

2022 CORS/INFORMS INTERNATIONAL CONFERENCE

Sunday, 10–10:55am

SP01

3rd Fl-Regency CD

Plenary: Managing Supply Chains in Turbulent Times

Plenary Session

1 - Managing Supply Chains in Turbulent Times

Hau Leung Lee, Graduate School of Business, 655 Knight Way, Stanford, CA, 94305, United States

The turbulent world today is faced with rapid technological advances, increasing disruptions due to disasters and pandemic, heightened interests in social responsibility and climate changes, and escalating trade frictions. Innovative companies have to navigate the turbulent times and transform their supply chain to face such challenges. Winning the long game requires new supply chain strategies. This is almost like supply chain management is undergoing a renaissance time. In 2004, I published an article in the Harvard Business Review, titled “The Triple-A Supply Chain,” in which I indicated that agility, adaptability and alignment were the three pillars of supply chain management. As I reflected on how the “renaissance supply chain leaders” were doing in redesigning their supply chains, I found that the Triple-A lens have to undergo some fundamental changes. Agility is about how companies can sense and respond to changes fast and effective. The clockspeed of agility has turned to super-agility, requiring a much deeper orchestration of the extended value chains. Adaptability used to be about how companies should adapt their supply chain over time. Now, adaptability is about how to build resilience by creating hybrid systems, leveraging the strengths of different resources and combining them appropriately. Finally, we cannot just align the interests of suppliers or customers, but also those of the bigger ecosystem within which a company operates in. As I examined the new Triple-A, new research ideas also emerged. In this talk, I will also show some such examples of recent research that were sparked by the new Triple-A.

Sunday, 11am–12:30pm

SB01

2nd Fl-Georgia A

Sustainable Operations SIG

General Session

Chair: Sanjith Gopalakrishnan

McGill University, McGill University, QC, Canada

2 - Analyzing the Impact of Article 6 of the Paris Agreement: A Model of Trade in Carbon Mitigation Outcomes

Manish Tripathy, Sauder School of Business, UBC, Vancouver, BC, Canada, manish.tripathy@sauder.ubc.ca

The Paris Agreement's Article 6 allows country A to facilitate carbon emission reduction in country B and claim this reduction in A's (not B's) national emissions. This trade in Internationally Transferred Mitigation Outcomes (ITMOs) is debated and misunderstood. We model ITMOs and analyze their impact on energy consumption, energy trade, emissions, and economic output of both countries.

3 - Effects and Persistence of Consumption Feedback on IoT Energy Platforms

Serasu Duran, Haskayne School of Business, Calgary, AB, T2N 1N4, Canada, serasu.duran@haskayne.ucalgary.ca
Nil Karacaoglu, Nur Sunar, Jacob Zijian Zeng

Eliminating excessive energy consumption can result in significant financial savings and environmental benefits. However, the effectiveness of real-time feedback in correcting excess usage has not been investigated for the commercial sector. To answer this question, we leverage detailed data on electricity consumption and abnormal consumption alerts in 14 brick and mortar stores of two major retailers to identify how managers react to real-time feedback and whether these effects persist over time.

4 - Sharing Newsboys

Setareh Farajollahzadeh, University of Toronto, Toronto, ON, M5G 2M4, Canada, setareh.farajollahzadeh@rotman.utoronto.ca

Ming Hu

We consider a network of socially connected newsvendors who can share their oversupply with their neighbors. We define two classes of social networks: friendship and acquaintances networks. We show that when the social network grows, all newsvendors increase their stocking levels in the acquaintance's network. In contrast, all newsvendors will decrease (resp. increase) their stocking levels for high fractile (resp. low fractile) products in the friendship network.

5 - Cooperative Security Against Interdependent Risks

Sanjith Gopalakrishnan, McGill University, Montreal, QC, V5B 3P9, Canada
Sriram Sankaranarayanan

Networked firms are exposed to various interdependent risks such as contamination in food supply chains or data breaches in technology networks. We examine whether and when firms can cooperatively secure themselves against such risks via cost-sharing mechanisms that are stable, fair, and implementable via a series of bilateral cost-sharing arrangements.

SB02

2nd FI-Georgia B

Data Science

General Session

Chair: Jenny Peraza Breedy

Intel Corporation, Belen, 4005, Costa Rica

2 - Evaluating and Improving Modularity Maximization Algorithms for Community Detection Using Exact Optimization Models

Samin Aref, University of Toronto, Toronto, ON, Canada, sare618@aucklanduni.ac.nz

Current modularity maximization algorithms fail to guarantee proximity to an optimal solution. We use an integer programming model alongside six heuristics for maximizing modularity in real and random networks. Our results indicate that the communities obtained from existing methods are 10% away from a modularity maximizing partition resulting in degenerate solutions far from the intended maximum-likelihood modular structure. Our formulation offers a new method for (1) detecting communities with a guarantee of optimality for a subcategory of networks with practical relevance and (2) obtaining a posteriori approximation guarantee for the performance of existing heuristics on any network.

3 - Optimal Deployment of Virtual Network Functions Using D-wave's Quantum-Classical Hybrid Optimization Solvers for 6g IoT Services

Mahzabeen Emu, Queen's University, Kingston, ON, Canada, 20me21@queensu.ca

Salimur Choudhury, Kai Salomaa

The optimal deployment of Virtual Network Function (VNF) in the edge Internet of Things (IoT) devices has been proven NP-hard. We propose the application of Quantum-Classical hybrid optimization solvers using D-Wave to ensure computationally efficient, scalable, and optimal solutions, even with the exponential growth of IoT devices. The quadratic unconstrained binary optimization (QUBO) problem formulation can further

increase quantum resource efficiency by 40%. It is also envisioned that quantum solvers can guarantee real-time VNF services. Thus, quantum applications can support futuristic VNF services and tackle intractability for the 6G telecommunication domain and beyond.

SB03

2nd FI-Plaza A

OR in Practice for Transportation and Logistics

Joint Session

Chair: Steven Shechter

University of British Columbia, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada

Chair: Julia Y Yan

University of British Columbia, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada

3 - Planning Bike Lanes with Data: Ridership, Congestion, and Path Selection

Jingwei Zhang, UCLA Anderson School of Management, Los Angeles, CA, M5S 1J5, United States, jingwei.zhang.phd@anderson.ucla.edu

Sheng Liu, Ayoun Siddiq

Urban bike lane expansion promotes cycling and reduces vehicle traffic, but narrows vehicle lanes and amplifies congestion. We study the bike lane planning problem while accounting for the conflicting effects. In an extensive case study on the City of Chicago with data collected from 8 sources, we first present a consistent estimator for travel-time parameters and then optimize new bike lane locations while enforcing traffic equilibrium. As a result, we estimate that 25 miles of new bike lanes can increase cycling ridership by 76%, with at most 7.5% increase in driving time between each OD pair and 4% decrease in systemwide total driving time.

4 - A Dynamic Model for Airline Fleeting and Scheduling

Chiwei Yan, University of Washington, Seattle, WA, United States, chiwei@uw.edu

Archis Ghate

COVID-19 has reshaped the global airline industry. Travel demands are volatile, and passengers have more flexibility in bookings and cancellations. More than ever, airlines have to be agile and adaptive in terms of their operational decisions. In this talk, we introduce a new dynamic model for airlines to make adaptive scheduling and fleeting decisions, based on evolving demand and booking signals. We derive theoretical,

algorithmic, and managerial insights from this model. We present computational experiments based on real-world scenarios to demonstrate potential benefits of this approach.

5 - A Framework for Modeling Inter-dependencies of E-commerce Decisions to Speed Planning and Development

Kermit Threatte, Director - Operations Research, Shopify Inc, Lincoln, MA, 01773, United States

An ecommerce supply chain has many parts from warehouse fulfillment, routing of customer orders, managing parcel carriers and positioning inventory and executing freight movements. All of these processes are interdependent and impact each other and often improvements in one area have unintended consequences in another. The talk will describe a framework to model and monitor these interdependencies and make coordinated choices and improvements to the supply chain.

6 - A Decision Support System for Home Dialysis Visit Scheduling and Nurse Routing

Antoine Sauré, University of Ottawa, Ottawa, ON, Canada, asaure@uottawa.ca

Ahmet Kandakoglu, Wojtek Michalowski

We describe a user-friendly decision support system for scheduling home dialysis services. The system employs a mixed integer programming model to create daily visit schedules and routes for nurses that minimize the cost of providing such services. In this model, we also consider nurses' workload balance, overtime work, need for mealtime breaks, restrictions and preferences associated with the time of the visits, and different types of services. The model was developed in collaboration with the Division of Nephrology at The Ottawa Hospital. Results show that the cost of home dialysis service can be potentially reduced by more than 25 percent.

SB04

2nd Fl-Plaza B

Recent Advancements in Inventory Management and Assortment Planning

General Session

Chair: Marco Bijvank

University of Calgary, University of Calgary, Calgary, AB, T2N 1N4, Canada

2 - Inventory Control and Learning for One-warehouse Multi-store System with Censored Demand

Recep Yusuf Bekci, McGill University, Montreal, QC, H3A 1G5, Canada, recep.bekci@mail.mcgill.ca

We study a two-echelon inventory control problem called the One-Warehouse Multi-Store (OWMS) system when the demand distribution is unknown. This system has a central warehouse that receives an initial replenishment and distributes its inventory to multiple stores in each time period during a finite horizon. In this work, we consider the OWMS problem when the demand distribution is unknown a priori. We propose a sophisticated algorithm based on a primal-dual learning and optimization approach. Results show that both algorithms have great theoretical and empirical performances.

3 - Capacitated Assortment Planning in Omni-channel Retailing in Presence of Products Return

Amin Aslani, PhD Candidate, University of Calgary, Haskayne School of Business, Calgary, AB, Canada, amin.aslani@ucalgary.ca

Osman Alp

This study investigates an omni-channel retailer that operates an online sales website and a physical store. The aim is to maximize the retailer's revenue by finding the optimal assortment in the physical store under the presence of products return. Products are differentiated by their attribute levels such as their color and size. Online sales are affected by the assortment decision because attribute levels that are not present in the physical store are likely to create more returns from online sales. We generate managerial insights for retailers regarding the assortment decisions depending on whether customers overvalue or undervalue the products that are available only on online sales website.

4 - Solving Multi-echelon Inventory Problems with Heuristic-guided Deep Reinforcement Learning and Centralized Control

Qihua Zhong, HEC Montréal, Montreal, QC, Canada, qihua.zhong@hec.ca

Yossiri Adulyasak, Martin Cousineau, Raf Jans

Multi-echelon inventory models aim to minimize the system-wide cost in a supply chain by applying a proper ordering policy to each stage. When backlog costs can be incurred in multiple stages, this problem is intractable using traditional optimization methods. To this end, we apply and compare three efficient deep reinforcement learning (DRL) algorithms to determine the inventory policy. We extend the problem to the centralized decision-making setting with significantly

larger state and action space. We also propose a heuristic-guided exploration mechanism to improve training efficiency. Experiments show significant cost savings learned by DRL agents against benchmark heuristics.

5 - Constant Production Cost in Make-to-order Models Can Lead to Poor Dynamic Decisions

Jiejian Feng, Assistant Professor, Wilfrid Laurier University, Waterloo, ON, Canada, jifeng@wlu.ca

Sapna Isotupa

In a make-to-order model, it is common to make two assumptions for the manufacturer to find the optimal price and/or lead time: the average production cost per unit of the product is constant, and that the demand is a decreasing function of the offered price and lead time. However, since the demand in the make-to-order production approach is the same as the number of products, the average production cost per unit of the product depends on the demand which is a function of the optimal price and lead time. We suggest not assuming constant production cost in the make-to-order models to make management decisions, and propose two approximate algorithms to search for optimal management decisions.

SB05

2nd Fl-Plaza C

Analytics I

Contributed Session

Chair: Meysam Fereidouni

University of Calgary

2 - Customer Insights Through Hierarchical Clustering: A New Methodology

Cecilia Ying, Queen's University, Kingston, ON, Canada, 18yly@queensu.ca

Stephen Thomas

Hierarchical clustering is a class of popular machine learning algorithms used to extract the main topics, concerns, and trends from customer messages. An open challenge is how to best tune the hyperparameters of these algorithms for a given domain. We propose a novel tuning methodology based on the cophenetic correlation distance. We demonstrate the effectiveness of our methodology on four benchmark datasets.

3 - Investigation of Research Trends in Chaebols

Chang-Kyo Suh, Professor, Kyungpook National University, Daegu, Korea, Republic of, ck@knu.ac.kr

Hyaejung Lim

A chaebol, a family-controlled industrial conglomerate, has played a significant role in South Korean economy. This study intended to explore the knowledge mapping of chaebols. In this research, we queried the Web of Science and collected academic articles and reviewed papers on the chaebol from the year 1970 to 2021. With these papers, we analyze references of the papers for the author co-citation analysis method. Then, we classified the major research issues in chaebols and identified research clusters. The result of analysis including the knowledge mapping of chaebols will be presented in the conference in details. We will also discuss the suggestion for further work.

4 - Emotional Influence Analysis for

Depression Detection

Xingwei Yang, Queen's University, Kingston, ON, Canada

Individual's mental states are influenced directly or indirectly through family and friends or colleagues. Social media as a popular platform where people express their feelings create a unique opportunity to capture behavioral attributes that represent an individual's thinking, mood, and emotions. A decision support system framework is designed to capture emotional influence from depressed and non-depressed friends to detect depression for social network users.

5 - Unsupervised Conversation Analytics

Cecilia Ying, Queen's University, Kingston, ON, Canada, 18yly@queensu.ca

Stephen Thomas

Companies reduce costs and increase efficiency by deploying chatbots as customer service's first point of contact. Through Conversation Analytics (CA) tools, companies can extract insights from the chatbot logs to understand trending topics and concerns. Traditional CA tools require human-annotated messages as training data, which is difficult and expensive to obtain. We study how to design and build practical CA tools without such data. We conduct an extensive empirical study on four benchmark datasets. We analyze the results and make practical recommendations.

6 - Gatekeepers Biased Intermediation and Policy Regulations

Meysam Fereidouni, University of Calgary, Calgary, AB, Canada

Barrie R Nault

The unique gatekeeping position of large online platforms may entice them to engage in biased intermediation. We explore the impact of biased intermediation on content providers' choice of output and market segmentation. We find that engaging in biased intermediation decreases content providers' aggregate output. Such potential negative

impacts have sparked antitrust concerns worldwide. We find that a policy intervention through the imposition of fines on the platform's revenue from prominence charges may reduce the surplus of content providers and consumers.

SB06

3rd Fl-Regency A

Tutorial: Wildfire Management: An Operational Research Perspective

Tutorial Session

1 - Wildfire Management: An Operational

Research Perspective

David L Martell, University of Toronto, Toronto, ON, M5S 3B3, Canada

Fire is a natural component of many forest ecosystems but wildfires can have very significant detrimental impacts on people, property, forest resources and infrastructure. British Columbia's 2021 fire season is of course, a recent poignant example. Fire cannot nor should it be eliminated from the forest but that poses complex challenges to those that live with fire and those that manage fire. I will provide a brief overview of wildfire management, describe some fire management problems I have studied, and identify some important open problems I believe operational researchers can help resolve.

SB07

3rd Fl-Regency B

Operations in Emergency Departments

General Session

Chair: Marco Bijvank

University of Calgary, University of Calgary, Calgary, AB, T2N 1N4, Canada

2 - Managing Capacity Reservation in Emergency Departments with Low Priority Strategic Patients

Marco Bijvank, University of Calgary, Calgary, AB, T2N 1N4, Canada, marco.bijvank@haskayne.ucalgary.ca

Guanlian Xiao

We consider the problem faced by emergency departments that must make a decision to split a fixed number of physicians between two service tracks. High-priority patients can be assigned to a dedicated track or be diverted to a shared track with non-preemptive priority over low-priority patients. The low-priority patients are strategic in the sense

that they choose to join or balk the shared track based on the queue length information they obtained. We study the impact of different information sharing policies on an optimal capacity reservation, and its consequences on system throughout and expected wait times.

3 - Development of a Generic Emergency Department Discrete Event Simulation Model

Evgueniia (Jenya) Doudareva, University of Toronto, Toronto, ON, Canada, jenya.doudareva@utoronto.ca

Michael Carter

The goal of this research was to develop a simulation model flexible enough to be applicable to any ED, that could be easily applied to diagnose bottlenecks and evaluate performance improvement approaches. We used Discrete Event Simulation (DES) to create a single input-driven generic model and validated it against limited de-identified datasets belonging to nine sites in Canada, U.S.A, and U.K. The key benefit of the model is its flexibility and the speed with which it can be implemented at any hospital in need of a DES study. The model can be used to evaluate performance and preview the effects of staffing and flow changes before implementing the improvement measures.

4 - Using Machine Learning to Predict Patients Who Leave Without Being Seen from a Pediatric Emergency Department

Majid Taghavi, Saint Mary's University, Halifax, NS, B4B 0R2, Canada, majid.taghavi@smu.ca

Julia Sarty, Peter Vanberkel, Katrina Hurley, Eleanor Fitzpatrick

Patients and their caregivers who seek care in an Emergency Department (ED) may choose to leave without being seen (LWBS) by a physician. This occurrence can account for up to 15% of all ED visits. Patients who LWBS do not receive the care they sought in the ED and may experience clinical deterioration related to delayed diagnosis or treatment. This study will focus on a pediatric ED and use descriptive analytics and machine learning methods to predict patients who are more likely to LWBS.

5 - Automated Data-Driven Modeling and Simulation of a Large Hospital Emergency Department (ED)

Dmitry Krass, Rotman School of Management, University of Toronto, Toronto, ON, M5S 3E6, Canada

Opher Baron, Arik Senderovich, Zijian Ling

The goal of this project is to develop an automated data-driven simulation model using event log data, process mining and queue mining techniques. We apply these tools to modeling the waiting times of ED in a large city hospital in

Toronto, Canada. We are particularly interested in evaluating the impact of consults on wait times. We find that while the first-order effects of consults are relatively minor, second-order effects are much stronger.

SB08

3rd Fl-Regency E

Sustainable Operations in Agriculture, Plastic Recycling and Rent-to-Own Models

General Session

1 - Blockchain Technology Adoption for Sustainable Supply Chain Performance Improvement

Samuel Yousefi, University of British Columbia, Kelowna, BC, Canada, samuel.yousefi@ubc.ca

Babak Mohamadpour Tosarkani

The adoption of blockchain technology (BT) can support decision-makers to improve the performance of multi-echelon supply chains (SCs) in terms of environmental, social, and economic aspects. We introduce an AI-based system analysis framework to quantify the impact of BT on SCs. In the proposed framework, modeling the causal relationships between BT characteristics and managerial targets implies that BT improves the sustainable performance of SCs. The results help SC managers overcome some management challenges in BT adoption.

2 - Managing Flexibility in Rent-to-own Contracts

Jose A Guajardo, University of California-Berkeley, Berkeley, CA, 94720-1900, United States

Access to electricity is a severe problem in many parts of the developing world. Several companies sell instead off-grid energy products using Rent-to-Own models, in which consumers make incremental payments over time to eventually become the owners of the product. Rent-to-Own models often imply giving degrees of payment flexibility to customers, which may increase the risk for companies given customers' income uncertainty. We develop a model of consumer behavior in Rent-to-Own and examine different design options for firms operating in these environments.

3 - Innovative Business Models in Ocean-Bound Plastic Recycling

Gonzalo Romero, Rotman, University of Toronto, Toronto, ON, M4K 1Y5, Canada, gonzalo.romero@rotman.utoronto.ca

utoronto.ca

Opher Baron, Zhuoluo Zhang, Sean Zhou

30 million tons of plastic waste reach the ocean each year, most from developing countries. We study novel business models to address this global problem. Firms aim at profitably recycling plastic to reduce ocean pollution while positively impacting local communities. They sell (a) plastic offsets and (b) segregated plastic. We find that adopting both attains more environmental impact, gives a higher income to the collectors while enjoying a higher profit than (a) or (b) alone. However, the largest collectors' share of the local supply chain profit is attained by (b). Moreover, the largest social impact may be attained by (a). We use empirical data to calibrate our model and unveil additional insights.

SB09

3rd Fl-Regency F

Covid Models: I

General Session

Chair: Peter Vanberkel

Dahousie University, Dahousie University, Halifax, NS, B3H 4R2, Canada

2 - A Framework for Comparing N95 and Elastomeric Facepiece Respirators on Cost and Function

Peter Vanberkel, Professor, Dahousie University, Halifax, NS, B3H 4R2, Canada, peter.vanberkel@dal.ca

Ceilidh Bray

SARS-CoV-2 has posed implications for personal protective equipment supply such as N95 respirators. Using activity based costing methods and SIR modelling we examined if elastomeric facepiece respirators (EFRs) are efficacious substitutes for N95s through comparing their functionality and cost. We evaluate respirator stockpiling requirements and costs depending on PPE utilization, disinfection strategies, and epidemiological characteristics of a pandemic.

3 - Intra-provincial Benchmark Analysis of Covid-19 in Canada

Fredrik Odgaard, Ivey Business School, Western University, London, ON, N6G 0N1, Canada, fodegaard@ivey.uwo.ca

Mehmet A Begen, Jafar Sadeghi

COVID-19 has posed great challenges to people, business, government, and society at large. In addition to the direct consequences on healthcare and hospitals, the pandemic strained eldercare, employment, economic growth, and exacerbated mental health and social issues. During the first part of the pandemic, the narrative focused on "flattening the curve" with researchers forecasting COVID-19 infections and

deaths, and the success of health strategies. After two years, we can now assess the numbers to gain insight. We present a non-parametric data-driven Data Envelopment Analysis to assess COVID-19 in ten Canadian provinces over the period March 2020 to November 2021. The objective is to derive worst- and best-case intra-provincial benchmarks to assess if and to what extent the situation could have been worse and better. To account for socio-economic impact our analysis incorporates official monthly unemployment rates and an established stringency index reflecting the level of social restrictions imposed by the provincial governments.

4 - Predicting Ventilator Requirement for Future Covid Variants

Luv Khandelwal, Brock University, St Catherines, ON, Canada, lk20ks@brocku.ca

Anteneh Ayanso

The study aims to predict the number of ventilators required for different variants of Covid-19 with higher transmission rates. Data from Covidestim.org is used for the number of cases, reproduction number, and severe cases. Severe cases were modelled as the target variable after the total vaccinations were merged with the original dataset. Total vaccinations data was sourced from Ourworldindata.org. Time series analysis was run for a set of combinations of forecast leads and seasonality. A prediction model was used for all states of the United States. The prediction model performs reasonably well, its performance validated using lower and upper confidence limits and prediction standard errors.

5 - University Course Scheduling During a Pandemic

Matthew Petering, Associate Professor, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, mattpete@uwm.edu

Mohammad Khamechian

Most universities have responded to the COVID-19 pandemic by offering courses in three formats: online, hybrid (with online and in-person components), or in-person. Option 1 discourages student interaction; option 2 has low classroom utilization; and option 3 poses health risks or is limited to small courses meeting in large rooms. We propose a new approach to course scheduling which allows more than one classroom to be assigned to the same course. Our method allows all courses—even the largest—to have a limited number of socially distanced, in-person meetings each semester. A math model and heuristic method are developed for implementation. Analyses of life-sized problem instances are promising.

SB10

3rd Fl-Balmoral/Windsor

Analytics and Optimization

General Session

Chair: John W Chinneck

Carleton University, Ottawa, ON, K1S 5B6, Canada

2 - An Efficient Placement of Homeless in Shelters: A Recovery Strategy from Homelessness

Peash Saha, PhD student, Queen's University, Kingston, ON, Canada, p.saha@queensu.ca

Salimur Choudhury, Kai Salomaa

Homelessness is alarmingly increasing and the number of shelters is having a sharp hike. The manual recovery process is running behind to overcome this social problem. We study the optimization problem of homeless-shelter matching and propose an efficient solution to expedite the recovery. We first use machine learning models to determine each shelter's suitability score for all homeless using significant factors, such as the economic status of location and homeless profile. In the second phase, an iterative algorithm outputs the best match shelter for the homeless with a higher recovery possibility with employment. Real-time improvement of the solution is done based on any update in the shelters.

3 - A Prediction-based Approach for Online Dynamic Radiotherapy Scheduling

Tu San Pham, Polytechnique Montreal, Montreal, QC, Canada, phamtusan@gmail.com

In this paper, we propose a prediction-based approach for an online dynamic appointment scheduling problem in the context of radiotherapy treatment. We solve the problem in a rolling horizon setting where treatment requests of different priorities and deadlines are revealed daily. It is difficult to reserve a proper treatment capacity for urgent patients. In our approach, a regression model learns from offline solutions to smartly delay treatments of non-urgent patients. The approach successfully reduces overdue treatments while maintaining reasonable waiting times for non-urgent patients.

4 - Learn to Search in Local Branching

Defeng Liu, Polytechnique Montreal, Montreal, QC, Canada, defeng.liu@polymtl.ca

Matteo Fischetti, Andrea Lodi

local branching (LB) has been one of the first primal heuristics for MIP exploring large neighborhoods through MIP solvers. For a LB algorithm, the choice of the neighborhood size is critical to performance. In this work, we investigate the

relation between the size of the search neighborhood and the behavior of the underlying LB algorithm, and we devise a learning based framework for guiding the neighborhood search of the LB heuristic. We computationally show that the neighborhood size can indeed be learned, leading to improved performances and that the overall algorithm generalizes well both with respect to the instance size and, remarkably, across instances.

5 - Fitting General and Regression Hyperplanes in the Presence of Confounding Outliers

John W Chinneck, Distinguished Research Professor, Carleton University, Ottawa, ON, K1S 5B6, Canada, chinneck@sce.carleton.ca

J. Paul Brooks

Finding a good hyperplane fit for a large data set in many variables in a small amount of time is a challenging computational problem. A main difficulty is recognizing and removing confounding outliers before making a fit because outliers (especially clustered outliers) can severely skew many fitting methods. We present a new method for fitting hyperplanes to general datasets (try to match the points) and for regression (try to match the output variable values). We compare our method to other state-of-the-art hyperplane fitting methods and show that it produces better fits in much less time. It is very fast and scalable and easily handles data sets having thousands of data point in small amounts of time.

SB11

3rd Fl-Oxford/Prince of Wales

New Models in Revenue Management

General Session

Chair: Murray Lei

Queen's University, Queen's University, Kingston, ON, K7L 3N6, Canada

Chair: Guang Li

Queen's University, Queen's University, Kingston, ON, K7K 0H3, Canada

3 - Pricing and Returns in the Era of Big Tech: Implications of Information Asymmetry Reversal

Kiarash Mohammad Hassani, Queen's University, Kingston, ON, Canada

Yanzhe (Murray) Lei, Anton Ovchinnikov

We present a model to optimize the return policy of a monopolistic seller, who may have better information about consumers' tastes than the customers themselves.

We analyze how return policy and tech-enabled superior information affect the firm's profit and consumer surplus. The results show that Pareto-improving situations exist.

4 - Selling and Renting Mechatronics (Digitally Controlled Physical Goods)

Xianfeng Meng, Queen's University, Kingston, ON, Canada
Guang Li, Anton Ovchinnikov

Firms that sell digital goods routinely utilize free-premium-upgrade business models for product differentiation. When downloading an app, one can try a free version first, then pay to unlock permanent premium functionality or rent additional temporary functionality. Recent technological advances allow physical goods firms to do the same: they can create products with identical hardware that are digitally controlled to allow for similar differentiation. This paper presents a stylized model to explore when physical goods firms should adopt such digitally-enabled product differentiation instead of the traditional product line design with high- and low-end products.

5 - A Data Driven Approach to Resort Revenue Management

Aliaksandr Nekrashevich, Queen's University, Kingston, ON, Canada

Yuri Levin, Guang Li, Mikhail Nediak

Small to medium-scale resorts strive to differentiate themselves from the rest of the hospitality industry by offering their customers unique experiences beyond a typical set of standard services. In their reliance on an experience-seeking customer base, they may benefit from the integrated property and revenue management strategies leveraged by major casino empires. However, they typically lack the scale to develop advanced resort management systems to maximize the customer base value at a reasonable price point. Our research seeks to study a system that comprehensively serves the unique needs of resorts in handling experience-seeking travellers.

6 - Near Optimal Dynamic Pricing Policies Under Trade-in Programs

Murray Lei, Queen's University, Kingston, ON, K7L 3N6, Canada, yl64@queensu.ca

Zhuoluo Zhang, Sean Zhou

Trade-in programs target customers who seek to salvage or upgrade their old products. In this paper, we consider a firm that offers both trade-in-for-cash and trade-in-for upgrade programs. The firm further resells the refurbished products together with new products over a finite selling horizon. By controlling the trade-in prices and the selling prices jointly,

the firm seeks to optimize the total revenue. We propose computationally efficient policies that have near-optimal performance guarantees.

SB12

34th Fl-Seymour

ENRE1: Climate, Weather, and Operations

General Session

Chair: Michael Pavlin

Wilfrid Laurier University, Wilfrid Laurier University,
Waterloo, ON, N2L 3C5, Canada

2 - The Last-mile Problem Impacted by Weather

Bryan Sydnor, Self Employed, Long Beach, CA, United States, bryansydnor@icloud.com

Recent years have seen a dramatic increase in the reliance on delivery of essential goods; takeout and groceries from the gig economy. Packages from Amazon, FedEx, UPS, and DHL. Each addressing difficulties in the last-mile problem with their own proprietary algorithms. Transportation hubs are being redefined as every grocery store, and restaurant in the community. Final destinations are being expanded to include nearly every residential address. The 2020-21 winter saw six storms, the 2021-22 winter has already seen 3 storms. We'll discuss the disruption of weather on the last-mile and address big data approaches to the weather problem without reverse engineering current proprietary algorithms.

3 - Application of Machine Learning Methods for Cost Prediction of Drought in France

Antoine Heranval, Mission Risques Naturels, Paris, France, antoine.heranval@sorbonne-universite.fr

Antoine Heranval, Sorbonne Université, CNRS, Laboratoire de Probabilités, Statistique et Modélisation, LPSM, Paris, France, antoine.heranval@sorbonne-universite.fr

Olivier Lopez, Maud Thomas

This paper deals with the prediction of the total amount of the damages caused by a drought episode under the French "Catastrophe Naturelle" regime. Thanks to a partnership with the Mission Risques Naturels, we had access to a database of natural catastrophe claims fed by the major French insurance companies. Combining the information about drought event claims contained in the database with meteorological and socioeconomic data allowed us to increase our knowledge of the exposure. Our prediction approach relies on the comparison of different statistical models and machine learning algorithms. To improve the performance, we propose an aggregation the different models.

4 - Design of Weather Rebate Sharing Contract

Piyal Sarkar, Ryerson University, Canada, Toronto, ON, Canada, piyal.sarkar@ryerson.ca

Mohamed Wahab Mohamed Ismail, Liping Fang

To address weather risk in supply chains, we propose a class of contract that performs better than a traditional revenue sharing contract. Contract parameters are designed to consider the risk aversion attitude of supply chain members. Conditional Value at Risk (CVaR) is used as the risk measure. The new class of contract combines a Cooling Degree Days (CDD)-based rebate structure with financial risk hedging. This class of contract can be utilized for administering supply chains of weather-sensitive products.

5 - Land Investment Decisions Under Climate Change: A Case-study of the Mississippi River Basin

Zhenggao Wu, University of Waterloo, Waterloo, ON, Canada, z365wu@uwaterloo.ca

Stan Dimitrov, Michael Pavlin

This paper studies the impact of climate change on land investment decisions. Given trajectories of land values implied by popular climate forecasting models in the Mississippi River basin, we consider optimal decisions using a range of frameworks including considering risk attitudes via a robust optimization model. Results include finding that different climate models dramatically change investment decisions through the key role played by precipitation forecasts.

SB13

34th Fl-Stanley

Entertainment Design 1

General Session

Chair: Craig Fernandes

University of Toronto, 5 King's College Road, Toronto, ON, M5S 3G8, Canada

2 - Understanding and Quantifying Decision Making in Sports

Robyn Ritchie, PhD, Simon Fraser University, Vancouver, ON, Canada

Thomas Loughin, Alexandre Leblanc

With growing quantities of data, the applications of statistical, mathematical and machine learning technics in sports are at an all-time high. Descriptive event and tracking data allow researchers to analyze any moment in the game. Sports analytics has elevated the level of competition in many sports and, now more than ever, finding

an edge to increase a team's win probability is crucial. By understanding when major events are most likely to occur under various circumstances or evaluating decision making throughout the game, we can help to improve player tactics and team strategies. We look at how sports analytics can be used to assess decision making and improve various aspects in sports.

3 - Constructing a Points System in Snowboarding Slopestyle Events via Bayesian Regression

XueGe Huang, University of Toronto, Toronto, ON, Canada, cocoxuege.huang@mail.utoronto.ca
Albert Loa, Nathan Sandholtz, Timothy Chan

The goal of rating systems is to objectively evaluate multiple performances over a certain period of time. Concerns with the current International Ski Federation (FIS) rating system stem from reward imbalance across tiers and selective participation. This has implications on athlete funding through national team selections and Olympic qualifications. We use Slopestyle snowboarding data from world, continental, and national events between 2016 and 2019 to estimate athlete skill using Bayesian regression. We propose a new points system that better matches both within tier athlete skill and skill gap between similarly ranked athletes across multiple tiers.

4 - Estimating the Causal Effect of Injury

Tyrel Stokes, PhD, McGill University, Montreal, QC, Canada

Estimating the causal effect of injury is an important and challenging question for epidemiologies and sport decision makers. Injuries, for one, occur non-randomly and injured players remain unobserved from a performance perspective for a non-random time. Further, performance paths can be very heterogeneous and non-linear. To make progress, we leverage two ideas. First, we use bayesian hierarchical models to share information between and within players. Second, we leverage recent ideas in meta-analytics to choose performance metrics which are both discriminant and stable to increase the signal of our estimates and reduce the expected complexity of the unknown latent trajectories.

5 - Inferring Optimality Criteria in Markov Decision Processes: An Application to the Fourth Down Decision in Football

Lucas Wu, Simon Fraser University, Burnaby, BC, Canada

For decades, coaches' observed fourth down decisions in the NFL have remained distant from analysts' recommendations. Leveraging inverse optimization, we assume that the coaches' observed decisions are optimal but that the risk

preferences governing their decisions are unknown. Our goal is to infer these latent risk preferences such that the resulting model yields their observed decisions as optimal. We frame a football game as a Markov decision process. Using the quantile function to parameterize risk, we estimate a risk-sensitive policy which yields the coaches' decisions as minimally suboptimal. We find that coaches in general exhibit conservative risk preferences.

SB14

34th Fl-Cypress

Queueing Models of Patient Flow

General Session

Chair: Jing Dong

Columbia University, Columbia University, New York, NY, 10027-6945, United States

Chair: Vahid Sarhangian

University of Toronto, University of Toronto, Toronto, ON, M5S 3G8, Canada

3 - Skills-based Routing Under Demand Surges:

The Value of Future Arrival Rates

Jinsheng Chen, Columbia University, New York, NY, 10027-6714, United States, jc4823@columbia.edu

Jing Dong, Pengyi Shi

Motivated by recent development in predictive analytics, we study how to utilize future demand information to design optimal routing strategies when facing demand surges. We consider a multi-class multi-pool parallel server system with partial flexibility, where overflowing a customer to a non-primary server-pool can be associated with efficiency loss and other costs. An example of such a system is a hospital, where patients arrive with different medical needs. Our results explicitly characterize how to incorporate future demand into routing decisions and quantify the benefit of doing so.

4 - Scheduling with Load-dependent

Service Rates

Vahid Sarhangian, University of Toronto, Toronto, ON, M5S 3G8, Canada

Berk Gorgulu, Jing Dong

In practice, service times can be affected by system load. Scheduling under load-dependent service times is challenging, especially when the impact of system load is heterogeneous across different customer classes. Motivated by empirical findings, we study multiserver queueing systems with load-dependent service rates. Using a fluid model, we first quantify a meta-stability phenomenon for multiclass queues with class-dependent service rate slowdown.

Moreover, we develop scheduling policies that effectively avoid convergence to equilibria with poor performance in the stochastic system.

5 - The Effects of Information Granularity on Abandonment and System Performance in Observable Priority Queue

Junqi Hu, University of Toronto, Toronto, ON, M4Y0B9, Canada, junqijh.hu@utoronto.ca

Philipp Afeche, Rouba Ibrahim, Vahid Sarhangian

Motivated by empirical studies of the abandonment behavior of customers in service systems, we propose new priority queueing models with time-varying arrivals and state-dependent abandonment depending on the granularity of state information available to the customers. We investigate the performance under three levels of information granularity (no, partial, and full information) by exploiting a fluid model of the system. For each information level, we establish the existence, uniqueness, and stability of an equilibrium. Then, we compare the equilibria under the three information designs and provide insights on the effects of information granularity on queue length and abandonment rate.

Sunday, 1:30–3pm

SC01

2nd Fl-Georgia A

Healthcare Operations Management SIG

General Session

2 - Individualized Dynamic Patient Monitoring Under Alarm Fatigue

Hossein Piri, University of British Columbia-Sauder School of Business, Vancouver, BC, V6B 1X9, Canada, hossein.piri@sauder.ubc.ca

Woonghee Tim Huh, Steven Shechter, Darren Hudson

Hospitals are rife with alarms, many of which are false. This leads to alarm fatigue, in which clinicians become desensitized and may inadvertently ignore real threats. We develop a partially observable Markov decision process (POMDP) model for recommending dynamic, patient-specific alarms in which we incorporate a cry-wolf feedback-loop of repeated false alarms. We develop structural results of the optimal policy and perform a numerical case study based on clinical data from an intensive care unit (ICU). We find that compared to current approaches of setting patients' alarms, our dynamic patient-centered model significantly reduces the risk of patient harm.

3 - Entropy-based Evolutionary Diversity Optimization for the Patient Admission Scheduling Problem

Amirhossein Moosavi, University of Ottawa, Ottawa, ON, Canada

Computing diverse sets of high-quality solutions has gained increasing attention among the evolutionary computation community in recent years. It allows practitioners to choose from a set of high-quality alternatives. We employ a population-based diversity measure, called the high-order entropy measure, in an evolutionary algorithm to compute a diverse set of high-quality solutions for the patient admission scheduling problem. In contrast to the previous studies, our approach allows diversifying the solution set based on different components of the objective function. Experimental results show that our algorithm can find a set of diversified and high-quality solutions.

4 - Optimal COVID-19 Vaccination Facility Location

Jingyuan Hu, UCLA Anderson School of Management, Los Angeles, CA, United States, jingyuan.hu.phd@anderson.ucla.edu

Elisa Frances Long, Fernanda Bravo

Socioeconomic disparities in COVID-19 vaccination rates are partially attributable to poor vaccination site selection. We formulate a COVID-19 vaccination location problem as a large-scale mixed-integer program, selecting from >58,000 pharmacies and >30,000 dollar stores nationwide. The optimal solution allocates 37% of vaccinations to dollar stores, achieving a 62% reduction in travel distance, and reduces racial disparities as measured by a newly constructed Gini coefficient. We also document empirical evidence of a strong negative relationship between travel distance to a vaccination site and vaccination uptake.

5 - Customer Participation and Performance in Healthcare Services: An Intervention-based Study

Rob Glew, University of Cambridge, Cambridge, United Kingdom, rg522@cam.ac.uk

Duncan McFarlane, Darius Danaei

Many studies have examined the benefits of consumer participation (CP) in services: it can improve employee and customer satisfaction. However, emerging research has established that CP also has a dark side, leading to ambiguity and stress. We contribute to resolving this conflict with a large-scale intervention-based study of a viral testing service. We compare customer perceptions of the service and its operational performance before and after an intervention to increase CP. Our findings show that while CP improved

the efficiency of the service delivery system, it also reduced service performance. This sheds light on the complex nature of CP and guides decision-makers on its costs and benefits.

SC02

2nd Fl-Georgia B

Recent Topics on Data-driven Decision Making

General Session

Chair: Wenhao Li

Postdoc, University of Toronto, University of Toronto

2 - Dimension Reduction in Contextual Online Learning via Nonparametric Variable Selection

Wenhao Li, Postdoc, University of Toronto, Toronto, ON, Canada

We consider a contextual online learning problem with high-dimensional covariate x and decision y . The reward function to learn, $f(x,y)$, does not have a particular parametric form. The literature has shown that the optimal regret is $O(T(dx+dy+1)/(dx+dy+2))$, where dx and dy are the dimensions of x and y . In many applications, only a small subset of variables in the covariate affect the value of f , which is referred to as sparsity in statistics. To take advantage of the sparsity structure of the covariate, we propose a variable selection algorithm called BV-LASSO. Using it as a subroutine, we can achieve the regret $O(T(dx'+dy+1)/(dx'+dy+2))$, where dx' is the effective covariate dimension.

3 - Joint Order Partitioning and Routing for Courier Fleets on Crowdsourced Delivery Platforms

He Wang, Georgia Tech, Atlanta, GA, 30332-0205, United States

Adam Behrendt

Crowdsourced delivery platforms have made use of two types of couriers: ad-hoc couriers, who are more flexible, and committed couriers, who are more reliable. In this paper we show that by designing a system that intelligently utilizes order partitioning between the two delivery channels (e.g., makes routing and partitioning decisions jointly), the delivery platform can exploit the benefits of each courier base to improve customer service and reduce the total cost when compared to order pooling.

SC03

2nd Fl-Plaza A

Lessons Learned from Optimization in Practice

General Session

Chair: Jeffrey D Camm

Wake Forest University, Wake Forest University, Winston-Salem, NC, 27109, United States

2 - Using Hybrid Optimization for Decisions Making When Speed is Critical: Examples from the Gig Economy and on the Battlefield

Karla Hoffman, Professor, George Mason University, Fairfax, VA, United States, khoffman@gmu.edu

Ryan J. O'Neil

Many dynamic environments require technology that assist in real-time decision-making. Some applications require a feasible solution in less than a minute, or even in a few seconds. Techniques using hybrid algorithms designed with problem structure in mind have proven very powerful. We describe alternative approaches using constraint programming, decision diagrams and heuristics. We highlight our successes in using these techniques to solve routing and scheduling, as well as channel assignment in a contested battlefield.

3 - Solving and Implementing Optimization Models in Heavy Industry

Alexandra Newman, Colorado School of Mines

Optimization models in heavy industry are notorious for (i) requiring detailed discipline-specific knowledge, (ii) necessitating large amounts of difficult-to-verify data, (iii) lacking specialized mathematical structure, and (iv) residing in unsophisticated environments. We discuss ways to overcome these challenges, providing case studies from the mining, renewable energy, and steel industries.

4 - Optimization: The Most Powerful Recommendation Engine

Jeffrey Camm, Wake Forest University, Winston-Salem, NC, 271209, United States

In this talk, we discuss how to use optimization models to improve decision making and drive positive change. By using optimization models to generate multiple alternatives, some optimal to the model and some not, we discuss via real-world examples obtained from over 20 years of practice, how to provide valuable alternatives for solving real-world problems. We discuss real applications in supply chain optimization, bank branch location, biodiversity conservation, textile mill planning, marketing, and data science.

SC04

2nd Fl-Plaza B

Emerging Topics in Supply Chains

General Session

Chair: Xuan Zhao

WLU, WLU, Waterloo, N2V 2S7, United States

Chair: Ju Qiu

Doctoral student, Wilfrid Laurier University, Wilfrid Laurier University, Waterloo, ON, N2L 3C5, Canada

3 - Platforms with Uncertain Information

Xiaokai Wu, PhD, Wilfrid Laurier University, Waterloo, ON, N2L3C5, Canada

We investigate how ride-hailing platforms decide their quality standard, a major concern in the emerging ride-hailing market. Do ride-hailing platforms economize safety facing the pressure of consumers' waiting and competition? Is regulation necessary to ensure safety? We construct a model with two platforms competing for consumers and drivers to derive the platform's optimal pricing strategy and optimal service standard. We show that platforms tend to increase the service quality standard when the market size is either small or large. Besides, competition may bring a higher service standard than the social planner. This study provides a framework to analyze the efficiency of the regulations.

4 - CSR Efforts and Accommodation Strategy in a Shipping Supply Chain Facing Downstream Entry

Peng Xu, Doctoral student, Nanjing University, Nanjing, N2L 3C5, China, pengxu@smail.nju.edu.cn

Peng Xu, Doctoral student, Wilfrid Laurier University, Waterloo, ON, Canada, pengxu@smail.nju.edu.cn

Xuan Zhao, Tiaojun Xiao

The downstream entry is commonly observed in the shipping industry. Thus, it is worth exploring (i) under what conditions the entrant should enter? (ii) whether the port should accommodate the downstream entry? and (iii) how the entry impacts consumer surplus and social welfare? This paper adopts a game-theoretic framework to explore these issues within a two-stage shipping supply chain. Further, we examine how the corporate social responsibility (CSR) efforts of carriers, incumbent channel structure, and pricing mode affect our results.

5 - Introducing a Bi-objective Location-routing Problem in E-commerce Logistics with Failed Home Deliveries

Alireza Amini, Wilfrid Laurier University, Waterloo, ON, Canada

Michael Haughton

6 - Independent Showrooms vs. Cooperated Showrooms: Which is Better for an Online Retailer in the Competitive Market

Ju Qiu, Hefei University of Technology, Hefei, China, qiuju1210@hotmail.com

Ju Zhao, Zhao Xuan, Xiaojian Hu

This paper studies how an online retailer can deliver information to customers by two different showroom strategies---independent showroom (IS) strategy (resolves valuation uncertainty) and cooperative showroom (CS) strategy (resolves valuation uncertainty and preference uncertainty). Results show that, the online retailer and BM retailer will cooperate to open the showroom even though this move might hurt the BM retailer's profit. CS strategy performs best when products sold by two retailers are similar; however, IS strategy will perform best when products are dissimilar and consumers' uncertainty level on preference is low but uncertainty level on valuation is high.

SC05

2nd FI-Plaza C

Analytics II

Contributed Session

Chair: Mehdi Kargar

Ryerson University

2 - Supply Chain Data and Analytics At-scale for Risk Management in the Covid Era

Prabhakar Thanikasalam, Sr. Director, Advanced Analytics and Supply Chain, Flex (flex.com), Austin, TX, United States, PRABHAKAR.THANIKASALAM@FLEX.COM

Flex (flex.com) operates one of the world's largest and most diversified supply chains with more than 16k suppliers, 1 million SKU's for more than 1K customers in 6 industry verticals, etc. with operations on a global scale in 30 different countries! The last 2+ years have been a once-in-a-lifetime set of challenges for SC Risk mgmt - Covid-19 issues, supply/logistical challenges, and lately, semiconductor shortages across all industries. The proposed talk will cover the data and analytics/data science activities supporting this journey - I lead advanced analytics and data for the SC org at Flex.

