networks: An Empirical Investigation
Marcus A Bellamy, Boston University, Rafik B. Hariri Building, 595 Commonwealth Avenue, Boston, MA, 02215, United States, bellamym@bu.edu, Soumeng Ghosh, Manpreet Singh Hora

We examine the relationship dependence characteristics and structural configuration of a firm’s supply chain as drivers of its performance using supply chain relationship data from the Bloomberg database. We demonstrate how firm performance may be influenced by the manner in which its cost is concentrated upstream as a customer, its revenue is concentrated downstream as a supplier, and its supply network is structured.

2 - Capacity Expansion Under Demand Uncertainty With Uncertain Probabilities
Heejung Kim, University of California- Berkeley, Berkeley, CA, 94720-1777, United States, kimheejung@berkeley.edu, Philip Kaminsky

Pharmaceutical industries make capacity investment decisions while clinical trials for products are running. The demands are highly dependent on the test results, and estimating exact probability distribution of the results is difficult. We focus on developing and understanding capacity expansion models that are robust to any possible probability distributions using multistage stochastic programming for different objectives - minimizing expected cost, value at risk and conditional value at risk.

3 - Supply Chain Partner Environmental Health And Firm Performance
Marcus A Bellamy, Assistant Professor, Boston University, Rafik B. Hariri Building, 595 Commonwealth Avenue, Boston, MA, 02215, United States, bellamym@bu.edu

We empirically examine the relationship between the environmental initiatives and outcomes of a firm’s supply chain partners and firm performance. We draw from environmental, financial, and supply chain data to identify key mechanisms related to the environmental health of a firm’s supply chain that influence its economic performance.

4 - Component Procurement And End Product Assembly In An Uncertain Supply And Demand Environment
Ramesh Bollapragada, San Francisco State University, School of Business, 1600 Holloway Avenue, San Francisco, CA, 94132, United States, rameshb@sfsu.edu, Saravanan Kuppusamy, Uday S Rao

In this paper, we examine a multi-product, multi-component, procurement and assembly problem with both supply and demand uncertainties. We explicitly model the uncertainty using a stochastic program that facilitates procurement and assembly decisions. We present a stochastic linear programming model of the problem which we solve using its deterministic equivalent with a finite number of scenarios. We identify the key drivers that need attention from managers in the manufacturing industry, when there is limited knowledge of future demand and component availability.

5 - Correlation Between Supply Networks’ Strategic And Operational Risk Mitigation Strategies
Shabnam Rezapour, University of Oklahoma,
2248 Houston Ave. apt 2, Norman, OK, 73071, United States, shabnam_rezapoor@yahoo.com, Janet K. Allen, Farrokh Mistree

A supply network’s performance is affected by two types of uncertainty: 1) disruptions distorting its topology; and 2) variations affecting its flow planning. We show that strategic risk mitigation strategies, such as robustness and resilience, and operational risk mitigation strategies, such as reliability, neutralizing impacts of disruptions and variations respectively are correlated. A model is developed to simultaneously determine robustness, resilience and reliability. Our findings show that the correlation between: i) robustness and resilience is negative; ii) robustness and reliability is positive; and iii) resilience and reliability is negative.

■ SD79
Legends G-Omni
Health Care, Modeling IV
Contributed Session
Chair: Utpal Kumar Bhattacharya, Associate Professor, Indian Institute of Management Indore, Pitampur Road, Prabandh Sikhar, Indore, 453556, India, utpalb@iimidr.ac.in

1 - Optimal Radiotherapy Treatment Policy Based On Tumor Biological Response: A Partially Observable Markov Decision Process Framework
Nasrin Nouri, PhD Student, University of Houston, 9701 Meyer Forest Dr., Apt 6207, Houston, TX, 77096, United States, nouri.nasrin@gmail.com

In radiotherapy treatment planning the prescribed dose is delivered in equal fractions of dose during 30 to 40 sessions to give healthy organs time to recover. Depending on tumor state, the tumor growth and its response to radiation will change, hence a dynamic treatment plan is required. It is not possible to observe the tumor before each session through CT images so we are faced to uncertainty of tumor state. In this study we develop a partially observable Markov decision process to provide optimal treatment policy when the density of tumor is uncertain. This approach provides the optimal policy determining when to choose a less effective, less harmful dose over a more effective, more harmful dose.