3 - Keyword Search Over Enterprise Data Using Advanced Machine Learning

Mehdi Kargar, Assistant Professor, Ryerson University, Toronto, ON, Canada, kargar@ryerson.ca

Morteza Zihayat, Jaroslaw Szlichta

Online search engines such as Google develop a convenient interface to search the web based on a set of input keywords. However, such an interface is currently not available for enterprise data. Enterprise data are usually structured with information about entities scattered across different parts of the database. Forming the final answer is challenging since different pieces of information must be combined together. Here, we present a keyword search system over enterprise data using advanced large-scale machine learning and deep learning techniques that empowers business users to explore relevant data.

SC06

3rd Fl-Regency A

Tutorial: Causal Inference in the Presence of Network Interference

Tutorial Session

1 - Causal Inference in the Presence of Network Interference

Christina Lee Yu, Cornell University, Ithaca, NY, 14853, United States

Randomized experiments are used across a variety of domains to estimate causal effects of proposed treatments. Classical approaches to experimental design rely on critical independence assumptions that are violated when the outcome of an individual is affected by the treatment of another individual, referred to as network interference. We will survey the computational and statistical challenges of causal inference under network interference and the different proposed approaches to adjust for network interference. We will present a new hierarchy of models and estimators that enable statistically efficient and computationally simple solutions under nonparametric polynomial models.

SC07

3rd Fl-Regency B

Home Health Care Logistics

General Session

Chair: Antoine Sauré

Telfer School of Management, University of Ottawa,
Telfer School of Management, University of Ottawa,
Ottawa, ON, K1N 6N5, Canada

Chair: Jonathan Patrick

University of Ottawa, University of Ottawa, Ottawa,
ON, K1N 6N5, Canada

3 - A Periodic Home Care Nurse Scheduling and Routing Problem with Time Windows and Skill Requirements

Peyman Varshoei, PhD Candidate, University of Ottawa, Ottawa, ON, Canada, pvars059@uottawa.ca

Jonathan Patrick, Onur Ozturk

In this study, a highly constrained static multi-objective home-care nurse scheduling and routing problem with periodic visits, visit time windows, and skill requirements is studied. The objectives are minimization of nurses' total travel distance, nurses' workload inequity, and rejected visit requests, and maximization of continuity of care. To solve this NP-hard problem, we aim to propose a hybrid two-phase evolutionary algorithm based on a Non-dominated Sorting Genetic Algorithm-II and a Strength Pareto Evolutionary Algorithm 2.

4 - Addressing Uncertainties in Home Health Care Routing and Scheduling Problems

Sandra Blais-Amyot, University of Ottawa, Ottawa, ON, Canada, sblai056@uottawa.ca

Onur Ozturk

Optimized Routing and Scheduling (RS) for mobile caregivers is essential for the efficient management of Home Health Care services. Unexpected events may affect the initial caregiver's schedule by delaying or accelerating visits. Therefore, the RS should be continuously updated to deliver services that respect the constraints while minimizing total costs. In this research, we solve a mixed-integer linear programming problem that considers time uncertainties throughout the day. We integrate our solution method in a re-optimization model capable of updating the current schedule to provide an optimal outcome. Results show an improvement or no change in 85% of cases when re-scheduling patients.

5 - Dynamic Home Care Visit Scheduling and Care Provider Routing Problem with Uncertain Arrivals and Number of Visits

Jonathan Patrick, University of Ottawa, Ottawa, ON, K1N 6N5, Canada, patrick@telfer.uottawa.ca

Antoine Sauré

We describe a home care visit scheduling and care provider routing problem. We consider uncertainty around the number of new arrivals and the number of visits for each patient. Decisions include whether or not to accept a new patient and if accepted how to schedule their visits in order to minimize routing costs. Given the size of the problem, we discuss several approaches to find feasible solutions to it.

SC08

3rd Fl-Regency E

Challenges in Sustainable Operations and Supply Chain Management

General Session

Chair: Serasu Duran

Ph.D., University of Calgary, Calgary, AB,
T2N1N4, Canada

2 - Why do Companies Need Operational Flexibility to Reduce Waste at Source?

Yara Kayyali Elalem, EPFL, Lausanne, Vaud, Switzerland,
yara.kayyalielelem@epfl.ch

Isik Bicer, Ralf W Seifert

We analyze the environmental benefits of operational flexibility that emerge in the form of less product waste during the sourcing process by considering three different options: (1) lead-time reduction, (2) quantity-flexibility contracts, and (3) multiple sourcing. We use a multiplicative demand process to model the evolutionary dynamics of demand uncertainty. We then quantify the impact of key modeling parameters for each operational-flexibility strategy on the waste ratio. Our results indicate that operational-flexibility strategies that rely on the localization of production are key to reducing waste and improving environmental sustainability at source.

3 - Renewable Mini-grid Projects for Rural Electrification

Serasu Duran, Haskayne School of Business, Calgary, AB,
T2N 1N4, Canada, serasu.duran@haskayne.ucalgary.ca

Feyza G. Sahinyazan

Rural communities around the globe rely on diesel-generated electricity which are cost-inefficient, harmful for the environment and subject to disruptions. Policy makers need to develop sustainable solutions for these communities to meet the Sustainable Development Goals regarding clean energy and reduced inequalities. In this study, we explore the operational opportunities and challenges of renewable mini-grid deployment in remote regions.

4 - Ex-ante and Ex-post Cooperation Among Renewable Energy Producers in Day-ahead Electricity Markets

Sanjith Gopalakrishnan, McGill University, Montreal, QC,
V5B 3P9, Canada

Sriram Sankaranarayanan

A major challenge faced by renewable producers is the inherent uncertainty in the future availability of renewable energy. A fundamental operational strategy to mitigate uncertainty is risk pooling. Risk pooling exploits the general principle that aggregating the availability across various locations will result in a net lower supply variability since low supply in one location can be offset by a higher supply in another. We use a game-theoretic model of bidding in day-ahead electricity markets to analyze the welfare implications of ex-ante and ex-post cooperation among renewable producers.

5 - Retreat, Defend, or Attack? Optimal Investment Decisions in Green Technology Under Competition

Osman Alp, University of Calgary, Calgary, AB, T2N 1N4,
Canada, osman.alp@ucalgary.ca

Tarkan Tan, Maximiliano Udenio

Firms that invest in more sustainable technologies as a proactive measure against changing market dynamics are likely to gain a significant competitive advantage. We analyze a firm's optimal green investment strategy, accounting for the uncertainty in the competitors' actions and the future green market size. We develop a stylized model under three stages and characterize the optimal policy as 'Retreat', 'Defend', or 'Attack' strategy when green market size is known, one of which is optimal based on the problem parameters. We conduct theoretical and numerical analyses regarding the optimal solution and the regret associated with making sub-optimal decisions, when the green market size is random.

SC09

3rd Fl-Regency F

Emerging Logistics Systems Design

General Session

Chair: Sibel Alumur Alev

University of Waterloo, University of Waterloo,
Waterloo, ON, N2L 3G1, Canada

2 - Sustainability in Profit Maximizing Hub Location Problems: Comparison of Solution Methods

Sinem Kinay Savaser, Rotman School of Management,
Kitchener, ON, N2N 0A2, Canada

Gita Taherkhani, Omer Burak Kinay, Wenjing Guo

In this paper, we focus on sustainability in profit maximizing hub network design problem in which we assume that the transportation cost between every pair of nodes includes a carbon tax, and each arc has a carbon capacity to limit the

generated carbon emissions. To provide a more reliable solution framework for this problem, we take the demands as stochastic parameters and then develop two solution approaches for solving our problem: reinforcement learning techniques and Benders-based algorithm coupled with sample average approximation scheme.

3 - Last-mile Delivery System with Crowdkeeping

Xin Wang, HEC Montreal, Montreal, QC, Canada

Okan Arslan, Erick Delage

To improve the efficiency of last-mile deliveries when customers are possibly absent from their homes, we propose the idea of employing the crowd to work as keepers and provide storage service. Crowd keepers have much flexibility, high mobility, large availability, and potentially lead to lower costs. We develop a bi-level model by considering customer preferences, keeper behaviors, platform operations, and the participants' coordination by jointly determining the location, assignment, routing, and pricing decisions. We implement computational studies on a dataset obtained from Amazon.

4 - Infrastructure Design for Shared Autonomous Transportation

Sibel Alumur Alev, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

Omer Burak Kinay, Fatma Gzara

We introduce the staging facility location and AV lane deployment problem for shared autonomous transportation. To respond to a call for a trip, an AV leaves from a staging facility, travels between the origin and destination nodes of the trip, and returns to a staging facility. We seek to find the optimal locations of staging facilities utilizing a bi-objective model that minimizes total travel distance and the total AV travel not occurring on AV lanes with respect to a given AV lane deployment budget and a number of staging facilities to locate. We develop a Benders decomposition algorithm with Pareto-optimal cuts and evaluate the trade-offs with optimal solutions on benchmark instances.

5 - Hub Location Routing with Private Fleet and Optional Carrier Partial Delivery

Sara Moustafa Ismael Ahmed, Concordia University, Montreal, QC, H3H1K6, Canada, ah_sar@encs.concordia.ca

Ana María Anaya-Arenas, Ivan Contreras

In the e-commerce industry, customers are demanding greater flexibility and lower delivery time. Hence, companies need to rethink their distribution network to face the new challenges in an economic way. Current practices, including optimizing the location and routing decisions are essential, but not sufficient on their own. Examples like Amazon and

Flip-Kart show that adopting outsourcing strategies are essential for a company's competitive survival. We hence propose a new multi-commodity model that considers simultaneously the hub location and routing decisions, while optimizing the option of using a common carrier. Additionally, we propose two matheuristic algorithms to solve the model.

SC10

3rd Fl-Balmoral/Windsor

Data Analytics and Optimization for the Public Sector

General Session

Chair: Fereshteh Mafakheri

École nationale d'administration publique (ENAP), Université du Québec, École nationale d'administration publique (ENAP), Montreal, QC, H2T 3E5, Canada

Chair: Zahra Vazifeh

Concordia University

3 - Urban Infrastructure Planning to Manage Stormwater

Aiqi Zhang, University of Toronto, Toronto, ON, 999077, Canada, aq.zhang@rotman.utoronto.ca

Sheng Liu, Wei Qi

We propose an urban water infrastructure planning problem that integrates the sewage system and retention basins as control tools. Leveraging the classical Intensity-Duration-Frequency (IDF) Curve to characterize rainfall scenarios, we analyze the flooding cost of each scenario and show that even the scenarios with the same return period on the IDF Curve can result in entirely different flooding costs, providing an operational perspective for the planning. Applying robust optimization techniques, we provide tractable infrastructure solutions that hedge against worst-case rainfall scenarios. Finally, we extend our model to the case of capacitated sewage systems and multiple catchments.

4 - Government Support and the Production of Covid Products Under Uncertainty

Ben Charoenwong, Assistant Professor, National University of Singapore, Singapore, Singapore, bizbgc@nus.edu.sg
Alan Kwan, Jing Li

Using data on customer searches and product listings from North America's largest online platform for supplier sourcing, we study supplier responses into the market for Covid-19 products during the pandemic. While many suppliers produced related products, only a fraction pivoted into the

market for Covid-19 products. However, government support appears to induce more entry: firms (1) with prior government contracts, (2) in states with more state budget appropriations for Covid-19, (3) and in Democrat states were all more likely to enter a Covid product market conditional on demand. In addition, government interest predicts supplier entry over three times better than customer interest.

5 - A Knapsack Problem to Detect Key Drivers in Causal Inference

Nima Safaei, Sr. Data Scientist, Scotiabank, Toronto, ON, Canada, nima.safaei@scotiabank.com

Explainability is one of the key properties of AI systems for high-risk fields. Causal Inference (CI) is a vital tool for producing insightful explainability. The various CI methods usually result in different causal graphs with different inter-connectedness and density; given a high-dimension feature space. One idea to compare or unify different causal graphs is to find the key drivers/parents impacting other features in the graph. In this research work, a binary knapsack model is proposed to detect these key drivers. Using a publicly available econometrics dataset, the experimental results reveal the capability of the proposed optimization model to correlate various causal graphs.

6 - Bioenergy Supply Chain Coordination: A Revenue Sharing Mechanism

Zahra Vazifeh, Concordia university, Montreal, QC, Canada, z_vazif@encs.concordia.ca

Fereshteh Mafakheri, Chunjiang An

The present paper proposes a game theoretic approach to coordinate the entire supply chain of bioenergy. Due to the hierarchical nature of decision making, the interactions among the supply chain participants have been considered through a two player Stackelberg game. In order to provide enough incentives for suppliers to play in a way that optimize the benefits of entire supply chain, a revenue sharing contract by energy conversion facilities as the leaders could be investigated. We illustrate the proposed methodology through an empirical case study on three Canadian northern communities and demonstrate the effects of the revenue sharing contract on suppliers and communities.

SC11

3rd Fl-Oxford/Prince of Wales

Decision Analytics in Retail Management

General Session

Chair: Sentao Miao

McGill University, McGill University, Montreal, QC,

H3C 6L7, Canada

2 - Combining a Smart Pricing Policy with a Simple Replenishment Policy: Managing Uncertainties in the Presence of Stochastic Purchase Returns

Alys Jiaxin Liang, Michigan Ross, Ann Arbor, MI, 48104, United States

It is generally accepted in the industry that returns are inevitable and often considered as the necessary cost of doing business. The ever-increasing rates of returns have prompted businesses to properly manage their reverse logistics system. In this paper, we consider a single warehouse joint inventory and pricing problem in the presence of stochastic purchase returns. A key feature of our model is that we allow a general stationary (random) return time distribution. We propose an easy-to-implement joint inventory and pricing policy and show that it is near optimal in the setting with a large annual market size, which is a practically relevant setting for many product categories

3 - Dynamic Pricing with Fairness Constraints

Sentao Miao, McGill University, Montreal, QC, H3C 6L7, Canada, sentao.miao@mcgill.ca

Maxime Cohen, Yining Wang

This paper studies dynamic pricing with unknown demand under two types of fairness constraints: price fairness and demand fairness. For price fairness, the retailer is required to (i) set similar prices for different customer groups (called group fairness) and (ii) ensure that the prices over time for each customer group is relatively stable (called time fairness). We propose an algorithm based on an infrequently-changed UCB method, which is proved to yield a near-optimal regret. For demand fairness, the retailer is required to satisfy that the resulting demand from different customer groups is similar. We design an algorithm and prove that our algorithm also achieves a near-optimal performance.

SC12

34th Fl-Seymour

ENRE2: Sustainable Supply Chain and Emergency Response

General Session

Chair: Niloofar Akbarian

The University of British Columbia, The University of British Columbia, Vancouver, BC, Canada

2 - A Techno-economic Environmental Investigation of Hemp-based Biocomposite Supply Chain: Case Study in Western Canada

Niloofer Akbarian-Saravi, University of British Columbia, KELOWNA, BC, Canada, niloofer.akbarian@ubc.ca

Abbas S. Milani, Taraneh Sowlati

To manufacture emerging biocomposites, different Supply Chain (SC) designs may be opted by industries, depending on factors such as material storage, processing capacity, and equipment availability. Accordingly, in order to realize the most cost-competitive and environmentally friendly SC design, techno-economic analyses along with Life Cycle Assessment (LCA) need to be considered. Moreover, a sensitivity analysis should be conducted to evaluate how economic and environmental criteria are affected by each decision parameter. The integration of these techniques has been shown in the present work through a new hemp-based biocomposite SC design in Western Canada.

3 - A Tactical Model for Sustainable Rail-road Transportation Under Disruption Risks

Asefeh Hassani Goodarzi, École de technologie supérieure ÉTS, Montreal, QC, Canada, asefeh.hassani-goodarzi.1@ens.etsmtl.ca

Armin Jabbarzadeh, Marc Paquet

With the rapid growth of the transportation industry, environmental and social concerns have been increasingly raised. Multi-modal transport can be considered as a promising solution to reduce greenhouse gas emissions and negative externalities by shifting from road to rail, which is a more environmentally friendly mode. The vulnerability of multimodal networks to random disruptions though requires resilient planning of such systems. This study therefore focuses on developing an optimization approach for resilient and sustainable planning of rail-road transport systems at the tactical level.

SC13

34th Fl-Stanley

Entertainment Design 2

General Session

Chair: Keith A Willoughby

University of Saskatchewan, University of Saskatchewan, Saskatoon, SK, S7N 5A7, Canada

2 - In Game Win Probability Models for Soccer

Stephen Hill, University of North Carolina-Wilmington, Wilmington, NC, 28403-5611, United States

In game win probability models for football (soccer) are often overly simplistic and do not adequately take into account various aspects of play. In this presentation, a new in game win probability model for football (soccer) is presented along with validation results and implications.

3 - Have Rule Changes Impacted a Key Strategic Curling Decision?

Kent Kostuk, Engcomp, Saskatoon, SK, Canada

Keith Willoughby

There is an age-old debate in the curling community about which last-end scenario is preferred: to be ahead one point without last shot; or behind by one with last shot. These scenarios have previously been compared using data from an era where high scoring ends were not the norm. Over the past 20 years rule changes have impacted end-by-end scoring. We investigate if these changes have impacted the preferred scenario.

4 - From the Marathon to Olympic Agenda 2020: Methods for Adding Sports to Keep the Olympics Entertaining

Raymond Stefani, California State University, Long Beach, CA, United States

Since WW2, the IOC employed three systems to increase the Olympics' entrainment value. From 1948-2000, non-medal demonstration sports were included, the best six becoming continuing sports. From 2004-2016, a system of re-valuating all 28 Sports Federations proved unworkable (two sports became continuing and two were dropped). Olympic Agenda 2020 has proven very successful (500 athletes may be added in new sports, with a 10,500-athlete limit). Sport climbing, surfing and skateboarding have become continuing sports. Lacrosse (2028) as well as cricket and netball (2032) might be contested.

5 - Is Momentum a Myth? Analyzing Outcomes from the Canadian Football League

Keith A Willoughby, University of Saskatchewan, Saskatoon, SK, S7N 5A7, Canada, willoughby@

edwards.usask.ca

Kent Kostuk

Sports enthusiasts frequently debate the presence of momentum in player performance, team success and game results. Whether it's portrayed as the "hot hand" or a severe slump, commentators may refer to those moments in a game that yield to swings in a team's outlook. Using several seasons' worth of data from the Canadian Football League, we analyze specific situations that seemingly

contribute to a shift in game results. We investigate the relationship between momentum-inducing circumstances and overall team effectiveness.

SC14

34th FI-Cypress

Recent Advances in Queueing System Analysis and Optimization

General Session

Chair: Haoran Wu

Chair: Qi-Ming He

University of Waterloo, Waterloo, ON, N2L 3G1, Canada

3 - Continuous Approximations of Discrete Phase Type Distributions and Their Applications to Reliability Models

Qi-Ming He, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

Using Erlangization, we construct two types of continuous phase-type (PH) random variables that approximate discrete PH-random variables and finite discrete random variables. The key idea of the method is to use Erlang random variables to approximate constants. The approximations have i) explicit closed form PH-representations; ii) a small set of parameters, iii) the same mean as the original random variable; iv) moments and variances that can be arbitrarily close to that of the original random variable; v) distribution functions that converge to that of the original random variable; and vi) distribution functions that decreasing in convex order. (Joint work with Baoliang Liu and Haoran Wu)

4 - Equilibrium and Optimal Behaviour in a Passenger-taxi Two-sided Queue with Non-zero Matching Time

Yiqiang Q. Zhao, Carleton University, Ottawa, ON, K1S 5B6, Canada

We consider a passenger-taxi double-ended (or two-sided) queue with negative passengers and non-negative (two-point) matching time. The objective is to get the equilibrium joining strategy and the social optimal strategy under two information levels. The theoretical results show that the passenger utility function in the partially observable case is monotonic. The equilibrium strategy and socially optimal strategy of the observable case are both threshold-type. Numerical results are shown to illustrate the theoretical result.

5 - Using Laplace Transforms to Study Fluid Queues with Periodic Transition Rates

Barbara H Margolius, Cleveland State University, Cleveland, OH, 44120, United States, b.margolius@csuohio.edu

We consider a single buffer fluid system, $\{X(t), J(t): t \geq 0\}$, in which the instantaneous rate of change of the fluid is determined by the current state of a background continuous time Markov chain (CTMC) with finite state space called the "environment". The environment process, $\{J(t) : t \geq 0\}$ has a time-varying generator $T(t)$ and period of length 1 such that $T(t) = T(t + 1)$ for all $t \geq 0$. We develop methods to compute the limiting distribution of the bivariate process (buffer level $X(t)$, environment state $J(t)$) for each time t within the period as the number of periods tends to infinity. We use a Laplace transform approach to facilitate the analysis.

6 - SEH: Size Estimate Hedging Scheduling of Queues

Douglas Down, McMaster University, Hamilton, ON, L8S 4L8, Canada, downd@mcmaster.ca
Maryam Akbari-Moghaddam

For a single server system, Shortest Remaining Processing Time (SRPT) is known to be optimal. We consider the case when exact information about processing times is unavailable. When SRPT uses estimated processing times, underestimation of large jobs can significantly degrade performance. We propose an index-based policy with a single parameter, Size Estimate Hedging (SEH), that only requires estimated processing times. A job's priority is increased dynamically according to an SRPT rule until it is determined that it is underestimated, at which time the priority is frozen. Numerical results suggest that SEH has desirable performance for settings that are consistent with what is seen in practice.

Sunday, 3:10–4pm

SP02

3rd FI-Regency CD

Plenary: Harold Larnder Prize: Creating Success Stories of Operations Research

Plenary Session

1 - Harold Larnder Prize: Creating Success Stories of Operations Research

Ravi Ahuja, Optym, Dallas, TX, United States

This talk will share the insights of a researcher and practitioner who in his first 20+ years of career focused on developing models and algorithms, and in the latter 20+ years focused on applying those techniques to solve real-world decision problems faced by transportation and logistics companies. The first part of the talk will describe what techniques appear to be most successful in practice - techniques that are intuitive, practical and use common sense - techniques that you can explain to your grandparents, and they will get those. The talk will give overview of several business problems and techniques that worked very well and why. However, just developing the right models and algorithms isn't enough to make an impact. The second part of the talk will describe what additional capabilities you need to be a successful practitioner and create success stories for the OR discipline.

Sunday, 4:30–6pm

SD01

2nd FI-Georgia A

Supply Chain Management SIG

General Session

Chair: Vibhuti Dhingra

2 - Combating Excessive Overtime in Global Supply Chains

Jiayu Chen, University of Calgary, Calgary, AB, T2N 1N4, Canada, jiayu.chen1@ucalgary.ca

Chuanya Jiao, Anyan Qi

Workers in developing economies may be forced to work excessive overtime, which causes mental and physical issues and results in brand damages to the buyers if exposed in public. We develop a game-theoretic model of a dyadic supply chain and analyze the buyer's strategies to combat excessive overtime, including auditing and cross-training. We derive equilibrium outcomes and study the interaction of the strategies and their impact on the degree of excessive overtime and social welfare. We find that: (i) cross-training can be a substitute or complement to auditing, (ii) it may reduce or increase overtime, and (iii) it may benefit both the manufacturer and the supplier.

3 - Bike-sharing Systems: Economic and Environmental Implications of Operational Strategies

Sanjith Gopalakrishnan, McGill University, Montreal, QC, Canada

Daniel Granot, Frieda Granot

Despite their growing popularity as a sustainable urban transport option, bike share programs in several cities such as Seattle and Montreal have run into financial difficulties due to low ridership and high operational costs. Further, their environmental benefits are ambiguous since a majority of users are substituting from public transport or walking. In this work, we adopt a consumer transport mode choice model and analyze the economic and environmental implications of three key operational levers: the pricing structure, station coverage and density, and frequency of rebalancing operations.

4 - Impacts of Energy Price Surcharges and Mitigating Interventions on Supplier Competitiveness

Jason Nguyen, Ivey Business School, London, ON, Canada, jnguyen@ivey.ca

Karen L Donohue, Mili Mehrotra

There has been growing debate on the potential unintended consequences of using energy price surcharges to account for energy externalities. While energy price surcharges can help encourage Energy Efficiency (EE) investments, they can also negatively affect business competitiveness and reduce domestic manufacturing. Extant research on the topic often overlooks details at an operational level, including supply chain interactions and potential competition from external jurisdictions, that may have important implications in practice. Our study addresses this gap by analyzing how these factors impact the effectiveness of energy price surcharges to encourage supply chain EE investments.

5 - Disruption Externalities in Project Supply Chains

Vibhuti Dhingra, Schulich School of Business, York University, Toronto, ON, Canada, vibhuti@schulich.yorku.ca

Harish Krishnan, Juan Serpa

Project networks involve several participants; clients, contractors, and subcontractors; each working on multiple projects concurrently. By tracking a network of 2.6 million public projects over a five-year span, we show that when a project suffers a localized disruption, other projects in the network get delayed because participants reallocate resources to the disrupted project. This creates a domino-effect externality that ripples through the network, causing delays across unrelated projects.

SD02

2nd FI-Georgia B

COVID-19 Models: II

2022 CORS/INFORMS INTERNATIONAL CONFERENCE

General Session

Chair: Hossein Piri

University of British Columbia-Sauder School of Business, University of British Columbia-Sauder School of Bu, Vancouver, BC, V6B 1X9, Canada

2 - Optimizing Inter-Hospital Patient Transfer Decisions During a Pandemic: A Queueing Network Approach

Frances Pogacar, University of Toronto, Toronto, ON, Canada, frances.pogacar@mail.utoronto.ca

Timothy Chan, Fahad Razak, Fahad Razak, Vahid Sarhangian, Amol Verma, Amol Verma

During the COVID-19 pandemic in Ontario, inter-hospital patient transfers were utilized to maintain hospital capacity and ensure that patients receive timely and appropriate care. Our work demonstrates that redistributing patients can help balance the COVID burden and have significant improvements on ward and ICU occupancy. Using queueing models and their fluid approximations to consider the dynamics between ward and ICU, we develop a mixed-integer program to find optimal transfers of incoming patients. We validate our queueing model with historical occupancy data and use simulation to quantify the benefit of optimized transfer decisions.

3 - Course Scheduling Under Sudden Scarcity: Applications to Pandemic Planning

Julia Y Yan, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada

Cynthia Barnhart, Dimitris Bertsimas, Arthur J Delarue

Physical distancing requirements during the COVID-19 pandemic dramatically reduced the effective capacity of university campuses. Under these conditions, we examine how to make the most of newly scarce resources in curriculum planning and course timetabling. In the summer of 2020, our models were critical to evaluating proposals that included expanding the academic calendar, teaching across multiple rooms, and rotating student attendance; some of these proposals were then implemented at MIT Sloan.

4 - Fighting Covid-19 at Cornell University

Peter Frazier, Cornell University, Ithaca, NY, 14853, United States, pf98@cornell.edu

J Massey Cashore, Ning Duan, Shane Henderson, Alyf Janmohamed, Brian Liu, David B Shmoys, Jiayue Wan, Yujia Zhang

Universities faced a difficult decision in summer 2020: whether to reopen for in-person instruction despite the pandemic and how to protect students, employees, and

the surrounding community if they did. Operations research and analytics played a fundamental role in this decision at Cornell University. Using these tools, the speaker and other members of Cornell's COVID-19 Mathematical Modeling team guided the university as it successfully reopened for in-person instruction in fall 2020 under the protection of an asymptomatic screening that tested all undergraduate students twice per week.

5 - Optimal Scheduling of a Multi-clinic Healthcare Facility in the Course of a Pandemic

Hossein Piri, University of British Columbia-Sauder School of Business, Vancouver, BC, V6B 1X9, Canada, hossein.piri@sauder.ubc.ca

Mahesh Nagarajan, Steven Shechter

Due to the social distancing requirement during the COVID-19, the elevator capacity in high-rise buildings has been reduced by 50-70 %, which makes social distancing challenging in the lobby and elevator halls. This could increase the chance of the spread of the disease and would pose significant safety risks. Therefore, it is necessary to design an intervention that could help safely managing the elevator queues and reduce the elevator wait times. In this work, we focus on minimizing the elevator wait time in a multi-clinic facility by controlling the people arriving at the elevator halls, which is possible by optimizing the clinic schedule.

SD03

2nd FI-Plaza A

Real-World Operations Research and Analytics Applications

General Session

Chair: Stefan E Karisch

Amazon, Amazon, Seattle, WA, 98124, United States

2 - Optimizing the Supply Chain at Canada Drives

Andrew Hall, VP, Data & Analytics, Canada Drives, Vancouver, BC, Canada

Jacky Chan

Canada Drives is the largest online dealership in Canada. The business has been scaling rapidly offering the best place to buy and sell used vehicles.

In order to fuel this growth, we must balance purchasing, reconditioning, pricing and promotion of our vehicles. This involves deploying ML models of market prices, optimization of pricing policies, modelling sales velocities, and adapting the inventory mix. Balancing these factors is necessary to

ensure sufficient supply - challenging in recent industry conditions - and to achieve unit economics and business profitability goals.

We will explain our approach to optimizing our supply chain, and how we have implemented solutions in practice.

3 - Data-Driven Algorithm Selection for Supply Chain Planning

Masoud Chitsaz, Kinaxis, Ottawa, ON, Canada, mchitsaz@kinaxis.com

Large-scale supply network optimization requires the solution of hundreds of product families, where each product family includes a set of final products that share some limited resources in the product structure and/or production process. Due to computing server limitations, many of these problems should be solved one after another. Traditionally, one algorithm (optimization engine) is used to find quality solutions for all problems. Our investigation shows different algorithms perform (time and quality) differently on different sizes of these problems. In this talk, we explain this computing challenge and highlight directions to efficiently solve these problems.

4 - Operations Research & Analytics at Amazon

**Stefan Karisch, Amazon, Seattle, WA, United States
Timothy Jacobs**

The Middle-Mile Planning, Research, and Optimization Sciences (mmPROS) team is central to this goal and charged with developing an evolving innovative suite of decision support and optimization tools to facilitate the design of efficient air and ground transport networks, optimize the flow of packages within the network to efficiently align network capacity and shipment demand, and effectively utilize scarce resources, such as aircraft, trucks, and rail services. This talk will describe some of the innovative tools developed to design and operate these networks. They rely heavily on mathematical optimization models and algorithms, machine learning, stochastic modeling and simulation, metaheuristics, and advanced analytics.

SD04

2nd Fl-Plaza B

Optimizing Supply Chain Planning and Operations
General Session

Chair: Sinem Kinay Savaser

Rotman School of Management

2 - Inventory Allocation Strategies for Omnichannel Retailing

Mahsa Mahboob Ghodsi, HEC Montreal, Montreal, QC, Canada, mahsa.mahboob-ghodsi@hec.ca

Mehmet Gumus, Necati Ertekin

Nowadays many retailers have started omnichannel fulfillment initiatives that allow customers to pick up online orders in-store or have online orders shipped to stores. To stay competitive, retailers need to choose the least costly and most efficient option to fulfill the orders while maintaining the highest profit levels. With omnichannel strategies, retailers face a trade-off between allocating stocks to store inventory or distribution center inventory. In this project, we aim to understand what motives retailers to adopt different omnichannel fulfillment strategies and analyze under what conditions it is beneficial for a retailer to offer omnichannel fulfillment strategies.

3 - An E-fulfillment Problem with Order Rejections in an Omni-channel Retailer

Sinem Kinay Savaser, Rotman School of Management, Toronto, ON, N2N 0A2, Canada, sinem.savaser@rotman.utoronto.ca

Opher Baron, Andre Augusto Cire

We investigate a data-driven approach to the e-fulfillment processes of a Canadian omni-channel retailer. Online orders are primarily satisfied by a distribution center and in case of insufficient inventory, brick-and-mortar stores can ship the order. However, stores can accept or reject a fulfillment request based on local information unknown to the retailer. The retailer must then establish a sequence of stores to request fulfillment to minimize expected transportation and delay costs. We present the optimal policy for single-item orders and show that multi-item orders are NP-Hard and evaluate different approximations that leverage a large-scale data set provided by the retailer.

4 - An Overview Of Analytical Models For Coordinating Sustainability And Resiliency In Supply Chains

Simranjeet Singh Chadha, Ph.D. Candidate, Dalhousie University, Halifax, NS, Canada, chadha@dal.ca

M. Ali Ülkü, Uday Venkatadri

Disruptions stifle economies and highlight how delicate and vulnerable the Supply Chains (SCs) are. The current pandemic confirmed the growing consensus that the four pillars of sustainability (economic, environmental, social, and culture) are closely intertwined. This talk entails a discussion on a state-of-the-art literature review on contracting for sustainable and resilient SCs. Our analysis confirms an increasing trend in the sustainability and coordination nexus literature. However, coordination for resilience remains

a gap. To tackle this gap, the talk will identify potential methodological approaches with mathematical models, concluding with some managerial insights.

5 - Resource-constrained Project Scheduling with Multiple Sites: A Continuous-time MILP-based Approach

Norbert Trautmann, University of Bern, Bern, 3012, Switzerland, norbert.trautmann@unibe.ch

Tamara Bigler, Mario Gnaegi

The execution of a project often requires resources which are distributed among multiple sites, and therefore transportation times must be considered for moving some mobile resource units or the output of some precedence-related activities. Example applications arise in a make-to-order production that is carried out by several partners in a supply chain, and in hospital clusters that are sharing pools of medical personnel and medical devices. We present a MILP-based approach for minimizing the duration of such a project subject to completion-start precedence and renewable-resource constraints.

6 - Strategic Blockchain Adoption to Deter Deceptive Counterfeiters

Samir Elhedhli, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, elhedhli@uwaterloo.ca

Joe Naoum-Sawaya, Paulo DeCarvalho

We investigate the strategic use of blockchain technology to deter deceptive counterfeits, such as pharmaceutical products, that infiltrate legitimate distribution channels. We consider a setting where blockchain increases the capability of detecting counterfeits. This capability comes at an increasing cost that may financially discourage manufacturers from adopting the technology. We find that blockchain is not always financially beneficial and manufacturers can strategically balance between product quality and blockchain investment. Furthermore, genuine manufacturers may be less interested to differentiate products based on quality, but rely on blockchain to block counterfeits.

SD05

2nd Fl-Plaza C

Analytics III

Contributed Session

Chair: Mark Lokanan

Royal Roads University

2 - The Role of Web Browsing in Credit Risk Prediction

**Betty Johanna Garzon Roza, University of Edinburgh, Edinburgh, United Kingdom, johanna.garzon@ed.ac.uk
Jonathan Crook, Galina Andreeva**

This paper examines new web browsing variables and incorporates them into survival analysis as predictors of probability of default (PD). Using a large sample of purchase and repayment credit accounts from a major digital retailer and financial services provider in the UK, we show that these new variables enhance the predictive accuracy of probability of default (PD) models at account level. This also holds in the absence of credit bureau data, therefore, the new information can help people who may not have a credit history (thin file) who cannot be assessed using traditional variables.

3 - Estimating Sales Pipeline Deals Conversion for Cloud Demand Forecasting

Wuqin Lin, Microsoft, Bellevue, WA, United States

Arjun Mukherjee

In Azure, there are multi-billion sales deals in pipelines at any moment in time. The sales deals are in different stages of conversion, maturity, probability of closing and eventual closure towards consumption of Cloud resources. An approach, which is in Production, has been developed using ensemble of Survival models to estimate probability of sales conversion over a certain horizon which is then fed into Cloud Demand Forecasting processes. Additionally, a unique approach has been developed for converting revenue dollars to expected cloud resource units along with discerning incremental growth to position appropriate cloud capacity in regions and availability zones.

4 - Costly Signaling: An Alternative Mechanism for Reputation Systems in Online Freelancing Platforms

Fatemeh Delkhosh, University of Calgary, Calgary, AB, Canada

Barrie R Nault

Freelancers may misrepresent their capabilities in online freelancing platforms due to financial incentives. To deal with agency issues, we propose a costly signaling mechanism where the platform designs a test for the freelancers who claim to be high type. Our results show that the costly signaling mechanism can encourage all freelancers to tell the truth and it also increases the proportion of high type freelancers. However, this may come true at the expense of freelancer surplus as the platform charges freelancers with a higher fee.

5 - Predicting Disciplinary Hearing for Ethical Violation: The Case of IIROC

Mark Lokanan, Royal Roads University, Victoria, BC,

Canada, mark.lokanan@royalroads.ca

This paper aims to classify disciplinary hearings into two types (settlement and contested). The objective is to employ binary machine learning classifier algorithms to predict the hearing outcomes given a set of features representing the victims, offenders and enforcement. Data for this project came from the Investment Industry Regulatory Industry of Canada's (IIROC) and comprises cases that made their way through the IIROC ethics enforcement system and were decided or negotiated by a hearing panel. Results from the random forest machine algorithm indicate with high accuracy that the top features to predict settlement outcomes are mitigating and aggravating factors.

SD06

3rd FI-Regency A

Tutorial: Analytics for Social Impact

Tutorial Session

1 - Analytics for Social Impact

Phebe Vayanos, University of Southern California, Los Angeles, CA, 90089, United States

We discuss work in collaboration with community partners and policy-makers focused on homelessness and public health in vulnerable communities. We present research advances to address one key cross-cutting question: how to assign scarce intervention resources while accounting for the challenges of open world deployment? We show concrete improvements over the state of the art based on real world data. We are convinced that by pushing this line of research, analytics can play a crucial role to help fight injustice and solve complex problems facing our society.

SD07

3rd FI-Regency B

Health Care Scheduling and Capacity Planning

General Session

Chair: Jonathan Patrick

University of Ottawa, University of Ottawa, Ottawa, ON, K1N 6N5, Canada

Chair: Antoine Sauré

Telfer School of Management, University of Ottawa, Ottawa, ON, K1N 6N5, Canada

3 - Intraday Scheduling of Chemotherapy Patients

Pablo Andres Rey, Departamento de Industria, Facultad de Ingeniería and Programa Institucional de Fomento

a la Investigación, Desarrollo e Innovación, Universidad Tecnológica Metropolitana, Santiago, Chile

Alejandro Cataldo, Antoine Sauré, Alejandro Cifuentes, Gustavo Angulo

Over a given planning horizon, cancer treatment centres assign patients first to specific days (interday) and then to specific times within each day (intraday). The latter process including the definition of medication preparation time on the day of treatment or a previous and we address it using an integer programming model that attempts to schedule all patients assigned to the horizon. A case study is conducted using actual data from a Chilean cancer centre to compare through simulation the schedules generated by the proposed approach and the centre's manual method. The results show that the proposed approach performs better on makespan, treatment chair occupancy and number of overtime hours.

4 - Staff Scheduling for Residential Care Under Pandemic Conditions: The Case of Covid-19

Amirhossein Moosavi, University of Ottawa, Ottawa, ON, Canada

Onur Ozturk, Jonathan Patrick

This research studies the current staff member scheduling methods in residential care facilities to enhance them for pandemic conditions. We introduce two new objective functions and a new constraint set to consider the impacts of communal spaces (e.g., shared rooms) and a cohorting policy (classification of residents based on their risk of infection) on the spread of infectious diseases. To solve large-sized instances of this problem, we present a heuristic algorithm and compare it with two benchmark algorithms. Our findings show that the government of Canada needs to increase the staffing capacity of residential care facilities in order to make them able to deal with upcoming pandemics.

5 - A Finite-horizon Dynamic Capacity Planning Model for Hospitals in Mass Casualty Incidents

Afshin Kamyabniya, University of Ottawa, Ottawa, ON, Canada, akamy007@uottawa.ca

Antoine Saure, Jonathan Patrick

This research proposes a finite-horizon dynamic capacity planning model for hospitals to optimize the assignment of relevant services to injured people with various urgency levels under multiple sources of uncertainties, such as patient arrivals at hospitals. This study aims to control the capacity of hospitals by employing different strategies over time ranging from transferring patients to other hospitals from a hospital, early discharge of patients, etc. We model the dynamic process as a Markov decision process. Because the

state space is too large for a direct solution, we solve the equivalent linear program through approximate dynamic programming and evaluate it using a case study.

6 - Optimizing Intra-hospital Patient Transport Services

Christopher Sun, Massachusetts Institute of Technology, Cambridge, MA, 02142-1383, United States, cfsun@mit.edu

Christopher Sun, Massachusetts General Hospital, Boston, MA, United States, cfsun@mit.edu

Martin S Copenhaver, Retsef Levi, A. Cecilia Zenteno

Intra-hospital patient transportation services are an integral part of daily logistic activities in a hospital, facilitating patient flow between inpatient units on stretchers, wheelchairs, and beds. Delays stemming from suboptimal transport practices can significantly impact operations of procedural areas and test sites, potentially compromising quality of care. In this project, we identified the primary drivers of patient transport delays at Massachusetts General Hospital, and propose analytical frameworks to address these issues.

SD08

3rd Fl-Regency E

Topics in Sustainability and Social Responsibility

General Session

Chair: Elaheh Rashidinejad

Rotman School of Management, University of Toronto, University of Toronto, United States

2 - Effects of Usage-Based Auto Insurance: A Dynamic Mechanism-Design Approach

Mona Imanpoor Yourdshahy, Beedie School of Business, Simon Fraser University, Vancouver, BC, V6G 0A3, Canada, mona_imanpoor@sfu.ca

Mahesh Nagarajan, Hao Zhang

Tracking drivers' behaviour, Usage-Based Insurance (UBI) allows insurance companies to connect insurers' premiums more closely to their actual driving performance. This paper provides a theoretical model to capture the effects of UBI on the auto insurance market. We formulate the underlying problem as a dynamic principal-agent model with hidden information and hidden action. Developing a dynamic programming algorithm, we characterize the full history-dependent optimal contract. The model results lead to interesting managerial insights including the extent to which a UBI policy can outperform a traditional policy, and how the potential gains depend on the demographics of the target market.

3 - An Operational Perspective on Micro-financing in Developing Countries

Elaheh Rashidinejad, Rotman School of Management, University of Toronto, Toronto, ON, Canada, e.rashidinejad@rotman.utoronto.ca

Opher Baron, Gonzalo Romero

We compare two microfinancing structures in developing countries where an entrepreneur with zero initial budget borrows a loan to start a business. The entrepreneur faces a Newsvendor problem with finance and effort considerations. We characterize conditions under which a community bank, which can apply social pressure on the entrepreneur to pay all of its debt back, improves individual and social welfare in comparison with a social bank, which has no such mechanism. We study the banks under profit maximization or zero profit objectives. Our theoretical model provides insight for policymakers when designing microfinancing structures to maximize social impact and help alleviate poverty.

4 - Potty Parity: Process Flexibility via Unisex Restrooms

Setareh Farajollahzadeh, University of Toronto, Toronto, ON, M5G 2M4, Canada, setareh.farajollahzadeh@rotman.utoronto.ca

Ming Hu

We study the problem of inequitable access to public restrooms by women and the LGBTQ+ community. We adopt a queueing system with horizontally differentiated customer preferences and study the benefits enabled by the unisex restroom. We propose an inclusive measure of potty parity and provide insights on how to retrofit restrooms to be more efficient and inclusive. We provide a numerical study with empirically calibrated parameters to show the magnitude of the impact of unisex rooms in a stadium.

SD09

3rd Fl-Regency F

Smart-city Operations

General Session

Chair: Wei Qi

McGill University, McGill University, Montreal, QC, H3A 1G5, Canada

Chair: Yan Zhang

McGill University, Montreal, QC, Canada

3 - An Exponential Cone Programming Approach for Managing Electric Vehicle Charging

Long He, The George Washington University, Washington,

DC, 119245, United States, longhe@gwu.edu

Long He, National University of Singapore, Singapore, Singapore, longhe@gwu.edu

Li Chen, Yangfang (Helen) Zhou

We consider the electric vehicle (EV) charging scheduling problem that minimizes the expected total cost including demand charges, under stochastic arrivals. We formulate it as a stochastic program (SP). For the SP with unlimited chargers, we derive an exponential cone program (ECP) approximation as an upper bound. For the SP with limited chargers, we extend this ECP by also leveraging the idea from distributionally robust optimization (DRO). We numerically benchmark the ECP with sample average approximation (SAA) and a DRO approach using a semi-definite program (SDP). We find that while SDP cannot be solved, ECP scales well and runs efficiently and results in a lower mean total cost than SAA.

4 - Dynamic Dispatching and Routing with Random Demand: On-demand Delivery from Stores

Sheng Liu, University of Toronto, Toronto, ON, M5S 1J5, Canada, sheng.liu@rotman.utoronto.ca

Zhixing Luo

Motivated by a large grocery chain store who offers fast on-demand delivery services, we model and solve a stochastic dynamic driver dispatching and routing problem for delivery systems where on-time performance is the main target. We propose a novel structured approximation framework to approximate the value function via a simplified dispatching and routing policy. We analyze the structural properties of the approximation framework and establish its performance guarantee under large-demand scenarios. We then develop efficient exact algorithms for the approximation problem based on Benders decomposition and column generation, which deliver verifiably optimal solutions within minutes.

5 - Online Facility Location

Yan Zhang, PhD student, McGill University, Montreal, QC, H3A1G5, Canada, yan.zhang13@mail.mcgill.ca

Junyu Cao

Wei Qi

We formulate an online facility location problem, joint with operational level decisions. The scope of facility location problems continues to expand, while the models of facility location problems have been so far largely restricted to be in a static, offline fashion, prescribing one-shot facility placement. In an online setting, the decision maker is subject to parameter uncertainties. However, she is able to adjust facility locations while updating her parameter estimation from historical observations. To

this end, we propose an online algorithm that integrates the continuous approximation approach. The algorithm is both computationally efficient and has a near-optimal regret guarantee.

6 - Integrated Planning and Control of Drone Networks for Emergency Medical Response

Jamal Chu, University of Toronto, Toronto, ON, Canada, jamal.chu@mail.utoronto.ca

Sheng Liu, Wei Qi, Timothy Chan

Drones have been proposed as a supplemental response to medical emergencies such as cardiac arrest and anaphylactic shock through the delivery of time-critical supplies. Recent work has focused on separate drone base placement and dispatch policies via two-stage models, which may lead to performance loss compared to an integrated model. We propose a novel stochastic integer program to jointly optimize base placements and dispatch policies and compare our integrated placement-dispatch model to a two-stage model using cardiac arrest data from Virginia Beach.

SD11

3rd Fl-Oxford/Prince of Wales

Aysajan's Session

General Session

Chair: Aysajan Eziz

Ph.D., Western University, Ivey Business School, ON, Canada

2 - Analysis of Pricing Mechanism in an Automated Market Maker

Aysajan Eziz, Ivey Business School, London, ON, N6G 5E1, Canada

With more than \$80 billion total value locked, crypto market has experienced tremendous growth in 2021. Among many technical developments in the field, automated market maker (AMM) plays a fundamental role by enabling swaps between different cryptocurrencies in decentralized exchanges. In this study, I discuss how automated market makers work, how prices of cryptocurrencies are determined, and the role of liquidity providers and traders in an AMM. I also analyze the conditions in which a liquidity provider is better off by holding a pair of cryptocurrencies, instead of providing liquidity. Finally, I study how arbitrage causes prices to converge between centralized and decentralized exchanges.

3 - Product-based Approximate Linear Programs for Network Revenue Management

Saied Samiedaluie, University of Alberta, Edmonton, AB,

T6G 2R6, Canada, samiedal@ualberta.ca

Rui Zhang, Dan Zhang

The approximate linear programming (ALP) approach has received significant attention in the network revenue management literature. A popular approximation is separable piecewise linear (SPL) approximation. In this paper, we propose a product-based SPL approximation and show that the resulting ALP admits compact reformulations, like its resource-based counterpart. Further, the new approximation allows us to derive a set of valid inequalities to speed up the computation, and select “better” optimal solutions. In a set of 208 instances, bid-price policies based on the new approximation generate higher expected revenues than resource-based policies, with an average revenue increase of 1.8%.

4 - On-demand Transportation: Drivers Wages versus Platform Profit

Raghav Singal, Tuck School of Business, Dartmouth College, Hanover, NH, 03755, United States, rs3566@columbia.edu

Omar Besbes, Vineet Goyal, Garud N Iyengar

Motivated by the debate around drivers’ welfare in on-demand transportation, we propose a framework to evaluate current practices and possible alternatives. The platform allocates time slots to drivers, who are strategic agents maximizing their expected utility, which depends on their temporal preference (when to drive), slots they are allocated, and time they spend on-road. We use our framework to evaluate existing policies and propose improvements with respect to platform profit and drivers’ wages.

5 - Optimal Pricing and Information Sharing in Queueing Systems

Xinchang Wang, Washington State University, Pullman, WA, 99164-4746, United States, xinchang.wang@wsu.edu

Sigrun Andradottir, Hayriye Ayhan

We study optimal pricing in a queueing system that can be observable or unobservable, depending on how customers receive information to estimate sojourn time. Our objective is to determine whether the service provider is better off making the system observable or unobservable under optimal pricing. We formulate the optimal pricing problem using Markov decision process (MDP) models. We show that if no customers overestimate sojourn time in the observable system, it is in the interest of the service provider to make the system observable. We also show that if all customers overestimate sojourn time, the service provider is better off making the system unobservable.

34th Fl-Seymour

ENRE3: Novel Optimization Models for Power System Operations and Planning

General Session

Chair: Mehrdad Pirnia

University of Waterloo, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

2 - Chance Constrained Model for Electric Storage Capacities

Mehrdad Pirnia, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

We present a chance constrained model to optimize the operations of the storage capacities in the presence of uncertainty, when operating in both energy and reserve markets. We estimate the expected value of storage cost as a function of its expected total activity, and use several analytical methods to approximate the storage expected activity.

3 - Evaluating the Contribution of House Batteries and Solar Panel Systems to Reducing Carbon Footprint

Fuat Can Beyluniođlu, University of Waterloo, Waterloo, ON, Canada, fcbeylun@uwaterloo.ca

Mehrdad Pirnia, Robert Duimering

Albeit its urgency, the impact of renewables on reducing emissions is still an open question due to difficulties in collecting reliable data and developing realistic models. Using Ontario grid intensity, historical customer demand and solar radiation monthly statistics, our study adopts optimization and simulation approaches to assess the contribution of house battery and a solar rooftop to reducing emissions. Our procedure aims to develop charge discharge strategies to for a cost saver and environmentalist customer. Our results suggest that a solar rooftop and house battery can remove up to 60% of carbon footprint with an accurate enough day ahead demand and grid intensity forecast.

4 - Constraint-Guided Deep Neural Network for Solving Optimal Power Flow

Amir Lotfi, University of Waterloo, Waterloo, ON, Canada, amir.lotfi@uwaterloo.ca

Mehrdad Pirnia

In this presentation, we propose a nested Deep Neural Network-based Optimal Power Flow (DNN-OPF) algorithm to first classify the feasible and infeasible cases, and then predict the solutions of the model. The suggested approach normalizes outputs and uses activation functions to respect the limits of generators. The suggested method is applied on

IEEE24-bus, IEEE 300 bus, and PEGASE 1354 bus systems and the results show significant improvement on accuracy of the results and execution time, comparing to traditional gradient-based methods, such as Newton-Raphson and Gauss-Seidel methods.

5 - Long Term Capacity Expansion Planning Models with Inverse Optimization-based Operational Cost Approximation

Ali Rafieepouralavilavijeh, University of Waterloo, Waterloo, ON, Canada

Mehrdad Pirnia, Michael Pavlin

Electricity planning models rely on identifying cost parameters of market participants to predict their operations and prescribe the required energy mix, satisfying demand in long planning horizons. In this presentation, we propose an inverse optimization model to estimate the overall cost of electricity production by market participants while considering various characteristics of energy sources. The obtained cost parameters can then be used in long-term planning models with operational constraints to represent approximate hourly operations of such generators. The proposed method is applied on a modified 24-bus-test-system and Ontario electricity market.

6 - Pathways to Decarbonizing Electricity in Northeastern North America

Florian Mitjana, HEC Montréal, Montréal, QC, Canada, florian.mitjana@hec.ca

Michel Denault, Dominique Orban, Pierre-Olivier Pineau

To analyze pathways to GHG targets in 2050, we develop a stochastic multi-stage investment and operation model that covers generation, transmission, and storage capacities. Long-term uncertainties are handled, such as demand growth and investment costs. The best strategies show that early decisions, as well as transmission investments, play a crucial role in decarbonizing at reasonable cost.

SD14

34th Fl-Cypress

Multiserver Queues: Emerging Techniques in Performance Analysis

General Session

Chair: Ziv Scully

Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

2 - Work Conserving Finite Skip Model

Isaac Grosof, Carnegie Mellon University, Pittsburgh, PA,

United States, igrosof@cmu.edu

Many important multiserver models have a previously-unexplained similarity: identical mean response time behavior is empirically observed in the heavy traffic limit. We explain this similarity for the first time.

To do so, we introduce the work-conserving finite-skip (WCFS) class of models. We prove tight bounds on mean response time for any model in the WCFS class, which includes many important queueing models with no previous bounds on mean response time.

3 - Throughput and Delay Optimality of Power-of-D Choices in Inhomogeneous Load Balancing Systems

Daniela Hurtado-Lange, William and Mary, Williamsburg, VA, 23188, United States

It is well-known that the power-of-d choices routing algorithm maximizes throughput and is heavy-traffic optimal in load balancing systems with homogeneous servers. However, if the servers are heterogeneous, throughput optimality does not hold in general. We find necessary and sufficient conditions for throughput optimality of power-of-d choices when the servers are heterogeneous, and we prove that almost the same conditions are sufficient to show heavy-traffic optimality.

5 - Overview of Analysis Techniques for Multiserver Queues

Ziv Scully, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

This talk will give a high-level overview of several techniques, new and old, that have been used to analyze multiserver queueing systems. These include: Stein's method, the drift method with heavy-traffic state-space collapse, the tagged job method, Lindley recursion, and mean field approximations.

Monday, 8:30–10am

MA01

2nd Fl-Georgia A

Interface of Finance, Operations, and Risk Management (iFORM) SIG

General Session

Chair: Isik Bicer

Schulich School of Business, York University, Schulich School of Business, York University, ON, Canada

2 - Rethinking Retail Inventory Performance and Financial Risk

Isik Bicer, York University Schulich School of Business, New Orleans, United States

We examine the financial motives of retailers to unnecessarily increase inventory levels and test whether excess inventory risk should be included in asset pricing models to calculate the cost of capital. We fill the gap in the literature at the intersection of operations management and finance by showing what types of retailers are prone to high inventory risks and how to incorporate such risks into asset pricing models.

3 - Optimizing Order Quantity and Pricing Decisions of a Product Portfolio with Capacity Constraint

Yara Kayyali Elalem, EPFL, Lausanne, Vaud, Switzerland, yara.kayyalialalem@epfl.ch

Isik Bicer, Ralf W Seifert

We simultaneously optimize order quantity and selling price decisions of multiple products to maximize profits of a retailer with a capacity constraint. We formulate the problem using the newsvendor model and use a multiplicative demand model. We then model demand of an item as the product of the number of customer visits and the choice probabilities of purchasing the product using the characteristic function. Finally, we apply Fast Fourier transform to obtain the optimal order quantities and prices from empirical data and compare the results to those using the newsvendor model.

4 - Matching Suppliers with Financing Sources: A Practical Review and Analysis of Supply Chain Finance

Philipp Schneider, EPFL, Lausanne, Switzerland

Isik Bicer

Supply chain finance (SCF) solutions offer suppliers and buyers immense potential for improving the utilization of working capital in a global supply chain. Early payment schemes, reverse factoring, letter of credit and dynamic discounting are commonly used in practice to finance trade and establish trust between supply chain parties. In this talk, we will discuss main trade-offs of each financing option, how to combine and match them with different suppliers.

5 - When and Who to Hire Next? Risk-return Tradeoffs in New Technology Enterprises

Sonia Bagherirad, York University, Toronto, ON, M3J 3K8, Canada, sbagherirad18@schulich.yorku.ca

Moren Levesque, Adam Diamant

This article studies the hiring decision of new technology enterprises. It offers a discrete-time dynamic programming model that examines when founders should hire their first employee, who among the STEM or non-STEM workforce that employee should come from, and when they should stop hiring. We identify labor market- and firm-based contingencies whereby founders should favor a STEM hire over a non-STEM hire, as well as two threshold-based policies for starting and stopping hiring.

MA02

2nd FI-Georgia B

Integration of Optimization and Machine Learning

General Session

Chair: Carl Laird

Carnegie Mellon University, Carnegie Mellon University, Fayetteville, AR, 72703, United States

Chair: Joshua Pulsipher

Chemical Engineering, Pittsburgh, PA, United States

Chair: Carl Laird

United States

4 - Using Physics Informed Machine Learning for Optimization of Computationally Expensive Constrained Simulation Models

Zachary Kilwein, Georgia Institute of Technology, Atlanta, GA, United States

Physics-informed Neural Networks (PINNs) have emerged as a competitive approach to solving forward and inverse differential equation problems across scientific and engineering domains. In this work, we consider PINN's applicability to challenging model-based problems in process systems engineering, including chemical unit optimization, PDE constrained optimization problems, and model predictive control. Novelty includes larger state space models than shown in literature, integrated use of PINNs to solve forward problem/embedded optimization, and application to chemical engineering based models.

5 - Bayesian Optimization Approaches for High-Throughput Experiments

Leonardo Gonzalez, University of Wisconsin, Madison, Madison, WI, United States

The increased prevalence of modular and high-throughput experimental platforms in fields like biology, chemistry, and engineering has allowed scientists to collect information at volumes and speeds not previously possible. To fully take advantage of this capability, researchers require design of

experiment (DoE) strategies that can select blocks rather than sequences of experiments. Bayesian optimization (BO) has been proven to be an effective DoE method; however, it is inherently a sequential approach. We propose parallelization frameworks that exploit high-throughput experiments to accelerate convergence and to improve the performance of BO.

6 - A Scalable Global Optimization Algorithm for K-center Clustering

Jiayang Ren, Phd Student, University of British Columbia, Vancouver, BC, Canada, rjy12307@mail.ubc.ca

Kaixun Hua, Yankai Cao

k-center problem is a well-known clustering method and can be formulated as a mixed-integer nonlinear programming problem. This work provides a practical global optimization algorithm for this task based on a reduced-space spatial branch and bound scheme. Convergence is guaranteed by only branching on the centers of clusters, which is independent of the dataset's cardinality. In addition, a set of bounds tightening techniques are proposed to significantly accelerate the convergence. We also present computational results on 26 UCI datasets. Notably, for the dataset with 4 million samples and 18 features, the serial implementation can reach an optimality gap of 0.1% within 2 hours.

7 - Data-driven Surrogates for Infinite-dimensional Optimization Problems

Joshua Pulsipher, Carnegie Mellon University, Pittsburgh, PA, United States, jpulsiph@andrew.cmu.edu

Carl Laird

We present a modeling approach to embed complex modeling considerations (e.g., PDEs) in infinite-dimensional optimization (InfiniteOpt) problems via proposed data-driven surrogates. Surrogate models have proved useful in finite-dimensional settings to reduce model complexity and/or enable applications that lack complete analytical representations. We propose an analogous approach for InfiniteOpt problems, and in particular consider the use of neural operator models which can produce high fidelity (mesh-independent) infinite-dimensional operator approximations (e.g., for PDE solutions).

MA03

2nd Fl-Plaza A

Sports Analytics at the Team and League Levels

General Session

Chair: Eli Olinick

Southern Methodist University, Southern Methodist

University, Dallas, TX, 75275-0123, United States

2 - Basketball Team Formation Problem Under Trade and Superstar Considerations

Megan Muniz, Colorado School of Mines, Littleton, CO, United States, meganmuniz@mines.edu

Tulay Flamand

The Team Formation problem (TFP) is defined by the allocation of individuals that match a required set of skills as a group in order to maximize one or more positive outcomes or attributes. The aim of this paper is to incorporate several novel considerations into a TFP formulation. We frame the problem using the National Basketball Association as a setting and introduce a game-theoretic perspective to the TFP literature. This allows us to create competitive balance among teams and to account for decisions in a multiple-stakeholder scenario. Furthermore, we include synergy, trades, and Superstar considerations. To quantify synergy among players, we present a predictive model using historical data.

3 - The FIFA World Cup: Club Rankings, Tournament Performance, and Policy

Kiefer Joe Burgess, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

We use an association football (soccer) dataset of over 1 million matches to test the accuracy of various ranking methodologies. We present a new methodology that incorporates a factor for league competitiveness and evaluate it against the available alternatives. These rankings are then used as a metric of the quality of squads fielded at the FIFA World Cup. We use this quality metric and other player data to estimate if squad quality has declined after FIFA introduced more teams in the 1998 World Cup. We use our results to draw conclusions about the 2026 World Cup policy change.

4 - Magic Numbers for the Korean Baseball (KBO) League

Alexandra M Newman, Colorado School of Mines, Golden, CO, 80401-1887, United States

The Korean Baseball Organization governs two professional baseball leagues in South Korea, most notably the KBO League, which consists of 10 teams that play each other multiple times during the regular season. Unlike American baseball, games can end in a tie. We modify existing integer-programming models to capture the KBO's rules and demonstrate solutions that correspond to magic numbers for clinch and playoff spots. At the time of this writing, this is the only publicized mathematically rigorous approach that determines these numbers. We illustrate the ways in

which we solve the models, including an unintuitive result that mixed-integer nonlinear programs can yield solutions more quickly than their linearized counterparts. We also demonstrate the excitement of the Korean fans who can more closely follow how their teams are performing, especially near the end of the season, via a web-based tool.

5 - Towards Automated Magic Number Proofs

Eli Olinick, Southern Methodist University, Dallas, TX, 75275-0123, United States

Magic numbers capture the attention of fans across a variety of professional sports, and provide information regarding when a team has clinched or been eliminated from a playoff spot. Mixed integer programming (MIP) models for determining magic numbers for various professional sports have been proposed in the literature and implemented in practice. Often the proof that a magic number is correct relies on showing that a MIP model is infeasible. Although fans enjoy tracking these numbers, most must take them on faith. We discuss strategies for automating the process of justifying magic numbers to sports fans in plain English.

MA04

2nd Fl-Plaza B

***Session Canceled - Recent Advances in Supply Chain Management

General Session

Chair: Michael R Wagner

University of Washington, University of Washington, Seattle, WA, 98195, United States

MA05

2nd Fl-Plaza C

Analytics IV

Contributed Session

Chair: Eman Almehdawe

University of Regina, Regina, SK, S4S 0A2, Canada

2 - Swimming Pool Freshwater Management Using Real-time Occupancy and Activity Levels

Hoda Mofidinasrabadi, MAsc. Student, University of Toronto, Toronto, ON, Canada, h.mofidinasrabadi@mail.utoronto.ca
Faezeh Azhari

A new method for determining required freshwater quantities in swimming pools is presented based on occupancy and activity data obtained through real-time monitoring and artificial intelligence. Estimated amounts of water evaporation and body fluid release are used to predict levels of disinfection by-products, which are then used to determine wastewater and required freshwater. The proposed method is evaluated through simulation and validated for a small pilot swimming pool.

3 - Endowment Analytics for the Wealthiest Universities

Henry Han, Baylor University, Waco, TX, United States

Endowment plays an increasingly important role in the higher education business. However, there are almost no methods available to evaluate university endowment usage.

In this study, we tackle this problem from an AI approach to build an intelligent machine learning system. The AI system can automatically classify endowment usage as well-used, fairly-used, and poorly-used for a given university. It is interesting to find that public universities are more likely to misuse their endowments than private ones. Moreover, the social network analysis shows that the number of Twitter followers is highly correlated with the university endowment amount.

4 - Two Metaheuristic Algorithms for the Technician Routing and Scheduling Problem with Time Windows and Balanced Workloads

Eman Almehdawe, Associate Professor, University of Regina, Regina, SK, Canada, eman.almehdawe@uregina.ca
Ehsan Pourjavad

We develop an optimization model for the Technician Routing and Scheduling Problem (TRSP) with several features; soft time windows, different working hours for technicians, lunch-break time-window, and overnights. Since the studied problem is NP-hard, commercial solvers can provide optimal solutions when the problem size is small. Hence, we develop a Simulated Annealing (SA) and a Genetic Algorithm (GA) that are capable of generating near-optimal solutions. The proposed model and solution algorithms are evaluated via a large set of experiments that are based on a telecommunication service provider in Canada.

MA06

3rd Fl-Regency A

Tutorial: The Continuous Approximation Paradigm in Logistics Systems Analysis

Tutorial Session

1 - The Continuous Approximation Paradigm in Logistics Systems Analysis

John Gunnar Carlsson, University of Southern California, Los Angeles, CA, 90089, United States

The continuous approximation (CA) paradigm has been an effective tool for obtaining managerial insights in logistics problems since the seminal papers of Few and Beardwood, Halton, and Hammersley in the 1950s. The core concept in CA is that one replaces detailed data in a problem instance with concise algebraic expressions. This tutorial will provide an overview of recent advancements in this area, as well as promising future research directions.

MA07

3rd Fl-Regency B

Transportation in Healthcare

General Session

Chair: Nadia Lahrichi

Ecole Polytechnique de Montreal, Ecole Polytechnique de Montreal, Montreal, QC, H3C3A7, Canada

Chair: Valérie Bélanger

HEC Montreal, Vancouver, Canada

3 - Analysis and Simulation of Aeromedical Interhospital Transportation: The Case of the Quebec Aeromedical Evacuations Program

Valérie Bélanger, HEC Montréal, Montreal, QC, Canada, valerie.3.belanger@hec.ca

Joëlle Cormier, Marie-Ève Rancourt

Equitable access to health care is essential to ensure the sustainability of a population. To facilitate access to specialized care, patients in the regions can count on an aeromedical interhospital transfer service. The aircraft fleet currently used in Quebec to carry out these emergency transfers will have to be replaced shortly and several compromises have to be made when choosing a new aircraft between speed, capacity or accessibility to the patient.

The goal of this project is to develop a methodology to evaluate the different types of planes and their impact on the process. The project is in partnership with the Quebec aeromedical evacuations program and the ministry of Health and Social services.

4 - Simulation of Volunteer Transportation of Breast Cancer Patients During Their Treatments

Marzieh Ghiyasinab, Polytechnique Montreal, Montreal,

QC, Canada

Nadia Lahrichi

Transportation to treatment centers is a major concern for cancer patients. Besides the costs and accessibility, patients need a certain degree of comfort in their transport process. The objective of this research is to analyze various aspects of implementing a volunteer ride service for patients in an organization located in the Montreal area. Therefore, a simulation model is created, and strategic and operational scenarios are tested which include one by one or multiple services, driver schedules, number of patients, and return requests. The results provide a decision support tool for the organization to analyze the capacity and service level in possible situations and choose the best strategy.

5 - Using Patients' Clinical Trajectories to Anticipate Resource Demand and Hospital Capacity: A DES-based Tool

Eduardo Redondo, Faculty of Business Administration, Université Laval, Québec, QC, Canada, eduardo.redondo-ruiz-diaz.1@ulaval.ca

Eduardo Redondo, Interuniversity Research Center on Enterprise Networks, Logistics and Transportation (CIRRELT), Québec, QC, Canada, eduardo.redondo-ruiz-diaz.1@ulaval.ca

Vittorio Nicoletta, Valérie Bélanger, José P. Garcia-Sabater, Paolo Landa, Julien Maheut, Juan A. Marin-Garcia, Angel Ruiz

An anticipation tool is proposed to help healthcare managers improve resource availability at healthcare services. To this end, patients' expected resource consumption was considered, providing the recent Covid-19 pandemic a base scenario to reflect the potential applications of the tool. Based on detected consumption habits, a data generator was developed to expand the scope of analysis before different patients' influx. A discrete-event simulation model (DES) was built, integrating the former blocks into a single tool. Numerical experiments with generated scenarios illustrated potential uses of the tool at different decision levels and the impact of decisions on both system and patients.

MA08

3rd Fl-Regency E

COVID-19 Policies and Decisions

General Session

Chair: Nadia Lahrichi

Ecole Polytechnique de Montreal, Ecole Polytechnique de Montreal, Montreal, QC, H3C3A7, Canada

2 - Analyzing Sustainability and Resilience for COVID-19 Testing

Fannie L. Côté, Polytechnique Montreal, Montreal, QC, Canada, fannie.lcote@polymtl.ca

Nadia Lahrichi

This study aims to analyze the efficiency of a mixed public-private system COVID-19 PCR testing laboratories. We developed a discrete-event simulation model that represents the flow of samples in the labs from specimen collection to reporting results. Different scenarios were then tested to see the potential resilience of laboratories to face different events during a pandemic. Scenarios include demand variation, different work organizations and disruptions. We use simulation to compare laboratories at different administrative levels (including private) and compare to benchmark laboratories.

3 - Optimizing Covid-19 Pandemic Control Policies via Meta-heuristic and Reinforcement Learning Algorithms Trained on Covid-19 Big Data Sets

Fatemeh Navazi, PhD Candidate, McMaster University, Hamilton, ON, Canada

Yufei Yuan, Norm Archer

In the Covid-19 era, big data sets about Covid-19 mitigation policies and their effects were gathered across the world. In this research, we analyze Covid-19 big data sets to find the optimal Covid-19 control policies using meta-heuristic and reinforcement learning algorithms, which benefit from both learning and optimization. Time series gathered by Oxford University capturing different Covid-19 control policy implementation levels are utilized. Also, pandemic stages and immunity levels caused by vaccination are considered. Developing a decision support system to help public health policymakers is vital in dealing with possible future pandemics or new Covid-19 variants' outbreaks.

4 - How Do Attitudes and Impacts of Covid-19 Affect Demand for Microtransit?

Ricardo A Daziano, Cornell University, Ithaca, NY, United States, daziano@cornell.edu

The Covid-19 pandemic dramatically reduced demand for public transportation and other shared mobility services. Using survey data to understand demand for microtransit in 4 US cities, we find little correlation between the pandemic and interest in microtransit. These results are reassuring for demand in the receding stages of Covid-19: it is possible that demand for services such as microtransit rebound to pre-pandemic levels comparatively quickly.

5 - User Perceptions of Sharing COVID Exposure Information

Sue Feldman, UAB, Birmingham, AL, United States, sf8588@gmail.com

Benjamin Schooley

Sharing COVID exposure information is not as unfiltered as expected and can be met with social stigma when doing so. We report on willingness to share COVID exposure status as well as usability of the application used to do so. Survey results revealed that ethnicity and age may be important factors for trust in sharing exposure information. Participants rated the app as useful (n=490, 79%), easy to use (n=490, 79%), and reported satisfaction with its use (n=546, 88%). Public health institutions, employers, schools, healthcare providers and technology designers may want to consider these findings as they construct technologies and perform outreach campaigns aimed at mitigating disease spread.

MA09

3rd Fl-Regency F

Emerging Technology- and Data-driven Delivery Systems

General Session

Chair: Opher Baron

University of Toronto, University of Toronto, Toronto, ON, M5S 3E6, Canada

Chair: Mehdi Nourinejad

York University, University of Toronto, Richmond Hill, ON, L4B 4G6, Canada

3 - Provably Good Region Partitioning for On-time Last-mile Delivery

Sheng Liu, University of Toronto, Toronto, ON, Canada, shg.liu@rotman.utoronto.ca

John Gunnar Carlsson, Nooshin Salari, Han Yu

On-time last-mile delivery is expanding rapidly. This paper studies the optimal region partitioning policy to minimize the expected delivery time of customer orders in a stochastic and dynamic setting. We characterize the structure of the optimal partitioning policy and show its expected on-time performance converges to that of the flexible dispatching policy in heavy traffic. We then develop partitioning algorithms with performance guarantees, leveraging ham sandwich cuts and 3-partitions from discrete geometry. We demonstrate the efficiency of the proposed region partitioning policy via numerical experiments using synthetic and real-world data sets.

4 - Human In The Loop Automation: Ride-hailing With Remote (Tele-) Drivers

Saif Benjaafar, University of Minnesota, Minneapolis, MN, 55455-0150, United States, saif@umn.edu

Xiaotang Yang, Zicheng Wang

We study the novel concept in which drivers can remotely operate vehicles (without being physically in the vehicle). We examine the extent to which tele-driving can improve the operational efficiency of ride-hailing and mitigate the spatial mismatch between supply and demand.

5 - Optimizing the Assignment of Parcels, Lockers, and Customers for the Mobile Parcel Lockers in Tandem with City Buses

Si Liu, McMaster University, Hamilton, ON, Canada, lius278@mcmaster.ca

Elkafi Hassini

We propose the use of a smart mobile locker in tandem with city buses (SML-CB). For SML-CB, the e-commerce parcels are fed into the smart lockers in bus terminals, and the locker is attached to a bus to travel with it to deliver parcels to customers on its route. We study a main operational problem that assigns parcels, lockers, and customers to lockers, routes, and bus stops, respectively, and model the problem as a quadratic assignment problem with quadratic constraints. We develop a greedy-based heuristic and test the model as well as the heuristic on both randomly generated data sets and real data sets from the Region of Peel, Canada.

6 - Fleet Composition Optimization in Drone Enabled Deliveries

Bahar Dehqani Viniche, York University, Toronto, ON, Canada, bahardv@yorku.ca

Opher Baron, Oded Berman, Mehdi Nourinejad

Drones have the potential to reduce delivery cost and time when they can be launched en-route from trucks in last-mile logistics. Drones operate at a lower cost and shift traffic from roads to sky, but they have certain operational limitations that shall not be violated during trucks and drone delivery including the flight range, truck capacity, and launching/retrieval coordination. We seek to derive the optimal routing design for a stylized model of trucks and drones delivery operations using a circular model which allows us to develop analytical derivations of delivery cost in addition to the optimal fleet composition.

Large-scale Optimization

General Session

Chair: Amirhossein Vaeztehrani

University of Waterloo, University of Waterloo, Waterloo, ON, Canada

2 - An Improved Integral Column Generation Algorithm Using Machine Learning

Issmail El Hallaoui, Polytechnique Montreal, Montreal, QC, Canada, issmail.elhallaoui@gerad.ca

In this presentation, we propose a new algorithm for the crew pairing problem, called Improved Integral Column Generation with Prediction (I2CGp), which leaps from one integer solution to another until a near-optimal solution is found. Our algorithm introduces a set of reduced subproblems containing only flight connections that have a high probability of being selected in a near-optimal solution and are, therefore, solved faster. We predict flight connection probabilities using a deep neural network. We test I2CGp on real-life instances and show that it outperforms state-of-the-art methods used in commercial airline planning software, both in term of solution quality and time.

3 - Online Optimization of the Dial a Ride Problem with the Integral Primal Simplex

Elahe Amiri, Polytechnique Montreal, Montreal, QC, Canada, elahe.amiri@polymtl.ca

Antoine Legrain, Issmail El Hallaoui

Metropolitan areas seek to increase the use of ridesharing services to decrease congestion, parking issues, and pollution. Several initiatives propose such a service like UberPool. However, they rarely use advanced optimization methods due to complex implementation in practice. Developed algorithms for Dial a Ride Problem (DARP) in dynamic mode often try to batch requests to take advantage of the static optimization. They restart the optimization for each new batch without using previous solutions. We aim to develop an algorithm for dynamic DARP that reuses previously computed solutions using the strengths of the integral primal simplex to expand the current routes with the new arrival requests.

4 - MPILS: An Automatic Tuner for MILP Solvers

El Mehdi Er Raqabi, Polytechnique Montreal, Montreal, QC, Canada

We address the parameter configuration problem. We introduce a multi-phase tuner based on the iterated local search metaheuristic to find good, if not optimal, configuration(s) for efficiently solving large-scale optimization problems by MILP solvers. The tuner tunes on a small pool of parameters, which is dynamically enhanced

MA10

3rd Fl-Balmoral/Windsor

with new promising parameters. It benefits from the accumulated information to forbid less promising parameter combinations using statistical learning. Numerical results on instances from the MIPLIB library and a real large-scale optimization problem are shown.

5 - Dynamic Constraint Aggregation for the Generalized Set-partitioning Problem

Alpha-Saliou Barry

Pure set-partitioning is one of the classical problems of combinatorial optimisation. It consists in finding a partition of a set of tasks with minimal cost. Many techniques have been developed to solve its linear relaxation quickly. One of the most promising techniques is dynamic constraint aggregation. We will present the adaptation of this method to the linear relaxation of a generalization of the set-partitioning problem: find a set of parts that covers each task a fixed number of times (one or more).

6 - An Exact Algorithm for Parallel Batch Scheduling on a Single Machine to Minimize Total Flow Time

Onur Ozturk, University of Ottawa, Ottawa, ON, Canada, ozturk@telfer.uottawa.ca

We study a parallel batch scheduling problem. Jobs have different release dates, processing times, and unit sizes. Multiple jobs can be processed at the same time in a batch as long as machine capacity is not exceeded. The processing duration of the batch is determined by the longest processing time of jobs in that batch. We aim to minimize the total flow time. First, we present mixed integer linear programming models. Then, the problem is modelled inspired by a set partitioning model that schedules batches at different time instants. Due to large number of variables, we solve the linear relaxation of this model by column generation, and obtain integer solutions using a binary tree search.

MA11

3rd FI-Oxford/Prince of Wales

Pricing and Resource Planning in Revenue Management

General Session

Chair: Yun Zhou

McMaster University, McMaster University, Hamilton, ON, L9A 0A3, Canada

2 - Inventory Management of Fresh/Non-fresh Perishable Products

Mohammad Moshtagh, McMaster University, Hamilton, ON, Canada

Yun Zhou, Manish Verma

Fresh grocery products lose their quality over time and no longer are demanded by a portion of customers due to low quality, while there are some customers seeking to buy non-fresh items at a lower price. To increase the number of sales and decrease wastages, in this study, we optimize ordering and pricing policies in a fresh/non-fresh inventory system where lifetimes, lead time, and demands are stochastic, and substitution is allowed between two demand streams. We model an (r,Q) ordering problem as a 2D Markov chain and apply the Level Crossing method to obtain the optimal replenishment and pricing decisions. Given the complexity of the model, the problem is reformulated as a MIP and solved exactly.

3 - Negative Spillover on Service Level Across Priority Classes: Evidence from a Radiology Workflow Platform

Saman Lagzi, University of Toronto, Toronto, ON, Canada

Timothy Chan, Gonzalo Romero,

Bernardo (Bernie) Quiroga, Nicholas Howard

We study a radiology platform that connects radiologists with hospitals. We investigate whether low priority tasks with a high pay-to-workload ratio have a shorter turnaround time. We also investigate if having many low priority tasks with high pay-to-workload increases the turnaround time of higher priority tasks. We show turnaround time is decreasing in pay-to-workload for lower priority tasks, whereas it is increasing in workload for high priority tasks. More importantly, we find evidence of a spillover effect: Having many economically attractive tasks with low priority can lead to longer turnaround times for higher priority tasks, increasing the likelihood that those tasks are delayed.

4 - Personalized Pricing with Strategic Consumers

Xin Geng, University of Miami, Coral Gables, FL, 33146-2000, United States, xgeng@bus.miami.edu

Huiqi Guan, Haresh B Gurnani

Personalized pricing refers to the strategy of setting tailored prices for each consumer. In response to the retailer's such practice, consumers may take strategic actions, such as staying anonymous and delaying purchase. We examine the economic implications of personalized pricing given the consumers' strategic behaviors.

5 - Dynamic Assortment Planning with Uncertainty in Customer Preferences

Shuai Zhang, McMaster University, Hamilton, ON, Canada, zhans72@mcmaster.ca

Kai Huang

We study an original equipment manufacturer (OEM) who produces an assortment of products and sells them over a multi-period selling season. At the beginning of season, the OEM sets up a product line, subject to a cardinality constraint. During each period, the OEM dynamically changes the assortment it carries by, based on the preference of customers in each period and then produces the ordered products in an assemble-to-order system. The uncertainty embedded in customer preferences is addressed by a stochastic programming model and a branch-and-price algorithm is proposed as the solution approach.

6 - Optimal Alliance Strategies for Car Manufacturer and Car-sharing Platform

Hao Zhang, University of British Columbia, Vancouver, BC, Canada

Lifei Sheng, Qiong Jia, Yue Guo

We study the alliance strategy (revenue sharing, RS, or profit sharing, PS) between a car manufacturer and a car-sharing platform company to provide a one-way car-sharing service. Our model includes strategic consumers who choose from private cars, public transportation, and the car-sharing service. We identify two opposing effects of car sharing from the manufacturer's perspective: it cannibalizes the sales in the retail market and it encroaches into the demand for public transportation. We compare the profitability of the two parties under RS and PS, examine the choice between new energy vehicles and traditional fuel vehicles, etc., contingent on the size and infrastructure of the city.

MA12

34th Fl-Seymour

ENRE4: Modeling and Optimization of Renewable Energy System

General Session

Chair: Qianpu Wang

National Research Council Canada, National Research Council Canada, ON, Canada

2 - Design and Optimization of a Power Distribution and Control System for a Microgrid Suitable for Remote Facilities

Imran Khan, National Research Council Canada, Ottawa, ON, Canada

The test bed Microgrid at the National Research Council will consist of Distributed Energy Resources (DERs) including variable speed Diesel Generator, the Photovoltaic Systems and the Battery Energy Storage. The objective is to design

and integrate these DERs to provide a stable power system to displace fossil fuel with higher penetration of renewable energy at remote facilities in the artic. The optimized design has three tiers; the power distribution system, the power control and the remote monitoring communication interfaces. The optimization will be implemented in the primary control of the main bus and the energy management system that will determine the dispatch of the DERs and the power flow.

3 - An Evaluation Framework for Assessing Grid-scale Energy Storage Technologies

Ryan Baker, National Research Council Canada, Ottawa, ON, Canada, Ryan.Baker@nrc-cnrc.gc.ca

Jianjun Yang, Kouros Malek, Qianpu Wang

Here, we present a technology evaluation framework, tailored to grid connected Energy Storage. A top-down approach is used, with stage-gate evaluation criteria that includes assessing the total annual revenues for all incumbent technologies, ranking new technology classes on a level playing field using annualized data, and performing a detailed technical performance and financial profitability analysis using actual operational data. Such an analysis framework can provide electricity market participants a clearer technical and business insight of which storage technologies, capacities and durations could operate on a grid connected network in a reliable, safe and affordable manner.

4 - The Challenges of Integrating a Detailed Physics-based Model of Lithium-ion Batteries Into Power System Optimization

Anton Vykhodtsev, University of Calgary, Calgary, AB, Canada, anton.vykhodtsev@ucalgary.ca

Darren Jang, Qianpu Wang, William Rosehart, Hamidreza Zareipour

The operation and planning decisions in the power system with the lithium-ion battery energy storage system are mostly obtained using a simple linear model derived from the system perspectives. This model does not consider the processes inside the battery and may lead to the wrong conclusions. In this work, a more detailed model based on partial differential equations and nonlinear algebraic expressions is considered. The adaptation of this model to the optimization framework for the power system studies is discussed and verified.

5 - Investment in Vehicle to Grid and Distributed Energy Resources: Distributor versus Prosumer's Perspectives and the Impact of Applicable Rates

seyyedreza Madani, HEC Montreal, Montreal, QC, Canada,

seyyedreza.madani@hec.ca

Pierre-Olivier Pineau

This study sheds light on some less investigated aspects of the smart home development problem; who should invest and control Distributed Energy Resources (DER)? The prosumers themselves or the utility in charge of supply? What combination of DER should be used? And, what is the right tariff to impose? This study develops a mathematical model for controlling DER in smart homes based on real-world data and agents' cost components. The results highlight the importance of deploying V2G in making the investment scenarios profitable.

MA13

34th FI-Stanley

Marketing

Contributed Session

Chair: Yongqin Lei

Ivey Business School, Western University, London, ON, N6G 0N1, Canada

2 - FYI, this Article is Gr8! : Netspeak Writing Style's Effect on Persuasiveness of the Text and the Moderating Role of Social Role

Poorya Selkghafari, University of Guelph, Guelph, ON, Canada, pselkgha@uoguelph.ca

Amirali Kani, Amir Sepehri

Using the role theory lens, we study how applying a specific writing style affects the persuasiveness of the text and how the writer's role moderates this effect. In a study of more than 45000 rental ads using NLP techniques, we found that when an individual uses netspeak style, the description text is more persuasive; however, it is less persuasive when the writer is an organization. Our results help broaden the understanding of how social roles moderate the effect of writing styles on persuasiveness. Also, these findings along with future studies of other writing styles can help managers modify their ad content based on their social role, position, and expectations of consumers to get the best results.

3 - Triple Uncertainties: Credence Goods, Deceptive Counterfeits, and Fake Reviews

Yongqin Lei, PhD student, Western University, London, ON, Canada, yle.phd@ivey.ca

Hubert Pun, Fredrik Odegaard

Credence goods are products whose qualities are difficult to evaluate even after consumption. We use a game-theoretic model to study an online marketplace of credence goods in the presence of fake product reviews. We show that when will sellers and customers benefit from fake reviews.

MA14

34th FI-Cypress

CORS Practice Prize Session

General Session

Chair: Antoine Legrain

Polytechnique Montreal, Montreal, QC, H3T 1J4, Canada

MA15

34th FI-Grouse

Analytics in Sports and Video Games

General Session

Chair: Raghav Singal

Dartmouth College, Columbia University, New York, NY, 10027, United States

2 - Exploring Fair, Stable and Optimal Income Pools in Professional Baseball

Craig Fernandes, University of Toronto, Toronto, ON, Canada, craig.fernandes@mail.utoronto.ca

Timothy Chan, Ningyuan Chen

In the context of professional baseball, even the best players must compete in the Minor league for a few years before they are eligible for the Major league. The average annual salary in the Minors is \$8000, grossly incomparable to the \$4.4 million in the Majors. The average probability of transferring from the Minors to the Majors is only 14%. As such, income pools involve Minor league players signing a contract which stipulates that if a member makes it to the Majors, they will contribute a portion of their earnings to be shared within their pool. We explore the decision problem of which pools a player should join to maximize their expected utility, as well as define notions of fair, stable, and optimal pools.

3 - Learning Noise-informed Optimal Serving Strategies in Tennis

Nathan Sandholtz, Assistant Professor, Brigham Young University, Provo, UT, United States, nsandholtz@stat.byu.edu

In tennis, an important factor to consider in a player's serving strategy is their execution error, or their distribution of shots around an intended target. This error distribution will affect where the player should actually target in order to maximize the probability of winning the point. In collaboration with the BYU men's and women's tennis teams, we conducted an experiment to estimate the spatial distribution of a player's serves in relation to a prescribed target location. We show how these estimated distributions can be combined with a surface of point win-probabilities over the service region (conditional on serve location) to find "noise-informed" optimal aiming locations.

4 - Integration of Analytics Techniques for Algorithmic Sports Betting

David Bergman, University of Connecticut, Waltham, MA, 02451-7121, United States

The integration of machine learning and optimization opens the door to new modeling paradigms that have already proven successful across a broad range of industries. Sports betting is a particularly exciting application area, where recent advances in both analytics and optimization can provide a lucrative edge. In this talk we will discuss three algorithmic sports betting games where combinations of machine learning and optimization have netted me significant winnings.

5 - Matchmaking Strategies for Maximizing Player Engagement in Video Games

Mingliu Chen, Columbia University, New York, NY, 10128, United States

We consider a class of online video games whereby players are repeatedly matched by the game to compete against one another. Players have different skill levels which affect the outcomes of matches, and the win-loss record influence their willingness to remain engaged. The goal is to maximize the overall player engagement over time by optimizing the dynamic matchmaking strategy. The optimal policy always matches as many low-skilled players who are not at risk of churning to high-skilled players who are one loss away from churning. In some scenarios when there are too many low-skilled players, high-skilled players are also matched to low-skilled players that are at risk of churning.

Monday, 10:15–11:05am

MP01

3rd Fl-Regency CD

Plenary: Anti-Human Trafficking Efforts and the Potential of Operations Research

Plenary Session

1 - Anti-Human Trafficking Efforts and the Potential of Operations Research

Renata Alexandra Konrad, Worcester Polytechnic Institute, Worcester, MA, 01609, United States

Human trafficking is a complex issue affecting society and economy. Forced labour and sexual exploitation represent a multi-billion dollar global industry, victimizing tens of millions of adults and children of all gender identities worldwide. It transcends national borders, is prevalent in both impoverished and wealthy countries, and undermines fundamental human rights and a broader sense of global order. Do engineers have a role to play in countering human trafficking activity? I believe they do. To date human trafficking research has primarily focused on qualitative studies, statistical estimations of prevalence, and insights generated from economic models. However, a variety of engineering and analytical techniques have the potential to help address the unique challenges facing anti-human trafficking efforts including: the covertness of traffickers, the hidden nature of victim-survivors, fragmented data, and limited resources. This presentation will discuss ongoing transdisciplinary collaborations in this sphere and draw from several examples of ongoing projects.

Monday, 11:15am–12:45pm

MB01

2nd Fl-Georgia A

Service Management SIG

General Session

Chair: Yichuan Ding

McGill University, McGill University, Montreal, QC, H3A 1G5, Canada

Chair: Yiwen Jin

UBC, Sauder School of Business, UBC, Sauder School of Business, Vancouver, BC, V6T 1V8, Canada

3 - The Cost of Task Switching: Evidence from Emergency Departments

Yiwen Jin, University of British Columbia, Vancouver, BC, V6T 1V8, Canada, yiwen.jin@sauder.ubc.ca

Yige Duan, Yichuan Ding, Mahesh Nagarajan, Garth Hunte

Using a comprehensive data set with over 650,000 patient visits to four EDs, we investigate the impact of task switching on physician productivity, quality of care, patient routing, and patient waiting time. We construct an instrumental variable to address endogeneity issues. We find that switching between different types of patients increases the average pick-to-pick time by 3.4 to 16 percent or 0.8 to 3.1 minutes per patient. Task switching also affects how physicians route patients, though we find little impact on healthcare quality. A counterfactual analysis further shows that eliminating the switch cost can reduce the average waiting time and census at greater scale.

4 - Dynamic Service Allocation with Returns: A Restless Bandit Approach

Xinyuan Zhang, Sauder School of Business, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada, xinyuan.zhang@sauder.ubc.ca

Michael Kim, Hossein Abouee-Mehrzi

We study the dynamic allocation of limited resources (e.g., ICU services) in a healthcare system where patients discharged early may return. Specifically, we consider the optimal control of admissions and discharges to minimize system congestion and patient health-related costs. We develop a Markov control model that explicitly tracks patients' health states and readmission. In the one-bed setting, we fully characterize the optimal policy. In the multi-bed setting, we follow the restless bandit approach to solve our problem in a decentralized fashion. We prove indexability for our problem and test the performance of the proposed Whittle's index rule against various benchmark policies.

MB02

2nd Fl-Georgia B

Theoretical Advances and Software for Optimization under Uncertainty

General Session

Chair: Natalie Isenberg

Brookhaven National Laboratory, Brookhaven National Laboratory

Chair: Chrysanthos E Gounaris

Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States

3 - Counterfactual Explanations of Stochastic Programming Solutions

Tushar Rathi, University of Minnesota, Minneapolis, MN, 55419, United States

Rishabh Gupta, Qi Zhang

Stochastic programming (SP) is a powerful approach to optimization under uncertainty. However, it has not been widely applied in practice for which a commonly cited reason is that it is often difficult to understand SP solutions, especially when they differ significantly from solutions obtained via deterministic optimization. In this work, we develop a systematic method for explaining two-stage SP solutions through the generation of so-called counterfactuals, which are changes in model parameters that would have led to an alternative solution (e.g., the solution to the expected value problem) specified by the user, and through a form of dimensionality reduction in the recourse variables.

4 - PyROS: A Cutting-set Based Robust Optimization Solver for Nonconvex, Equality Constrained Problems in Python

Natalie M Isenberg, Post-Doc, Brookhaven National Laboratory, Upton, NY, United States, nisenberg@bnl.gov

Natalie M Isenberg, Post-Doc, Carnegie Mellon University, Pittsburgh, PA, United States, nisenberg@bnl.gov

Jason Sherman, John Sirola, Chrysanthos E Gounaris

In this talk we will present PyROS, an open-source and Python-based robust optimization solver for non-convex, equality-constrained, two-stage optimization models using adjustable robust optimization. The PyROS solver implements a generalized robust cutting-set algorithm with decision rules. Key features of PyROS include the suite of pre-implemented uncertainty set classes, as well as constant, affine, and quadratic decision rule options for handling second-stage (control) variables. We present results on a comprehensive library of two-stage, nonlinear optimization problems, showcasing the performance of PyROS in identifying robust optimal solutions.

MB03

2nd Fl-Plaza A

Humanitarian and Disaster Logistics Management

General Session

Chair: Marie-Eve Rancourt

Canada

Chair: Feyza G. Sahinyazan

Simon Fraser University, Simon Fraser University, Burnaby, BC, V5A 1S6, Canada

3 - Prediction of Severe Covid-19 Infection at the Time of Testing: A Machine Learning Approach

Faraz Khoshbakhtian, University of Toronto, Toronto, ON, Canada, faraz.khoshbakhtian@mail.utoronto.ca

Ardian Lagman, Dionne Aleman, Randy Giffen, Proton Rahman

We designed and implemented a high-performance and interpretable machine learning framework for detecting severe COVID-19 cases at the time of RT-PCR testing. Our models showed high-sensitivity and promising results in learning to detect severe cases from the limited information available before presentation at a hospital including age, comorbidities history, and patients' self-reported symptoms. In addition, we developed a novel extension to SHAP interpretability to explain the outputs from the models.