2 - Reserving Walk-in Times In Primary Care
Brigitte Werners, Professor, Ruhr-University Bochum, Fac. Management and Economics, Bochum, 44780, Germany, or@rsib.de

For a primary care physician with varying workload demand, capacity reservation for walk-ins and scheduled appointment slots is optimized on a tactical level. Number and position of the scheduled appointments influence waiting times for patients, capacity for treatment and the utilization of PCs. A multi-criteria mixed-integer linear programming model is suggested to find an acceptable compromise solution. Results are evaluated by an extensive stochastic simulation study.

3 - Econometric Model Of Critical Care Outreach Team And Intensive Care Unit
Ali Haji Valabzadeh, The University of Auckland Business School, Private Bag 92019, Auckland, 1142, New Zealand, a.valabzadeh@auckland.ac.nz, Valery Pavlov

To analyse the role and functionality of the critical care outreach team (CCOT) in hospitals, and particularly, its interactions with the ICU, we develop an econometric model of CCOT and ICU. This allows us to estimate the impact of CCOT intervention in detecting the critically ill patients in the ward on the ICU length of stay, potential ICU readmission and patient outcome.
1 - Setting Optimal Planned Leadtimes In A Configure To Order Manufacturing System
Sjors Jansen, PhD Candidate, Eindhoven University of Technology (TU/e), PO. Box 513, Paviljoen E13, Eindhoven, 5600MB, Netherlands, s.w.jansen@tue.nl, Zumbl Alat, Ton de Kok, Ivo Adan
We study the production planning in Configure To Order (CTO) manufacturing systems. The system consists of multiple stages that converge to one final assembly stage. Leadtimes per stage are stochastic due to extensive testing at the end of each stage. Our goal is to determine optimal planned leadtimes for each stage such that the total expected production costs are minimized. We derive Newsvendor equations for each individual stage. This set of equations is solved and the exact optimal planned leadtime for each stage is obtained. These equations give an important insight in the dynamics of the system, since they indicate to what extend a specific stage can be blamed for the lateness of the final product.

2 - Introduction Of A Motor Assembly Test Bed To Verify Manufacturing Technology
Jungryul Bae, Korea Institute of Industrial Technology (KITECH), Seoul, Korea, Republic of, somanythat@naver.com, SeHwan Ahn, YongJu Cho, Chul Kim, Hyunchul Tae
A Testbed is a place of verifying newly developed manufacturing technologies before apply it in practice. We built a motor-assembly Testbed that comprises seven connected facilities in a line. We have tested several manufacturing technologies including simulation, quality management, and IoT on the Testbed. In this presentation, we aim to introduce our Testbed and share our experience. The final goal of the Testbed is to enhance the localization ratio of a convergence of the IoTs and manufacturing technology.Keywords: Connected Smart Factory (CSF), Testbed, IoTs, manufacturing technology.

3 - Modeling The Impact Of Product Variety On Inventory: Application To Strategic Assembly Sequencing And Supply Chain Design
Jeonghun Ko, University of Michigan; Ajou University, 1205 Beal Ave., Industrial & Operations Engineering, Ann Arbor, MI, 48109, United States, jeonghan@umich.edu, Heng Kuang
This paper models the impact of variety on assembly supply chain design when limited commonality exists between products. We derive theorems on the impact of product variety on safety inventory, and provide a measure to approximate the impact. The theorems and new measure are applied in two problems: optimal process sequencing and optimal assembly decomposition. We prove that to prioritize the process with a smaller number of variants will reduce the supply chain cost no matter the commonality is.

4 - Finite Capacity Material Requirement Planning System For Supply Chain Network
Benyaphorn Paopongchuan, Sirindhorn International Institute of Technology, Pathum Thani, 12121, Thailand, bp322@nitj.net
Benyaphorn Paopongchuan, New Jersey Institute of Technology, Newark, NJ, 07102, United States, bp322@nitj.net, Pisal Yenradee
Available Finite Capacity Material Requirement Planning (FCMRP) systems have some limitations. They are designed to determine production and purchasing plans in only one facility not in a multi-level supply chain network. Most systems lack of optimization capabilities. In addition, they do not manage bottleneck effectively. The proposed algorithm tries to develop FCMRP system that also considers finite capacity of some key supply chain customers.