4 - Reinforcing Schooling Access for the Syrian Refugee Children in Turkey

Feyza G. Sahinyazan, Simon Fraser University, Burnaby, BC, V5A 1S6, Canada

Sebnem Manolya Demir, Bahar Yetis Kara

Turkey hosts 3.6 million Syrian refugees, 47 % of whom are children and 400 thousand of them are distanced from education. To reinforce schooling access without burdening the existing capacity, we formulate an adapted version of the classical Capacitated Maximum Covering Problem(CMCP): CMCP with heterogeneity constraints (CMCP-HC) and two extensions: Cooperative CMCP-HC to improve the current schooling access in Turkey and Modular CCMCP-HC to provide a guide for early planning in the case of a future crisis. Results of our experimental analysis with the real-life data illustrate that our proposed approach improves schooling access from 50% to 64% and capacity utilization from 73% to 96%.

5 - Evacuation Network Design Under Traffic Congestion

Alfredo Moreno, HEC Montréal, Montréal, QC, Canada, alfredo-daniel.moreno-arteaga@hec.ca

The design of efficient evacuation networks plays a crucial role in the preparedness phase to reduce the impact of disasters. If the evacuation is not planned effectively, the increased flow of evacuees on the network during the evacuation can cause congestion, which increases the evacuation time and can result in further losses. Therefore, considering traffic congestion is essential to ensure safe and timely evacuations. In this study, we propose a mixed-integer programming model to tackle the evacuation network design problem under traffic congestion by means of a Cell-Transmission-Model based approach. We also develop a Benders decomposition algorithm to solve the problem.

6 - Predictive and Optimization Models for Food Aid Prepositioning in Remote Areas: The Case of World Food Programme in South Sudan

Valérie Bélanger, HEC Montréal, Montreal, QC, Canada

Marie-Ève Rancourt, Feyza G. Sahinyazan, Eeshaan Asaikar

In a humanitarian last-mile logistics network in remote areas, uncertainty in demand and road conditions could have adverse impacts on cost and access to beneficiaries. We propose a two-step approach for this problem and our methodology is tested on the case of the World Food Programme's operations in South Sudan. First, the demand for food aid is predicted using the Almost Ideal Demand System model and is calibrated using household expenditure survey data, whereas, the road accessibility uncertainty is modelled using historical data. Second, a two-stage multi-period stochastic optimization model is solved to better plan for food aid distribution and avoid airdrops. Results will be discussed.

MB04

2nd FI-Plaza B

Innovative Models on Supply Chain Risk Mitigation

General Session

Chair: Jing-Sheng Jeannette Song

Duke University, Duke University, Durham, NC, 27708-0120, United States

Chair: Yue Zhang

Smeal College of Business, Pennsylvania State University, Smeal College of Business, Pennsylvania State Univ

Chair: Babak Mohamadpour Tosarkani

University of British Columbia

4 - Using Internet-of-Things Point-of-Consumption Data for Smart Replenishment

Sandria Weisshuhn, Kühne Logistics University, Hamburg, Germany, sandria.weisshuhn@the-klu.org

Yale T. Herer, Kai Hoberg

Newly emerging smart replenishment systems at the point-of-consumption track product usage via smart, connected devices and use this data to automate order processes. Based on a large industry dataset from the professional coffee industry, we develop models for demand forecasting, inventory control, and replenishment under inventory inaccuracies.

5 - Robust Supply Chain Design in the Context of Mass Personalization

Hoora Katoozian, Concordia University, Montreal, QC, Canada

Masoumeh Kazemi Zanjani

The producers of high-tech products are faced with the satisfaction of heterogeneous customer needs through individualization along the value chain. Manufacturing highly personalized products requires a flexible and reconfigurable supply chain. In this paper, the problem is formulated as a two-stage stochastic problem that seeks the optimal selection of suppliers/producers and logistic careers while maximizing the expected profit and service level under a set of scenarios plausible to random demand and technological capability of suppliers.

6 - Online-offline Vehicle Routing Using Reinforcement Learning: A Markov Decision Process Model

Mahsa Mohammadi, The University of British Columbia, Kelowna, BC, Canada, mahsa.mohammadi@ubc.ca

Babak Mohamadpour Tosarkani

This investigation aims to develop a novel heuristic approach for large-scale dynamic vehicle routing problems with stochastic requests. Spatial and temporal approximation are integrated into the Markov decision process under rigid time window. Rollout algorithms are incorporated into the value function approximation to offer high quality policies. Predictive tools and prescriptive optimization approaches are employed to examine online-offline vehicle routing problems. This model will assist decision-makers to fulfill spontaneous online demand and scheduled early-request services simultaneously.

MB05

2nd Fl-Plaza C

Simulation & Optimization

Contributed Session

Chair: Masoud Fakhimi

University of Surrey

2 - Simulating Wisdom of Crowds: Agent Based Modeling for Prediction Markets

Majid Karimi, California State University San Marcos, San Marcos, CA, United States

Stanko Dimitrov

Prediction markets are mechanisms for the collection and aggregation of forecasts. Firms use prediction markets as decision support systems to elicit and aggregate employees'

predictions on the outcome of future events. Even though prediction markets are being utilized on a grander scale, relatively little is known about their microstructure. In particular, very few studies have focused on the impact and the interplay of design choices such as market mechanisms, crowd size, and incentives on prediction market performance. In this study, we propose the use of Agent-Based Models and the Empirical Game-theoretic Analysis for studying prediction markets' microstructures.

3 - Monte Carlo Experimentation Using a Resource Allocation Model of Geographically-distributed Air Cadet Flying

Victor Isaac, Defence Research and Development Canada (DRDC), Ottawa, ON, Canada

A stochastic Resource Allocation Model (RAM) was developed to analyze the number and distribution of aircraft involved in air cadet glider training across Canada. Monte Carlo experiments were conducted using the model so that the effect of fleet size and program policy could be analyzed in a probabilistic manner. Numerous scenarios regarding changing resource availability and demand were investigated in silico. Metrics reported by the model include measures of performance and accessibility. The design and application of the model will be discussed in the context of flight training, but linkages to distributed service delivery in general will be made.

4 - Discrete Event Modelling of Technician Populations for Equipment Modernization

Ryan Ambrose, Junior Defense Scientist, Department of National Defense - Defense Research and Development Canada, Dartmouth, NS, Canada, ryan.ambrose@ecm.forces.gc.ca

François-Alex Bourque

The modernization of military equipment requires a pool of qualified technicians who can provide maintenance support throughout the transition from existing assets to new. A discrete event simulation is developed to track the career of individual technicians to ensure readiness. Distributions for career trajectories are taken from nominal estimates, where technicians are tracked through hiring, training, and leaving the maintenance scope. A benchmark scenario is presented, doubling the technician population to prepare for modern equipment transition.

5 - A Conceptual Hybrid Modelling Approach for Sustainable Development Analytics

Masoud Fakhimi, Lecturer in Operational Research, University of Surrey, Guildford, United Kingdom, masoud.fakhimi@surrey.ac.uk

As sustainability is rapidly becoming vital for industries, dealing with its challenges is also becoming more complex and pricey. M&S could be valuable in providing this understanding and insight in coping with such complex systems. This research argues that such systems demand in their representation a hybrid M&S approach that leverages the precision of Discrete-event Simulation (DES) and the ability of soft OR methods such as Qualitative Systems Dynamics (QSD) to capture multiple perspectives and the effect of unquantifiable variables. This work makes a contribution to M&S literature on sustainability and then proposes a DES-QSD Hybrid M&S Framework for sustainability analytics.

MB07

3rd Fl-Regency B

Healthcare Analytics I

General Session

Chair: Martin Cousineau

HEC Montréal, HEC Montréal, Montreal, QC, H3T 2A7, Canada

2 - New Insight into the CATIE Study by Constrained Confidence Partitioning

Andreas Brieden, UniBW Munchen, Neubiberg, Germany, andreas.brieden@unibw.de

The CATIE schizophrenia trial was a very influential randomized controlled trial in patients with chronic schizophrenia. Patients were followed for up to 18 months under treatment with a randomly assigned antipsychotic. The primary endpoint, time to discontinuation of treatment for any reason, is influenced by individual patient characteristics, external factors as well as effects of drug treatment. New insight concerning time to discontinuation and the efficacy of different second-generation antipsychotics is obtained by applying an innovative survival analysis based on constrained confidence partitioning (ccp).

3 - The Effect of Visibility on Forecast and Inventory Management Performance During the Covid-19 Pandemic: Final Results

Martin Cousineau, HEC Montréal, Montréal, QC, H3T 2A7, Canada, martin.cousineau@hec.ca

Kaveh Dehkhoda, Valérie Bélanger

During the COVID-19 pandemic, healthcare organizations suffered a shortage of essential medical supplies such as personal protective equipment, which resulted in severe consequences. The goal of this study is to assess the impact of one potential factor for this shortage, i.e., the lack of

visibility over the consumption of personal protective equipment. To do so, different forecasting methods combined with a period review inventory system are tested on semi-simulated data that include various visibility issues.

MB08

3rd Fl-Regency E

Managing Uncertainties in Cancer Treatment and Logistics

General Session

Chair: Louis-Martin Rousseau

Polytechnique Montreal, Polytechnique Montreal, Montreal, QC, H3C 3A7, Canada

2 - Patient Rescheduling in Radiotherapy

Louis-Martin ROUSSEAU, Polytechnique Montréal, Montréal, QC, Canada

Dina Ben Tayeb, Nadia LAHRICHI

The patient scheduling in radiotherapy is a complex problem that is managed under hard constraints. In real life, many disruptions can change the planning process. Our work focuses on patient rescheduling in radiotherapy centers in the context of machine breakdown. We present a decision tool for patient rescheduling that allows a multi-objective evaluation of performance according to managers' priorities. We develop a mixed integer programming model that minimizes the changes compared to the initial planning, and we evaluate different scenarios. Our objective is to find the best way to handle these disruptions based on the management decisions.

3 - A Prediction-based Approach for Online Dynamic Radiotherapy Scheduling

Tu San Pham

In this paper, we propose a prediction-based approach for an online dynamic appointment scheduling problem in the context of radiotherapy treatment. We solve the problem in a rolling horizon setting where treatment requests of different priorities and deadlines are revealed daily. It is difficult to reserve a proper treatment capacity for urgent patients. In our approach, a regression model learns from offline solutions to smartly delay treatments of non-urgent patients. The approach successfully reduces overdue treatments while maintaining reasonable waiting times for non-urgent patients.

4 - Machine Learning for Survival Prediction of Hematopoietic Cell Transplantation

Hamed Shourabzadeh, PhD Candidate, University of Toronto, Toronto, ON, Canada, hshurabi@mie.utoronto.ca

**Dionne Aleman, Louis-Martin Rousseau,
Fotios Frank Michelis**

Allogeneic hematopoietic cell transplantation (HCT) is curative for numerous hematological diseases; however, is associated with significant morbidity and mortality. Conventional methods fail to accurately predict the outcome of HCTs. Machine learning (ML) models may uncover associations for the generation of HCT prediction models. We investigate the prognostic potential of multiple ML algorithms when applied to a single-center database. The results demonstrated improved predictivity compared to the previous studies. The application of ML on healthcare databases provides a useful tool to identify variables with prognostic potential; however, are associated with certain challenges.

MB09

3rd Fl-Regency F

Recent Advances in Network Optimization/ Interdiction and Applications in Logistics

General Session

Chair: Sheng Liu

University of Toronto, University of Toronto, Toronto,
ON, M5S 1J5, Canada

3 - Multilevel Critical Node Problem: Complexity and a Novel Greedy Approach

**Margarida Carvalho, University of Montreal, Montreal,
QC, H3T 1J4, Canada**

Adel Nabli, Pierre Hosteins

The Multilevel Critical Node (MCN) problem is a sequential game played between a defender and an attacker. In this work, we expose the computational complexity of the game and its subgames for different variants of it. Due to the theoretical intractability of MCN, we propose a curriculum learning approach for automatically designing a greedy approach to solve it, which can be generalized for multilevel budgeted combinatorial problems.

4 - Driver Exploration in Crowdsourced Delivery

**Sheng Liu, University of Toronto, Toronto, ON, M5S 1J5,
Canada, sheng.liu@rotman.utoronto.ca**

Qin Xiao, Hongyan Dai, Stanley Lim

We study the exploration behaviors of drivers on a crowdsourcing on-demand delivery platform. We empirically estimate the exploration effect on drivers' earning rate and its interactions with the past delivery performance and capacity. We leverage the empirical findings to design order

recommendation policies that improve drivers' delivery performance and earning rate, which creates a win-win situation for the platform and workers.

5 - Delivering in Congested Urban Areas

Maryam Darvish, ULaval, Quebec, QC, Canada, maryam.darvish@fsa.ulaval.ca

**Carise E Schmidt, Arinei C Silva, Leandro C Coelho,
Alex Silva**

This talk introduces the time-dependent fleet size and mix multi-depot vehicle routing problem. The problem is vital in city logistics as its solution impacts the performance of distribution companies and can help design policies to improve traffic and congestion issues. We propose a mathematical model and several valid inequalities for the problem. The performance of which is compared with a powerful matheuristic developed to solve larger instances of the problem generated from real traffic data of Quebec City. Managerial insights on the location of the facilities and the fleet mix are provided.

6 - Accelerating the Calculation of Makespan

Used in Scheduling Improvement Heuristics

**Golshan Madraki, Assistant Professor, Clarkson University,
Potsdam, NY, United States, gmadraki@clarkson.edu**

Most scheduling heuristics iteratively perturb a trial schedule and recalculate the makespan in each iteration. We decrease the computation time of these scheduling heuristics by accelerating the calculation of makespan (longest path in the graph) in each iteration. Scheduling perturbations are represented by edge additions and deletions in the graph. The major contribution of this study is that our algorithm executes once to update the length of the longest path regardless of the number of added and deleted edges. Our experiments show that our algorithm is the best in all cases

MB10

3rd Fl-Balmoral/Windsor

Applied Learning and Optimization

General Session

Chair: Rafid Mahmood

Nvidia, Nvidia, Mississauga, ON, L5M 7Y6, Canada

Chair: Raghav Singal

Dartmouth College, Dartmouth College

3 - Low-budget Active Learning via Wasserstein Distance: An Integer Programming Approach

**Rafid Mahmood, Nvidia, Mississauga, ON, L5M 7Y6,
Canada, rafid.mahmood@mail.utoronto.ca**

Sanja Fidler, Marc Law

Given restrictions on the cost of labeling data, active learning is the process of training a machine learning model selectively labeling a subset of an unlabeled data pool. The large scale of data sets used in deep learning forces most sample selection strategies to use efficient heuristics. We introduce a scalable integer programming algorithm for selecting and labeling a core set of data by minimizing the discrete Wasserstein distance from the unlabeled pool over a latent feature space. Numerical results on several data sets show that optimization outperforms existing approaches under low budgets, allowing us to develop image classifiers while reducing labeling costs to less than 1% of a data pool.

4 - Model-free Approximate Bayesian Learning for Conversion Funnel Optimization

Raghav Singal, Dartmouth College, Hanover, NH, 10027, United States, singal@dartmouth.edu

Garud N Iyengar

We study sequential interventions from the point-of-view of a firm promoting a product under a conversion funnel model of consumer behavior. Our model captures the consumer state (e.g. interaction history with the firm) and allows consumer behavior to vary as a function of her state and firm's interventions (e.g. emails). The firm's wishes to maximize conversion probability (product purchase) but does not know the state-specific effects of interventions and must learn on the fly. We propose a new learning algorithm for this problem, which inherits the simplicity of Thompson sampling. We prove its asymptotic optimality and benchmark its performance with existing approaches on a real-world dataset.

5 - Incentivize Myopic Agents to Explore in Banditing

Jialin Li, University of Toronto, Toronto, ON, Canada

Ningyuan Chen, Ming Hu, Sheng Liu

We model a restaurant rating platform as a multi-armed bandit. Agents visiting this platform always behave greedily, unless incentivized by the principal to explore a suboptimal arm. We develop regret lower bounds when incentive budget has a limit, for an arbitrary strategy to decide when to make agents explore. The result suggests an optimal rate of budget and best times of expenditure. It provides an insight of how the part of regret accumulated by exploration actions affects the total regret amount. A matching upper bound is available when we adopt a simple method that spends budget all at the beginning.

6 - Posterior Sampling Approaches for Nonstationary Bandits

Yonatan Mintz, University of Wisconsin Madison, Madison, WI, 53715, United States

Jinxin Tao

Nonstationary stochastic bandit settings, where the parameters of each arm are unknown to the decision maker but may change over time according to a set of known dynamics are common in many applications from online advertising to personalized healthcare, and can be modeled as a reducing or gaining unknown efficacy (ROGUE) bandits. We present a novel Thompson Sampling algorithm we call ROGUE-TS to optimize this setting and show that this algorithm achieves logarithmic in time expected regret. We also present computational results that show that ROGUE-TS improves over and is competitive with state of the art algorithms in terms of cumulative regret and average reward.

MB11

3rd FI-Oxford/Prince of Wales

Decision Analytics Under Uncertainty

General Session

Chair: Saman Lagzi

University of Toronto, University of Toronto, Toronto, ON, M4Y1R5, Canada

2 - Price, Wage, and Fixed Commission in On-demand Matching

Yun Zhou, McMaster University, Hamilton, ON, L9A 0A3, Canada, zhouy185@mcmaster.ca

Ming Hu

This paper studies an on-demand matching platform that crowdsources a service from independent suppliers and sells it to customers. The platform offers a wage to the supply side and charges a price to the demand side. We consider a set of market conditions, under each of which the volume of participating demand and supply depends on the price and the wage. We examine the effect of the elasticities of demand and supply on the performance of the fixed commission contract and provide a lower bound on its performance as a function of those elasticities.

3 - Use Neural Networks to Guide Data-driven Operational Decisions

Saman Lagzi, University of Toronto, Toronto, ON, M4Y1R5, Canada, saman.lagzi16@rotman.utoronto.ca

Ningyuan Chen, Joseph Milner

We use Neural Networks as approximation algorithms to address complex problems. Given sample data that includes observations of decision variables, covariates and the objective function value, we train a neural network,

where the input of the neural network is the covariates and decision variables, and its output is the predicted value for the objective function. Then, for a given set of covariates, the decision variable is chosen so the predicted value of the neural network is optimal. We characterize the performance of our methodology in terms of the generalization bound of the Neural Network and show strong performance on both the Newsvendor problem and the assortment pricing problem.

4 - Dynamic Relocations in Car-Sharing Networks

Mahsa Hosseini, University of Toronto, Toronto, ON, M5R 3L8, Canada, mahsa.hosseini@rotman.utoronto.ca

Joseph Milner, Gonzalo Romero

We propose a dynamic car relocation policy for a car-sharing network with centralized control and uncertain, unbalanced demand. The policy is derived from a reformulation of the fluid model approximation of the dynamic problem. We project the full-dimensional fluid approximation onto the lower-dimensional space of relocations only. Our policy exploits these gradients to make dynamic car relocation decisions. We close the optimality gap on average by 30% in static and time-varying settings.

5 - Learning Consumer Preferences from Bundle Sales Data

Setareh Farajollahzadeh, University of Toronto, Toronto, ON, M5G 2M4, Canada, setareh.farajollahzadeh@rotman.utoronto.ca

Ningyuan Chen, Guan Wang

We study the problem of learning customer-reservation prices from sales data, including bundles. (1) We provide an analytical framework to study this problem and develop a Monte Carlo expectation-maximization algorithm. (2) We extend the base model to study the censored sales data. (3) We use the mixture of Gaussian distribution to classify the customer preferences. (4) We establish that if we initiate within a basin of the optimal point, our algorithm linearly converges to a good fixed point, i.e., a constant distance of the global optimum.

MB12

34th Fl-Seymour

ENRE5: ML and Optimization Models for Energy Systems

General Session

Chair: Fuat Can Beylunioglu

2 - Equilibria in Interdependent Natural-gas and Power Markets: An Analytical Approach

Amir Mousavian, Associate Professor, Clarkson University, Potsdam, NY, United States

Beheshteh Raouf

Antonio J. Conejo

This research addresses the analytical Nash-Cournot equilibrium models to represent the joint operation of natural-gas and power markets with the assumption that the market participants in each market make their own decisions independently seeking maximum profits, as often is the case in the real world. We develop an analytical equilibrium model and apply the Karush-Kuhn-Tucker (KKT) approach to obtain Nash-Cournot equilibria for the interdependent natural-gas and power markets. We use a double-duopoly case to study the interaction of both markets and to derive insightful analytical results and derive closed-form analytical expressions for spot-market equilibria in both markets.

3 - Robust Training for ML Boosted AC-OPF

Fuat Can Beylunioglu, University of Waterloo, Waterloo, ON, Canada, fcbeylun@uwaterloo.ca

Mehrdad Pirnia, P Robert Duimering

Solving AC-OPF, using traditional optimization solvers is challenging, due to the associated non-convexities. As an alternative Neural Networks have been suggested to solve such problems. However, training requires a large amount of data, and networks may predict solutions even when the inputs are outside of the problem domain. In this study, a robust method of training the NN is proposed, based on an iterative feedback process in which necessary data is populated at each iteration, based on examples for which the network fails to generate satisfactory predictions. Results indicate that robust training can achieve similar or better prediction performance to regular training while using less data.

MB13

34th Fl-Stanley

Teaching, Assessment, and Content Development for Business Analytics

General Session

Chair: Tiffany Bayley

Ivey Business School, Ivey Business School, London, ON, N6H 3W9, Canada

Chair: David Wheatley

Wilfrid Laurier University

3 - Be the Referee: A Proposed Evaluation Method for Introductory Business Analytics Courses

Kyle D Maclean, Ivey Business School, London, ON, N5X0G9, Canada, k.d.maclean@gmail.com

Tiffany Bayley

In large courses, evaluation methods often present a tradeoff between grading efficiency/consistency, and the ability to differentiate how thoughtful a student is on subtle analytical issues.

We discuss a, to our knowledge, new type of assignment that tries to balance this tradeoff. In this assignment type, we provide students a pre-written analytical report and ask them to find the errors in it. In this talk, we provide an example we used in a 600 student introductory course and discuss considerations of how to design this evaluation method. We then show how grading it can be both very efficient and consistent.

4 - Teaching Supplier-Retailer Collaboration by Using Basic Excel Simulation

Ardavan Asef-Vaziri, California State University, Northridge, CA, 91330-8378, United States

In this talk, we show how metrics of supplier-retailer collaboration such as service level, fill rate, expected loss, expected leftover, profit sharing, and value of exact information can be taught to undergraduate students by using a very basic Excel simulation. The simple model is understandable to undergraduate students. It enables the students to get close to optimal solutions by intuition not by using analytical formulas.

5 - Falling Attention Spans and the Rise of the Pause Procedure

David Wheatley, Wilfrid Laurier University, Waterloo, ON, Canada, dwheatley@wlu.ca

I discuss the use of the pause procedure (taking short, regular breaks during lectures) in both online and in-person settings. The focus is on qualitative feedback and survey results, with some discussion about past and planned experiments to test lecture recall.

2 - Delay-join the Shortest Queue Routing for a Parallel Queueing System with Removable Servers

Mark E Lewis, Cornell University, Ithaca, NY, 14853-3801, United States

Douglas Down, Pamela Badian-Pessot

We consider a parallel processing network with removable servers. Beginning with the single server model with power and service rate control, we study the importance of a delayed restart when the server is off. In particular, we show that an optimal policy exists that delays restarting until a "safety stock" of work is in the system. It then behaves similarly to that of the classic service rate control models. With that as the backdrop, we consider scheduling with the ability to remove servers. We introduce "delay-JSQ" (join the shortest queue) policies, show their stability and asymptotic optimality in the two-server case, and conclude with a detailed numerical study."

3 - Blood Platelet Inventory Management: Incorporating Data-Driven Demand Forecasts

Maryam Motamedi, McMaster University, Hamilton, ON, Canada

Jessica Dawson, Na Li, Douglas Down

Platelet products are viewed as a vital product used for treating serious diseases. Since platelet demand is uncertain and highly variable, platelet inventory management is challenging. In this work, we propose a data-driven inventory management model for platelet products that incorporates demand forecasts in the inventory management process. The proposed model uses forecast-dependent target inventory levels to determine an ordering policy that has the goal of minimizing both shortage and wastage. Experimental results show that forecast-dependent target inventory levels not only result in zero shortage and wastage for our data but keep the inventory level very close to the actual demand.

4 - Recovering from Inefficiencies in Queueing Systems with Two Consecutive Waiting Zones

Michalis Panayides, PhD student, Cardiff University, Cardiff, United Kingdom, panayidesm@cardiff.ac.uk

The focus of this research is the development of a 3-player game between two queueing systems and a service that distributes individuals to them. The first aspect of this work is the creation of a queueing system with two consecutive waiting zones. The second part is modelling the behaviours that emerge from the game theoretic model between two such queueing systems and the distribution system. The model is applied in a healthcare setting between an ambulance service and two hospitals. In particular by using

MB14

34th Fl-Cypress

Stochastic Models

General Session

Chair: Douglas Down

McMaster University, McMaster University, Hamilton, ON, L8S 4L8, Canada

learning algorithms we can investigate how players arrive at inefficient behaviours along with ways to apply some incentive mechanism to escape them.

5 - Dynamic Control of Service Systems with Returns

Vahid Sarhangian, University of Toronto, Toronto, ON, M5S 3G8, Canada

Timothy Chan, Simon Yuxuan Huang

We study a queueing system with returns where at each service completion epoch, the decision maker can choose to reduce the probability of return for the departing customer at a cost that is convex increasing in the amount of reduction in the return probability. We characterize the structure of optimal long-run average and bias-optimal transient control policies for associated fluid control problems. Our results provide insights on the design of post-discharge intervention programs aimed at reducing hospital readmissions.

MB15

34th FI-Grouse

CORS Undergrad Student Paper Competition

General Session

Chair: Nadia Lahrichi

Ecole Polytechnique de Montreal, Montreal, QC, H3C3A7, Canada

Monday, 1:30–3pm

MC01

2nd FI-Georgia A

Sustainable Operations/ Energy

General Session

Chair: Shadi Goodarzi

University of Texas Austin, University of Texas Austin, Austin, TX, 78759, United States

2 - ***Late Cancellation - Performance-based Contracts for Energy Efficiency Projects

Ali Shantia, Toulouse Business School, Toulouse, 31000, France, a.shantia@tbs-education.fr

Sam Aflaki, Roman Kapuscinski

Energy Service Companies use performance-based contracts for Energy Efficiency projects. The performance of these contracts, however, is unverifiable by the clients. The achieved efficiency also encourages the client to

consume more energy (the rebound effect). We show that the mentioned effects, along with the client's risk aversion, diminish the performance of such contracts; therefore, they never achieve the first-best (FB) outcomes. We define and characterize a group of piece-wise linear contracts that perform reasonably well when FB outcome is difficult to achieve.

3 - A Distribution Model of Subsidy and Tax: Social Welfare Perspective

Shadi Goodarzi, University of Texas Austin, Austin, TX, 78759, United States

Mohammad Amini

This study aims to provide an appropriate tax/subsidy distribution model to optimize social welfare while cultivating renewable energy usage. The model determines the amount of tax collection and payment subsidy while considering a game between the policymaker, power plants, and manufacturers. The system components are determined based on existing studies and experiences of different countries. The proposed model is tested against data from 2009 to 2019 in the United States. The findings provide critical managerial implications and insights for policymakers to develop effective government subsidy and tax programs.

4 - Decarbonizing Buildings via Energy Demand Response and Deep Reinforcement Learning

Selva Nadarajah, Information and Decision Sciences, University of Illinois at Chicago, Chicago, IL, 60517, United States, selvan@uic.edu

Doseok Jang, Lucas Spangher, Costas Spanos

Energy demand response is projected to be critically important in decarbonizing the grids of the future. We propose an agent to communicate artificial price signals to workers as part of an office building demand response program, where workers react to this price signal by modifying their energy consumption to off-peak and less carbon intensive hours of the day. We assess the value of deep reinforcement learning (RL) technology to mitigate learning costs incurred when deploying such a price controller. The use of deep RL eliminates \$175,000 in initial investment, decreases by 30% the energy cost, and reduces emissions by 32% (106,000 tons of CO₂) compared to using a time-of-use rate.

MC02

2nd FI-Georgia B

Mixed-integer Quadratic Programming in Transportation and Logistics

General Session

Chair: Borzou Rostami

Wilfrid Laurier University, Wilfrid Laurier University,
Waterloo, ON, N2L 3C5, Canada

2 - Drone-assisted Parcel Delivery: Facing Future with the Past

Akbar Karimi, PhD, Wilfrid Laurier University, Waterloo, ON, Canada

For a network of coordinated fleets of trucks and drones performing last-mile delivery of commercial parcels, we develop a general and flexible approach to strategic planning at the face of an unknown demand dynamics. We introduce and emphasize a comprehensive view of demand capturing seasonal, daily and hourly dynamics. We then derive the required technical results to embed the demand dynamics into mixed-integer nonlinear programs to obtain optimal solutions with guaranteed service levels. We present a decomposition approach for the efficient solution of the model.

3 - A Dual Bounding Framework For Binary Quadratic Combinatorial Optimization

Mahdis Bayani, Polytechnique Montreal, Montreal, QC, H3C 1N2, Canada, mahdis.bayani@polymtl.ca

Borzou Rostami, Yossiri Adulyasak, Louis-Martin Rousseau
We propose a unified framework to reformulate any Binary quadratic programming (BQP) problem with linear constraints to a new BQP problem defined on a graph. This framework relies on the concept of stars in the graph and partitioning the quadratic costs into in-star and out-of-star interactions. We exploit the star-based structure of the new reformulation to develop a decomposition-based column generation algorithm. We evaluate the performance on different quadratic structures in which the quadratic component of the problem is dealt with in the column generation master problem and in its subproblem.

4 - 3D Printing: Dual Sourcing Through Second-order Cone Programming

Parang Zadtootaghaj, Wilfrid Laurier University, Waterloo, ON, Canada, zadt1590@mylaurier.ca

Borzou Rostami

This study presents a general framework and solution method for consumer goods logistics subject to availability of 3D printer. We consider multiple products facing stochastic demands and utilize the make-to-stock versus the make-to-order (3D printing) method that employs a multi-class priority queue. The objective is to minimize the long-run average system cost by assigning the future demands to stock and/or print. We model the problem as a second-

order cone program and obtain an optimal solution through a decomposition algorithm. This modeling framework is flexible and extends to many settings, including among others, the dual sourcing in which each product could be both stocked and printed

5 - Service Time Window Design in Routing Optimization with Stochastic and Correlated Travel Times

Davod Hosseini, Sobey School of Business, Saint Mary's University, Halifax, NS, Canada, davod.hosseini@smu.ca

Borzou Rostami, Mojtaba Araghi

We propose a new approach to design time windows for a service provider that serves a set of pre-assigned customers with service or good delivery. The objective is to minimize the risk of violating the time windows. Two modeling frameworks are developed, which provide the service provider with a confidence level in planning reliable arrivals at the customers. While the first model deploys a stochastic programming framework, a distributionally robust optimization approach is proposed in the second model, where partial information on the probability distribution of travel times is available. This is performed by taking into account the variance of and the correlation between the travel times.

6 - The Bike-sharing System Through a Predict-then-optimize Paradigm

Borzou Rostami, Wilfrid Laurier University, Waterloo, ON, N2L 3C5, Canada

In this talk, we consider a bike-sharing system with uncertain demands. We reset up bikes once a day at nighttime to make sure bikes are ready in all stations by peak hours, which is a static case. The initial inventory decision is supported by two phases: prediction and optimization. First, we predict the demand for bikes and lockers on a fixed time scale (e.g., every 15-min). Understanding future demand will help the system rearrange inventory rationally to stations, satisfying more user demand. The optimization model is then built based on the prediction results to minimize the overall user dissatisfaction.

MC03

2nd FI-Plaza A

Railway Applications

General Session

Chair: Armin Jabbarzadeh

ETS, University of Quebec

2 - Equitable Routing of Rail Hazardous Materials Shipments Using CVaR Methodology

Davod Hosseini, Sobey School of Business, Saint Mary's University, Halifax, NS, B3H 3C3, Canada, davod.hosseini@smu.ca

Manish Verma

The low probability - high consequence nature of hazardous materials (hazmat) incidents dictates a risk-averse route planning approach. However, preparing routing plans for multiple hazmat shipments between various origin-destination pairs also raises the question of risk equity, and not just the minimization of hazmat risk. Hence, the objective is to design an equitable routing plan for different rail hazmat shipments, which precludes certain population zones from being subjected to intolerable levels of hazmat risk. We propose a mathematical framework that makes use of CVaR to generate minimum-risk shipment routes while promoting risk-equity in both the arcs and yards of railroad networks.

3 - A Robust Optimization Approach for Designing Emergency Response Network of Rail Hazmat Shipments

Hassan Sarhadi, Assistant Professor, F.C. Manning School of Business, Acadia University, Wolfville, NS, B3M 0C7, Canada, hassan.sarhadi@acadiau.ca

Manish Verma

With the increase in production of oil and gas across North America, railroads will have to carry more oil shipments in the future. While increase in the hazmat traffic leads to higher revenues for railways, it also increases the risk of catastrophic accidents with exorbitant economic and environmental costs. Thus, designing emergency response networks is vital in mitigating the risk of increased rail hazmat traffic. In this study, we propose a robust optimization model that determines the location of response facilities and equipment packages needed considering the inherent uncertainty in the problem. The model is then tested on a case study of a railroad network in Ontario (Canada).

MC04

2nd Fl-Plaza B

Supply Chain Management I

Contributed Session

Chair: Mohammad Nikoofal

Ryerson University

2 - The Global Supply Chain: Turning Crisis Into Opportunity

Mazyar ZahediSeresht, University Canada West (UCW),

Vancouver, BC, Canada

Peyman Chalabi

Supply Chain not anymore looks like a cost for businesses. Now, it is considered a significant part, especially for manufacturing. Because of the present supply chain issue caused by the Covid-19, businesses must reconsider their supply chains and how companies deal with their vendors. The company's success and planning are strongly dependent on advanced digital technology, especially advanced analytics. Compared to organizations who faced problems, organizations who were successful were likely to have advanced- analytics tools 2.5 times more. 71% of the businesses who faced problems dealing supply chain during the crisis said they are storming advanced analytics tools and increasing their use

3 - The Impact of Cost Auditing on Supply Chain Social Responsibility

Zhengping Wu, Syracuse University, Syracuse, NY, United States, zwu12@syr.edu

Haiying Yang

Firms increasingly recognize the importance of their upstream suppliers' social responsibility. However, they may fail to heed the unintended negative consequences of their own common practices on the suppliers' social responsibility decision. Our study shows that cost auditing may undermine the supplier's social responsibility choice, which sheds light on the reluctance of many suppliers to commit to social responsibility programs.

4 - Outsourcing Decision in the Presence of Supplier Copycatting

Shobeir Amirnequiee, PhD Candidate, Ivey Business School, London, ON, Canada, samirnequiee.phd@ivey.ca
Hubert Pun, Joe Naoum-Sawaya

Supplier copycatting occurs when a supplier copies the manufacturer's product and encroaches on the market with copied product. To investigate this phenomenon, we propose a multi-period game theoretic approach where a manufacturer (M) outsources the production to a supplier pool including a high-quality supplier with copycatting capabilities (A) and a low-quality supplier (B). Our results indicate that (1) an increase in the quality of the copied product can make M switch from outsourcing to supplier B to outsourcing to supplier A, (2) upon an improvement in supplier B's quality, M may abandon the supplier, and (3) both suppliers might be worse off from an improvement in process quality.

5 - Developing a Resilient Semiconductor Supply Chain for the Automotive Industry

**Parveen S Goel, Director Engineering and Projects
Westerns Canada, Canada Post, Richmond, BC, Canada,
psgoel1465@gmail.com**

A resilient global supply chain is critical for the automotive industry to ensure business continuity and profitability. This research focuses on the future supply chain strategies for automotive companies to address the current constraints of semiconductor availability and other potential future disturbances. The industry experts were surveyed to identify root causes, long-term forecasts, and how the industry is adapting.

6 - Public-private Partnership to Secure Containerized Supply Chains

**Mohammad Ebrahim Nikoofal, Associate Professor,
Ryerson University, Toronto, ON, Canada, m.nikoofal@ryerson.ca**

Morteza Pourakbar, Mehmet Gumus

This paper develops a public-private partnership (PPP) model to enhance the security of containerized supply chains. We study the interaction between customs inspection capacity and the incentives offered in security programs. We develop a sequential game between government, firms, and terrorist. The government decides on the inspection capacity and incentives to establish a PPP. Next, firms decide on the collaboration level followed by a strategic terrorist decision to infiltrate. In equilibrium, the government ranks all the firms and induces collaboration only on a subset of them. We characterize the value of PPP and the required condition to implement the inspection-free lane.

MC05

2nd Fl-Plaza C

Data Mining

Contributed Session

Chair: Dewan Wahid

McMaster University

2 - Big Data Approach to Engineering & Manufacturing Bill of Materials

Bryan Sydnor, Self Employed, Long Beach, CA, United States, bryansydnor@icloud.com

Production starts with the design view of a product requiring the translation of an indented Bill Of Materials (BOM) from an Engineering BOM (EBOM) to a Manufacturing BOM (MBOM). The MBOM starts as a digital twin of an EBOM and continues a transformation throughout production planning & execution. When the data structure of both BOMs are organized with specific characteristics the data in the

BOMs can leverage machine learning algorithms during production planning & execution while providing feedback maintaining an engineering digital twin. We'll address BOM data strategies, how they use machine learning algorithms during planning & execution while maintaining an engineering digital twin.

3 - Developing Criteria for Measuring Sensor Data Quality

**Sunho Kim, Honorary Professor, Myongji University,
Yongin, Gyeonggi-do, Korea, Republic of, shk@mju.ac.kr
Dongwoo Lee, Sangyub Lee, Sungkun Kim, Tae-Hyoung Choi**

For analysis and utilization of sensor data in smart environments such as IoT or WSN, it is necessary to improve the quality of sensor data through pre-processing. Until now, international standards related to data quality have not considered quality criteria and measurement methods for real-time stream and bulk data such as sensor data. In this study, quality characteristics suitable for sensor data collected in digital format and data anomalies affecting them are derived. In addition, quality measurement indicators called quality measures are defined for each quality characteristic and data anomaly. The quality of sensor data can be improved by supplementing the data anomalies in various ways.

4 - A Hybrid Framework for Invoice Categorization Based on the Line-item by Using a Keyword Network Approach

**Dewan F. Wahid, PhD Candidate, McMaster University,
Hamilton, ON, Canada, wahidd@mcmaster.ca
Dewan F. Wahid, PhD Candidate, FreshBooks Inc.,
Toronto, ON, Canada, wahidd@mcmaster.ca
Elkafi Hassini**

An invoice is a business document that lists details of products or services provided by a merchant to its consumer. As a cloud-based accounting company, our industrial partner wants to categorize invoices based on the corresponding line items (provided products or services). In this project, we formulated a keyword network from invoice descriptions and used a hybrid framework (with an unsupervised clustering and a supervised classifier) to identify invoice-line items categories. Our framework shows promising results to identify invoice line-item categories for large-scale data.

MC06

3rd Fl-Regency A

Tutorial: Opinion Dynamics on Directed Random Graphs

Tutorial Session

1 - Opinion Dynamics on Directed Random Graphs

Mariana Olvera-Cravioto, University of North Carolina Chapel Hill, 204 E Cameron Ave., 335 Hanes Hall, Chapel Hill, NC, 27599, United States

A popular way of modeling the exchange of information among individuals in a society is to use a large random graph whose vertices represent the individuals and whose edges represent acquaintances or friendships. Once the graph is realized we can model the exchange of information by defining a Markov chain on the graph whose transition probabilities determine how individuals will update their opinions once they listen to those of their acquaintances. If the listening relationship between individuals is not symmetric, we can assume the graph is directed. This tutorial will explain how to model and analyze opinion dynamics using the DeGroot-Friedkin model on directed random graphs, with the goal of proving conditions under which either consensus or polarization occurs. The techniques presented in the tutorial also extend to the analysis of a wide class of Markov chains on directed random graphs.

MC07

3rd Fl-Regency B

Scheduling in Healthcare

General Session

Chair: Valérie Bélanger

Vancouver, Canada

Chair: Ana María Anaya-Arenas

ESG-UQAM, Montréal, QC, H2X1L7, Canada

Chair: Nadia Lahrichi

Ecole Polytechnique de Montreal, Ecole

Polytechnique de Montreal, Montreal, QC,

H3C3A7, Canada

3 - On Integrating Patients Appointment Grids and Technologist Schedules in a Radiology Center

Dina BEN TAYEB, Polytechnique Montréal, Montréal, QC, Canada

Louis-Martin ROUSSEAU, Nadia LAHRICHI

In this work, we study the simultaneous optimization of appointment grid and technologist schedules in a radiology center. We develop a mixed integer programming model

that provides an optimal allocation of personal resources to maximize the machine utilization and the number of treated patients. We evaluate the optimization model using a real case of the CHUM radiology department. We study different scenarios by testing several technologist rules and planning construction methods.

4 - Casual/On-Call Personnel Scheduling

Prakash Prakash, Polytechnique Montreal, Montreal, QC, Canada

We present a novel flexible on-call personnel scheduling system that interacts with on-call employees to allocate on-call shifts. The flexibility in the system allows an on-call employee to freely select from or reject the shifts offered and also for a senior employee to replace/bump a junior employee from a current assignment under certain conditions. The objective of this dynamic problem is to minimize such schedule changes but also ensure maximum shift assignments before the end of the horizon. An IP is formulated for the deterministic problem under complete information and is solved approximately to gain insights that allow us to propose different policies for the dynamic problem.

5 - A Two-phase Approach for the Radiotherapy Scheduling Problem

Tu San Pham

The Radiotherapy Scheduling Problem focuses on optimizing the planning of radiotherapy treatment. We propose a two-phase approach for the problem where treatment sessions are assigned to machines and days on the first phase while the specific appointment times are decided in the second phase. Several Mixed Integer Programming and Constraint Programming models are proposed. We analyse the performance of the models on data generated based on real data from a large cancer center in Montréal. We also conduct a simulation to evaluate the impact of different scheduling strategies on the schedule.

MC08

3rd Fl-Regency E

Global Health Operations

General Session

Chair: Rebecca Alcock

Madison, WI, 53711, United States

2 - Operational Challenges for EMS Platforms in Developing Countries

Stef Lemmens, Rotterdam School of Management,

Rotterdam, 77300, Netherlands, s.lemmens@rsm.nl
Pieter van den Berg, Andre Du Pin Calmon, Andreas Gernert, Gonzalo Romero

Many developing countries lack the health-emergency infrastructure of the developed world. In this context, our industry partner Flare (operating in Nairobi, Kenya) coordinates existing ambulance providers by operating an platform. Flare aggregates the available ambulance capacity and demand for emergency services. Since ambulance platforms in developing countries make use of independent ambulance providers, the ambulance fleet can only be partially relocated. We study the operational challenges for such platforms as they often lack the knowledge about all ambulances' availability and their location, and typically do not fully control these ambulances.

3 - On the Frontline: Engaging Health Workers to Mitigate the Last-mile Stock-out of Health Commodities in Developing Countries

Amir Karimi, The University of Texas at San Antonio, San Antonio, TX, 78210, United States

Anant Mishra, Karthik Natarajan, Kingshuk K Sinha

We empirically investigate whether and to what extent variations in the (i) the physical context where training is administered (i.e., onsite vs. offsite training); (ii) the familiarity of the trainer who administers the training (i.e., familiar vs. unfamiliar trainer); and (iii) the timing of the week when training is administered (i.e., early-week vs. mid-week vs. late-week training) impact the learning outcomes of health workers and subsequently the likelihood of health commodity stock-outs in public health supply chains in developing countries.

4 - Health Clinic Electrification in LMICs via a Novel V2G Network

Rebecca Alcock, University of Wisconsin-Madison, Madison, WI, 53711, United States, ralcock@wisc.edu

Justin J. Boutilier

More than one billion people worldwide receive healthcare in a facility without electricity. Energy inequities in healthcare have many consequences, including increased mortality and higher incidence of disease. To address this, we are investigating a vehicle-to-grid system that will equip resource-limited health clinics with the electricity needed to keep them running, while enabling mobile health services via access to electric bicycles. In this talk, we will discuss the current state and early findings of the mathematical frameworks used for sizing the system.

MC09

3rd Fl-Regency F

Heavy-Duty Trucks in the Freight Transport Sector

General Session

Chair: Hossein Zolfagharinia

Ryerson University, Wilfrid Laurier University, Waterloo, ON, N2J 2N9, Canada

2 - ***Late Cancellation - A Deep Semi-supervised Machine Learning Algorithm for Detecting Transportation Modes Based on GPS Tracking Data

Paria Sadeghian, PhD Candidate, Dalarna University, Borlange, Sweden, psd@du.se

Arman Golshan, Xiaoyun Zhao, Johan Håkansson

Transportation research has benefited from the adoption of GPS data since a higher volume of data can be acquired. Travel information and frequently visited locations can be extracted from raw GPS data. However, transportation modes cannot be extracted directly and require more complex analytical processes. Common approaches for detecting transportation modes rely on manual labelling of trajectories with accurate travel information. This research proposes a method of semi-supervised machine learning algorithm by using minimal labelled data. The method adopts a deep neural network architecture to map the latent information to detect transportation modes.

3 - Robust Optimization for Multi-objective Electric Vehicle Routing Problem with Uncertain Energy Consumption

Afsane Amiri, PhD Candidate, Ryerson University, Toronto, ON, Canada, afsane.amiri@ryerson.ca

Hossein Zolfagharinia, Saman Hassanzadeh Amin

This study presents a robust model for the Electric Vehicle Routing Problem to address energy consumption uncertainty, which is essential in determining the travel range and the number of required recharges. The objectives of the problem are to minimize the transportation costs and maximize the customers' satisfaction in terms of on-time delivery. A Monte-Carlo simulation is applied to investigate the robust solutions for different levels of uncertainty. In addition, multi-objective solution approaches are integrated with a metaheuristic algorithm to solve the model for large-size instances.

4 - The Covid-19 Pandemic and the Wellbeing of Long-haul Truck Drivers: A Case Study Analysis

Diana Vassyukova, Ryerson University, Toronto, ON, Canada, dvassyukova@ryerson.ca

Hossein Zolfaghariania, Annika Hillebrandt

Truck drivers serve as the backbone of supply chains, yet little scholarly research exists to understand the impact of crises on their wellbeing. Given the severity of the Covid-19 pandemic, we adopt a case study methodology to explore the effects of the pandemic on the wellbeing of Canadian long-haul truck drivers. Additionally, we uncover personal and organizational resources that have been effective in combatting 'pandemic' stressors. The results illustrate the multi-dimensional physical, psychological and social impacts on the truck drivers' wellbeing. We then propose a comprehensive list of support strategies for management to take a more proactive role in supporting their employees.

5 - How Does Load Information Benefit Motor Carriers in the Spot Market?

Hossein Zolfaghariania, Ryerson University, Toronto, ON, Canada, h.zolfaghariania@ryerson.ca

Mehdi Najafi

This study investigates the benefits of load information for motor carriers. More specifically, we focus on single-truck operators, which contribute to a large number of trucking firms in North America. We first formulate the problem as if the existing information is perfect, i.e., not subject to any change. We then develop a stochastic dynamic programming model to address the imperfectness of the available information. Our analyses illustrate that the benefits of load information can be as large as 30% on average, even if the information is not perfect. In addition, we observed that the earned benefit could be larger when there are more than one group of clients, e.g., low risk and high risk.

MC10

3rd Fl-Balmoral/Windsor

Analyzing and Optimising Bidding Decisions in Large-Scale Electricity Markets

General Session

Chair: Andrew Rosemberg

Invenia Labs, Invenia Labs, Cambridge, Cambridge, United Kingdom

Chair: Bruno Fanzeres dos Santos

Pontifical Catholic University of Rio de Janeiro, Pontifical Catholic University of Rio de Janeiro, Rio

de Janeiro, 22451-900, Brazil

3 - Two-Stage Robust Mathematical Programs with Equilibrium Constraints: A CCG Algorithm and Computational Enhancements

Bruno Fanzeres dos Santos, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, 22451-900, Brazil

We present numerical procedures to solve Two-Stage Robust Mathematical Programs with Equilibrium Constraints (TSR-MPECs). Firstly, a column-and-constraint generation algorithm is described based on a reformulation of the TSR-MPEC into a single-level equivalent mixed-integer linear program. Then, a set of technical results are derived and three algorithms are constructed aiming at enhancing the computational capability to handle particular structures of TSR-MPECs. To conclude, numerical experiments are conducted on the particular application of optimal offering strategies in day-ahead electricity markets to illustrate the effectiveness and intuition of the solution proposals.

4 - Efficient Multi-nodal Strategic Bidding in Electricity Markets

Andrew Rosemberg, Researcher, Invenia Labs, Cambridge, CB2 1AW, United Kingdom

Bruno Fanzeres dos Santos, Rafaela Ribeiro

Multi-nodal strategic bidding in real electricity markets is complex given the structure behind the clearing process - i.e. a hard bilevel problem. Many solution methods try to find good answers for this problem but they often need great computational effort (e.g. MPEC) or have poor solution quality (such as zero and first-order methods). Nevertheless, projecting the decision vector onto lower dimensions provides reasonable empirical results even though some of the feasible region is lost. A comparison between different heuristics and exact methods, with and without the projection, is presented in this talk.

5 - Simulating a Real-World Market Clearing Process: Technical Challenges and Lessons Learned

Raphael Saavedra, Invenia Labs, Cambridge, United Kingdom, raphael.saavedra@invenialabs.co.uk

Mahdi Jamei, Nicholas Robinson, Branwen Snelling, Abraham Alvarez Bustos, Andrew Rosemberg, Chris Davis

Studies on optimal power flow and electricity markets generally use test systems. These, while based on reality, are often outdated and lack information (e.g. credible offers, bids, or the fuel types of generators), making it impossible to accurately evaluate the impact of counterfactual inputs. In this presentation, we go over our approach to simulating the market clearing of a real-world grid, from data fetching

to outputting the final results. We highlight the technical challenges we faced and useful lessons learned from undergoing such a project within an industry context.

6 - Reducing CO2 Emissions with Virtual Transactions: A Bottom-up Simulation in MISO

Max Lensvelt, Invenia Labs, Cambridge, United Kingdom, max.lensvelt@invenialabs.co.uk

Thomas Gillam, Joshua Chadney

We analyse the impact of virtual transactions on CO2 emissions in the Midcontinent Independent System Operator (MISO) grid, using a full-scale proprietary simulation of the network. This is the first bottom-up analysis of the impact of virtual transactions on emissions. This simulation-based approach is extended to explore methods for building portfolios of virtual transactions that would maximally reduce emissions in the grid, subject to economic and regulatory constraints.

MC11

3rd FI-Oxford/Prince of Wales

Optimal Transport and Financial Mathematics

General Session

Chair: Silvana Pesenti

University of Toronto, University of Toronto, Toronto, ON, M5S 3G3, Canada

2 - Efficient Convex PCA with Applications in Ranked Data and Wasserstein Geodesic PCA

Ting Kam Leonard Wong, University of Toronto, Toronto, ON, Canada, tkl.wong@utoronto.ca

Convex PCA is a recently introduced methodology for dimension reduction where the data is constrained to lie in a convex subset of a Hilbert space. In this work, we provide an in-depth theoretical analysis regarding its consistency, and propose an efficient algorithm when the underlying convex set is finite dimensional and polyhedral. We apply this method to study the ranked capital distribution of the US equity market, and also to Wasserstein geodesic PCA which is the original motivation of convex PCA. This is joint work with Steven Campbell.

3 - Measuring Association with Wasserstein Distances

Johannes Wiesel, Columbia University, New York, NY, United States

Let $\pi \in \Pi(\mu, \nu)$ be a coupling between two probability measures μ and ν on a Polish space. In this talk we propose and study a class of nonparametric measures of association

between μ and ν , which we call Wasserstein correlation coefficients. These coefficients are based on the Wasserstein distance between π and the disintegration of π with respect to the first coordinate. We also establish basic statistical properties of this new class of measures: we develop a statistical theory for strongly consistent estimators and determine their convergence rate in the case of compactly supported measures μ and ν .

4 - Reverse Sensitivity Analysis for Risk Modelling

Silvana Pesenti, University of Toronto, Toronto, ON, M5S 3G3, Canada

We consider a modeller conducting sensitivity analysis of a model consisting of random input factors, a corresponding random output of interest, and a baseline probability measure. The modeller seeks to understand how the model changes under a stress on the output's distribution. Specifically, for a stress on the output, we derive the unique stressed distribution that is closest in the Wasserstein distance to the baseline output's distribution and satisfies the stress.

The proposed framework is model-free and allows for stresses such as (a) the mean and variance, (b) any distortion risk measure including the Value-at-Risk and Expected-Shortfall, and (c) expected utility type constraints.

5 - Transport Type Metrics Involving Singular Base Measures and Applications in Game Theory and Economics

Brendan Pass

We develop the theory of a metric on the set of probability measures on a given domain in Euclidean space. This metric is based on a slight refinement of the notion of generalized geodesics with respect to a base measure ν and is relevant in particular when ν is singular with respect to Lebesgue measure; it is also closely related to linearized optimal transport. We discuss several properties and applications; special attention is paid to a proof of convergence of an iterative scheme to solve a variational problem arising in game theory. This is joint work with Luca Nenna.

MC12

34th FI-Seymour

Energy Policy & Planning

Contributed Session

Chair: Antoine Lesage-Landry

Polytechnique Montréal, Montréal, QC, H3C 3A7, Canada

2 - EV Charging Stations Planning with PV Carports Considering the Graph Theory and Net-metering Scheme

Caio dos Santos, Researcher, University of Campinas, Campinas, Brazil, caiodos.santos@hotmail.com

José Carlos Andrade, Christiano Lyra

This paper proposes a strategy to allocate and size charging stations (CS) for electric vehicles (EV) combined with carport PV systems. The mixed-integer linear programming model finds optimal locations and sizes of the CS based on graph theory and minimizes the investment and operation costs to indicate proper sizes of the carport PV considering the net-metering scheme. A Brazilian case is used to test the strategy and certify the benefits of the proposals. The results show that any CS does not cover up to 140 km (almost half of the EV's range) of EV travel due to the strategic deployment.

3 - Balancing Cost and Resilience: Distributed Energy System Design and Dispatch

James Grymes, Major, Colorado School of Mines, Golden, CO, United States

As the frequency and duration of grid outages increase, backup power systems are becoming more important for ensuring critical infrastructure can continue to provide essential services. Distributed energy resources such as solar, storage, and combined heat and power are increasingly common sources of onsite power generation. However, a system sized to maximize economic savings may be insufficient to sustain the critical load for an extended outage. In this work, we solve a multi-objective mixed integer linear program to explore the tradeoffs between cost and resilience.

4 - Robust Optimal Sizing of a Stand-alone Hybrid Renewable Energy System Using Dynamic Uncertainty Sets

Ali Keyvandarian, PhD Candidate, Dalhousie University, Halifax, NS, Canada, ali.keyvandarian@dal.ca

Ahmed Saif

The research presents robust optimal sizing of an isolated hybrid renewable energy system (HRES) composed of wind turbines, solar photovoltaic panels, a battery bank, and a diesel generator. Unlike classic robust HRES sizing models that capture the unpredictable nature of renewable energy sources via static uncertainty sets, we use dynamic uncertainty sets (DUSs) that account for the temporal correlations in wind and solar power outputs. The DUSs are constructed based on time series models selected via a statistical framework to have the best description of wind

and solar power output behavior. An iterative algorithm based on column-and-constraint-generation is developed to solve the problem.

5 - Geometric Time Aggregation for RCPSP and Its Application to Underground Mining

Eduardo Moreno, Universidad Adolfo Ibáñez, Santiago, Chile, eduardo.moreno@uai.cl

Rodrigo A Carrasco, Diego Fuentes

Resource-constrained Project Scheduling Problems (RCPSP) naturally appear in the context of strategic mine planning. In particular, underground mining problems require a fine time granularity, making them very hard to solve using current tools. We propose a geometric aggregation of the time periods for RCPSPs to reduce the size of the problem. This technique balances the discount-rate effect of the NPV with the number of jobs in later periods. We show that this aggregation provides a theoretical ϵ -approximation algorithm. Extensive computational experiments show that this approximation is better in practice, particularly for real underground mine planning problems.

6 - Optimally Scheduling Public Safety Power Shutoffs

Antoine Lesage-Landry, Polytechnique Montréal, Montréal, QC, Canada

Félix Pellerin, Joshua A Taylor, Duncan S Callaway

In an effort to reduce power system-caused wildfires, utilities carry out public safety power shutoffs (PSPS) in which portions of the grid are de-energized to mitigate the risk of ignition. The decision to call a PSPS must balance reducing ignition risks and the negative impact of service interruptions. In this work, we consider three PSPS scheduling scenarios, which we model as dynamic programs. We provide optimal or asymptotically optimal policies for each case, the first two of which have closed-form expressions. Lastly, we show the equivalence between the first PSPS model and critical-peak pricing, and obtain an optimal scheduling policy to reduce the peak demand based on weather observations.

MC13

34th Fl-Stanley

Market Design in the Service Sector

General Session

Chair: Vibhuti Dhingra

2 - Privacy-Preserving Personalized Revenue Management

Murray Lei, Queen's University, Kingston, ON, K7L 3N6, Canada, yl64@queensu.ca

Sentao Miao, Ruslan Momot

We examine how data-driven personalization can be made while preserving consumer privacy. We consider a firm that chooses a personalized price based on each new customer's individual features but needs to learn individual demand generating parameters from data. We extend a classical framework of personalized pricing by requiring also that the pricing policy preserves consumer privacy, or formally that it be differentially private. We find that with a sufficient amount of historical data in hand, firms can achieve privacy at a cost of the same order as the "classical" loss in revenue due to estimation error. We also extend our analysis to the setting of personalized assortment optimization."

3 - Optimal Subscriptions for Ridesharing Platforms

Ben Berger, Tel Aviv University, Tel Aviv, Israel

Ben Berger, Columbia Business School, New York, NY, United States

Hongyao Ma, David C. Parkes, Shreyas Sekar

We study the use of subscriptions in ridesharing platforms such as Uber. We model the operations of these platforms under network effects - higher idle supply implies lower rider pickup time and lower driver idle time. We show that real time prices cannot maximize welfare alone, but together with subscriptions they can if riders are homogeneous or differ in riding frequency. Finally, we show how such subscriptions can be designed using only information observable from a Walrasian equilibrium.

4 - How Does Popularity Information Affect Product Design

Guangrui(Kayla) Li, York University, Toronto, ON, Canada, kaylali@schulich.yorku.ca

Zheng Gong

Popularity information serves as quality signal for consumers. Past literature has shown that the revealing popularity information herds consumers to the popular products and leads to a superstar phenomenon. However, the previous literature takes the product design as given. In this project, we examine the impact of popularity information revealing on firms' product design strategy by using a policy change on Wechat Official Account platform. Interestingly, we found that the revealing of popularity information leads to less clicks for the top influencers. Furthermore, top influencers reduced advertising after popularity information shock, but topic choice remained unchanged.

5 - The Effect of Expedited Payments on Project Delays: Evidence from Quickpay Reform

Vibhuti Dhingra, Schulich School of Business, York University, Toronto, ON, Canada, vibhuti@schulich.yorku.ca

Volodymyr O Babich, Harish Krishnan, Jie Ning

Contractors are typically not paid instantaneously upon completing the project tasks and furnishing the invoice. We study the impact of payment timings on project delays. We develop theories that explain how payment duration affects project completion, and generate testable hypotheses. We empirically test these hypotheses using data on U.S. public projects. Our identification strategy uses a policy amendment that expedited payments to certain federal contractors as an exogenous shock.

MC14

34th Fl-Cypress

Combinatorial Optimization

Contributed Session

Chair: Boris Grimm

Zuse Institute Berlin, Berlin, 10555, Germany

2 - Maximal Perimeter of a Convex Small Polygon

Christian Bingane, Polytechnique Montreal, Montreal, QC, Canada, christian.bingane@polymtl.ca

A small polygon is a polygon of unit diameter. The maximal perimeter of a convex small polygon with $n=2^s$ sides is unknown when $s \geq 4$. In this work, we construct a family of convex small n -gons, $n=2^s$ with $s \geq 4$, and show that their perimeters are within $O(1/n^8)$ of the maximal perimeter. From this result, it follows that Mossinghoff's conjecture on the diameter graph of a convex small 2^s -gon with maximal perimeter is not true when $s \geq 4$.

3 - A Lyapunov Function Approach for Approximation Algorithm Analysis in Submodular Maximization

Donglei Du, Professor, University of New Brunswick, Fredericton, NB, Canada, ddu@unb.ca

The Lyapunov function approach has been widely adopted in control theory and in mathematical programming to analyze the stability and convergence of various algorithms. We extend this approach to the design and analysis of approximation algorithms as a systematical framework in both continuous-time and discrete-time settings. We then propose using the exponential integrator method systematically to transform continuous-time algorithms to discrete-time implementations. We use various submodular

maximization problems, which has recently gained huge attraction and momentum in machine learning, as running examples to illustrate these two frameworks.

4 - ***Late Cancelation - Coordination of Drills in an Open-pit Mine: Constraint Programming Formulations

Mohamed Maftah, Polytechnique Montréal, Montréal, QC, Canada, mohamed.maftah@polymtl.ca

Michel Gamache, Michel Gendreau, Bruno Agard

We introduce a vehicle routing and scheduling type of problem where (1) the underlying graph dynamically changes as nodes are visited, (2) the availability of the tasks that are to be performed depends on the position of the vehicles and (3) the relative positions of the vehicles with respect to each other are constrained. This problem arises in open-pit mines when trying to coordinate multiple electrical drilling machines. In order to solve this problem -as well as an extension of it- we propose two constraint programming models with the objective of minimizing the makespan. In order to accelerate the solving process we develop a heuristic algorithm that constructs a starting point.

5 - Optimizing Aircraft Engines' Maintenance Schedule

Mohammad Rahim Akhavan Kazemzadeh, Air Canada, Montreal, QC, Canada, mohammadrahim.akhavankazemzadeh@aircanada.ca

Keith Dugas

Engines are the most valuable and complex assets of an airline. Approximately half the maintenance cost is related to engine maintenance events. Regulatory agencies mandate that an airline upholds a maintenance program based on three core constraints, the number of hours/cycles or calendar days that have accumulated since the last refurbishment of a component installed on an engine. The problem complexity for an engine's life span is in millions of variables. In this presentation, we explore how Air Canada built a strategic planning tool that determines the optimal schedule of engines' shop visits by minimizing its total remaining life while considering extensive list of operational constraints.

6 - Solving Combinatorial Optimization Problems with Fujitsu's Quantum Inspired Digital Annealer

Claudia Cambero, Fujitsu, Vancouver, BC, Canada

Jeffrey English, Portia Murray, Shivam Verma

Classical optimization solvers have frequently struggled with NP-hard problems, particularly for large-scale combinatorial optimization problems. Fujitsu's Digital Annealer is a

quantum-inspired computing solution solving combinatorial optimization problems in quadratic unconstrained binary optimization (QUBO) form. This talk introduces the QUBO approach for scheduling optimization problems and provides examples of recent applications by Fujitsu Intelligence Technology's Team using the Digital Annealer to digitally transform healthcare, field service, and production scheduling by creating solutions to problems in these areas.

7 - Railway Rolling Stock Optimization with Maintenance Paths

Boris Grimm, Freie Universität Berlin, Berlin, Germany

Boris Grimm, Zuse Institute Berlin, Berlin, Germany

Ralf Borndörfer, Julian Bushe

The Rolling Stock Rotation Problem is the task of a cost optimal assignment of railway rolling stock to trips such that all operational requirements are satisfied. Typically, vehicle maintenance is one of these requirements and the focus of this talk. A novel IP model is presented which is based on the work of Borndörfer et. al.(2016) but in contrast uses maintenance paths for individual vehicles to model maintenance requirements. To solve the model different column generation procedures were implemented, evaluated on real world instances and compared with each other in terms of runtime and solution quality.

MC15

34th FI-Grouse

CORS Open Student Paper Competition

General Session

Chair: Nadia Lahrichi

Ecole Polytechnique de Montreal, Montreal, QC, H3C3A7, Canada

Monday, 3:30–4:30pm

MP02

3rd FI-Regency CD

Plenary Panel: Role of Operations Research in Pandemic Preparedness: Lessons Learned from COVID-19

Plenary Session

1 - Moderator

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States

2 - Panelist

John R Birge, University of Chicago, Chicago, IL, 60637-1656, United States

3 - Panelist

Margaret L Brandeau, Stanford University, Stanford, CA, 94305-4121, United States

4 - Panelist

Mahesh Nagarajan, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada

Tuesday, 8:30–10am

TA04

2nd Fl-Plaza B

Supply Chain Management II

Contributed Session

Chair: Foad Esmaeili

Concordia University

Chair: Foad Esmaeili

Hitek Logistic Inc.

2 - An Improved Possibilistic TOPSIS Model with Application

Srimantoorao S Appadoo, Professor, University of Manitoba, Winnipeg, MB, Canada, ss.appadoo@umanitoba.ca

Yuvraj Gajpal

This paper extends the TOPSIS model proposed by Ye and Li(2014) to include the centered possibilistic variance to calculate the relative closeness. The TOPSIS model provided by Ye and Li(2014) does not consider the deviations between the mean in the computation of variance formula. Hence, the TOPSIS method proposed by Ye and Li(2014) is very restrictive. We pointed out this flaw in their TOPSIS methodology and provided the correct procedure. We apply the new proposed TOPSIS model to select the best Covid Vaccine.

3 - Substitution of Provider and Firm

Cybersecurity Investments in Supply Chains

Hooman Hidaji, Assistant Professor, University of Calgary, Calgary, AB, Canada

As cybersecurity threats become more prevalent and IT supply chains more intertwined, providers and firms need to invest in cybersecurity to secure their supply chain. A critical managerial problem is the level and interaction of

the cybersecurity efforts and investment by the provider and firms. We use a general-form analytical model to study this problem in presence of downstream competition. We find that depending on the level of competition among firms, the providers' and firms' investment in cybersecurity may either substitute or complement one another. We discuss the important implications of our findings for firms, providers, and policy-makers.

4 - Dynamics of Contagion Effect

Alireza Azimian, University of Windsor, Windsor, ON, Canada, aazimian@uwindsor.ca

Competing firms often benefit from each other's failures because of demand shifts; however some events adversely affect other firms in the industry, a phenomenon known as "contagion". While contagion is generally initiated by extreme events, cases such as the Mad Cow crisis in Canada in 2003 indicate that contagion can also be initiated by non-severe events. Aiming to enable firms to evaluate their contagion risks, we combine the cases of contagion with the relevant literature to conceptualize the process of contagion and the contributing factors. We posit that the signal-value of the event and the identity of the focal-firm's stakeholder plays the central role in the contagion process.

5 - Using Hashing Methods to Categorize Data Into Buckets to Improve Query Execution Performance

Foad Esmaeili, Research Assistant, Concordia University, Montreal, QC, Canada

Foad Esmaeili, Research Assistant, Hitek Logistic Inc., Montreal, QC, Canada

Richard Cote, Fereshteh Mafakheri, Fereshteh Mafakheri

Long execution performance time to fetch data from a database lowers user experience of a website. How fast data is fetched from a database becomes more vital in websites dealing with supply chains since an origin and a destination are needed to be queried to handle a shipment. In this study, hashing methods are implemented to categorize data into predetermined buckets. Therefore, auditing a shipment is performed on one specific bucket of data rather than the whole data. Such a system cuts down the query execution time and enables the website to deliver better user experience.

TA05

2nd Fl-Plaza C

Machine Learning I

Contributed Session

Chair: Nima Aminpour
University of Calgary, Calgary, AB, Canada

2 - Truncated LinUCB for Stochastic Linear Bandits

Yanglei Song, Assistant Professor, Queen's University,
Kingston, ON, Canada, yanglei.song@queensu.ca
Meng Zhou

We consider linear bandits with i.i.d. contexts. The popular LinUCB algorithm is shown to have a cumulative regret that is suboptimal in the dimension d and time horizon T , due to its over-exploration. A truncated version is proposed and termed Tr-LinUCB, which follows LinUCB up to a truncation time S and performs pure exploitation afterwards. The Tr-LinUCB algorithm achieves $O(d \log(T))$ regret if $S = Cd \log(T)$ for a sufficiently large constant C , and a matching lower bound is established, which shows its rate optimality in both d and T under a low dimensional regime. Further, if $S = d \log^2(T)$ for some $\beta > 1$, the loss compared to the optimal is a multiplicative $\log(T)$ factor, which does not depend on d .

3 - Towards Diffusion Approximations for Stochastic Gradient Descent Without Replacement

Stefan Perko, Friedrich Schiller University Jena, Jena, Germany, stefan.perko@uni-jena.de

Stochastic gradient descent without replacement (SGDo) is predominantly used to train ML models in practice. However, the theory of this algorithm remains underexplored compared to its "with replacement" and "infinite data" counterparts. We propose an approximation to SGDo based on a family of SDE's driven by a stochastic process we call (an) epoched Brownian motion (EBM). We investigate this diffusion approximation by considering an application of SGDo to linear regression. Explicit convergence results are derived. Finally, the validity of approximations with EBM's are further substantiated by numerical experiments.

4 - Unconstrained Demand Forecasting for a Major Recreational Products Manufacturer

Lea Gauthier, PhD, IVADO Labs Inc, Montreal, QC, Canada, lea.gauthier@ivadolabs.com
Greta Laage, Srushti Dhope, Louis-Philippe Bigras, Yossiri Adulyasak, Maxime Cohen, Emma Frejinger

The powersport market is very dynamic in North America, with lots of competitors, production innovation and societal trends transforming the way people want to explore outdoors. All these factors make market planning difficult for BRP's teams in charge of demand forecasting. To top it all off, COVID 19 recently created a sudden demand spike and supply issues further disrupting the industry. In this

presentation, we aim to propose an ML based approach to forecast future sales coupled with strategies to estimate missed passed opportunities due to inventory shortages.

5 - Discovering Trip Purposes and Patterns with Probabilistic Topic Modeling Using Transit Smart Card Data

Nima Aminpour, Graduate Student (M.Sc.), University of Calgary, Calgary, AB, Canada, nima.aminpour@ucalgary.ca
Saeid Saidi

Using subway AFC (Auto Fare Collection) datasets, this study uses probabilistic topic modeling based on an adaptation of the Latent Dirichlet Allocation, to discover activity type for each transit trip. The emphasis is on discovering more detailed categories of activities, rather than just focusing on work or home activities. Furthermore, determines the impact of the pandemic on each discovered categories.

TA06

3rd Fl-Regency A

Tutorial: OR and Analytics for Public Policy: Lessons from the Pandemic

Tutorial Session

1 - OR and Analytics for Public Policy: Lessons from the Pandemic

Peter Frazier, Cornell University, Ithaca, NY, 14853, United States, pf98@cornell.edu

The COVID-19 pandemic laid bare gaps in governments' ability to base policy on data and quantitative reasoning. This talk argues that OR and analytics can help craft more effective policy and that the COVID-19 crisis has created a window of opportunity for change. We draw lessons from the speaker's experience at Cornell University, where OR is a fundamental part of the university's pandemic response. We focus on practical tools and techniques for policy-focused OR-based decision support in public health and other public- and private-sector decision domains.

TA07

3rd Fl-Regency B

Emergency Care Operations

General Session

Chair: Saied Samiedaluie

University of Alberta, University of Alberta,
Edmonton, AB, T6G 2R6, Canada

2 - Models of the Impact of Triage Nurse

Standing Orders on Emergency Department Length of Stay

Saied Samiedaluie, University of Alberta, Edmonton, AB, T6G 2R6, Canada, samiedal@ualberta.ca

Vera Tilson, Armann Ingolfsson

Standing orders allow triage nurses in emergency departments (EDs) to order tests for certain medical conditions before the patient sees a physician, which could reduce the patient's ED length of stay (LOS). Several studies in the medical literature documented a decrease in average ED LOS for a target patient population, resulting from the use of standing orders. We formulate models of the operational impact of standing orders and test several policies for whether to order tests at triage for individual target patients, as a function of ED congestion. We find that a threshold policy, with a threshold whose value can be estimated easily from model primitives, performs well across a wide range of parameter values. We demonstrate potential unintended consequences of the use of standing orders, including over testing and spillover effects on non-target patients.

3 - Patient Selection by Emergency Physicians During Their Shift

Mahdi Shakeri, University of Calgary, Calgary, AB, T3A 2E6, Canada, mahdi.shakeri@ucalgary.ca

Marco Bijvank

We study the patient selection decision-making of physicians in emergency departments throughout their shift when multiple patient types are present in the waiting area. Usually, physicians prioritize patients based on their severity score or waiting time. However, when physicians get closer to the end of their shift, they need to be more mindful which patient to select next for initial assessment. We present a time-dependent patient selection policy that considers patients' clinical and operational characteristics as well as the remaining time in a physician's shift.

4 - Predicting Heart Attack Incidence in Alberta

Amir Rastpour, Ontario Tech University, Oshawa, ON, L1H 7K4, Canada, amir.rastpour@ontariotechu.ca

Reidar Hagtvædt, Armann Ingolfsson, Padma Kaul

Knowledge of heart attack incidence rates in different geographical jurisdictions can help health care authorities utilize treatment capacity effectively and efficiently. In this research, we use empirical data from Alberta and apply a Poisson regression model with a linear link function to estimate the heart attack occurrence rate in the province granularized by postal codes. The model is based on age, education, and income level variables.

TA08

3rd Fl-Regency E

Applications in EMS Operations and Planning

General Session

Chair: K.H. Benjamin Leung

University of Toronto, United States

2 - Modeling Volunteer Response in Emergency Medical Services

Hemeng Li, Cornell University, Ithaca, NY, 91711, United States, hl2359@cornell.edu

Shane Henderson, Caroline Jagtenberg,

Pieter van den Berg

Out of hospital cardiac arrest requires immediate treatment and patient survival can be improved by combining traditional ambulance response with the dispatch of volunteers alerted via an app. We model the presence of volunteers throughout a region as a Poisson point process and derive analytical expressions for the response time distribution and survival rates. Moreover, we consider the optimal volunteer location distribution that maximizes survival rates to guide the recruitment of volunteers, both in terms of the number of volunteers needed to make a substantial impact on survival rates and in city locations where additional recruitment would be most beneficial.

3 - The Fine Line Between Life and Death: Strategic Placement of Citizen Responder System Defibrillators

Derya Demirtas, Assistant Professor, University of Twente, Enschede, 7511 HN, Netherlands, d.demirtas@utwente.nl

Robin Buter, Marieke Blom, Ruud W Koster, Stieglis Remy, Erwin Hans, Hendrik Koffijberg

Citizen Responder Systems alert nearby volunteers via smart phones and guide them to the cardiac arrest victim. Some volunteers are also asked to retrieve a close by automated external defibrillator (AED). However, numerous AEDs are barely used due to poor location choices. In this study, we develop a GRASP algorithm that dynamically creates candidate AED locations and chooses near-optimal locations for new AEDs. Large instances can easily be solved since locations are created dynamically, keeping the problem size manageable. We apply this methodology to North Holland and show that the coverage can increase significantly. On a municipality level, relative improvements range from 1% to 122%.

4 - Fairness-Efficiency Tradeoff in Public Defibrillator Placement

K.H. Benjamin Leung, University of Toronto, Toronto, ON, Canada, benkh.leung@mail.utoronto.ca

Gareth Clegg, Diane Lac, Timothy Chan

Integer linear programming can be used to determine optimal locations of public defibrillators for out-of-hospital cardiac arrest. Prior research has focused on maximizing spatial coverage of new defibrillators for nearby cardiac arrests; however, this can lead to allocations that are inequitable across neighborhoods in practice. We introduce a formulation of the maximum coverage location problem (MCLP) that optimizes for fairness using the Nash social welfare function, and compare the standard and fairness-based MCLP on historical cardiac arrests in four cities across Scotland.

TA10

3rd Fl-Balmoral/Windsor

Banking Analytics

General Session

Chair: Cristian Bravo

University of Western Ontario, London, ON, N6A 5B7, Canada

2 - The Impact of Gender and Ethnic Board Diversity on Corporate Debt Issuance

Yuhao (Jet) Zhou, Western University, London, ON, Canada, yzo82@uwo.ca

Collins Ntim, Matt Davison, Cristián Bravo Roman

The purpose of this study is to investigate the impact of diversified boards regarding the issuance of debt on the U.S. financial market. The companies included in the SP1500 index were selected, as they are representative of the overall economy of the United States, and the index contains a variety of company sizes. Among the companies included in the study are over 700 boards and over 15000 bonds issued by those firms. The results of using regression analysis suggest that cost and diversification have a significant relationship. Considering that regulators in Europe, the U.S., and Canada all promote diversification, the results of the study are consistent with their policy.

3 - Credit Limit Adjustment Using Reinforcement Learning

Sherly Alfonso-Sánchez, Western University, London, ON, Canada, salfonso@uwo.ca

Sherly Alfonso-Sánchez, Universidad Nacional de Colombia, Bogotá, Colombia, salfonso@uwo.ca

Kristina Sendova, Cristián Bravo Roman

Reinforcement learning has been explored for many kinds of problems, from video games with deterministic environments to portfolio management with stochastic behavior. In our work, we seek to find and automatize an optimal policy to credit limit adjustment. We simulated the impact of those actions based on historical data provided from a Supper-App company in Latin America to train the models. Our work represents a data-driven process for limit adjustment considering not only the net profit but also the provisions required, thus can lead to improvements and more consistent processes in risk management.

4 - Dynamic Multilayer Graph Neural Networks for Credit Risk Analytics

Sahab Zandi, Western University, London, ON, Canada, szandi@uwo.ca

Sahab Zandi, University of Southampton, Southampton, United Kingdom, szandi@uwo.ca

María Óskarsdóttir, Christophe Mues, Cristián Bravo

Graph Neural Network (GNN) has been mostly used for single-layer static networks in which nodes are linked based on one source of connection while the network remains unchanged over time. In this work, we study multilayer dynamic networks which are comprised of multiple time-varying layers, each of which representing a source of connection. The aim of this research is to leverage these networks within GNNs and to study their applications to the problem of credit risk modelling. Preliminary results demonstrate that, when it comes to predicting probability of default for the clients, our proposed model brings interesting insights compared to traditional methods such as network-enhanced regression.

5 - A Granular-level Stress Testing Methodology for Financial Institutions

Joëlle Zavitz, The University of Western Ontario, London, ON, Canada, jzavitz8@uwo.ca

Cristian Bravo Roman, Nicholas Atkins

Financial institutions are mandated by law to stress test their credit risk models to evaluate their exposure. Historical financial crises revealed weaknesses in stress testing practices, including the presence and implementation of standard, publicly-available stress testing methods. This presentation will introduce a replicable, granular-level stress testing methodology that assesses the robustness of credit scorecards given an economic shock. The methodology calibrates a credit scorecard for each consumer, defines a set of scenarios, and trials two approaches, economic and data-driven, to stress the scorecards.

TA11

3rd Fl-Oxford/Prince of Wales

Risk Pricing and Optimization

General Session

Chair: Fangda Liu

University of Waterloo, Atlanta, GA, 30326,
United States

2 - On Stochastic Approximation and Option Pricing

Anne MacKay, Université de Sherbrooke, Sherbrooke, QC,
Canada, anne.mackay@usherbrooke.ca

Michael A Kouritzin

We consider almost sure convergence rates of averaged linear stochastic approximation algorithms, when applied to data with triangular dependence structure. We find that when the data is replaced by its running average in the algorithm, convergence may be faster. We then obtain rates of convergence of price estimates in the context of American option pricing via a dynamic programming algorithm with stochastic approximation. From a methodological point of view, our results show that using averaged data in the pricing algorithm leads speeds of convergence that are more robust to the choice of parameters.

3 - Estimation of the Adjusted Standard-deviatile for Extreme Risks

Fan Yang, University of Waterloo, Waterloo, ON, N2L
3G1, Canada

In this paper, we modify the Bayes risk for the expectile, the so-called variantile risk measure, to better capture extreme risks. The modified risk measure is called the adjusted standard-deviatile. First, we derive the asymptotic expansions of the adjusted standard-deviatile. Next, based on the first-order asymptotic expansion, we propose two efficient estimation methods for the adjusted standard-deviatile at intermediate and extreme levels. By using techniques from extreme value theory, the asymptotic normality is proved for both estimators. Simulations and real data applications are conducted to examine the performance of the proposed estimators.

4 - Deep Reinforcement Learning for Dynamic Expectile Risk Measures: An Application to Equal Risk Option Pricing and Hedging

Jonathan Yumeng Li, University of Ottawa, ON, Canada
Erick Delage, Saeed Marzban

In this talk, I will present a new deep reinforcement learning (DRL) method for solving risk-averse dynamic programming problems. Prior to our work, most risk-averse dynamic programs can only be solved based on static risk measures, leading to time-inconsistent policies, or based on dynamic programming solution schemes that are impracticable in realistic settings. Our work extends for the first time the deep deterministic policy gradient algorithm, an off-policy actor-critic reinforcement learning (ACRL) algorithm to solve dynamic programs formulated based on time-consistent dynamics expectile risk measures. Our numerical experiments confirms that the new ACRL algorithm produces high quality solutions for the application of equal-risk pricing and hedging problems and that the generated hedging strategy outperforms the strategy produced using a static risk measure when the risk is evaluated at later points of time.

5 - Insurance with Heterogeneous Preferences

Fangda Liu, University of Waterloo, Waterloo, ON, 30326,
Canada, fangda.liu@uwaterloo.ca

Tim Boonen

This presentation introduces an optimal insurance problem with finitely many individuals who have heterogenous preferences. A monopolistic, risk-neutral insurer applies linear pricing, and cannot discriminate in the insurance premium rate. In the first model individuals can self-select their insurance coverage given the premium rate. In the second model, the insurer offers only one insurance contract and individuals can either buy it or not. We determine the close-form solutions to two models. Since the preferences of individuals are generally unobserved, we also present a simulation-based framework in which we simulate the risk-aversion parameters of the individuals.

TA12

34th Fl-Seymour

David Martell Student Prize

General Session

Chair: Foroogh Abasian

FPIInnovations, FPIInnovations, Quebec, QC, Canada

2 - A Robust Optimization Model for Tactical Planning of the Forest-based Biomass Supply Chain for Syngas Production

Sahar Ahmadvand, University of British Columbia,
Vancouver, BC, V6T2G9, Canada

Taraneh Sowlati

Production of bioenergy and biofuels from forest biomass provides an economically attractive use of an otherwise wasted material. However, the forest biomass supply chain has many challenges and uncertainties that impact its economic performance. In this paper, the supply chain of forest-based biomass for syngas production is optimized at the tactical level considering uncertainties. A robust optimization model is developed and applied to the case of a pulp mill in BC. The supply chain cost in the robust model is 67% higher than that of the deterministic model. But, the robust model provides a single optimal solution that is feasible for all parameter values in the considered uncertainty intervals.

3 - Prediction of Softwood Lumber Prices Using a Multivariate Descriptive Model, Submitted in Journal of Applied Statistics

Mohamed Sami Ben Ali, doha, Doha, 2713, Qatar

4 - A Goal Programming Model for the Optimization of Log Logistics Considering Sorting Decisions and Social Objective

Salar Ghotb, University of British Columbia, Vancouver, BC, Canada

Taraneh Sowlati

Log logistics include sorting, processing, and transporting of logs from their place of harvest to demand locations. These activities account for a significant portion of the total log procurement costs; therefore, attempts were made in previous studies to optimize some aspects of log logistics. However, operational details, such as sorting decisions, truck compatibility requirements, and social objectives, are often disregarded in the optimization literature. Incorporating these details into the model makes the results more realistic and applicable. To address these gaps, a bi-objective mixed-integer programming model is developed in this paper to optimize log logistics. The first objective is to minimize total logistics costs, and the second objective is to provide a balanced workload for trucking contractors. The bi-objective model is solved using the goal programming approach. The model is applied to log logistics of a large Canadian forest company, where trucking contractors use heterogeneous fleet of trucks to carry various log sorts from cutblocks to sort yards for sorting. The planning horizon is 4 weeks with daily decisions. The goal programming model generates balanced workloads for the contractors with less than 0.4% increase in total costs compared to the single objective model where only the total cost is minimized.

TA13

34th Fl-Stanley

New-tech Enabled Market Design

General Session

Chair: Wei Qi

McGill University, McGill University, Montreal, QC, H3A 1G5, Canada

Chair: Yan Zhang

McGill University, Montreal, QC, Canada

3 - Price Competition in the Presence of Social Comparison and Demand Uncertainty

Yun Zhou, McMaster University, Hamilton, ON, L9A 0A3, Canada, zhouy185@mcmaster.ca

Tony Haitao Cui, Ming Hu, Zhoupeng (Jack) Zhang

We consider the price competition between a duopoly selling differentiated substitutable products under additive demand uncertainty, in which firms' decisions are influenced by social comparison. We demonstrate how opposite-directional social comparisons interact with demand variability to change competitive behaviors. We show that the stronger the behind aversion behavior, the more intense the price competition. Surprisingly, there is a threshold on the market variability above which price competition is more alleviated and below which price competition is more intensified, when the firms exhibit stronger ahead-seeking behavior.

4 - Courier Dispatch in On-demand Delivery

Mingliu Chen, Columbia University, New York, NY, 10128, United States

We study a courier dispatching problem in an on-demand delivery system where customers are sensitive to delay. The effect of temporal pooling is evaluated by comparing systems using the dedicated strategy, where only one order is delivered per trip, vs. the pooling strategy, where a batch of consecutive orders is delivered per trip. We capture the courier delivery system's spatial dimension by assuming that following a Poisson process, demand arises at a uniformly generated point within a disk-shaped service region. With revenue maximization, we find that the dispatching strategy depends critically on customers' patience level, the size of the region, and whether the firm can endogenize the demand.

5 - Implications of Worker Classification in On-Demand Economy

Zhoupeng (Jack) Zhang, Rotman School of Management, University of Toronto, Toronto, ON, M5S 3L1, Canada, zhoupeng.zhang@rotman.utoronto.ca

Ming Hu, Jianfu Wang

How shall gig workers be classified? We approach this policy question with a focus on the welfare of long-term (LT) workers, who take gig jobs as primary rather than supplemental income sources. Compared with the status quo of the contractor mode, we show that uniform classifications (the employee and the contractor+ mode) suffer from issues of workers being undercut or overjoining and will not always make LT workers better off. Discriminatory approaches such as to classify gig workers according to their needs or to operationally prioritize LT workers can Pareto improve over uniform classifications. Our work highlights the importance of worker type-dependent regulations in the on-demand economy.

6 - Combining a Smart Pricing Policy with a Simple Replenishment Policy: Managing Uncertainties in the Presence of Stochastic Purchase Returns

Alys Liang, PhD Candidate, University of Michigan, Ross School of Business, Ann Arbor, MI, United States, jiaxinl@umich.edu

Stefanus Jasin, Joline Uichanco

It is generally accepted in the industry that returns are inevitable and often considered as the necessary cost of doing business. The ever-increasing rates of returns have prompted businesses to properly manage their reverse logistics system. In this paper, we consider a single warehouse joint inventory and pricing problem in the presence of stochastic purchase returns. A key feature of our model is that we allow a general stationary (random) return time distribution. We propose an easy-to-implement joint inventory and pricing policy and show that it is near optimal in the setting with a large annual market size, which is a practically relevant setting for many product categories.

TA14

34th FI-Cypress

Queueing Models and Applications

General Session

Chair: Zhe George Zhang

Western Washington University, Western Washington University, Bellingham, WA, 98225-9077, United States

Chair: Jing Dong

Columbia University, New York, NY, 10027-6945, United States

3 - Algorithms for Queueing Systems with Reneging and Non-preemptive Priorities Modeled as Quasi-birth-death Processes

Amir Rastpour, Ontario Tech University, Oshawa, ON, L1H 7K4, Canada, amir.rastpour@ontariotechu.ca

Armann Ingolfsson, Burhaneddin Sandikci

We have recently developed an iterative algorithm for a class of infinite level-dependent quasi-birth-and-death (LDQBD) systems, which includes the Erlang A system with two impatient customer classes where one class has a preemptive priority over the other class. Our algorithm calculates stationary probabilities with any desired accuracy and provides bounds on performance measures that can be expressed as a probability. In this presentation, we focus on extending the algorithm for systems with non-preemptive priorities and calculating performance measures that are not in the form of a probability.

4 - Difference Equations Approach for Multi-server Queueing Models with Removable Servers

Douglas Down, McMaster University, Hamilton, ON, L8S 4L8, Canada, downd@mcmaster.ca

James Kim, Mohan L Chaudhry, Abhijit Datta Banik

We consider queueing systems with both static (always available) and dynamic (removable) servers. The two server groups may have homogenous or non-homogenous service rates. We first summarize various approaches for analyzing such models. We then show that the difference equations approach achieves higher numerical efficiency than the direct method. While the model of this queueing system is not new, the methodology for solving it is. We conclude by discussing some open problems/directions.

5 - The Relationship Between Expected Service Times and Service Rates for State-dependent Queues

Likang Ding, PhD Candidate, University of Alberta, Edmonton, AB, T5A 5G9, Canada, likang@ualberta.ca

Bora Kolfal, Armann Ingolfsson

Queueing models are typically formulated in terms of service rates but recent empirical queueing research focuses on expected service times. We study service times in Markovian queueing models with state-dependent service rates. Our research question is to analyze the relationship between service rates and expected service times. We provide closed-form solutions to convert service rates into expected service times and vice versa. In general, expected service times are not the inverse of service rates, and state-dependent

service times are not exponentially distributed. We find conditions under which monotonicity in service rates implies monotonicity in expected service times and vice versa.

6 - Maximizing Client Satisfaction in Queues with Time-varying Arrival Rates

Leila Rabiei Fard, Graduate Student, University of Saskatchewan, Saskatoon, SK, Canada, ler451@usask.ca
Ebrahim Samei, Hamed Samarghandi

This study considers a queue with time-varying arrival rate. We consider various staffing scenarios, including those that result in refusal of service to clients due to staffing and resource shortages. Under each considered scenario, the utility functions of the service provider and the clients are developed and the visit and wait time to maximize each are investigated. Finally, the cases where client satisfaction and the establishment's profit maximization goal push the visit time in different directions are identified. These circumstances call for more regulation to protect the customers when the service provider delivers a service on behalf of a government entity.

TA15

34th FI-Grouse

Application-Driven Decision-Making Under Uncertainty

General Session

Chair: Danielle Ripsman

University of Waterloo, University of Waterloo,
Waterloo, ON, N2L 3G1, Canada

2 - Performance Analysis of Probabilistic and Robust Optimization: An Special Case of Left-hand Side Breast Cancer

Amirhossein Vaeztehrani, University of Waterloo,
United States

Houra Mahmoudzadeh

In radiation therapy, one of the challenges that may cause a discrepancy between the planning and delivery phases is the uncertainty caused by different sources like errors in delineation and body positioning. This paper focuses on modeling the geometry uncertainty due to breathing motions by stochastic and robust approaches and comparing the results in terms of solution complexity and clinical quality.

3 - A Defender-attacker-defender Approach To Robust Optimization For The Kidney

Exchange Problem With Non-Homogeneous Uncertainty

Carolina Riascos, University of Toronto, Toronto, ON, M6G 2A1, Canada, carolina.riascos@mail.utoronto.ca

Merve Bodur, Dionne Aleman

Two-stage robust optimization models for the kidney exchange problem have been shown to follow the structure of a defender-attacker-defender game model to plan for back-up transplants when the initially selected ones fail in practice. We show that the attacker's problem can be reformulated as a feasibility-seeking problem. Besides homogeneous vertex/arc failures, our model also considers different failure budgets between vertices and arcs. We test our model on publicly available instances, and find significant computational improvements over state-of-the-art approaches in most cases.

4 - Robust Short-Term Underground Mine Planning Using a Constraint Programming Model with the Confidence Constraint

Younes Aalian, Polytechnique Montreal, Montreal, QC, Canada, younes.aalian@polymtl.ca

Michel Gamache, Gilles Pesant

Short-term underground mine planning is a complicated procedure that deals with the uncertainty in activity durations. In this paper, a Constraint Programming (CP) model is developed for optimization of short-term schedules in underground mines. Furthermore, a confidence constraint is introduced to ensure sufficiently long durations for tasks with a given threshold probability and produce robust schedules up to the threshold. The model is tested on a real dataset of a Canadian underground gold mine.

5 - Robust Approaches to Radiation Therapy Treatment Planning

Danielle Ripsman, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, daripsman@uwaterloo.ca

Houra Mahmoudzadeh

Automated radiation therapy treatment planning approaches, such as fluence map optimization (FMO), take the burden of manual, iterative planning for cancer treatments, off the plate of busy clinicians. Uncertainty within the treatment process, however, leads to growth in the already large, time-consuming problems, when it is incorporated into a robust optimization framework.

Robust FMO (RFMO) problems have previously been shown to run quicker using constraint generation (CG) approaches. This talk will address the structure of CG in RFMO, and discuss how closed-form algorithms can make the heuristic even more efficient. These improvements are demonstrated on real-world RFMO problems.

TA16

34th FI-English Bay

Machine Learning for Combinatorial Optimization

General Session

Chair: Quentin Cappart

Polytechnique Montréal, Polytechnique Montréal,
Laval, QC, H7G 1H4, Canada

2 - Learning to Select Operators in Meta-heuristics: An Application to Flowshop Scheduling Problem

Maryam Karimi Mamaghan, IMT Atlantique, Brest, France,
maryam.karimi@imt-atlantique.fr

Mehrdad Mohammadi, Bastien Pasdeloup, Patrick Meyer

This study develops a general framework to dynamically select search operators of meta-heuristics using Q-learning as a reinforcement learning algorithm. The operators are selected online based on both their performance history and the status of the search in terms of being trapped in a local optimum or not. In this way, the meta-heuristic adapts the search operators to the current status of the search. The framework is applied to the flowshop scheduling problem and shows significant improvement in terms of optimality gaps and convergence rate compared to the state-of-the-art algorithms.