5 - Similarity Coefficient Model For Solving an Oil Global Facility Location Problem
Ali AlArjani, PhD Candidate, University of Wisconsin - Milwaukee, 4848 N Lydell Ave, Milwaukee, WI, 53217, United States, alarjan2@uwmu.edu
Solve an oil global facility location problem by a new similarity coefficient model for cluster analysis that model ranks multiple countries and cluster them in groups each group have similar attributes.

SD91
Davidson Ballroom A-MCC
Joint Session HAS/MSOM-HC: Statistical Decision-Making with Applications in Healthcare
Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations
Sponsored Session
Chair: Mohsen Bayati, Stanford University, Stanford, CA, United States, bayati@stanford.edu
Co-Chair: Hamsa Bastani, Stanford University, 10 Comstock Circle, Apt 304, Stanford, CA, 94305, United States, hbs@stanford.edu
1 - Approximation Methods For Adaptive Clinical Trial Design
John R Birge, University of Chicago, John.Birge@ChicagoBooth.edu
We present a data-driven approach to planning clinical trials and designing novel drug therapies for metastatic breast cancer (MBC). First, we describe construction of a large database of MBC clinical trial results and tools to help clinicians visualize the data. Next, we use statistical models to predict efficacy and toxicity outcomes of trials before they are run, with implications for selecting between multiple drug therapies for testing. Finally, we use optimization models to design novel therapies that strike a balance between maximizing patient outcomes and learning about new drugs; initial evaluation suggests these models may improve trial outcomes compared to current practice.

2 - An Analytics Approach To Designing Drug Therapies For Cancer
John M Silberholz, MIT, Cambridge, MA, 02139, United States, josilber@mit.edu, Dimitris Bertsimas
We present a data-driven approach to planning clinical trials and designing novel drug therapies for metastatic breast cancer (MBC). First, we describe construction of a large database of MBC clinical trial results and tools to help clinicians visualize the data. Next, we use statistical models to predict efficacy and toxicity outcomes of trials before they are run, with implications for selecting between multiple drug therapies for testing. Finally, we use optimization models to design novel therapies that strike a balance between maximizing patient outcomes and learning about new drugs; initial evaluation suggests these models may improve trial outcomes compared to current practice.

3 - Online Decision-making With High-dimensional Covariates
Hamsa Sridhar Bastani, Stanford University, 10 Comstock Circle, Apt 304, Stanford, CA, 94305, United States, hsridhar@stanford.edu, Mohsen Bayati
Big data has enabled decision-makers to personalize choices based on an individual’s observed characteristics. We formulate this problem as a multi-armed bandit with high-dimensional covariates, and present a new efficient algorithm that achieves near-optimal performance. Our analysis is proving convergence of the LASSO estimator despite non-iid data induced by the bandit policy. We evaluate our algorithm using a real patient dataset on warfarin dosing; here, a patient’s optimal dosage depends on her genetic profile and medical records. Our algorithm outperforms existing bandit methods as well as physicians to correctly dose a majority of patients.

4 - Estimating Average Treatment Effects In High-dimensional Observational Studies
Stefan Wager, Stanford University, Stanford, CA, United States, swager@stanford.edu, Susan Athey, Guido Imbens
There are many studies where researchers are interested in estimating average treatment effects and are willing to rely on the unconfoundedness assumption, which requires that treatment assignment is as good as random conditional on pre-treatment variables. The unconfoundedness assumption is often more plausible if a large number of pre-treatment variables are included in the analysis, but this can worsen the finite sample properties of existing approaches to estimation. In this paper, we propose a new method for estimating average treatment effects in high dimensions that achieves the semi-parametric efficiency bound without requiring any modeling assumptions on the propensity score.

SD92
Davidson Ballroom B-MCC
INFORMS Optimization Society Prize Session
Award Session
Chair: Suvrajeet Sen, University of Southern California, 3715 McClintock Ave, Los Angeles, CA, 90089, United States, s.sen@usc.edu
1 - Optimization Society Awards
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The Optimization Society sponsors four awards annually. They are a) the Khachiyan Prize for lifetime contributions in optimization, b) the Farkas Prize for exceptional mid-career accomplishments, c) the Young Optimization Researcher award, and finally, d) the student paper prize competition. These awards are highly competitive and coveted, and this session is dedicated to congratulating the winners, and their lasting contributions to optimization. The award winners will present brief overviews of their prize-winning contributions.