3 - Ecole: A Gym-like Library for Learning inside Combinatorial Optimization Solvers

Maxime Gasse, Polytechnique Montréal, Montréal,
QC, Canada

In this talk I will present Ecole, a new library to simplify machine learning research for combinatorial optimization. Ecole exposes several key decision tasks arising in general-purpose combinatorial optimization solvers as control problems over Markov decision processes. Its interface mimics the popular OpenAI Gym library and is both extensible and intuitive to use. We aim at making this library a standardized platform that will lower the bar of entry and accelerate innovation in the field. Documentation and code can be found at <https://www.ecole.ai>.

4 - Learning to Branch with Tree MDPs

Didier Chételat, Polytechnique Montréal, Montréal, QC,
Canada, didier.chetelat@polymtl.ca

State-of-the-art mixed-integer linear programming solvers rely on the branch-and-bound algorithm, in which one must repeatedly branch according to some branching rule. Recently, there has been interest in using reinforcement learning to learn such branching rules, but this approach

has proven difficult to make work. In this talk, we revisit the work of Etheve et al. (2020) and propose a new paradigm, tree MDPs, that provides a more suitable formulation of the branching problem. We derive algorithms that exploit this formulation, and show that the resulting learning is accelerated compared to regular RL, and increases scalability.

5 - Routing and Wavelength Assignment with Deep Reinforcement Learning

Peyman Kafeai, Polytechnique Montreal, Montreal, QC,
Canada, peyman.kafeai@polymtl.ca

Louis-Martin Rousseau, Quentin Cappart

Decision-making problems have profited from the recent advances in the Deep Reinforcement Learning (DRL). DRL has shown promising results in the field of Network Optimization and Optical Networks. In this work, we formulate a simultaneous path selection and wavelength assignment algorithm in a Wavelength Division Multiplexing framework. We propose a DRL agent to solve this problem. A Graph Neural Network embeds each state, and a DRL agent selects a path and a wavelength such that the rejected connection requests is minimized. We do not consider wavelength any converters. We simulate the algorithm under dynamic load and compare the results with the baselines in the literature.

Tuesday, 10:15–11:05am

TP01

3rd FI-Regency CD

Plenary: Mathematical Perspectives in Infrastructure Resilience Modeling

Plenary Session

1 - Mathematical Perspectives in Infrastructure Resilience Modeling

Elise Miller-Hooks, George Mason University, Fairfax, VA,
22030-4422, United States

Secure and functioning civil infrastructure systems are of paramount importance to society. To ensure that effective services can be provided in a disaster's aftermath enabling society to recover, agencies charged with managing and operating these systems must invest in measures that safeguard their performance under disaster incidents and less major disruptions. This lecture will describe developed mathematical and algorithmic approaches for quantifying the resilience of individual and interconnected infrastructure lifelines under multiple hazard threats and identifying mitigation, preparedness and response measures with maximum impact. System users play an important role in the

services they experience. Thus, both the behavior of technical components and how the system enables its varying users to adapt are considered. Together, critical lifelines support societal activities occurring within building facilities related by a common community function, e.g. health care or education. This lecture continues with the reframing of the resilience analysis taking a community function, or service-based, perspective. From this perspective, human capital (i.e., human infrastructure), equipment and consumable resources can be integrated within the resilience analysis by accounting for their roles in creating and maintaining service capacities.

Tuesday, 11:15am–12:45pm

TB03

2nd Fl-Plaza A

Health Applications Relevant to Practice II

General Session

Chair: Steven Shechter

University of British Columbia, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada

Chair: Maria Esther Mayorga

North Carolina State University, North Carolina State University, Raleigh, NC, 27695, United States

3 - Using System Dynamics Modeling to Strengthen Acute Mental Health Crisis Systems

Kristen H Lich, PhD, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, klich@unc.edu

Raymond L Smith, Elizabeth La

Many communities are struggling to meet the needs of adults in acute mental health crisis well and in a timely manner. Wait times in Emergency Departments and other crisis care settings can span days to weeks - stressing patients, family/friends, and systems providing mental health and other types of critical care. Due to delays, adults in crisis end up interacting with criminal justice systems and homeless shelters, burdening their limited resources. Many attempts to solve this problem have failed. We developed a hybrid system dynamics/discrete-event simulation model to represent Anytown, US - and serve as a framework for learning and planning for model adaptation and use within communities.

4 - A Queuing Model for Ventilator Capacity Management During the COVID-19 Pandemic **Alexander R Rutherford, Simon Fraser University, Burnaby,**

BC, Canada, arruther@sfu.ca

Samantha L. Zimmerman, Alexa van der Waall, Monica Norena, Peter Dodek

We applied a queuing model to inform mechanical ventilator capacity planning in British Columbia during the COVID-19 pandemic. Using discrete event simulation, we projected ventilator access metrics under epidemic scenarios with different transmission levels—due to public health measures and social distancing. Hybrid optimization using simulation and the fixed point approximation identified the capacity required to maintain patient access to this critical resource. Our model projections demonstrate that public health measures potentially averted up to 50 deaths per day during the first wave of the pandemic in BC, by ensuring that ventilator capacity was not reached.

- Covid-19 Simulation Model to Support Local Decision Making

Erik Rosenstrom, North Carolina State University, Raleigh, NC, 27605, United States, erosens@ncsu.edu

From the onset of the COVID-19 pandemic, local health officials have been at the frontlines of public health policy. Spurred by the needs of these officials in North Carolina, we developed a stochastic agent-based simulation model of COVID-19 spread to help inform public health policy. Since July of 2020, we have supported local decision making with respect to the impact of nonpharmaceutical interventions (NPIs), vaccination, equitability of vaccination strategies, school NPI policy's impact on the community, and emerging variants, such as omicron, under parameter uncertainty. We emphasize the expression of uncertainty, interpretability of results, and collaboration with health officials.

- Simulating the Long-term Health Impact of First-time Colorectal Cancer Screenings Provided Through the Colorectal Cancer Control Program

Maria Esther Mayorga, North Carolina State University, Raleigh, NC, 27695, United States

Priscille Ruth Koutouan, Kristen Hassmiller Lich, Meghan O'Leary

We estimated the value of first-time colorectal cancer (CRC) screenings provided to low-income and underinsured individuals through the Colorectal Cancer Control Program (CRCCP) in terms of preventing adverse CRC outcomes. We used observed CRC screening and follow-up data for 78,685 individuals, and modeled multiple future screening scenarios, to simulate lifetime CRC cases, CRC deaths, and total life-years. We then compared their outcomes in

the absence of the CRCCP screening. Averting 25-30% of cancers, deaths, and life-years lost, the CRCCP is associated with substantial health gains.

TB04

2nd FI-Plaza B

Supply Chain Management III

Contributed Session

Chair: Bennet Gabriela Ornelas

Universidad Autonoma de Ciudad Juarez

2 - Data-driven Inventory Optimization: A Demand Forecasting Approach

Mahya Seyedan, Concordia University, Montreal, QC, Canada

Chun Wang, Fereshteh Mafakheri

Retailers are usually required to forecast the future demand to respond to the volatility of the market demand and optimize the costs of the inventory system. This study aims to predict the lead time demand distribution with machine learning methods and compare the results with statistical methods. The forecasting results will be used in an inventory optimization model to calculate safety stock and minimize total cost.

3 - Evaluating Human Behaviour in Response to AI Recommendations for Judgmental Forecasting

Kai Hoberg, Kuehne Logistics University, Hamburg, Germany

Naghme Khosrowabadi, Christina Imdahl

We study planners' adjustments to AI-generated demand forecasts and use a large dataset from a leading AI provider and a large European retailer with 30 million forecasts at the SKU-store-day level. In our two-phase analysis, we aim to understand the adjustments made by planners and the quality of these adjustments. We find that product characteristics such as price, freshness, and discounts are important factors when making adjustments. Large positive adjustments occur more frequently but are often inaccurate, while large negative adjustments are generally more accurate but fewer in number. Our findings provide insights for the better use of human knowledge in judgemental forecasting.

4 - Simulation and Optimization Based Integrated Approach to Concrete Delivery Scheduling Problem to Optimize the Project Performance

Parminder Singh Kang, Assistant Professor, Mount Royal University, Calgary, AB, Canada, pkang@mtroyal.ca

Alistair Duffy

This paper focuses on the concrete delivery scheduling (NP-hard) problem subjected to internal and external constraints. The concrete deliveries need to be processed by various supply chain partners to fulfill the delivery requirements determined by customers subjected to internal and external constraints. Such as materials & equipment uncertainties, concrete quality, delivery times, construction site delays, congestion, traffic conditions etc. This paper investigates a sector-specific problem for a non-fixed construction project to generate a daily concrete delivery schedule to maximize daily throughput and minimize queues at the construction site.

5 - Application of Neural Networks for the Prediction of Inventory Management

Bennet G Ornelas, Student, Universidad Autonoma de Ciudad Juarez, Juarez, Mexico, al206522@alumnos.uacj.mx
Luis A Perez

The high demand for products with different characteristics makes us see an uncertain environment to determine with precision the management of materials, specifically the inventory of the raw material used to manufacture the products demanded by the market. A good inventory planning results in significant improvements in cost reduction and an increased service for the customers. In this sense, this project addresses the problem of inventory prediction through the application of artificial neural networks.

TB05

2nd FI-Plaza C

Machine Learning II

Contributed Session

Chair: Matthew Timothy Mullarkey

University of South Florida, St Pete Beach, FL, 33706, United States

2 - *Late Cancellation - Triage and Mitigation of Context-sensitive Cyber Vulnerabilities Using a Machine Learning and Optimization Framework**

Soumyadeep Hore, University of South Florida, Tampa, FL, 33613, United States

Ankit Shah

Computer and network systems of organizations routinely remain unpatched, thus making them vulnerable to security breaches from the adversaries. This is because of two reasons: (i) unavailability of adequate technology and security personnel resources and (ii) patching strategies that do not consider organization-specific context of the vulnerabilities.

In this talk, we propose a machine learning and optimization framework to address this critical need to develop a resource-constrained approach for effectively identifying and mitigating important context-sensitive cyber vulnerabilities. We validate our approach on a real-world vulnerability data set and present our findings.

3 - Machine Learning-based Analysis of Information Diffusion in Large-scale Media Platforms

Ivan Belik, Associate Professor, Norwegian School of Economics, Bergen, Norway

Denis Utochkin

We employ Reddit as a source of rich consumer-generated content on which users' preferences and information diffusion patterns can be fruitfully studied. We collected and analyzed over 270 million postings spanning the entirety of 2019 of activity in 1,027 Reddit communities. Our analysis reveals two key findings. First, the importance of users' attitudes towards a brand is far outweighed by the importance of their position in the social media network's topology. Second, commonly used measures of network centrality fail to identify influential spreaders under certain conditions.

4 - Minimizing Loss of Air Cargo Revenue Using Machine Learning

Yassine Parakh, Lead Data Scientist, Air Canada, Montréal, QC, Canada, yassine.parakh@aircanada.ca

Ankei Yau, Philippe Branchini, Navjot Singh

Air Canada Cargo charges rates based on a shipment's characteristics including volume, weight, etc. When a shipment is tendered, it goes through a process to validate if there is a discrepancy between the given and actual attributes that would result in loss of revenue. However, it is not feasible to manually verify every shipment. To help operators prioritize which shipments to inspect, we use a machine learning model to estimate the likelihood of mismatch through a classification approach. The deployed system resulted in revenue increase with more accurate billing while minimizing the manual effort. We present the model and approaches used to overcome challenges related to unbalanced data.

5 - Transforming Business Development in the Recruiting Industry Through Neural Network Based Machine Learning for Authorship Attribution

Matthew Timothy Mullarkey, Professor of Instruction, University of South Florida, Tampa, FL, United States, mmullarkey@usf.edu

Denis Edwards

The IT staffing industry is a competitive market. Working with a leading IT staffing firm, we discover authorship attribution (AA) hidden in the massive data of digital job postings placed by staffing firms. We find it possible to identify the specific employer for any anonymized IT job posting using a set of discriminate stylistic features processed iteratively with an innovative neural network ML classifier. The resultant algorithm accurately predicts the identity of the employers so the sales process can offer IT candidates in real-time to fulfill an open position. To our knowledge, this is the first research to offer a neural network-based approach to AA to solve lead generation.

TB06

3rd FI-Regency A

Tutorial: Inverse Optimization: Theory and Application

Tutorial Session

1 - Inverse Optimization: Theory and Application

Timothy Chan, University of Toronto, Toronto, ON, M5S 3G8, Canada, tcychan@mie.utoronto.ca

Inverse optimization describes a process that is the reverse of traditional mathematical optimization. Unlike traditional optimization, which seeks to compute optimal decisions given an objective and constraints, inverse optimization takes decisions as input and determines an objective and/or constraints that render these decisions approximately or exactly optimal. In recent years, there has been an explosion of interest in the mathematics and applications of inverse optimization. This tutorial will provide a comprehensive introduction to the theory and application of inverse optimization.

TB07

3rd FI-Regency B

OR Applications in Healthcare

General Session

Chair: F. Safa Erenay

University of Waterloo, University of Waterloo, Kitchener, ON, N2N 0A2, Canada

2 - A Data Analytics Framework to Capture Individualized ALS Progression

F. Safa Erenay, University of Waterloo, Kitchener, ON, N2N 0A2, Canada

Haoran Wu, Kalyan Pasupathy, Brian Crum, Osman Ozaltin

ALS leads to motor neuron degeneration and functionality loss in limb/bulbar functions. We defined a staging system of 25 disease tollgates to analyze ALS progression. We developed binary classification models to map classical staging systems to ours using data from Mayo Clinic. We then augmented 6000 patients' data from PRO-ACT with tollgate info and derived time trajectories of passing ALS tollgates using interval-censored Kaplan-Meier curves. Next, we used classification trees to identify risk factor combinations with significantly different tollgate time trajectories. These risk groups with different ALS progression aggressiveness lead to an analytical model to individualize ALS care.

3 - Markov Models to Minimize Drug Wastage in Cancer Care

Krishna Sabareesh Rajangom, PhD Candidate, University of Waterloo, Waterloo, ON, Canada, ksrajangom@uwaterloo.ca

F. Safa Erenay, Qi-Ming He, Avram Denburg

High wastage of left-over cancer drugs is a major concern with increasing drug costs. Left-over drug occurs when dose demands (based on body surface area or weight) do not match the available drug vial sizes. The wastage could be reduced through vial sharing, optimizing vial sizes, and better inventory management given the limited (six hours) time window for sharing the left-over drug. We developed a Markov decision process to analyze the drug wastage for different wastage mitigation methods. The model, which is built and validated using medical data, considers stochasticity in patient arrivals and dosage requirements. The model is extended to consider both scheduled and walk-in demand arrivals.

4 - Linking Predictive and Prescriptive Analytics for Healthcare Services: The Case of Frail and Elderly Patients

Elizabeth Williams, PhD Student, Cardiff University, Cardiff, United Kingdom, WilliamsEM20@cardiff.ac.uk
Daniel Gartner, Paul Harper

Ageing is one of the most common and well-known risk factors for most chronic diseases putting an increasing pressure on healthcare resources. In this work, we develop classification and regression trees to determine homogeneous clusters of patient attributes. Incorporating the associated length of stay distributions into a two-stage stochastic model provides novel insights for capacity planning of hospital beds and staffing requirements within a network of hospitals in the UK. Our approach highlights how applying two healthcare analytics paradigms can be useful for decision makers to capture the stochastic nature of healthcare and make more robust strategic planning decisions.

TB08

3rd Fl-Regency E

Healthcare Decision Making

General Session

Chair: Houra Mahmoudzadeh

University of Waterloo, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

Chair: Kimia Ghobadi

Johns Hopkins University, Johns Hopkins University, Baltimore, MD, 21218-2625, United States

3 - Prediction of Liver Radiotoxicity in Hepatocellular Carcinoma Patients

Ibrahim Chamseddine, Massachusetts General Hospital, Harvard Medical School, Boston, MA, United States, ichamseddine@mgh.harvard.edu

Yejin Kim, Brian De, Issam El Naqa, Dan G. Duda, John Wolfgang, Jennifer Pursley, Harald Paganetti, Jennifer Wo, Theodore Hong, Eugene J. Koay, Clemens Grassberger

Radiotherapy can achieve excellent local tumor control in hepatocellular carcinoma patients but may jeopardize liver function. During treatment planning, dose constraints are applied to the liver to reduce risk, but they rely on single dose-volume thresholds and ignore patient-specific sensitivity. To improve liver toxicity risk evaluation, we developed an ensemble neural network that considers the entire dose-volume histogram and incorporates patient-specific variables. Independent model validation showed strong predictive performance, especially in high-risk patients. Sensitivity analysis and decision curves signify potential clinical utility to personalize radiotherapy.

4 - Learning from Good and Bad Decisions Using Inverse Optimization

Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, hora.mahmoudzadeh@uwaterloo.ca

Kimia Ghobadi

Traditional inverse optimization inputs an optimal observation and finds the problem parameters such that optimality conditions in linear programming are enforced for the given observations. In this talk, we propose an inverse optimization framework that can input any number of both acceptable (good) and unacceptable (bad) observations and find problem parameters that respect the classification of good/bad decisions as feasible/infeasible solutions and make the preferred solution optimal. We provide bounds on the number of constraints that need to be

inferred depending on the structure of the input data. We demonstrate the methodology in the context of radiotherapy treatment planning.

5 - Inverse Learning in Diets

Kimia Ghobadi, Johns Hopkins University, Baltimore, MD, 21218-2625, United States, kimia@jhu.edu

Fardin Ganjkanloo, Farzin Ahmadi, Tinglong Dai
we focus on Inverse Optimization techniques to recover underlying optimization models that lead to the observed decisions. We present a data-driven inverse optimization framework (Inverse Learning) to recover the parameters of underlying optimization models and their optimal solutions. We discuss hybrid inverse optimization and machine learning techniques to utilize the strengths of both approaches. Finally, we demonstrate our approach using examples in the context of precision nutrition and personalized daily diet recommendations.

6 - To Extend or Not to Extend? Dynamic Shift Lengths in Workforce Planning

Negar Ganjoughaghi, University of Calgary, Calgary, AB, T3G1V7, Canada, negar.ganjoughaghi@ucalgary.ca

Marco Bijvank

Alireza Sabouri

Emergency Departments face the challenging task of scheduling physicians to meet uncertain patient demand in the future. To better match physician availability with patient arrivals, we consider the possibility of dynamically extending shifts. A Markov Decision Process is formulated to decide on extending a shift by balancing the cost associated with shift extensions and the cost of patients waiting. Our numerical results suggest that shift extensions can reduce expected wait times by 20% with the same number of physicians compared to strategies that create static shifts.

TB09

3rd Fl-Regency F

Covid Models: III

General Session

Chair: Gizem Nemutlu

Brandeis University, Brandeis University, Burlington, MA, 01803-3872, United States

Chair: Lauren N Steimle

Georgia Tech ISyE, Atlanta, GA, 30308, United States

2 - Periodic Vaccination Against COVID-19

Jade Xiao, Georgia Institute of Technology, Atlanta, GA, United States, jadexiao@gatech.edu

Turgay Ayer, Jagpreet Chhatwal

Waning immunity to SARS-CoV-2 and the inevitability of viral mutations will necessitate a large-scale periodic booster vaccination program. Fast-paced, high-volume vaccination may quickly extinguish an epidemic, but it may have an unintended downstream effect of creating a surge in population susceptibility later when vaccinated people lose their immunity all at the same time. We conducted a simulation study to show how staggering vaccinations over time maintains population susceptibility and therefore incident deaths at a constant, manageable level; whereas rapidly vaccinating a large portion of the population in a single pulse leads to large recurrent epidemics between booster rounds.

3 - Can D2C Save Disrupted Supply Chains?

Blockchain B2B Comes to the Rescue

Jinwook Lee, Drexel University, Philadelphia, PA, United States, jl3539@drexel.edu

Lanqing Du, Sejong Yoon, Paul Moon Sub Choi

What once seemed long-lasting, the business-to-business-to-consumer (B2B2C) model has gradually shifted to the direct-to-consumer (D2C) alternative. This transition has been accelerated due to the COVID-19 pandemic, which has negatively affected the global supply chain with a wide range of obstacles. These trends motivate us to investigate new business models through innovative operations. This research studies how centralized D2C business models can enhance by decentralized business-to-business (B2B) channels to mitigate supply chain disruptions. Its strategic guidance and managerial benefits are demonstrated through network representation, simulation, and optimization models.

4 - Determining the Optimal Covid-19 Testing Centre Locations and Capacities Considering the Disease Dynamics

Esma Akgun, University of Waterloo, Waterloo, ON, N2L 6P1, Canada

Sibel A.Alumur, F. Safa Erenay

Early isolation of the positive cases through testing is one of the key methods to control the COVID-19 pandemic. However, this intervention relies on fast access to testing, which has become a global challenge due to the recent variants and surge in testing demand. We propose a multi-period location and capacity allocation model that determines the locations and capacities of COVID-19 testing centers under budget and capacity constraints. We apply our model to the case of locating COVID-19 testing centres in the Region of Waterloo, Canada. The results of our

numerical analyses provide practical insights to the public health decision-makers on the locations and timing of testing capacity expansions.

5 - Helping Colleges Respond to Covid-19: Multi-objective Optimization to Address Sudden Classroom Space Scarcity Due to Social Distancing

Lauren N Steimle, ISyE Georgia Tech, Atlanta, GA, 30308, United States

Mehran Navabi, Mohamed El Tonbari, Natashia Boland, Dima Nazzal

During the COVID-19 pandemic, social distancing led to sudden drops in classroom capacity. This presented a challenging problem for colleges wanting to deliver in-person instruction. In response, campus planners had to decide which classes to deliver in remote, in-person, and hybrid formats, and how to make the most of existing classroom space on campus by reassigning classes to classrooms. We present a multi-objective optimization approach that considers various trade-offs and administrative preferences for assigning course modes and classrooms under sudden space scarcity. We discuss insights that informed a collaborative decision-making process with the Georgia Tech COVID-19 Task Force.

TB10

3rd Fl-Balmoral/Windsor

Randomized Quasi-Monte Carlo (RQMC)

General Session

Chair: Florian. Puchhammer

Ph.D., University of Waterloo, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

2 - Monte Carlo and Quasi-Monte Carlo Density Estimation

Pierre L'Ecuyer, Université de Montréal, Montreal, QC, H3C 3J7, Canada, lecuyer@iro.umontreal.ca

Estimating the density of a continuous random variable X has been studied extensively in settings where n independent observations of X are given and the goal is to estimate its density from that. Popular methods include histograms and kernel density estimators. We consider instead the situation where the observations are generated by Monte Carlo simulation from a model. Then we have more control over how the observations are generated and this can be exploited to produce more accurate density estimators, often

with better convergence rates than the classical ones. We examine and compare various approaches to do that, both theoretically and empirically.

3 - Quasi-monte Carlo for Vector Functions of Integrals

Aleksei G. Sorokin, Illinois Institute of Technology, Chicago, IL, United States, asorokin@hawk.iit.edu
Jagadeeswaran Rathinavel, Fred J Hickernell

Quasi-Monte Carlo methods present an efficient approach for multivariate numerical integration. Algorithms exist to adaptively sample the integrand until a user defined error tolerance is satisfied. This work describes our extension of such methods to support adaptive sampling to satisfy error criteria for vector functions of multiple integrals. These enhanced algorithms are implemented in the QMCPy Python package with support for vectorized, economical integrand evaluation. Motivating examples include the approximation of sensitivity indices, coefficients for Bayesian logistic regression, and vectorized acquisition function values in Bayesian optimization.

4 - Efficient Simulation of Markov Chains with Array-RQMC

Florian Puchhammer, University of Waterloo, Waterloo, ON, Canada, florian.puchhammer@uwaterloo.ca

Pierre L'Ecuyer, Amal Ben Abdellah

Randomized quasi-Monte Carlo (RQMC) can significantly reduce the variance in numerical integration problems in a moderate number of dimensions. When considering a Markov chain with RQMC, this dimensionality increases linearly in the number of steps over which we simulate the chain. The Array-RQMC algorithm has been specially designed for situations where the number of steps is large. It simulates an array of realizations of the chain and reorders them after each step via some sorting function. In this talk, we demonstrate how to apply Array-RQMC effectively. Moreover, we discuss efficient strategies to construct such sorting functions for option pricing problems and chemical reaction networks.

5 - Randomized Quasi-Monte Carlo Methods on Triangles: Extensible Lattices and Sequences

Gracia Dong, University of Waterloo, Waterloo, ON, Canada, gracia.dong@uwaterloo.ca

Erik Hintz

Recently, Basu and Owen proposed two low-discrepancy constructions for the triangle. One based on a finite lattice; the other is a triangular van der Corput sequence. We give an extensible lattice construction for points in the triangle randomized using a simple shift. We also examine

the one-dimensional projections of the deterministic triangular van der Corput sequence and quantify their sub-optimality compared to the lattice construction. We show how to use the triangular van der Corput sequence to construct a stratified sampling scheme and that nested scrambling is a way to implement an extensible stratified estimator. A numerical study is performed to compare the different constructions.

TB11

3rd Fl-Oxford/Prince of Wales

Risk Management

General Session

Chair: Abel Cadenillas

University of Alberta, University of Alberta,
Edmonton, AB, T6G 2G1, Canada

2 - The Engineering of Social Fintechs

Luis Seco, PhD, University of Toronto, Toronto,
ON, Canada

The development of databases and AI tools to analyze them are creating opportunities for the development of quantitative techniques in areas traditionally dominated by social science. In this talk, I will present the context and recent advances in the areas of ESG (Environment-Social-Governance) criteria and the way technology and quantitative techniques become relevant.

3 - Optimal Insurance Contract When the Number of Claims is a Cox Process

Abel Cadenillas, University of Alberta, Edmonton, AB, T6G 2G1, Canada

We consider a continuous-time model in which an insurer proposes an insurance contract to a potential insured. We assume that the number of claims process is a Cox process with shot noise intensity. The insurer selects the premium to be paid by the potential insured and the amount to be paid for each claim. In addition, the insurer can request some actions/efforts to the potential insured to reduce the number of claims. The insurer wants to maximize his expected total utility. We obtain a solution for the optimal premium, the optimal amount to be paid for each claim, and the optimal actions/efforts of the insured. [Joint work with Wenyue Liu].

4 - Portfolio Liquidation Under Self-exciting Order Flow

Ulrich Horst, Humboldt-Universität zu Berlin, Berlin, Germany, horst@math.hu-berlin.de

We consider a portfolio liquidation model with self-exciting order flow in which a large investor has an impact of future order flow. Assuming that the investor is risk neutral and impact parameters are deterministic constants we solve the model in closed form. If the feedback of current trading on future order flow is not too strong, the optimal trading strategy is of hyperbolic form. If the feedback effect becomes too dominating, cyclic strategies may emerge and beneficial round trips may exist. We implement our model on 110 NASDAQ stocks. Our strategy delivers increasingly superior performance to the commonly employed TWAP strategy. The talk is based on joint work with Ying Chen and Hai Tran.

5 - Estimation of Growth in Fund Models

Hyung Keun Koo, PhD, Ajou University, Suwon, Korea, Republic of, hkoo@ajou.ac.kr

Constantinos Kardaras, Johannes Ruf

We study estimation of growth in continuous-time fund models. We provide frequentist and Bayesian estimators and investigate the expected loss of growth due to estimation error. We show that a fund model allows one to reduce the dimension of the estimation problem. We provide a Bayesian approach and show that important quantities in estimation and loss of growth (passing from model to observations) are the first and second moments of the conditional law of the model growth-optimal portfolio and that the loss of growth due to estimation error increases as the investment universe does. We finally propose a shrinkage method which targets maximal growth with the least amount of deviation.

TB12

34th Fl-Seymour

Forest Operations and Management

General Session

Chair: Gregory Eric Paradis

Université Laval, Université Laval, Quebec City, QC,
G1R 1Y9, Canada

2 - Analytics for a Production-inventory-distribution System Under VMI, MTO, and MTS Policies: An Application in the Pulp and Paper Industry

Elaheh Ghasemi, PhD Candidate, Université Laval, Quebec, QC, Canada, elaheh.ghasemi.1@ulaval.ca
Nadia Lehoux, Mikael Rönnqvist

There are different ways for managing customer demands in the form of vendor managed inventory (VMI), make to order (MTO), and make to stock (MTS) policies, that have a direct effect on the performance of production systems in

terms of service level and logistics costs. This study proposes an optimization model to coordinate production planning and inventory management as well as distribution decisions according to the logistics strategies applied for different customers. The applicability of the presented model is analyzed through case studies motivated from a real-world application in the pulp and paper industry.

3 - Log Transportation Planning

Seyed Salar Ghotb, University of British Columbia, Vancouver, BC, Canada, salar2@mail.ubc.ca
Taraneh Sowlati

Log truck scheduling problem has different complexities that need to be addressed. This study presents an optimization model with a daily planning horizon that aims to provide schedules for heterogeneous trucks delivering logs from origins to destinations. The proposed model is applied to a forest company in British Columbia to assist decision makers in dispatching log trucks.

4 - Optimization of Harvest Scheduling at Operational Level

Rohit Arora, University of British Columbia, Vancouver, BC, Canada, rohita23@mail.ubc.ca
Taraneh Sowlati

A mixed-integer linear programming model is developed to optimize the scheduling of harvesting activities at the operational level, considering the precedence relationship between harvesting activities and possibility of assigning multiple machines for each harvesting activity at each cut block. The objective of the model is to minimize the total cost. The model determines the start time, end time and number of machines to be assigned for each harvesting activity at each cut block. This model is solved for few test problems. Heuristics will be developed to schedule the harvest activities of a large forest company.

5 - Modelling Pareto-optimal Tradeoffs Between Timber Harvest Volume and Red-breasted Nuthatch Population Density in Northeastern British Columbia

Gregory Paradis, Assistant Professor, University of British Columbia, Vancouver, BC, Canada, paradis@ubc.ca

Tati Micheletti, Eliot McIntire

Boreal landbirds, especially forest-associated ones, have been decreasing significantly since the early 70's. Using an aspatial LP-based harvest schedule optimization modelling framework, we tested the inclusion of a linear anticipation function that links forest landscape state to Red-breasted Nuthatch (*Sitta canadensis*) population density in Northern

British Columbia. We demonstrate that this approach can be used to estimate the location and shape of Pareto-efficient tradeoff frontiers between harvest levels and bird population density. The method could potentially be applied to other locations, as well as other non-timber forest values.

TB13

34th Fl-Stanley

Education Market Design

General Session

Chair: Sam Hwang

UBC, UBC, Vancouver, BC, Canada

2 - Do School Attendance Boundary Changes Worsen Racial Segregation in Public Schools? Evidence from Minnesota

Sejin Ahn, Vancouver school of economics, University of British Columbia, Vancouver, BC, Canada, sejin.ahn@ubc.ca

Sam Hwang

Sam Hwang

Racial segregation in public schools in the U.S. may not be only due to residential racial segregation. Anecdotal or legal evidence suggests that one mechanism through which public schools continue to be racially segregated is that school attendance boundaries are "gerrymandered". In this paper, we use 20-year panel data of school attendance boundaries in Minnesota to test this hypothesis. Our preliminary finding is that: a) attendance boundary changes have small long-run effects on the racial composition of the affected schools; and that b) at the school district level, we do not find evidence that boundary changes have any effect on racial segregation.

3 - Education Market Design in the Presence of Peer Effects: Theory and Evidence from South Korea

Oguz Bayraktar, University of Chicago, Chicago, IL, United States, obayraktar@uchicago.edu

Sam Hwang

Sequential admission (SA), i.e., private schools selecting students before public schools do, is a common market design in many school districts. In this paper, we study how SA affects the ability distribution across schools and the education outcome through peer effects. First, we show in a simple model that the sorting of high-ability students to private school is stronger under SA than Deferred Acceptance if private school tuition is sufficiently large. To quantify the effect of SA on education outcome, we

estimate students' preferences for peer quality and education production function, and simulate the distribution of test scores under counterfactual market designs.

4 - Redesigning Student Assignment Mechanisms: The Case of Seoul, Korea

Sam Hwang, Vancouver School of Economics, University of British Columbia, Vancouver, BC, Canada, hwangii@mail.ubc.ca

Which assignment mechanism should we use to allocate students to schools? We study the case of Seoul, Korea, where a non-strategy-proof mechanism is used to assign tens of thousands of students to schools. Simulation of counterfactual mechanisms requires identifying students' preferences over schools from their rank order lists. For identification, previous studies assumed that students have correct beliefs about their assignment probabilities. However, existing empirical evidence suggests that some students have unobservably incorrect beliefs. We study how students' ordinal preferences over schools can be identified by relaxing the assumption about the correctness of students' beliefs.

TB14

34th Fl-Cypress

Recent Advances on Parallel-server Systems

General Session

Chair: Daniela Hurtado Lange

Ph.D. in Operations Research, College of William and Mary, 200 Ukrop Way, Williamsburg, VA, 23185, United States

2 - A General Power-of-D Dispatching Framework for Heterogeneous Systems

Kristen Gardner, Amherst College, Amherst, MA, United States, kgardner@amherst.edu

Sherwin Doroudi, Jazeem Abdul Jaleel, Alexander Wickeham

The bulk of "power-of-d" dispatching policies studied in the literature assume that all servers have the same speed; meanwhile, real-world systems often exhibit server speed heterogeneity. We introduce a general framework for describing and analyzing heterogeneity-aware power-of-d policies. The key idea is that dispatching policies can make use of server speed information at two decision points: when choosing which d servers to query, and when assigning a job to one of those servers. We consider general families of both querying and assignment rules, analyze mean response time, and formulate novel optimization problems for the joint optimization of querying and assignment.

3 - Learning the Scheduling Policy in Time-Varying Multiclass Many Server Queues with Abandonment

Yueyang Zhong, The University of Chicago Booth School of Business, Chicago, IL, 60637-1610, United States, yzhong0@chicagobooth.edu

John R Birge, Amy R Ward

We consider a scheduling problem with minimizing the long-run average abandonment and holding costs as objective, in a time-varying multiclass $M_t/M/N+M$ queueing system, when the model parameters (arrival, service and reneging rates) are a priori unknown. We evaluate the performance by means of regret against the benchmark asymptotically optimal $c\mu/\eta$ rule with parameter knowledge. We propose a Learn-Then-Schedule algorithm, which achieves an optimal logarithmic regret rate. We extend the analysis to time-homogeneous multiclass $GI/M/N+GI$ queues.

4 - WINE: A New Queueing Identity for Analyzing Scheduling Policies in Multiserver Systems"

Ziv Scully, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, zscully@cs.cmu.edu"

There is a vast literature on scheduling in single-server queueing models, such as the $M/G/1$. In contrast, there are few results for scheduling in multiserver queues, such as the $M/G/k$. Even relatively simple policies, such as SRPT, were only recently analyzed in the $M/G/k$. Bringing $M/G/k$ scheduling up to speed with $M/G/1$ scheduling is an important aim of queueing research.

We present a new queueing identity, called "WINE", which enables a new method of analyzing the $M/G/k$ and other multiserver queues. We use WINE to obtain performance bounds for SRPT and other policies in the $M/G/k$. WINE, much like Little's law, holds in great generality and thus has the potential to help analyze a wide variety of systems.

5 - Stability and Instability of Parameter Agnostic Policies in Parallel Server Systems

Gorkem Unlu, Booth School of Business, The University of Chicago, Chicago, IL, 60637, United States

Yuan Zhong

We consider the X-Model parallel server system and examine its stability properties under parameter agnostic policies. Parameter agnostic policies are attractive because they require only the queue size information. However, they can lead to instability for relatively low system loads. For the X-Model system, we show that switching curve policies, where each server makes the service decision according to a non-decreasing function of queue sizes, can lead

to instability. We conjecture that there does not exist a parameter agnostic policy that stabilizes all underloaded parallel server systems.

6 - On Information Design in Dynamic Resource Allocation Systems

Kuang Xu, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States

Gal Mendelson

The acquisition and communication of real-time information is a bottleneck in modern resource allocation systems. This talk will discuss some of our recent work in understanding how to design effective information structures and inference mechanisms in the context of dynamic routing in parallel server systems.

TB15

34th FI-Grouse

Robust Optimization: Theory and Applications

General Session

Chair: Ian Yihang Zhu

University of Toronto, University of Toronto, Toronto, ON, M5S 3G8, Canada

2 - Adjustability in Robust Linear Optimization

Peter Zhang, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States, pyzhang@cmu.edu

Ningji Wei

We provide general conditions under which constant (a.k.a. static) policies are optimal for adjustable robust optimization. Our results provide a unifying framework to reinterpret and extend several existing results in the robust optimization literature and provide new geometric insights to understand this class of problems.

3 - Robust Multi-stakeholder Preference

Elicitation and Aggregation for Treatment Prioritization During the COVID-19 Pandemic

Caroline Johnston, University of Southern California, Los Angeles, CA, 90007, United States, cmjohnst@usc.edu

Simon Bleszenohl, Phebe Vayanos

In the COVID-19 pandemic, triage committees make ethically difficult decisions complicated by diverse stakeholder interests. We propose an automated approach to support group decisions by recommending a policy to the group - a compromise between individual preferences. To identify a policy to aggregate individual preferences, our system elicits preferences through strategically selected pairwise comparison queries. We propose a novel multi-stage robust

optimization formulation of this problem and evaluate our method on the issue of recommending policies for allocating ICU beds to COVID-19 patients. We show that our method attains higher utility than various methods from the literature.

4 - Structural Solution Approaches to Robust Optimization with Polyhedral Uncertainty

Danielle A Ripsman, PhD Candidate, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, daripsman@uwaterloo.ca

Houra Mahmoudzadeh

The robust counterpart of a linear optimization problem with polyhedral uncertainty is also linear but much larger than its nominal origin. In order to solve this counterpart efficiently, constraint generation (CG) approaches are often used in place of direct solution methods.

In this talk, we identify a subclass of polyhedral uncertainty with a bounded, continuous, knapsack-like CG subproblem structure, that may be solved with a proposed closed-form algorithm. We show that this class of polyhedral uncertainty includes the well-studied budget of uncertainty. Moreover, we characterize our algorithm using a radiation therapy treatment planning problem, and real-world treatment data.

5 - Network Flow Models for Two-stage Robust Binary Optimization

Ian Yihang Zhu, University of Toronto, Toronto, ON, M5S 3G8, Canada, i.zhu@mail.utoronto.ca

Merve Bodur, Timothy Chan

In this talk, we examine two-stage robust binary optimization problems with objective uncertainty, which are notoriously difficult to solve exactly. We show how a specific condition, termed selective adaptability, between first-stage and second-stage decisions facilitates a reformulation of the robust problem into a single MIP formulation representing a constrained network flow model.

TB16

34th FI-English Bay

Mixed Integer Bilevel Programming

General Session

Chair: Margarida Carvalho

University of Montreal, University of Montreal, Montreal, QC, H3T 1J4, Canada

2 - Optimal Placement of Electric Vehicle Charging Stations Under General Discrete Choice Models

Steven Lamontagne, University of Montreal, Montreal,

QC, Canada, steven.lamontagne@umontreal.ca

Margarida Carvalho, Emma Frejinger, Bernard Gendron

The literature highlights the importance of public charging infrastructure for EV adoption, and that effective placement of this can increase the number of EVs. We consider the problem of installing charging infrastructure so that EV adoption is maximised over a multi-period time horizon. To this end, we anticipate users' demand once charging stations are made available. This results in a stochastic bilevel program where at the lower level, users maximize their random utilities based on the charging choices available. We propose a maximum covering reformulation whose solving time is significantly lower than that of the standard single-level reformulation of the bilevel program.

3 - Different Perspectives on the Formulation of the Network Pricing Problem

Quang Minh Bui, PhD Student, Université de Montréal, Montréal, QC, Canada, quang.minh.bui@umontreal.ca

Bernard Gendron, Margarida Carvalho

The Network Pricing Problem is a bilevel problem where the leader maximizes their revenue by determining the optimal toll prices to charge on a set of arcs, under the assumption that the followers will react rationally and choose the shortest paths to travel. We explore several perspectives to formulate the problem, including arc-based, path-based, demand-based, and their combinations. Then, we analyze existing formulations in the literature, building a connection between them. Finally, we investigate on how enumeration can be used as a preprocessing method and what is its impact on the performance of each formulation.

4 - Sample Average Approximation for Bilevel Optimization Under Random Utility Maximization Models

Robin Legault, University of Montreal, Montreal, QC, Canada, robin.legault@umontreal.ca

Emma Frejinger, Bernard Gendron

Many bilevel problems require the use of flexible discrete choice models, such as the mixed multinomial logit model, to faithfully represent the followers' behavior. However, the resulting mathematical programs are in general challenging mixed-integer non-linear problems that can only be solved in reasonable time for a limited number of sampled followers, which can cause an important bias. To alleviate this issue, we propose a Monte Carlo simulation approach in which a set of realizations of the random utility terms are sampled for each simulated follower. We then present specific clustering methods that allow to reduce the number of lower-level variables at the cost of little or no loss of accuracy.

Tuesday, 1:30–3pm

TC03

2nd Fl-Plaza A

Pricing & Revenue Management

Contributed Session

Chair: Amirhossein Jafarzadeh Ghazi

Ontario Tech University

2 - Willingness to Pay for Airline Ancillary Fees Amidst Covid 19 Pandemic

Fouad H. Mirzaei, University of North Texas, Denton, TX, United States, fhmirzaei@unt.edu

Airlines are facing challenges of dwindling revenues from high-cost structures and intense competition amidst the COVID 19 pandemic. This pressure has made airlines universally look for opportunities to generate ancillary revenue as an additional source of revenue. Measuring airline travelers' willingness to pay is crucial in pricing and estimating ancillary revenue demand. In this study, we used the theory of planned behavior (TBP) to understand users' willingness to pay for ancillary fees and assess how risk perception affects users' willingness to pay.

4 - Strawberry or Vanilla this Week? How to Optimize Tailored Assortments for Variety-Seeking/Avoiding Consumers

Sumit Kunnumkal, ISB, India, India, sumit_kunnumkal@isb.edu

Dorothee Honhon, Ismail Kirci, Sridhar Seshadri

We consider the problem of a retail personalizing an assortment to a consumer who is variety-seeking or variety-avoiding, that is, less or more likely to buy the same product as in the previous period. We characterize the structure of the optimal assortment in single- and multi-period settings.

5 - Risk-sensitive Pricing Under Discrete Choice Models

Hongmin Li, Arizona State University, Tempe, AZ, United States, hongmin.li@asu.edu

Scott Webster

We examine a firm's pricing decision when managing a broad product line with the goal of optimally balancing the expected return on product investment with the revenue or profit risk associated with uncertain customer choices. We consider the multinomial logit (MNL) model (with both symmetric and asymmetric price sensitivities) and the mean-variance objective function. We show that the solution approach and results generalize to the nested logit (NL)

choice model. Our work illustrates how the level of risk tolerance influences the firm's optimal markups, and how this influence is affected by the structure of the choice models.

6 - Price and Quality Competition While

Envisioning a Quality-related Product Recall

Amirhossein Jafarzadeh Ghazi, Ph.D. Candidate, Ontario Tech University, Oshawa, ON, Canada, amirhossein.jafarzadehghazi@ontariotechu.ca

Salma Karray, Nader Azad

The adverse effects of a product recall can extend beyond the affected product to other brands in the category. Thus, it is necessary to study the competitor's reactions to the recall. While quality failures are the main culprit of recalls, studies focusing on quality decisions are scarce. This paper analyzes quality and pricing strategies for two competing firms facing a quality-related recall. We develop a stochastic Nash game where either firm may experience a recall. We find that the competitor lowers its price after the recall if post-recall consumer sensitivity to price is high enough. Surprisingly, we find that considering the risk of a recall does not always lead firms to enhance product quality.

TC04

2nd FI-Plaza B

Supply Chain Management IV

Contributed Session

Chair: Amin Shahmardan

McMaster University, Hamilton, ON, L8S 1A9, Canada

2 - Measuring Supply Chain's Responsiveness and Variability Due to Lot Size Flexibility at the Manufacturer Level

Karolay M. Yepes Buitrago, University of Puerto Rico, Mayagüez, PR, United States, karolay.yepes@upr.edu
Betzabé Rodríguez

Maintaining a flexible supply chain is a strategic capability in which many industries have shown interest nowadays, as it allows the chain to adapt to market needs. Still, adding flexibility could contribute to discontinue process stability. This study addresses the impacts of producing with flexible sizes, in a supplier manufacturer supply chain, with multiple products and uncertain demand. A case inspired by the pharmaceutical industry will be analyzed applying a system dynamics approach, to measure the impacts of lot size flexibility on supply chain responsiveness and variability. Managerial insights from the model will help to determine the viability of a flexibilization process.

3 - A Game Theoretic Model of Forced Labor Reduction in Supply Chains

Katherine Ashley, Northeastern University, Boston, MA, United States, k.ashley@northeastern.edu

Shawn Bhimani

Under current U.S. legislation, multinational companies are at risk of having imports into the United States blocked due to the alleged presence of forced labor in their supply chains, even if they are not aware that forced labor is being used. Using a game theoretic model, we study the equilibrium interactions between these firms, who may exert costly 'responsibility effort' to reduce the probability that a forced labor violation is reported, and enforcement organizations that allocate scarce resources to investigate multiple firms. We characterize policies that incentivize greater supply chain responsibility based on firm and industry parameters.

- The Multi-depot Prize Collecting Arc Routing for Connectivity Problem

Luana Almeida, Ph.D. Candidate, Dalhousie University, Halifax, NS, Canada, luana.almeida@dal.ca

Floris Goerlandt, Ronald Patrick Pelot

Following natural disasters, roads can be blocked with debris, communities can be isolated, and emergency operations can be hampered. We introduce the multi-depot prize collecting arc routing for connectivity problem (MPC-ARCP). In this problem, synchronized road clearing teams start at multiple locations and unblock the roads to reconnect the prioritized communities to critical supply infrastructures during a pre-determined time horizon.

4 - Returnless Refund in Online Retailing

Amin Shahmardan, Ph.D. Candidate, McMaster University, Hamilton, ON, Canada, shahmara@mcmaster.ca

Mahmut Parlar, Yun Zhou

Under the returnless refund (RR) strategy, customers may be granted a full refund without returning the product. We show that if customers are honest, i.e., they request returns only when they are not satisfied with the product, the retailer should offer (not offer) RR when the price of the product is low (high); for products with mid-range prices, it is optimal to use a randomized policy for granting returnless refund. Moreover, we establish a monetary threshold for the retailer's investment in technologies that can accurately classify customers as honest/dishonest.

TC05

2nd FI-Plaza C

Artificial Intelligence I

2022 CORS/INFORMS INTERNATIONAL CONFERENCE

Contributed Session

Chair: Andrew B Whinston

University of Texas-Austin, Austin, TX, 78712,
United States

2 - Service Usage limit for Our Cloud Customers

**Aven Samareh, Applied Data Scientist Tech Lead,
Microsoft, Los Angeles, CA, United States, basamare@
microsoft.com**

Arjun Mukherjee

In cloud, customers typically are given a certain limit to which they can deploy workloads. As customers reach closer to their limits, they sometimes have to manually open up support. Microsoft aspires to provide frictionless, differentiable experience, for our cloud customers; an ML-based solution that was placed into production with a positive customer experience impact. Through this automated capability, cloud resources are managed systemically by automatically setting them to expected usage several days out with a certain uncertainty range by combining predictions from two random walks with for the ensemble considering both volatility and growth in the past usage.

3 - Analysis of the Project Management Stack Exchange Question-and-answering Community Using Bert

**Fatemeh Delkhosh, University of Calgary, Calgary,
AB, Canada**

**Raymond A Patterson, Alireza Ahmadi, Guenther Ruhe,
Gouri Deshpande**

We targeted Project Management Stack Exchange, a widely used project management question and answering community to identify the primary needs of software project managers. We implemented BERT and Doc2vec embeddings on our data set to feed results into different machine learning methods and compared their performance. Our results show that BERT outperforms Doc2vec for pre-training and schedule management and planning phase are the main questions of concern for project managers.

4 - A Reinforcement Learning Approach for Identifying Offensive Language in Online Conversations

**Arezo Bodaghi, Concordia University, Montreal,
QC, Canada**

Ketra Schmitt, Benjamin C. M. Fung

The emergence of anti-social behaviors and the use of abusive language in social media platforms present a serious societal issue. A rich body of work has implemented machine and deep learning techniques for addressing

different aspects of offensive language. This research departs from existing work in that it aims to implement a self-learning model using reinforcement learning to identify online offensive content.

5 - Self Correcting AI System

**Andrew B Whinston, University of Texas-Austin, Austin,
TX, United States, abwhins@gmail.com**

Yunhao Yang

The presentation will introduce the concept of the self-correcting AI system, where users may be disappointed or reject the initial results. We initially explain these ideas in the applications to the recommender system but also consider the possibility of security failures. The approach is based on combining deep learning with probabilistic modeling.

TC06

3rd FI-Regency A

Tutorial: Markov Decision Processes in Health Care

Tutorial Session

1 - Markov Decision Processes in Health Care

**Steven Shechter, University of British Columbia,
Vancouver, BC, V6T 1Z2, Canada**

Markov Decision Processes (MDPs) provide a rich framework for sequential decision making under uncertainty. This tutorial will introduce theory, algorithms, and health care applications of MDPs. It will begin with basic MDP concepts, solution methods, and structural properties, and then provide overviews of two major extensions of MDPs: Partially Observable MDPs, and Reinforcement Learning. Applications in health care will be interspersed throughout, covering both system-level (i.e., resource allocation) and patient-level (i.e., medical decision making) models.

TC07

3rd FI-Regency B

ICU Pandemic Capacity Planning

General Session

Chair: Felipe Rodrigues

King's University College at Western University, King's
University College at Western University, London,
ON, N6A 2M3, Canada

2 - A Forecasting Tool for a Hospital to Plan Inbound Transfer of Covid-19 Patients from Other Regions

Mehmet A Begen, Western University, London, ON, Canada, mbegen@ivey.uwo.ca

Felipe Rodrigues, Greg Zaric

In April, 2021, Ontario, Canada was at the peak of its third wave of the COVID-19 pandemic. ICU capacity in the Toronto area was insufficient to handle all local COVID-19 patients. As a result, some patients from the Toronto area were transferred to other regions of the province. We developed a simple model to predict the impact on ICU utilization of patient transfers from outside to London. The model was implemented in Excel and helped to understand the impact of patient transfers on capacity, utilization and improve confidence of managers when making transfer decisions.

3 - Intensive Care Unit / Step-down Unit Queuing Game with Service Time Decisions

Felipe F. Rodrigues, Assistant Professor, Operations Management, King's University College at Western University, London, ON, N6A 2M3, Canada, frodrig7@uwo.ca

Yawo Kobara, Camila de Souza, David A Stanford

This research is an investigation of the length of stay (LOS) competition between the Intensive Care Unit (ICU) and the Step Down Unit (SDU). This game is characterized as a queuing game of two servers in tandem without a buffer between them, and with the length-of-stay as decision variable. We performed the model analysis under four different cooperation and competition scenarios. We found closed form solutions and performed a numerical analysis for validation and illustration purposes. The results show that under certain conditions, the critical care pathway performs better under coordination and or leadership at the ICU level.

4 - Forecasting ICU Census by Combining Time Series and Survival Models

Lori Murray, King's University College at Western University, London, ON, Canada, lsincla3@uwo.ca

John G Wilson, Felipe Rodrigues, Greg Zaric

We present an ICU census forecasting method that combines time series and survival models utilizing intensive care scoring systems. Our ICU census model was tested using data collected at a Canadian hospital during the global pandemic. This type of forecasting model may aid clinicians and managers when planning ICU capacity as well as staffing and surgical demand planning over a short time horizon.

5 - Invasive Mechanical Ventilation Duration Prediction Using Survival Analysis

Yawo Kobara, University of Western Ontario, London, ON, Canada

Felipe Rodrigues, Camila de Souza

In this study, first-day ventilated patients' ventilation time was analyzed using survival analysis. Parametric survival methods were used to characterize ventilation time and determined covariates associated with ventilation time.

The analysis of the duration of ventilation suggested that the log-normal distribution provided a better fit for the ventilation time, whereas the log-logistic Accelerated Failure Time model best describes the association between the covariates and the duration of ventilation. Significant predictors of the ICU ventilation time were determined.

TC08

3rd Fl-Regency E

Health Care I

Contributed Session

Chair: Mojtaba Araghi

Wilfrid Laurier University, Waterloo, ON, N2L 3C5, Canada

2 - Human Factors Considerations in Peer Support Specialist Software for Substance Abuse

Sue Feldman, UAB, Birmingham, AL, United States, sf8588@gmail.com

Benjamin Schooley, Calvin Madison

Human factors considerations are critical in designing applications for data collection and assessment completion for opioid and substance use disorder. In an effort to curb the opioid and substance use epidemic in Alabama, the state has implemented several recovery resource centers. These centers are staffed with state-trained peer support specialists and clinical social workers, all of varied skill levels. Often, these initiatives are seen as failures because they lack appropriate systems to collect/analyze data, adequately follow clients, and appropriately report outcomes. Findings report on system usability, intentions to use, barriers to use, and impact of use on client facing time.

3 - A Stochastic Approach for Scheduling Medical Interpreters

Abdulaziz Ahmed, Associate Professor of Health Informatics, University of Alabama Birmingham, Birmingham, AL, United States, aahmed2@uab.edu

Aida Jabali

This work discusses the development of a framework for scheduling medical interpreters in a stochastic environment. Our study is conducted based on real-life data collected from

a pattern hospital located near the metropolitan area of Minneapolis/St. Paul in Minnesota. A two-stage stochastic programming model is developed and solved using the sample average approximation (SAA) approach. The experimental results show the performance of the proposed solution approach and its practicality.

4 - Optimal Hearing Loss Screening for Pediatric Patients with Cystic Fibrosis Disease

Narges Mohammadi, Imperial College Business School, London, United Kingdom, n.mohammadi19@imperial.ac.uk
Mohammadreza Skandari

Patients with cystic fibrosis disease experience frequent pulmonary exacerbation and require antibacterial treatments. Intravenous aminoglycosides are the primary choice but they cause hearing loss. To detect possible hearing loss, there are several hearing assessment methods available. The overarching aim of this research is to design cost-effective strategies to monitor pediatric patients with CF disease to detect potential hearing loss and improve their quality of life using a hearing aid. To this end, we build a partially observable Markov decision process model to find policies that optimize the net monetary benefit of hearing screening for a pediatric CF population.

5 - Influencing Primary Care Antibiotic Prescription Behavior Using Financial Incentives

Mojtaba Araghi, Wilfrid Laurier University, Waterloo, ON, Canada, maraghi@wlu.ca

Salar Ghamat, Lauren Cipriano, Michael Silverman

Antibiotic resistance is a public health crisis fueled by overuse of antibiotics. We develop a physician compensation model to evaluate a two-part tariff incentive payment on reducing inappropriate antibiotic prescription. We consider public vs. private physician opportunity costs and exogenous vs. endogenous diagnostic accuracy. We show that the first-best policy is achievable in the absence of information asymmetry and when the incentive payments do not affect diagnosis decisions.

TC09

3rd FI-Regency F

Covid Models: IV

General Session

Chair: Adam Diamant

Operations Management and Information Systems,
Toronto, ON, M3J 1P3, Canada

2 - Two-stage Distributionally Robust Optimization for Network Balancing Problems

Aliaa Alnaggar, Postdoctoral Fellow, University of Toronto, University of Toronto, Toronto, ON, Canada, aliaa.alnaggar@utoronto.ca

Andre Augusto Cire, Adam Diamant

We propose a two-stage distributionally robust optimization problem for capacity rebalancing where resources are located at nodes of a network. The first stage establishes node capacities, while the second stage transfers resources across network links after observing demand. We show that, for partial moment ambiguity sets, the problem may be solved exactly for general second-stage networks via a separation algorithm, where the subproblem is a mixed integer second order cone program. Using publicly available data, we illustrate the benefits of the approach for repositioning ICU beds across hospitals.

3 - Shield-Net: Matching Supply with Demand During the COVID-19 Pandemic

Rebecca Alcock, University of Wisconsin-Madison, Madison, WI, 53711, United States, ralcock@wisc.edu

Justin J. Boutilier, Auyon Siddiq

The COVID-19 pandemic was marked by widespread shortages of personal protective equipment. Many domestic suppliers pivoted to producing PPE, but a key challenge that remained was the lack of an established marketplace to connect non-traditional suppliers to healthcare facilities. In response, we created an optimization model, Shield-Net, to match face shield requests with suppliers. Between March and September 2020, Shield-Net produced 390 matches, resulting in the shipment of 50,000+ face shields. This work contributed to the development of local PPE production initiatives in Guatemala with Engineers Without Borders and around the world with the United Nations Development Programme.

4 - Patient Admission Scheduling in Hospitals During Pandemics: Case of Covid-19

Peyman Varshoei, University of Ottawa, Ottawa, ON, Canada, pvars059@uottawa.ca

Jonathan Patrick, Onur Ozturk

During the COVID-19 pandemic, many hospital elective admissions were canceled. It resulted in record lows in bed utilization while creating massive backlogs. There was an argument to be made that the hospitals were kept empty by more than needed during the pandemic. We propose a new scheduling policy using an MILP-based patient admission scheduling heuristic that maximizes patient throughput while ensuring the hospital's ability to empty beds for the

pandemic patients quickly in the event of a surge in demand. The results confirm the efficiency of the proposed policy versus the current policy.

5 - Capacitated SIR Model with an Application to COVID-19

Chaoyu Zhang, Rotman School of Management, Toronto, ON, Canada, cyu.zhang@rotman.utoronto.ca

Ningyuan Chen, Ming Hu

The classical SIR model and its variants have succeeded in predicting infectious diseases' spread. To better capture the COVID-19 outbreak, we extend the SIR model to impose a testing capacity and differentiate the infected people into symptomatic and asymptomatic. Using this capacitated SIR model, we study how to choose the best type of testing method, how to allocate limited testing capacity over time and across symptomatic and asymptomatic people. We use the COVID-19 data and a sliding window method to calibrate our model and point out its public policy implications.

TC10

3rd Fl-Balmoral/Windsor

Machine Learning with Applications to Insurance and Finance

General Session

Chair: Ken Seng Tan

Ph.D., NANYANG BUSINESS SCHOOL, NANYANG BUSINESS SCHOOL, Singapore, Singapore

2 - Generalized Pareto Regression Trees for Extreme Event Analysis

Maud Thomas, PhD, Sorbonne University, Paris, 75006, France

We provide finite sample results to assess the consistency of Generalized Pareto regression trees, as tools to perform extreme value regression. The results that we provide are obtained from concentration inequalities, and are valid for a finite sample size, taking into account a misspecification bias that arises from the use of a Peaks over Threshold approach. The properties that we derive also legitimize the pruning strategies (i.e. the model selection rules) used to select a proper tree that achieves compromise between bias and variance. The methodology is illustrated through a simulation study, and a real data application in insurance against natural disasters.

3 - Compositional Data Regression in Insurance with Exponential Family PCA

Guojun Gan, University of Connecticut, Storrs, CT, 06269,

United States

Compositional data are multivariate observations that carry only relative information between components. Applying standard multivariate statistical methodology directly to analyze compositional data can lead to paradoxes and misinterpretations. Compositional data also frequently appear in insurance but do not receive deserved special treatment in most existing actuarial literature. In this talk, I will present the use of exponential family principal component analysis (EPCA) to analyze compositional data in insurance. I will also present some numerical results showing that EPCA is able to produce principal components that can improve the prediction accuracy of the regression model.

4 - Managing Weather Risk with a Neural Network-Based Index Insurance

Jinggong Zhang, PhD, Nanyang Technological University, Singapore, 639798, Singapore, jgzhang@ntu.edu.sg

Zhanhui Chen, Yang Lu, Wenjun Zhu

Weather risk affects economy, agricultural production in particular. Index insurance is a promising tool to hedge against weather risk, but current piecewise-linear index insurance contracts face large basis risk and low demand. We propose embedding a neural network-based optimization scheme into an expected utility maximization problem to design the index insurance contract. Neural networks capture highly nonlinear relationship between the high-dimensional weather variables and production losses. We endogenously solve for the optimal insurance premium and demand. This approach reduces basis risk, lowers insurance premium, and increases farmers' utility.

TC11

3rd Fl-Oxford/Prince of Wales

New Developments in Derivatives and Risk Management: Modelling, Pricing, and Hedging

General Session

Chair: Jean-François Bégin

Simon Fraser University, Simon Fraser University

2 - Long Memory in Option Pricing: A Fractional Discrete-Time Framework

Alexandru Badescu, PhD, University of Calgary, Calgary, AB, Canada, abadescu@ucalgary.ca

Maciej Augustyniak, Jean-François Bégin, Sarath Kumar Jayaraman

This article studies the impact of long memory on modelling returns and pricing options in discrete time. We propose a pricing framework based on affine multi-component volatility

models that admit ARCH(∞) representations, which not only nests a plethora of option pricing models from the literature, but also allows for the introduction of novel fractionally integrated processes for valuation purposes. We carry out an extensive empirical analysis which includes single and joint calibrations of a variety of short and long memory models to historical returns and S&P 500 options. Our results indicate that the inclusion of the long memory feature substantially improves the option pricing performance.

3 - Venturing into Uncharted Territory: An Extensible Parametric Implied Volatility Surface Model

Geneviève Gauthier, PhD, HEC Montréal, Montréal, QC, Canada

A parametric representation of implied volatility surfaces based on factors that adequately capture the moneyness and maturity slopes, the smile attenuation, and the smirk. Fitting performance on S&P 500 options compares favorably with existing benchmarks. The benefits of a smoothed implied volatility surface are illustrated through the valuation of illiquid index derivatives, the extraction of the risk-neutral density and risk-neutral moments, and the calculation of option price sensitivities.

4 - Optimal Quadratic Hedging in Discrete-time Under Basis Risk

Maciej Augustyniak, Associate Professor, Université de Montréal, Montreal, QC, Canada, maciej.augustyniak@umontreal.ca

Ismael Assani, Frédéric Godin

Recent literature has shown that basis risk can significantly impair hedging effectiveness. This article derives new semi-explicit expressions for optimal discrete-time quadratic hedging strategies under basis risk when the dynamics of the underlying asset and of the hedging instrument are driven by correlated processes with stationary and independent increments. Several numerical experiments are conducted to evaluate the performance of optimal quadratic hedges. Overall, we find that these hedges can significantly reduce the risk of hedging options with long-term maturities.

5 - Leveraging Prices from Credit and Equity Option Markets for Portfolio Credit Risk Management

Jean-François Bégin, Assistant Professor, Simon Fraser University, Burnaby, BC, Canada, jbegins@sfu.ca

Mathieu Boudreault

This paper presents a firm-specific methodology for extracting implied default intensities and recovery rates jointly from unit recovery claim prices—backed by out-of-

the-money put options—and credit default swap premiums, therefore providing time-varying and market-consistent views of credit risk at the individual level. We apply the procedure to about 400 firms spanning different sectors of the US economy between 2003 and 2019. The main determinants of default intensities and recovery rates are analyzed with statistical and machine learning methods linking default risk and credit losses to market, sector, and individual variables. Consistent with the literature, we find that individual volatility, leverage, and corporate bond market determinants are key factors explaining the implied default intensities and recovery rates. Then, we apply the framework in the context of credit risk management in applications like market-consistent credit value-at-risk calculation and stress testing.

TC12

34th Fl-Seymour

Bioenergy's Supply Chain

General Session

Chair: Krishna Teja Malladi

The University of British Columbia, The University of British Columbia, NULL

Chair: Sahar Ahmadvand

University of British Columbia, Vancouver, BC, V6T2G9, Canada

3 - Minimizing the Cost and GHG Emissions of Forest-based Biomass Gasification Supply Chain Considering Uncertainties

Sahar Ahmadvand, PhD Candidate, University of British Columbia, Vancouver, BC, V6T2G9, Canada, sahamdvd@mail.ubc.ca

A bi-objective robust optimization model is developed for the tactical supply chain planning of forest-based biomass gasification at a pulp mill considering variations and uncertainties. The model determines the optimal monthly upstream supply chain decisions including transportation, storage, and preprocessing of biomass. The objectives are to minimize upstream supply chain costs and GHG emissions. Robust optimization with an adjustable budget of uncertainty is used to model the uncertainties in supply, demand, and cost of biomass. The bi-objective model is solved using the augmented epsilon-constraint method and is applied to the case of a pulp mill in British Columbia.

4 - Techno-economic Analysis of Biofuel Production from Construction and Demolition Wood Waste

Kimiya Rahmani Mokarrari, University of British Columbia, Vancouver, BC, Canada, krah76@mail.ubc.ca

A techno-economic analysis is performed for biofuel production from construction and demolition wood waste received at the City of Vancouver's landfill in BC. Technical analysis determines operations and flow of wood waste. Furthermore, the economic feasibility of the biofuel production is determined considering all the relevant costs, cash benefits, and non-cash benefits resulting from emission reductions compared to landfilling all the waste.

5 - Developing a Sustainable Biocomposite Supply Chain Assessment Model Under Uncertainty: A Case Study in Western Canada

Niloofer Akbarian-Saravi, University of British Columbia, KELOWNA, BC, United States, niloofer.akbarian@ubc.ca
Abbas S. Milani, Taraneh Sowlati

Natural fibers are among the renewable sources used as reinforcement in composites due to their advantages in recyclability. This research aims to assess the value chain feasibility of a hemp-based biocomposite processing method. Moreover, there are different Supply Chain (SC) alternatives depending on decisions such as those related to storage, capacity, and equipment. To select the best SC with multiple sustainable and technical criteria, a combination of Bayesian Belief Network and Fuzzy Analytical Network Process will be applied. The outcome of this research helps practitioners of SC management to improve their decision-making capability and deal with uncertainties in their opinion.

6 - A Supply Chain Network Design for Construction and Demolition Waste Management Problem

Soroush Aghamohamadi, University of British Columbia, Vancouver, BC, Canada, bosjins@mail.ubc.ca
Taraneh Sowlati

The rapid growth of urbanization has resulted in a high amount of construction and demolition waste (C&DW) generation. A considerable portion of C&DW is landfilled, however, the limited amount of available space for landfilling necessitates alternative methods to manage C&DW. One of the management alternatives is the recycling of C&DW. Previous studies mainly focused on economic aspects of recycling C&DW. In this study, a mathematical programming model is developed to assess the environmental and social impacts alongside economic objective to provide more sustainable solutions.

TC13

34th Fl-Stanley

Engaging Students with Case Studies, the Pandemic, and Technology

General Session

Chair: David Wheatley

Chair: Tiffany Bayley

Ivey Business School, London, ON, N6G 0N1, Canada

3 - Moneyball for Murderball: A Case Study Using Analytics to Construct Lineups in Wheelchair Rugby

Timothy Chan, University of Toronto, Toronto, ON, M5S 3G8, Canada, tcychan@mie.utoronto.ca

Craig Fernandes, Albert Loa, Nathan Sandholtz

This case allows students to explore descriptive, predictive, and prescriptive analytics within the domain of wheelchair rugby (WCR). The coach of Canada's WCR team is interested in creating optimal lineups. A novel twist compared to other team sports, is that in WCR there is a well-defined constraint that limits which players can play together at the same time based on the physical ability of each player. This case involves exploratory data analysis, ordinary and weighted least squares regression, and linear and integer optimization models, including piecewise linear objective functions.

4 - Samsara for Science: Teaching Analytics Concepts by Illustrating Pandemic Phenomena

Srini Krishnamoorthy, Senior Lecturer, Simon Fraser University, Vancouver, BC, V5A 1S6, Canada, srinivas_krishnamoorthy@sfu.ca

The pandemic has provided the opportunity to illustrate phenomena like network effects as well as decision making principles like the precautionary principle. This talk will provide the content and the pedagogy used to incorporate pandemic phenomena in analytics courses.

5 - Does Technology-Enabled Teaching Spark Joy?

Tiffany Bayley, Ivey Business School, London, ON, N6G 0N1, Canada, tbayley@ivey.ca

Rob Austin, David Wood

Which advances in education technology should we sustain post-pandemic? Our Delphi study examines the role of technology-enabled teaching as we return to in-person learning. We solicited opinions of 23 experts in post-secondary business education whose roles are in academia, publishing, and consulting. To sustain the implementation of

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sensible technologies that engage students and have positive effects on student learning, our expert panel identified several strategies to mitigate challenges many educators face, from willingness to adopt technology to scarcity of funding and time.

TC14

34th FI-Cypress

Innovative Queueing Models

General Session

Chair: Alan Scheller-Wolf

Tepper School of Business, Tepper School of Business, Pittsburgh, PA, 15213-3815, United States

Chair: Yanhan Tang

Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

3 - A Mixture Model for Queue Inference Based on Inter-departure Time Data

Xiyuan Ge, University of Washington, Seattle, WA, 98195, United States, xiyuange@uw.edu

Masha Shunko, Serguei Netessine

We consider inference of service time and system sizes for M/G/1 queues solely based on inter-departure time data. Different from past literature, we adopt a mixture model free of recursions to calculate the likelihood of inter-departure times. Such a mixture model allows efficient parametric and nonparametric estimation for the unobserved service time distribution. We also leverage the semi-Markov property of the M/G/1 system and estimate the average queue size at each departure. With synthetic and real-life data, we illustrate the performance of our method and compare it with established methods previously proposed for similar problems.

4 - Asymptotic Analysis of Multi-Class Advance Patient Scheduling

Hossein Abouee Mehrizi, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

Mohamad Sadegh Shirani Faradonbeh, Mohamad Kazem Shirani Faradonbeh

We study an advance scheduling problem with different classes of patients whose service requests arrive randomly. The system incurs the daily resource cost and patient waiting costs, while the cost of waiting to receive an appointment is different than the cost of waiting to be served after receiving the appointment. Thus, the scheduler decides whether to schedule the patients waiting in line and, if so, which available appointment times should be assigned to them. We

analyze the problem in both fluid and diffusion scales and characterize the optimal scheduling policy based on a simple function of the system state. This function fully determines the scheduling at any given time.

5 - Split Liver Transplantation: An Analytical Decision Support Model

Yanhan Tang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, yanhanta@andrew.cmu.edu

Alan Scheller-Wolf, Sridhar R Tayur

Split liver transplantation (SLT) can potentially save two lives using one liver. To facilitate increased SLT usage, we formulate a multi-queue fluid model, incorporating size matching specifics, dynamic health conditions, transplant type, and fairness. We find the optimal organ allocation policy, and evaluate its performance versus other common allocations.

6 - Behavior-Aware Queueing: The Finite-Buffer Setting with Many Strategic Servers

Yueyang Zhong, The University of Chicago Booth School of Business, Chicago, IL, 60637-1610, United States, yzhong0@chicagobooth.edu

Raga Gopalakrishnan, Amy R Ward

Service system design is often informed by queueing theory. Traditional queueing theory assumes that servers work at constant speeds. That is reasonable in computer science and manufacturing contexts. However, servers in service systems are people, and, in contrast to machines, systemic incentives created by design decisions influence their work speeds. We study how server work speed is affected by decisions concerning (i) how many servers to staff and (ii) whether and when to turn away customers, in the context of a finite-buffer many-server queue in which the work speeds emerge as the solution to a noncooperative game.

TC15

34th FI-Grouse

Adaptive Robust Optimization

General Session

Chair: Amirhossein Salami

University of British Columbia

Chair: Maryam Daryalal

University of Toronto, University of Toronto, Ottawa, ON, K2T 1C7, Canada

3 - On Primal and Dual Bounding Techniques for Multistage Adaptive Robust Optimization

Maryam Daryalal, Department of Decision Sciences, HEC

Montreal, Montreal, QC, K2T 1C7, Canada, maryam.daryalal@hec.ca

Merve Bodur, Ayse Nur Arslan

In this work, we adapt the recent decision rules introduced in the stochastic programming literature to robust optimization both from the primal and the dual perspective. The resulting problems are challenging and require advanced techniques in their solution. Our methodology is illustrated with preliminary results on production planning and transportation problems.

4 - Regret in Multi-item Newsvendor Problem with a Budget Constraint and Fixed Ordering Costs

Amirhossein Salami-rad, Master of Science, University of British Columbia, Kelowna, BC, V1V 1V7, Canada

Amir Ardestani-Jaafari, Javad Tavakoli

We study a two-stage worst-case regret multi-item newsvendor problem with correlated demand, budget constraint and fixed ordering cost. We developed a column-and-constraint generation algorithm to solve the problem optimally. Finally, we investigate the impact of correlated demand, budget constraint and fixed ordering cost on robust and regret policy.

5 - A Two-stage Minimax Regret Location-transportation Problem

Pooya Pourrezaie-Khaligh, University of British Columbia, Kelowna, BC, Canada, pooya.pourrezaie@ubc.ca

Amir Ardestani-Jaafari, Babak Mohamadpour Tosarkani

We study a two-stage minimax regret location-transportation problem. We developed a column-and-constraint generation algorithm to solve the problem optimally. Finally, we compare the robust and regret policies in an extensive set of numerical experiments.

6 - Constructing a Reliable and Robust Hazmat Emergency Network

Ginger Yi Ke, Memorial University of Newfoundland, St. John's, NL, Canada, gke@mun.ca

Jlana Lu, James H. Bookbinder

This work designs a reliable and robust emergency logistics network to respond to incidents involving hazmat. The proposed bi-objective model considers the tradeoffs between risk and cost, where the level of hazmat risk can be reduced by expenditures that add extra capacities to certain links or establish additional facilities that aid recovery from incidents. Our analytical results reveal the necessity of embedding the consideration of uncertainty and unreliability into the emergency network design problems and outline the importance of hedging against unpredictability by system redundancies.

TC16

34th Fl-English Bay

Reinforcement Learning and Simulation-based methods for MDPs

General Session

Chair: Archis Ghate

University of Washington, University of Washington, Seattle, WA, 98195, United States

2 - Applying Wassestein-based Policy

Optimization to Demand Response Problems

Chaoyue Zhao, University of Washington at Seattle, Seattle, WA, 74075, United States

Model-free RL methods have been exploited to address demand response problems, but their performances are not ideal for real-world implementation. One major concern is most of these work limits the policy to a particular parametric distribution class and optimizing over such distributions results in local movements in the action space and thus leads to a sub-optimal solution. This framework will replace the untrustworthy probabilistic assumptions of policy gradient methods with an ambiguity set that covers all permissible distributions. A practical on-policy actor-critic algorithm is proposed. Experiments show that our approach demonstrates the stability and solution optimality.

3 - Simulation Methods For Markov Decision Processes

Martin L Puterman, Professor Emeritus, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada, martin.puterman@sauder.ubc.ca

The past 25 years has seen significant developments in the use of simulation (and function approximation) to find good policies for Markov Decision Processes (MDPs). Most of this research has appeared in the artificial intelligence literature and is often referred to as reinforcement learning. In order to include this material in a new introductory MDP text I am co-authoring with Tim Chan, I have tried to make sense of this vast literature from an operations research point of view. In this mini-survey I will share with you my perspectives on this vast and important field focusing on terminology, methods and simple numerical examples.

4 - Information-directed Policy Sampling For Episodic Bayesian Markov Decision Processes

Archis Ghate, University of Washington, Seattle, WA, 98195, United States

Victoria Diaz

We will present an information theoretic method to approximately solve Markov decision processes (MDPs) under incomplete information. We will consider an episodic Bayesian framework, where the decision-maker interacts with a stochastic system repeatedly over T episodes comprising N stages each. The decision-maker only knows that the true parameters that describe the stochastic system take values from a particular finite set. The decision-maker wishes to maximize expected total reward over all episodes. The algorithm is designed to balance the exploration-exploitation tradeoff. Regret bounds and computational results will be discussed.

Tuesday, 3:15–4:05pm

TP02

3rd Fl-Regency CD

Plenary Panel: Future of Quantum Computing in Optimization

Plenary Session

1 - Moderator and Panelist

David Bernal, NASA - USRA, Pittsburgh, PA, 15206-4367, United States

Quantum computing (QC) harnesses the properties of subatomic particles to perform computations in a fundamentally different way than classical computing. It is widely established that QC can, in the future, revolutionize the way we perform and think about computation. In particular, QC has the potential to radically transform our capability to solve extremely difficult combinatorial optimization problems for which no traditional numerical or theoretical efficient solution algorithms exist, as well as the potential to substantially speed up the solution of convex optimization problems that arise ubiquitously in practice. In this panel, five experts in QC from industry and academia, will discuss and answer questions about the challenges, trends, impact and perspectives that the combination of QC and optimization bring about.

2 - Panelist

Daniel Higginbottom, Photonic, Burnaby, BC, Canada

3 - Panelist

Catherine McGeoch, D-Wave Systems Inc., Amherst, MA, 01002, United States

4 - Panelist

Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights,

NY, 10598, United States

5 - Panelist

Elisabetta Valiante, 1QBit, Vancouver, BC, Canada

Tuesday, 4:15–5:45pm

TD03

2nd Fl-Plaza A

Scheduling

Contributed Session

Chair: Mageed Ghaleb

Ryerson University

2 - Particle Swarm Optimization Algorithm

with Time Buffer Insertion for Robust Berth Scheduling

Chulung Lee, Korea University, Seoul, Korea, Republic of, leecu@korea.ac.kr

Hyun Ji Park, Sung Won Cho

This paper investigates the robust berth allocation problem in container terminals. To handle the uncertainties in vessel arrivals, the problem is formulated as a scenario-based two-stage stochastic programming model. Furthermore, we introduce the time buffers to the model. We then develop an algorithm for time buffer insertion, which accommodates the adaptive search procedure for the time buffer into the Particle Swarm Optimization (PSO) algorithm. Different from the traditional PSO algorithm, a core operator is designed with a modified version to take the intelligent time buffer insertion approach.

3 - Evaluation of Nudge Scheduling Policy with Multiple Swaps

Maryam Elahi, Assistant Professor, Mount Royal University, Calgary, AB, Canada, melahi@mtroyal.ca

Timothy Meneses

One of the most commonly used scheduling policies is First Come First Serve (FCFS), which is simple to implement and preserves temporal fairness, however, it does not minimize the average response time. The Nudge scheduling policy stochastically improves upon FCFS by allowing a small arrival to nudge (get ahead of) a large task that is at end of the queue. Analysis of Nudge in previous literature is limited to the case where a task is nudged at most once. We examine a Variant of Nudge scheduling, where a task can be nudged up to K times. Our simulation results

suggest that increasing K will further reduce the average response time without significant degradation to the average performance of large tasks.

4 - Dynamic Shop-floor Scheduling Using Real-time Information: A Case Study from Thermoplastic Industry

Mageed Ghaleb, Postdoctoral Fellow, Ryerson University, Toronto, ON, Canada, mageed.ghaleb@ryerson.ca

Sharareh Taghipour

A predictive-reactive scheduling approach, which is based on a modified simulated annealing algorithm and an event-driven rescheduling policy, is introduced to solve the problem of dynamic shop-floor scheduling using real-time information in a case study from the thermoplastic industry. The production process is subject to the following constraints: batch processing, safety stocks, dedicated machines, machine-dependent setup times, precedence constraints, machine failures, and real-time updates. The conducted experimental study indicated that the proposed approach generates better results, in real-life planning and scheduling, compared to the methods based on dispatching rules.

TD04

2nd FI-Plaza B

Supply Chain Optimization I

Contributed Session

Chair: Aldair Alvarez

HEC Montréal

2 - Product Sharing: A Threat or an Opportunity for Competing Manufacturers?

Tao Li, Santa Clara University, Santa Clara, CA, United States

This paper studies the impact of product sharing on competing manufacturers under a platform's different quality entry barrier strategies. We build a game-theoretic analytical model and study the strategies of two manufacturers, an industry leader producing a high-quality product and an industry follower producing a low-quality product, in three markets: the N-S market where the sharing market does not exist, the L-S market and the H-S market where the platform sets a low and a high entry barrier, respectively. We show that it is not always beneficial for a manufacturer to join the sharing market.

3 - Assessing the Sustainability of Supply Chain and Performance Evaluation of

Suppliers Under Uncertainty Using Data Envelopment Analysis

Mazyar ZahediSeresht, University Canada West (UCW), Vancouver, BC, Canada

Shahrzad Khosravi

We redesign the model considering the uncertainty in the supply chain. Current literature that considers the monetary penalty for worth case scenario, we consider it as an externally imposed factor, which should be modeled as a constraint. In the post-pandemic, suppliers would also avoid congestion and prefer less crowded harbors. In this method, uncertainty is defined as a multi-scenario for inputs and outputs

4 - Reliability Optimization for Multi Stage Supply Chains with Discrete Cost Tradeoff Options

Ganapathy Lakshmikanthan, Professor, National Institute of Industrial Engineering, Mumbai, India, ganapathyl@gmail.com

Omkarprasad S Vaidya, Sushil Kumar

The recent pandemic has exposed the vulnerabilities of multi-stage supply chains to disruptions. We note that the reliability at each stage can be improved through investments in automation and technologies like IoT at some cost. We consider the problem of optimal reliability allocation to each stage given target reliability for the entire supply chain. We develop a heuristic approach for this discrete optimization problem and present some computational results.

5 - Production Routing with Consistency Requirements

Aldair Alvarez, HEC Montréal, Montreal, QC, Canada, aldair.alvarez@hec.ca

Jean-François Cordeau, Raf Jans

This work introduces the consistent multi-plant multi-product production routing problem. The problem consists in finding production routing plans minimizing the total cost and also meeting specific consistency requirements. In our context, consistency is defined as the degree to which certain features of the solutions remain invariant over time. We consider driver, source, product, and plant consistency. We present an exact branch-and-cut algorithm and a hybrid heuristic for the problem. Computational experiments show that the cost-consistency trade-offs can be explored efficiently.

TD05

2nd FI-Plaza C

Artificial Intelligence II

Contributed Session

Chair: Cindy Yao
Air Canada

2 - AI Workflow for Disease Activity Detection and Scoring

Greta Laage, IVADO Labs, Montreal, QC, Canada, greta.laage@ivadolabs.com

Michael F. Byrne, Enrico Cremonese, James E. East, Paul Lemaitre, Shima Nikfal, Remo Panaccione, Florian Soudan, Ludovic St-Denis, Simon P. Travis

Some medical conditions require a video assessment, conducted by trained specialists in order to characterize disease activity. Current approaches for analyzing videos can be long and costly as they are expert driven. Computer vision techniques in support of clinical diagnostics show great potential. We teamed up with a leading medical solutions provider and world-class doctors to develop a fully automated tool using deep learning models to identify and score disease activity in Ulcerative Colitive. The solution reached high scoring accuracy and is now being used in a Phase II clinical trial.

3 - Personalized Cure for the Diabetics Based on the Patient's Information and AI

Azam Dekamin, Ryerson University, Toronto, ON, Canada
M. I. M. Wahab, Aziz Guergachi, Pejman Jamili, Karim Keshavjee

This research proposes a modular medicine recommender system. It recommends the most effective antidiabetic based on a pan-Canadian dataset, including patient characteristics, lab tests, risk factors, and medications. The first module predicts the likelihood of success of each antidiabetic, and the second module uses the similarity computation to find cases most similar (with a positive outcome) to new patients. The proposed method integrates the results of both modules and recommends an effective antidiabetic for a particular patient. The interpretable results obtained from this research can be an assistant in health decision support systems.

4 - Improving Social Media Customer Service Using Deep Learning

Sue Abdinnour, Professor, Wichita State University, Wichita, KS, United States, sue.abdinnour@wichita.edu
Ross Gruetzemacher

It is common now for customers to complain on social media, especially when experiencing problems with air travel (flight delays, lost luggage, etc.). To maintain customer loyalty, airlines must respond to such complaints promptly and effectively. Social media customer service (SMCS) is important in other industries, too, and previous work has used natural language processing for classifying customer

complaints on Twitter. We will demonstrate that more advanced deep learning techniques significantly outperform this earlier work. We will also discuss future work applying this for airline SMCS.

5 - Predicting Airline Passenger No-show with Machine Learning for Revenue Optimization

Cindy Q Yao, Air Canada, Montreal, QC, Canada

Tianjiao Liu, Hasan Kamrul, Lea Gauthier, Alan Regis

Not all passengers show up for their confirmed flights. Airlines oversell seats to mitigate these no-shows, balancing between minimizing expected spoiled seats, minimizing expected denied boarding compensation, and maximizing level of service provided. We developed a machine learning forecasting algorithm that adapts to seasonality and fast-changing data and integrates novel PNR-based features to deliver more accurate passenger no-show predictions. We have since deployed the model to help guide oversell strategies to optimize airline revenue while minimizing seat spoilage.

TD06

3rd Fl-Regency A

Operations Management I

Contributed Session

Chair: Narges Sereshti

HEC Montreal, Montreal, QC, H3S2V7, Canada

2 - Minimum-Cost Selective Assembly

Thomas A. Weber, Professor of Operations, Economics and Strategy, EPFL, Lausanne, Switzerland, thomas.weber@epfl.ch

We consider the minimization of cost for a selective assembly system for a production output, given two random inputs and a finite number of matching classes. We determine optimality conditions for the optimal input portfolio, first using a normal approximation of the multinomial classification distributions, and second using a tight concave envelope instead of the exact output objective. The latter yields closed-form expressions for the optimal factor demands and total costs. A numerical study tests the practicality of the envelope solution, both as seed for a numerical solution and as a closed-form approximate solution, which allows for an analysis of structural properties.

3 - Dynamic Capacitated Lot Sizing and Disassembly Under Yield Uncertainty

Mazyar ZahediSereshti, University Canada West (UCW), Vancouver, BC, Canada

Sajjad Hedayati

Environmental issues have attracted a lot of interest in manufacturing. This paper considers a dynamic single-item incapacitated lot-sizing problem in which customers' demands can be satisfied by two processes: a manufacturing process utilizing raw material for production and a re-manufacturing process that disassembles returned products to origin parts. The yield of the returned products is stochastic. Due to modeling this stochastic hybrid manufacturing-re-manufacturing lot-sizing problem, we develop a two-stage mixed-integer stochastic programming approach and propose an exact algorithm that is based on Benders-Decomposition.

4 - Store Specific Planogram Customization at Canadian Tire

Philippe Grangier, IVADO Labs, Montréal, QC, Canada, philippe.grangier@ivadolabs.com

Louis-Philippe Bigras, Dawn Duan, Mouad Faik, Nabila Remli, Adrien Rimele, Shervin Shams-Shoaaee, Yossiri Adulyasak, Maxime Cohen, Andrea Lodi, Louis-Martin Rousseau

In retail, a planogram is a plan indicating which products and which fixtures should be placed where, within an aisle. These are typically created by corporate experts at the national level, and then require some adaptation by employees in each store to account for local variations (assortment, aisle geometry, forecast²). This adjustment process is time consuming and can lead to suboptimal store decisions. We present a tool developed in partnership between IVADO Labs and Canadian Tire to automatically generate store specific planograms.

5 - The Value of Flexibility in Stochastic Multi Level Lot Sizing Problem

Narges Sereshti, PhD candidate, HEC Montreal, Montreal, QC, Canada, narges.sereshti@hec.ca

Raf Jans, Yossiri Adulyasak

We study the stochastic multi-level capacitated lot sizing problem with service level constraint and in a general setting in which, in addition to the end items, their components may also have independent demand. We present a systematic approach to evaluate the value of adding flexibility in such context, under different settings. To this end, the problem with uncertain demand is modeled as a two-stage stochastic program considering different demand scenarios. We investigate two different strategies, which are the static strategy and a more adaptive one in which we apply the static-dynamic strategy for some or all the items.

6 - Harnessing the Power of Big Data-Towards the Development of Big Data Strategy

Deepa Bhatt, Assistant Professor, Montpellier Business School, Montpellier, France, d.bhatt@montpellier-bs.com
Elkafi Hassini, Al Mashalah Heider

Big data is rapidly becoming the lifeblood of the global economy (EPSC, 2017). It is an economic asset which when used properly results in a competitive advantage by enhancing performance, creating user-friendly products and services. While there is a strong case for the adoption of a big data strategy (e.g., Simon 2013 and Pope et al. 2014), there is a lack of research on how to align big data strategies with big data usage. Our proposed research will fill in this gap. In particular, the novelty in our research relies in proposing a theory and a framework for measuring big data capabilities and linking it to strategic big data implementation.

TD07

3rd Fl-Regency B

Healthcare Analytics II

General Session

Chair: Nasrin Yousefi

University of Toronto, University of Toronto, Toronto, ON, M4Y1R5, Canada

2 - Serviceminer: Automated Data-driven Simulation Mining in Service Systems

Zhijian Ling, University of Toronto, Toronto, ON, Canada, zhijian.ling@mail.utoronto.ca

Arik Senderovich, Dmitry Krass, Opher Baron

ServiceMiner is a tool for automatically learning simulation models from enriched system event log data. The simulation models can subsequently be used for analyzing system interventions and optimizing the system. We apply G/G/infinity network in our ServiceMiner, and the system can generate directly-follows graphs and estimate conditional sojourn time.

3 - A Decentralized Problem Decomposition Scheme for Outpatient Appointment Scheduling

Pardis Seyedi, University of Toronto, Toronto, ON, Canada, pardis.seyedi@mail.utoronto.ca

Michael W Carter, Kouros Eshghi

This study addresses the variability of wait times. We reduce them by a form of restricted central intake. This should provide better balance across hospitals and better respond to demand fluctuations. We expand the appointment scheduling model to include multiple sites and incorporate

random service times, patient preferences, and priorities. The problem is large-size as it combines all requests from a geographical region into one stream. The solution approach is decomposition and augmented Lagrangian. The results show that the proposed solution method offers relatively reliable, good-quality solutions with much lower CPU power and time than the usual solution methods of the literature.

4 - Healthcare Cost and Resources Evaluation to Analyze and Optimize Capacity Requirements

Parminder Singh Kang, Mount Royal University, Calgary, AB, Canada, pkang@mtroyal.ca

Ibrahim Alrashed

Sustaining various revenue streams is important to continue providing high-quality services. COVID-19 as very-low probability and very-high impact risk led to decreasing revenues and increasing resource burden for the service organizations. The Healthcare sector is also impacted by these risks. This paper aims to analyze the demand data for various healthcare services to develop a future representation of demand patterns so that capacity requirements can be established to provide required services. This paper will also investigate various revenue streams (such as paid treatment, paid training, and infrastructure investments) and the impact of demand changes on those revenue streams.

5 - Uncertainty Quantification in Inverse Optimization

Nasrin Yousefi, University of Toronto, Toronto, ON, M4Y1R5, Canada

Timothy Chan, Nathan Sandholtz

In applied optimization tasks, human decisions often exhibit "noise" around theoretical optimums. The presence of noise adds significant complexity when considering the inverse optimization problem, which is the problem of inferring unknown features of an optimization model such that observed decisions are rendered optimal. We use a Bayesian paradigm and assume a likelihood over observed decisions, but we constrain a pre-specified functional of the likelihood to be inversely optimal by carefully constructing the prior distributions. We then approximate the posterior distributions via MCMC methods and generate credible regions for the unknown optimization model parameters.

TD08

3rd Fl-Regency E

Health Care II

Contributed Session

Chair: Sue Feldman

UAB, Birmingham, AL, 35294, United States

2 - Application of Unsupervised Machine Learning Approach to Categorize Resource Utilization of Patients with Traumatic Spinal Injury

shahin basiratzadeh, University of Ottawa, Ottawa, ON, Canada

Ramtin Hakimjavadi, Wojtek Michalowski, Herna Viktor, Natalie Baddour, Philippe Phan, Philippe Phan

Assessment of resource utilization is challenging for Traumatic Spinal Injury (TSI) patients due to complex patient needs and high variability in individual characteristics. This research aims to categorize the initially heterogeneous TSI population into homogeneous subgroups by applying an unsupervised machine learning method. The functional independence measure motor score at discharge and the total length of stay were assessed as outcome features and an indicator for resource utilization. Data on 338 TSI patients from the Rick Hansen Spinal Cord Injury Registry was analyzed. Five distinct clusters were identified with significant inter-group differences ($p \leq 0.05$) in outcome features.

3 - A Multi-criteria System for Evaluating Cloud-based Big Data Platforms in Healthcare

Rakesh Verma, Associate Professor, National Institute of Industrial Institute, Mumbai, India, rakeshverma@nitie.ac.in

Saroj Koul

The vast amount of structured and unstructured data in healthcare is a prerequisite for solving different IT infrastructure solutions. Poor choice or upgrade of existing company systems with new technology for big data may result in serious consequences later when rectification attempts grow to be expensive. For instance, inappropriate technology may exert an adverse impact; hence assessment and comparison of big data platforms continue to be a topical problem. This research aims to create a multi-criteria system for evaluating cloud-based big data platforms for deploying, operating, and analyzing big data in healthcare.

4 - Lessons Learned from an NLP Algorithm to Detect OUD in the Deep South

Sue Feldman, Professor, University of Alabama at Birmingham, Birmingham, AL, United States, sfeldman@uab.edu

Tobias O'Leary, Abdullateef I Almudaifer, Whitney L Covington, Caleb M Carroll, Estera Crisan, Ellen Eaton, Lauren Walter, John D Osborne

Many persons with Opioid Use Disorder (OUD) do not access the healthcare system for explicit management of OUD or do not otherwise identify as OUD when seeking other medical

evaluation or treatment. By annotating at the mention level an OUD data set and fine-tuning a transformer-based Natural Language Processing (NLP) algorithm, we developed an OUD-specific NLP algorithm for a medical center to assist in the identification of patients with OUD, the aim to aid in real-time delivery of addiction resources and care. We implement a web-based registry for OUD case detection and identify challenges in case identification including limited and inconsistent documentation of opioid use versus disorders.

TD09

3rd Fl-Regency F

Transportation I

Contributed Session

Chair: Alexander Bryce

Concordia University

2 - Hierarchical Hub Location and Service Network Design Problem

M. Saleh Farham, Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT), Montreal, QC, Canada

Teodor Gabriel Crainic, Walter Rei

This study bridges the gap between scheduled service network design and multi-modal hierarchical hub location problems arising in consolidated interurban transportation systems.

The aim is to select hubs in multiple tiers, allocate hub capacities, and select services to satisfy time-dependent demand by minimizing the total hub location, capacity installation, and service selection costs. We address synchronization issues at hubs and define delivery revenue/penalty costs to assess service quality. Temporary hub location and service selection decisions are incorporated to account for unexpected demand (as in pandemics). Our computational analysis provides a detailed managerial insight.

3 - Parking Space Information Collection with Moving and Stationary Sensors

Mostafa Salari, Research Assistant Professor, University of North Dakota, Grand Forks, ND, United States, mostafa.salari@und.edu

Mehdi Nourinejad

Network information provided by current infrastructures has been impacted by the connected automated vehicles (CAVs) as a viable mode of transportation. CAVs use sensors such as radars, cameras and Lidars to collect data from a vehicle's surroundings. This paper focuses on the collection of parking

space information with both CAVs as moving sensors as well as the fixed infrastructures introduced as stationary sensors in a road network. We study the reliability of information dissemination from both sources as well as the optimized location of sensors. We also explore the traffic flow transfer between different paths to meet the minimum required information accuracy.

4 - Live Condition Monitoring for Maintenance Scheduling with Artificial Neural Networks

Alexander Bryce, Concordia University Montreal, Montreal, QC, Canada

With the advancement of technologies such as artificial intelligence and neural networks, the traditional methods of maintenance scheduling for mechanical components can be vastly improved with live condition monitoring principles. The investigation was to establish degradation characteristics from a given set of mechanical data, perform analysis through Fast Fourier Transform and then utilise the principles and methods of Artificial Neural Network classification in order to provide solution for maintenance prioritisation of a given component population. The next steps will be to apply the methodologies of genetic algorithms for dynamic maintenance scheduling.

TD10

3rd Fl-Balmoral/Windsor

Simulation Analysis

General Session

Chair: Eunhye Song

Penn State University, Penn State University, University Park, PA, 16802-6817, United States

2 - Fourier Discriminants for Dynamic Queue Length Behavior

Russell R Barton, Professor, Pennsylvania State University, University Park, PA, 16802-3603, United States, rrb2@psu.edu

Lucy E Gullon

Differences in queueing system dynamic behavior can be explored using the Fourier transform of regularly sampled queue length data. This dynamic data forms a time series whose Fourier coefficients can be used to identify changes in dynamic behavior for a single system or differences in dynamic behavior between different systems. These methods can be applied in stationary and nonstationary settings. Several examples will be presented showing the behavior of Fourier-based discriminator statistics.

3 - Performance Evaluation of an Agrophotovoltaic System Under Agent-based Simulation

Youngjin Kim, Dongguk University, Seoul, Korea, Republic of, yjin@dgu.ac.kr

Yeongjae On, Sojung Kim

This study aims at estimating performance of an Agrophotovoltaic (APV) system which produces crops as well as Photovoltaic (PV) energy. To consider complex interaction between multiple components in the system, Agent-Based Simulation (ABS) model was developed for the profit estimation. In addition, simulation-based optimization approach is adopted to identify the optimal solution in terms of the total profit. The proposed approach is calibrated and validated with field experiment data in South Korea. As a result, engineers can utilize the approach to maximize the profit of their APV systems.

4 - Selection of the Most Probable Best

Eunhye Song, Penn State University, University Park, PA, 16802-6817, United States, eus358@psu.edu

Taeho Kim, Kyoung-Kuk Kim

We consider a ranking and selection (R&S) problem where all k solutions' simulation output distributions depend on a common uncertain parameter with finite support. Given a probability simplex on the support, we define the most probable best (MPB) to be the solution whose probability of being optimal is the largest. We devise a series of interpretable and computationally efficient sequential learning algorithms and show that their sampling ratios achieve the optimality conditions for the asymptotically optimal sampling ratios that maximizes the large deviation rate of the probability of false selection almost surely as the simulation budget grows.

5 - Reducing and Calibrating for Input Model Bias in Computer Simulation

Luke A. Rhodes-Leader, Lancaster University, Lancaster, United Kingdom, l.rhodes-leader@lancaster.ac.uk

Lucy E. Gullon, Russell R Barton

Input model bias is the bias found in the output performance measures of a simulation model caused by estimating the input distributions/ processes used to drive it. When the simulation response is a non-linear function of its inputs, as is usually the case for complex systems, input modelling bias is amongst the errors that arise. In this talk, we introduce a method that re-calibrates the input parameters of parametric input models to reduce the bias in the simulation output. The proposed method applies sequential quadratic programming

with a closed form analytical solution at each step. The method is shown to reduce input modelling bias and the total mean squared error caused by input modelling error.

TD11

3rd FI-Oxford/Prince of Wales

Finance I

Contributed Session

Chair: Guangzhi Shang

Florida State University, Department of Marketing, College of Business, Tallahassee, FL, 32306, United States

2 - Monte Carlo Variance Reduction and American Option Exercise Strategies

François-Michel Boire, University of Western Ontario, London, ON, Canada, fboire2@uwo.ca

Mark Reesor, Lars Stentoft

Stopping time estimation errors in the Longstaff-Schwartz algorithm cause bias and alter the variance of the estimator. This paper discusses how these errors stifle the variance reduction efficiency gains of control variates and preclude an efficient combined implementation of control variates and importance sampling. With a corrected strategy the control variates method reduces standard error by a factor of up to 230 instead of 12 for a similar estimator with an uncorrected strategy, and adding importance sampling to control variates by a factor reaching 375 instead of 32 with an uncorrected one. A corrected strategy hence permits to maximize the efficiency of variance reduction tools.

3 - Parametric Inference of Multifactor Stochastic Volatility Models with Variance-Dependent Pricing Kernel

Golara Zafari, Simon Fraser University, Burnaby, BC, Canada, gzafari@sfu.ca

Jean-François Bégin

This study develops a class of discrete-time multifactor stochastic volatility dynamics with jumps for which the weak jump-diffusion limit resembles the well-established three-factor model of Andersen, Fusari, and Todorov (2015). Using a general pricing kernel that captures the equity risk premium and the risk associated with each volatility factor and jump component, we obtain closed-form model cumulants which are used to estimate the model by combining the efficient filters (i.e., the discrete nonlinear filter and the unscented Kalman filter). Simulation and empirical studies are conducted to assess the performance of the proposed estimation method and fit of the model, respectively.

4 - Optimal Execution with Quadratic Variation Inventories

Laura Leal, Princeton University, Princeton, NJ, United States

Rene A Carmona

We implement statistical tests arguing for the presence of a Brownian component in the inventories and wealth processes of individual traders. We use intra-day data from the Toronto Stock Exchange to provide empirical evidence of this claim. We work with regularly spaced time intervals, as well as with asynchronously observed data. The tests reveal with high significance the presence of a non-zero Brownian motion component. We extend the theoretical analysis of an existing optimal execution model to accommodate the presence of Itô inventory processes, and compare empirically the optimal behavior of traders in such fitted models to the actual behavior we read off the data.

5 - A New Approach to Credit Ratings

Stanislav Uryasev, Stony Brook University, New York, NY, United States

Artem Prokhorov

<https://www.sciencedirect.com/science/article/abs/pii/S0378426621000558?via%3Dihub>

6 - Optimal Hedging Policies and Commodity Firms: Models and Evidence

Kamal Smimou, Associate Professor, Ontario Tech University (University of Ontario Inst of Tech.), Oshawa, ON, Canada, kamal.smimou@ontariotechu.ca

Commodity firms and their hedging activities are a prominent topic of interest in financial economics. Adding to the current wave of attention, this study advances two theoretical optimization models guided by market depth (as a proxy for hedging demand) to (1) detect the most genuinely related and viable commodity futures contracts pertinent to the price movement of commodity companies traded in the stock market, and (2) elucidate when and how these optimal search strategies can enhance and affect hedging positions of investors. Likewise, we empirically document the joint dynamic behavior of these groups of assets while assessing the effects of including an optimal number of hedging instruments.

7 - Need for Speed, but How Much Does it Cost? Unpacking the Fee-speed Relationship in Bitcoin Transactions

Guangzhi Shang, Florida State University, Tallahassee, FL, United States, gshang@business.fsu.edu

Many cryptocurrencies allow users to “name your own price”, giving rise to a large variation in fee offerings and hence, variation in confirmation times. Yet, the time it takes a cryptocurrency transaction to be confirmed in the blockchain is not only affected by the fee offered, but also by the contemporaneous congestion level and the inherent randomness in the verification process. Using Bitcoin - the original and most heavily used cryptocurrency by far - as our empirical context, we stylize the transaction confirmation processes, propose a theoretical framework that maps the causal path from fee to speed, and estimate this framework using Bitcoin transaction data under periods of high volatility.

TD12

34th FI-Seymour

Diverse Discussions in Forestry

General Session

Chair: David L Martell

University of Toronto, University of Toronto, Toronto, ON, M5S 3B3, Canada

2 - Lidar Based Cellular Automaton Stand

Delineation Algorithm Applied to Private Woodlots in New Brunswick, Canada

Jules Comeau, Université de Moncton, Moncton, NB, E1A 3E9, Canada, jules.comeau@umoncton.ca

Michel Soucy

Current stand delineation using photo interpretation is better adapted for use on public and industrial forests, given the typical large stands and harvesting blocks. With the arrival of LiDAR data, the cellular automaton (CA) has shown promise to be an effective technique for improved stand delineation. However, these algorithms are ill fitted for use in the context of private forests, where we face problems of high fragmentation from small cut blocks, roads and trails, and property boundaries. We explore the modifications required for the CA to be effective in this context.

3 - Summary of Log Yard Studies

Luc G LeBel, FORAC / Université Laval, Québec, QC, G1A 0A6, Canada

Log yards contribute to the functioning of the Canadian wood supply chain. The OR research community has made contributions in recent years to guide decision makers in the best possible use of these logistics infrastructure. Yet, it is suggested that key aspects have yet to be fully addressed. In this presentation, an overview of research contributions in

the area log yard is first presented. Then, open problems that remain to be solved are highlighted for discussions on the best methods to apply.

4 - Wildfire Emergency Evacuation for Multi-type Injury Patients

Afshin Kamyabniya, University of Ottawa, Ottawa, ON, Canada, akamy007@uottawa.ca

Antoine Saure, Jonathan Patrick, Kai Huang, Nouredine Benichou

In this research, an open coordinated vehicle routing problem (OCVRP) model for wildfire evacuation is proposed to increase the number of survivors under minimal time windows with casualties of various urgency levels and multiple sources of uncertainties such as inaccessibility of routes. The OCVRP model guarantees the paramedic vehicles to freely end their trip at another location and restart from there in the following period under split pick-up and delivery transportation strategies to minimize overall performance compared to traditional VRP models. To evaluate the proposed OCVRP, we develop a novel meta-heuristics solution approach and apply it to an Australian wildfire case study.

TD13

34th Fl-Stanley

Algorithms and Mechanism Design

General Session

Chair: Vitor Farinha Luz

UBC, UBC, Vancouver, BC, Canada

2 - Optimal Recommender System Design

Changhwa Lee, University of Pennsylvania, Philadelphia, PA, United States, changhwa@sas.upenn.edu

Intermediaries such as Amazon and Google recommend products and services to consumers for which they receive compensation from the recommended sellers. Consumers find these recommendations useful only if they are informative about the quality of the match between the sellers' offerings and the consumer's needs. The intermediary wants the consumer to purchase the product from the recommended seller, but is constrained because consumers need not follow the recommendation. I frame the intermediary's problem as a mechanism design problem and show that in the optimal mechanism, the recommended seller has the largest non-negative virtual willingness to pay adjusted for the cost of persuasion.

3 - Deep Learning to Collude

Clemens Possnig, University of British Columbia,

Vancouver, BC, Canada

We consider the limiting behavior for a general class of independent reinforcement learning (RL) algorithms in repeated games. We allow RL agents to learn state-dependent repeated game strategies and show that the limit points of their independent learning process act as an equilibrium selection mechanism. Our class contains model-free actor-critic and gradient-based algorithms for continuous controls as special case. We allow for bias in the critic (gradient) estimator, give sufficient conditions and examples of algorithms in our class. We show that our framework enables us to determine which types of learners, under which market and payoff conditions, are more likely to arrive at collusion.

- Offering a Menu of Prices: The Role of Price Discrimination in a Two-sided Market

Parastoo Liaghat, University of Calgary, Calgary, AB, Canada, parastoo.liaghat1@ucalgary.ca

Alireza Sabouri

We consider a platform acting as an intermediary in a two-sided market, which provides the buyers' side with two options to choose from: a pay-per-use and a subscription option. We study the optimal pricing structure of the platform, and compare the results with that of a benchmark model with only one option for buyers. Our results suggest that depending on the per-transaction cost, the platform can take two different approaches in order to effectively discriminate buyers: either charging buyers a higher price compared to the benchmark, or increasing the number of transactions by discounting buyers.

4 - Risk Classification in Insurance Markets with Risk and Preference Heterogeneity

Vitor Farinha Luz, UBC, Vancouver, BC, V6S0G6, Canada, vitor.farinhaluz@ubc.ca

I analyze long-term contracting in insurance markets with asymmetric information. Firms compete in the provision of long-term insurance for risk-averse buyers. A risk-relevant characteristic is privately observed and follows a Markov process. Optimal contracts offer a choice between partial coverage and perpetual complete coverage policy in each period. Optimal contracts feature dynamic pricing: the complete-coverage premium decreases with the number of periods the buyer chooses partial insurance, which serves as a signal of low risk. Allocative efficiency increases along all histories.

TD15

34th FI-Grouse

Optimizing Platform Operations Under Uncertainty

General Session

Chair: Utsav Sadana

2 - A Column and Constraint Generation Algorithm for the Adaptive Robust Lot-sizing Problem with Backorder and Uncertain Production Yield

Paula Metzker Soares, PhD student, HEC Montreal, Montreal, QC, Canada, paula.metzker-soares@imt-atlantique.fr

Paula Metzker Soares, PhD student, IMT Atlantique, Nantes, France, paula.metzker-soares@imt-atlantique.fr
Simon Thevenin, Yossiri Adulyasak, Alexandre Dolgui

Production defects are a major issue for production planning, since they impact the quality and feasibility of the decisions. This work investigates the adaptive robust lot-sizing problem with backorder and uncertain production yield. Since the inventory balance constraints have a quadratic term on the uncertainty, the model is hard to solve. We propose a column and constraint generation algorithm to compute the optimal solution. Numerical experiments demonstrate that the algorithm offers a production plan that is both robust and easily changeable in an adaptive decision context.

3 - Supply Uncertainty and Newsvendor Overconfidence

Sam Kirshner, UNSW Business School, Sydney, Australia, s.kirshner@unsw.edu.au

The pull-to-centre (PTC) is a robust phenomenon in problems characterized by the newsvendor trade-off. However, experiments and analytical models have primarily analyzed setting where uncertainty is limited to demand. In practice, supply uncertainty is a prevalent challenge, adding complexity to newsvendor decisions. Accordingly, we examine whether the PTC effect occurs for a behavioural newsvendor under supply and demand uncertainties. We find that greater overconfidence leads to PTC and push-from-centre orders depending on uncertainty levels and profit margins. We test our predictions using an experiment and find empirical support for this novel phenomenon.

4 - Maximizing Profit in Hub Location Problems Under Price-dependent Uncertain Demand

Dung Tran, PhD Student, The University of Edinburgh, Edinburgh, United Kingdom, d.h.tran@sms.ed.ac.uk

Nader Azizi, Thomas W Archibald

This research considers the capacitated single assignment hub location problems with profit oriented objective and demand uncertainty. The problem is first formulated as a two-stage stochastic programming model in which price is exogenous. The model is extended by introducing price variables and price-dependent demand to investigate the joint effects of pricing, location and allocation decisions on profit. We propose both exact and heuristics solutions, then present and discuss the results from computational experiments.

5 - Decision-focused Learning for a Newsvendor with Side Information

Utsav Sadana, McGill University, Montreal, QC, Canada, utsav.sadana@mail.mcgill.ca

Erick Delage, Angelos Georghiou, Mehmet Gumus

The classical “predict-then-optimize” approach used in determining the optimal order quantity for a newsvendor is mainly concerned with minimizing the prediction error. However, the prediction is agnostic to the holding or stockout costs and can lead to suboptimal decisions. We provide an end-to-end decision-focused model where instead of learning the parameters to minimize prediction error, the decision error is minimized using surrogate optimization problems.

TD16

34th FI-English Bay

Bilevel Optimization: Theory and Applications

General Session

Chair: Ian Yihang Zhu

University of Toronto, University of Toronto, Toronto, ON, M5S 3G8, Canada

2 - A Data-driven Inverse Optimization Approach to Decision-focused Surrogate Modeling

Rishabh Gupta, Ph.D. Candidate, University of Minnesota, Twin-Cities, Minneapolis, MN, 55414, United States, rishabh@umn.edu

Joshua Larson, Qi Zhang

This work introduces a data-driven inverse optimization (IO) approach for constructing surrogate optimizers of reduced computational complexity compared to the original model. The IO approach is attractive as it allows direct decision-focused learning of surrogate model parameters, i.e., the models are trained to obtain (almost) the same optimal solutions as the original optimization models. Furthermore, in contrast to traditional machine learning models, IO allows

the incorporation of domain knowledge in the form of explicit constraints and tends to be more data-efficient. We demonstrate the effectiveness of our method using case studies based on industrial chemical process systems.

3 - A Machine Learning Approach for Approximating Scenario-Based Two-Stage Optimization Problems

Bo Lin, PhD Student, University of Toronto, Toronto, ON, M5S 0C6, Canada

Timothy Chan, Shoshanna Saxe

We study a two-stage optimization problem where the first-stage model determines the resource allocation, and second-stage models use the allocated resource to provide services in different scenarios. This model has a wide range of applications in transportation planning, energy market, etc. Considering a large scenario set helps inform the first-stage decision-making yet introduces considerable computational burden. We propose a machine learning approach to select a representative scenario set and build approximation models based on the selected set. The proposed method provides a bounded approximation for the original problem and demonstrates promising computational performance.

4 - Stable Decomposition of Bilevel Problems with Convex Follower

Geunyeong Byeon, Arizona State University, Tempe, AZ, 85281, United States, geunyeong.byeon@asu.edu

Pascal Van Hentenryck

We propose a decomposition method for bilevel problems with convex follower. Several novel schemes for generating numerically stable cuts, finding a good incumbent solution, and accelerating the search tree are discussed. A computational study demonstrates the computational benefits of the proposed method over a state-of-the-art, bilevel-tailored, branch-and-cut method; a commercial solver; and the standard Benders method on standard test cases and the motivating applications in sequential energy markets.

5 - Bi-level Network Interdiction Models to Address Human Trafficking

Kayse Lee Maass, Assistant Professor, Northeastern University, Boston, MA, 01507-5347, United States, k.maass@northeastern.edu

Baris Tezcan

Efforts to disrupt human trafficking must understand trafficking as a complex system such that a disruption to one portion of the network affects other network components. This presentation will discuss ongoing transdisciplinary anti-human trafficking efforts to develop bi-level network

interdiction models that address complexities such as trafficking interventions becoming more or less effective over time, traffickers recruiting new victims, and other adaptations that are necessary to adequately represent the nuances of human trafficking.

6 - Inverse Mixed Integer Optimization: Polyhedral Insights and Trust Region Methods

Ian Yihang Zhu, University of Toronto, Toronto, ON, M5S 3G8, Canada, i.zhu@mail.utoronto.ca

Merve Bodur, Timothy Chan

This talk examines inverse optimization for mixed integer optimization problems (MIPs). Specifically, we consider the problem of estimating objective function coefficients of a MIP so that a given solution is rendered optimal. A novel cutting-plane algorithm is described, which is shown to solve the inverse problem significantly faster than existing methods over a large set of benchmark instances.

Wednesday, 8:30–10am

WA03

2nd Fl-Plaza A

Vehicle Routing

Contributed Session

Chair: Joseph Robitaille

Université Laval

2 - Routing Plan for Migratory

Beekeeping Problem

Yuvraj Gajpal, University of Manitoba, Winnipeg, MB, Canada, yuvraj.gajpal@umanitoba.ca

Qiu Xintong, S.S. Appadoo

Commercial apiculture plays an important role because of its contributions to reducing poverty and conserving biodiversity. In this paper, a migratory beekeeping routing problem (MBRP) is studied and a mathematical model of MBRP is established to optimize the total profit of beekeepers, comprehensively considering several constraints. A variable neighbourhood search (VNS) algorithm is proposed to solve the MBRP. Thirty computational instances are utilized to test the proposed VNS. The outcome of this paper can help related organizations to change traditional production and operation methods, enhancing production efficiency and profit and reducing costs and resource waste.

3 - Dynamic Time-dependent Stochastic Routing for Hazardous Materials Transportation with a Single Vehicle

Danial Khorasanian, University of Toronto, Toronto, ON, Canada, danial.khorasanian@utoronto.ca

Chi-Guhn Lee

This paper investigates a dynamic stochastic time-dependent routing problem for a vehicle transporting hazardous materials from an origin to a destination. The objective is to minimize the risk while not exceeding a threshold travel time or a deadline for delivery of goods to the destination. We develop a constrained Markov decision process for this problem and solve it using some reinforcement learning methods. We evaluate the performance of these methods on some random instances and also a case study of greater Toronto area highways.

4 - Using Presence Pattern Predictors for Delivery-Efficient Route Optimization

Pascal L Wissink, Vrije Universiteit Amsterdam, Amsterdam, Netherlands

The notion that demographic and temporal variables retain predictive power for customer presence during parcel delivery suggests that a 'good' route depends on more than deterministic distances alone. In fact, the oft-neglected costs associated with redelivery attempts constitute more than 5% of the overall length in some of Amsterdam's districts. I present a simplified problem that illustrates how presence predictors can be exploited to incorporate the expected cost of redelivery attempts in earlier stages of route optimization. The results suggest that anticipating redelivery costs may lead to different route cost estimates and route decisions in earlier stages.

5 - A Disaggregated Integer L-shaped Method for the Stochastic Vehicle Routing Problem

Jean-François Côté, Professor, Laval University, Québec, QC, Canada, jean-francois.cote@fsa.ulaval.ca

Lucas Parada Pradenas, Michel Gendreau

This work presents a new integer L-shaped method for solving stochastic integer programs. The method is particularly effective for problems where solutions can be decomposed into different components. The second stage cost of each component is bounded by a new type optimality cuts and new lower bounding functionals. We propose an implementation for the classical vehicle routing problem where the customer demands are stochastic. Several new lower bounds on the recourse are also proposed to strengthen the lower bounding functionals. Computational experiments on instances from the literature show that the new method achieves state-of-the-art results.

6 - The Design of Territories and Delivery Schedules in Attended Home Delivery

Joseph Robitaille, Université Laval, Québec, QC, Canada, joseph.robitaille.1@ulaval.ca

Jacques Renaud, Côté Jean-François

The attended home delivery context brings several optimization challenges. When the presence of customers is required for the delivery to happen, the service provider and the customers must agree on a fixed delivery date and time. This leads to the problem of finding a delivery schedule where the merchandise can be conveniently delivered. Typical approaches work by using a set of predefined territories (e.g., zip codes) which were not designed for attended home delivery. This work goes a step further by redesigning the territories to obtain more economical delivery schedule. Our computation results show the effectiveness of our approach.

WA04

2nd FI-Plaza B

Supply Chain Optimization II

Contributed Session

Chair: Hemendra Nath Roy

University of Regina, Regina, SK, S4S 0A2, Canada

2 - Data Model for a Multi-Biomass Supply Chain

Nasim Zandi Atashbar, Indiana State University, Terre Haute, IN, United States, nzandiatashba@sycamores.indstate.edu

Christian Prins, Nacima Labadie, Kuntal Bhattacharyya

Biomass plays an important role as a key source of renewable energies. Given the high logistical cost associated with biomass adoption, having an efficient supply chain that provides bio-refineries with adequate quantities of biomass at a reasonable price and in a timely manner is critical. This study proposes a flexible data model for a multi-biomass supply chain. The role of this data model is to list, analyze and structure a large amount of data for a multi-biomass supply chain. The result is a set of tables containing input data that can be recorded in a database management system and then loaded into a mathematical programming environment to support biomass supply chain modeling and optimization.

3 - Improving Responsiveness of Pharmaceutical Supply Chains: A Stochastic Modeling Approach to Identify Optimal Postponement and Flexibility Strategies

Gregor Blosser, Research associate, University of

Innsbruck, Innsbruck, Austria, gregor.blossey@uibk.ac.at
Gregor Blossey, Research associate, European University
Viadrina Frankfurt (Oder), Frankfurt (Oder), Germany,
gregor.blossey@uibk.ac.at

Gerd J. Hahn, Achim Koberstein

The pharmaceutical industry is characterized by complex and rigid supply chain (SC) structures, which impedes the ability to respond to uncertainties. This has led to an increasing number of supply failures - an alarming trend that started long before the Covid-19 pandemic emerged. However, postponement and flexibility placement are widely recognized levers to improve SC responsiveness. Thus, a two-stage stochastic MILP model is developed to identify optimal postponement strategies and flexibility placement in pharmaceutical SCs. The integrated production and distribution problem considers demand uncertainty including the industry-specific case of uncertain tender outcomes.

4 - Retail Supply Chain Disruptions: A Resilient Supply Chain Network Design for Confronting the Consequences

Hemendra Nath Roy, Graduate Research Student,
University of Regina, Regina, SK, Canada, hemen_ipe07@icloud.com

Eman Almehdawe, Golam Kabir

We develop a mathematical model for a centralized retail supply chain that can be used to design or redesign the supply chain network. Our model incorporates different resilient strategies into the network design and aims at minimizing the impact of disruption. To accomplish our objective, we utilize a two-stage stochastic program to capture the uncertainty due to disruptions.

WA05

2nd Fl-Plaza C

Artificial Intelligence III

Contributed Session

Chair: Mayank Kejriwal

University of Southern California, Marina del Rey, CA, 90292, United States

2 - Bandit Based Sequential Planning of Parking Enforcement Patrol

Ali Reza Alemi, University of Calgary, Calgary, AB, Canada,
alireza.alemi@ucalgary.ca

Alireza Sabouri, Saeid Saidi

We consider the problem of finding an optimal routing plan for the parking enforcement patrol vehicles when only partial data about the distribution of violations over the

city is available. The decision maker faces the well-known exploration-exploitation trade-off, i.e., choosing the best route given the current information or trying new routes to gather data on potentially better routes. We propose a multi-arm bandit formulation and use reinforcement learning to sequentially generate routes to maximize the system expected reward.

3 - Knowledge Graphs in Media and E-Commerce

Mayank Kejriwal, Research Assistant Professor, University of Southern California, Los Angeles, CA, United States,
kejriwal@isi.edu

In recent years, knowledge graphs (KGs) have emerged as a cutting-edge application of fundamental Artificial Intelligence research in academia, industry and government alike. KGs can be generic or encyclopedic, such as the Google Knowledge Graph, but beyond search engines, KGs tend to be best suited for difficult analytics problems in specific domains. This talk will draw on the author's research experience and industry collaborations to discuss the challenges and applications of domain-specific KGs in e-commerce and media.

WA06

3rd Fl-Regency A

Operations Management II

Contributed Session

Chair: Gargi Adhav

Google

2 - Minimax and Fixed-rate Search Strategies with Directional Information

Young H Chun, Professor of Decision Science, Louisiana State University, Baton Rouge, LA, United States, prof@drchun.net

Seong-Jong Joo

We deal with the binary search problem with directional information, such as locating a flaw in an underground cable or pipeline. The target to be searched is represented by a point in a given interval. When we test a point within the interval, we learn whether the target is located to the left or right of the inspected point. As we continue the search process with directional information, we can narrow down the exact location of the target more precisely. This type of sequential search problem is known as a dichotomous search. We propose in the paper a generalized version of the continuous-type dichotomous search that considers the search cost, moving cost, and penalty cost of stopping early.

3 - Distribution Network Design in Omnichannel Retailing Considering Customers' Channel Preference

Dung Nguyen, Kühne Logistics University, Hamburg, Germany, phanthuydung.nguyen@the-klu.org
Dung Nguyen, Kedge Business School, Bordeaux, France, phanthuydung.nguyen@the-klu.org
Walid Klibi

Traditional retailers have shifted to omnichannel operations to sustain the growth of e-commerce. We develop a distribution network design framework in an omnichannel context that considers the impact of service policies on customers' channel choice, and inventory sharing across the online and offline channels. The discrete choice model is used to model channel choice at the location level. The model incorporates the costs of last-mile logistics activities (online order fulfillment and inventory replenishment) and uncertainties.

We use stochastic modeling and the decomposition method to solve the model, and then apply the model to a real-world case study inspired by our partner's operation.

4 - Alops in Cloud: Adding Intelligence to Cloud Network Operations

Gargi Adhav, Director Engineering, Google, Sunnyvale, CA, United States, gargiadhav@google.com

The Cloud space is growing more and more complex, with increasing scale, products and feature sets. Enterprises have multi-cloud strategies and have expectations of increased Reliability, Availability and lower MTTR in case of failures. Managing the operations in this highly dynamic and complex Cloud environment, requires an increased level of built in Intelligence that can stitch together ambiguous and complex inter-dependencies among systems.

This talk talks about how Google Cloud has applied AI/ML and advanced algorithms to add Intelligence to its operations of Cloud Networking.

WA07

3rd Fl-Regency B

Healthcare Operations Management

General Session

Chair: Hossein Abouee Mehrizi

University of Waterloo, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

2 - Does What Happens in the ED Stay in the ED? The Effects of Emergency Department Physician Workload on Post-ED Care Use

Mohamad Soltani, University of Alberta, Edmonton, AB, T6G 2R6, Canada, soltani@ualberta.ca

Robert Batt

Hessam Bavafa

Brian Patterson

Using a data set assembled from detailed ED visit-level data and exhaustive billing data in an integrated health system, we investigate whether physician workload during the patient visit in the ED impacts post-ED care use. The analyses show that there is an increasing concave relationship between ED physician workload and post-ED care use. Further, we identify ED physician test ordering behavior as a mechanism of these effects. Together, these findings provide evidence for the role of non-clinical factors in healthcare system utilization and suggest that when ED physician workload increases, resource utilization increases in the ED and several other channels of care in the healthcare system.

3 - Does Delay Stimulate Speedup? Evidence from Operating Rooms

Yiwen Jin, University of British Columbia, Vancouver, BC, V6T 1V8, Canada, yiwen.jin@sauder.ubc.ca

Yichuan Ding, Steven Shechter

We study how surgical teams respond to real-time deviations from schedules and the associated impact on surgical quality. We conduct GMM estimation based on Arellano-Bond method and we find surgical teams expedite by 1.5 to 2.0 minutes on average when facing ten-minute delay and vice versa. This effect is more evident among senior surgeons. We further propose a novel instrument variable to identify the speedup's impact on surgical quality and we find speedup increases 7/30-day readmission rates.

4 - Multi-Class Advance Patient Scheduling with Overtime: A Dynamic Robust Approach

Hamid Arzani, University of Waterloo, Waterloo, ON, Canada, hamidreza.khajeharzani@uwaterloo.ca

Hossein Abouee Mehrizi, Saeed Ghadimi

We develop a distributionally robust optimization framework for a multi-class advance patient scheduling problem and present an online algorithm to solve the problem. Specifically, we apply a smooth, coherent risk measure to quantify uncertainty in arrivals, allowing us to compute robust solutions against arrival perturbations. We examine the performance of the proposed algorithm using Ontario MRI data and show that the distributionally robust framework outperforms the dynamic stochastic approach significantly.

WA08

3rd Fl-Regency E

OR against COVID-19

Contributed Session

Chair: Gitanjali Adlakha-Hutcheon

Department of Defence, Ottawa, ON, K2H

8G1, Canada

2 - Fair Allocation of Scarce Resources during the COVID-19 Pandemic: A Case Study for Convalescent Plasma Distribution

Jasdeep Dhahan, Simon Fraser University, Burnaby, BC, Canada

Alexander R Rutherford, Andrew Shih, Na Li, Douglas Down

Resource planning during epidemics presents many challenges and fair decisions about resource allocation must be made. There is no standard definition of fairness. In a novel epidemic there is limited historical information available to inform decisions. We present practical strategies for the fair allocation of convalescent plasma in British Columbia using population densities, disease demographics, and resource utilization. A simulation model, calibrated to COVID-19 case data, is used to assess our allocation strategies and definitions of fairness.

3 - Covid19 Prediction Among Long Term Care Residents Using Explainable AI

Samira A. Rahimi, Assistant Professor, McGill University, Montreal, QC, Canada, samira.rahimi@mcgill.ca

Background: COVID19 patients, over 65, experienced higher severity and mortality rates than younger populations in Canada and globally. Objective: We aimed to create an explainable Machine Learning(ML) models for detecting and analyzing COVID19 among long-term care residents. Methods: We used four different explainable ML models on 986 COVID19 patients aged over 65 from Quebec BioBank.Results: Among the tested explainable ML models, Deep Forest exhibited the best accuracy and capacity. The model results were also analyzed with clinicians, as gold standard.Conclusion: We demonstrated the use of explainable ML models in the prediction of COVID19 and its severity among elderly.

4 - Covid-19 Lessons Identified: How Best to Frame the Problem to Enable Recovery?

Gitanjali Adlakha-Hutcheon, Senior Defence Scientist, Department of National Defence, Ottawa, ON, Canada
Stephane Lefebvre

Undoubtedly, the Covid-19 pandemic is a disruption that has impacted human existence at unprecedented scales from health to economies. How was this disruption addressed? What were the risks taken to inform recovery in governance systems, and within systems of government? How should scientific advice be solicited, and given during a pandemic? What were the lessons observed? How should the lessons identified be framed to enable recovery is also a big question. The presentation will probe such types of questions to determine whether there is a common thread running between disruption, risk and recovery from Covid-19.

WA09

3rd Fl-Regency F

Transportation II

Contributed Session

Chair: Rajan Batta

University at Buffalo (SUNY), Buffalo, NY, 14214-3001, United States

2 - Data Driven Synchronization Strategies of a Bus Line in a Transit Network

Laura Kolcheva, École Polytechnique de Montréal, Montreal, QC, Canada, laura.kolcheva@polymtl.ca
Antoine Legrain, Martin Trépanier

This research proposes an online control framework for a bus line using holding, skip-stop and speed change tactics. We build an arc-flow optimization model enumerating all possible tactics within a time horizon and then minimizing the total passenger travel time. Decisions are based on real-time passenger flow data and travel times. The methodology was tested on a case-study of the bus system of the city of Laval, Canada. A simulation framework has been developed, integrating data on smart card transactions and bus locations, to verify the performance and results of the optimization model.

3 - Fairness-aware and Efficient Large-scale Urban Network Control: A Macroscopic Fundamental Diagram Approach

Nadia Moshahedi, University of Calgary, Calgary, AB, Canada
Lina Kattan

We proposed a fair and efficient control strategy that optimizes the allocation of available transportation network capacity through metering the flow that transfers between various areas of the network. The optimization problem is modeled in a model predictive control scheme that facilitates online control while handling the non-linear

nature of the model. Performance of the proposed model is compared with the no control base scenario and three other basic control scenarios. The results indicate that the proposed approach outperforms other scenarios in terms of fairness and efficiency.

4 - Crowd-Sensing Parking Occupancy Detection

Elham Heydarigharai, PhD student, York University, Toronto, ON, Canada, eheydari@yorku.ca

Lack of real-time on-street parking availability data can lead to excessive parking search times and traffic congestion. We assess the impacts of cooperative sensing on parking availability detection. Sensor-equipped vehicles can measure gaps between parked cars as they drive. Aggregation of this information generates a real-time digital map depicting available parking spots. Applying Queueing Theory, we investigate the optimum number of sensor-equipped vehicles to provide a reliable map that maximizes drivers' social welfare.

5 - The Driver-aid Problem: Coordinated Logistics for Last-mile Delivery

Rui Zhang, Leeds School of Business University of Colorado Boulder, Boulder, CO, United States, rui.zhang@colorado.edu

Subramanian Raghavan

In the "Driver Aide Problem", a delivery vehicle is equipped with a "driver" and an "aide". The aide can assist the driver in two ways. As a "Jumper", the aide works with the driver, thus reducing the service time. As a "Helper" the aide works independently at a location while the driver leaves (to deliver packages at other locations) and then returns. The goal is to determine both the delivery route as well as the mode to use the aide to minimize the total time. We model this problem as an integer program with an exponential number of variables and constraints and develop a branch-cut-and-price approach. We discuss our computational experience and insights based on data provided by an industrial partner.

WA10

3rd Fl-Balmoral/Windsor

Simulation and Modelling in Finance and Actuarial Science

General Session

Chair: Kenneth Zhou

Arizona State University

2 - Green Nested Simulation via Likelihood Ratio: Applications to Longevity Risk Management

Kenneth Q. Zhou, Assistant Professor, Arizona State University, Tempe, AZ, 85287-1804, United States, kenneth.zhou@asu.edu

In the context of longevity risk management, the nested simulation problem is encountered in various applications. The standard nested simulation method demands a lot of computational effort, thereby making the risk analyses in these applications difficult. In this paper, we propose a green nested simulation (GNS) procedure for longevity risk management. The GNS procedure requires only small computations, achieves high accuracies, and is easy to implement. We demonstrate the GNS procedure with three numerical case studies. The empirical results indicate that the GNS procedure leads to estimates that are orders of magnitudes more accurate compared to the standard nested simulation.

3 - Mortality/Longevity Capital Risk Management: A Nested-Simulation Approach

Shuai (Alex) Yang, Aon, Toronto, ON, Canada, alex.yang2@aon.com

In this paper, we investigate a problem of mortality/longevity capital risk management using mortality-linked securities. We define the hedging objective in terms of some statistics of the projected mortality distribution, for example, the conditional tail expectation of the fair market values of an insurance contract in a future year. Our simulation results indicate that the optimal units in the hedging securities for an insurance provider and an annuity provider are always of the opposite signs. This finding provides a numerical justification to the market-making of the mortality-linked securities in the context of mortality/longevity capital risk management.

4 - Dimension Reduction via Neural Network for Enhancing Quasi-monte Carlo Method

Junichi Imai, Professor, Keio University, Tokyo, Japan, jimai@ae.keio.ac.jp

A quasi-Monte Carlo method (QMC) is a competitive alternative to Monte Carlo method (MC) that can improve numerical accuracy. A dimension reduction method, an attempt to reduce effective dimension, plays a crucial role for enhancing a QMC. The objective of this study is to develop an alternative dimension reduction algorithm, typically in pricing derivative securities. A noble feature of the proposed algorithm is to construct a nonlinear transformation by conducting regression via neural network. We demonstrate that this approach enables us to reduce effective dimension properly in pricing complicated derivatives for which existing methods hardly work efficiently.

WA11

3rd FI-Oxford/Prince of Wales

Pensions, Annuities, and Life-cycle Choices

General Session

Chair: Zhenzhen Fan

2 - Optimal Savings and Portfolio Choice with Risky Labor Income and Reference-Dependent Preferences

Servaas van Bilsen, PhD, University of Amsterdam, Amsterdam, Netherlands

This paper explores the joint impact of reference-dependent preferences and non-tradable risky labor income on optimal savings and portfolio decisions. We develop a non-trivial solution procedure to determine the optimal policies. Our results reveal that the impact of permanent labor income shocks on both the optimal savings rate and the optimal portfolio share is more pronounced under reference-dependent preferences than under CRRA preferences. In particular, we find that in a wide range of scenarios, individuals withdraw pension wealth already before retirement. Furthermore, we show that the optimal response of the savings rate to a fall in labor income exhibits large heterogeneity across the ratio of consumption to the reference level. Finally, we find that the optimal investment strategy is more conservative compared to the case with riskless labor income and CRRA preferences.

3 - Equilibrium Pricing of Variable Annuities

Yumin Wang, PhD, University of Manitoba, Winnipeg, MB, Canada, Yumin.Wang@umanitoba.ca

Min Dai, Bin Li, Dongchen Li

Variable annuities are prevalently valued using the risk-neutral pricing approach in the literature. Nevertheless, this approach is problematic due to impractical assumptions and misaligned results from market observations. In this paper, we propose a new equilibrium pricing model for variable annuities within a principal-agent framework. We demonstrate that the equilibrium pricing model can reconcile the mismatch from the risk-neutral pricing approach: the resulting insurance fees and policyholder behavior are more consistent with the empirical observations, and insurers persistently participate in the market even with high initial expenses due to high profitability of the product.

4 - Asymmetric Information and Longevity Risk Transfer

Hong Li, PhD, University of Guelph, Guelph, ON, Canada

This paper proposes a principal-agent framework to study the optimal transfer of longevity risk between a reinsurer and a hedger under information asymmetry. Most hedgers in the real world have rather small portfolios which are hard to be accurately estimated by the reinsurer. Using indemnity longevity swaps as an example of reinsurance product, we derive the analytical solution to the optimal risk premiums and incentive-compatible hedge demands in a separating equilibrium and examine the conditions for the existence of the separating equilibrium. The theoretical results are evaluated using real-world mortality data.

WA12

34th FI-Seymour

Forestry

Contributed Session

Chair: Mikael Ronnqvist

Universite Laval, Quebec, QC, G1V OA6, Canada

2 - Towards a Mathematical Model for an Intelligent Manufacturing System in the Wood Industry

Mustapha Ouhimmou, Associate Professor, École de technologie supérieure, Montréal, QC, Canada, mustapha.ouhimmou@etsmtl.ca

Siamak mushakhian, Loubna Benabbou

We aim to develop an intelligent manufacturing system for the management of production processes in the wood industry. We formulate the problem as a mathematical model to maximize the occupancy rate of a high frequency (HF) dryer, as well as the total added value of the lumbers. The model has been solved using the CPLEX solver. The main results shows that lumbers in grade 2, which are not classified as premium or economy is key factor. These lumbers have the potential to become premium by passing through the HF. Decreasing the standard deviation of moisture distribution can increase the net profit of the system. It increases the proportion of potential lumbers which can go to the re-drying loop.

3 - Probability Distribution Prediction of Wood Moisture Content via Deep Learning Model

Mouhcine Laaroussi, École de Technologie Supérieure, Montreal, QC, Canada, mouhcine.laaroussi.1@ens.etsmtl.ca

Loubna Benabbou, Mustapha Ouhimmou, Foroogh Abasian, Samir Haddad, Samuel Gendron

Conventional wood drying kilns use a batch of lumbers to dry at the same time. This process complicates the control of the final moisture content (MC) for every lumber board. Indeed, this is the key requirement of the customers. To solve this problem, our approach consists of using a deep learning model to predict the probability distribution of the MC over all the lumbers at the end of the drying process. The model uses the batch's initial mean MC, the drying conditions and duration to predict the frequencies of the distribution without any assumptions on the density function.

4 - The Small and Medium-size Forest-to-lumber Supply Chain in Chile, the Bio Bio Region Case Study: Preliminary Results

Francisco P Vergara, Universidad del Bío-Bío, Concepcion, Chile, fvergara@ubiobio.cl

An efficient supply chain (SC) and a high rate of growth of Radiata Pine could be keys to the Chilean forest industry's success. However, for small and medium-size forest companies (SME), the timber supply has been jeopardizing their sustainability. The forest-to-lumber SC for SMEs at the Bio-Bio Province case study was surveyed. Open source agent-based modeling and simulation platforms were surveyed to model the case study and horizontal collaboration. However, platforms' libraries are very open compromising their ability to model, rather than program a negotiation algorithm from scratch.

5 - Transport Agreements Including Distance, Time, Fuel Consumption and General Difficulty

Mikael Rönnqvist, Professor, Universite Laval, Quebec, QC, Canada, mikael.ronnqvist@gmc.ulaval.ca

In practical transports, it is important to find the contractual agreement for the payment between the transportation service company and the client who agrees to use the services. The most common agreement is based on distance, which is good on average but when comparing two specific routes with the same start and end points, it typically is unfair. For example, one route may take a motorway for 120 km and another uses low quality private roads for 60 km. The time and fuel consumption may be similar but the payment very different (factor of two). We propose a new function that balances both the quantitative difficulty and distance to define a new agreement. We present numerical results from case studies.

WA13

34th Fl-Stanley

Integer Programming I

Contributed Session

Chair: Parang Zadtootaghaj

Wilfrid Laurier University

2 - Searching for Hypergraphs Using Reinforcement Learning

Parsa Salimi, University of Waterloo, Waterloo, ON, Canada

Tamon Stephen

We investigate the potential of deep reinforcement learning methods for identifying interesting or extremal combinatorial structures. The concrete aim is to find hypergraphs that are challenging for the Fredman and Khachiyan duality checking algorithm. Wagner used this approach with some success on graphs: one of the objectives here is to extend this approach to hypergraphs. We are able to find an example of a hypergraph on 8 variables that surpasses previously known examples. We conclude with computational experiments on more variables and a benchmark of various reinforcement learning algorithms for this task.

3 - Nurse Scheduling Problem with Soft Constraints

Antoine Legrain, Polytechnique Montreal, Montreal, QC, Canada, antoine.legrain@polymtl.ca

The Nurse scheduling problem is very challenging as it generally computes personalized schedules. The talk will focus on the deterministic version of the problem described in the INRC-II competition. One specificity is that most constraints are soft and thus can be violated at the price of a penalty. Classical branch-and-price algorithms underperform with soft constraints as they generally solve a classical resource-constrained shortest-path. In this talk, I will present a different approach to implement more aggressive domination functions for soft constraints, allowing to solve optimally many instances from the INRC-II involving up to 120 nurses and 4 shifts over a 4 to 8-weeks horizon.

4 - 3D Printing: Dual Sourcing Through Second-order Cone Programming

Parang Zadtootaghaj, Wilfrid Laurier University, Waterloo, ON, Canada

This study presents a general framework and solution method for consumer goods logistics subject to availability of 3D printers. We consider multiple products facing stochastic demands and utilize the make-to-stock versus the make-

to-order (3D printing) method that employs a multi-class priority queue. The objective is to minimize the long-run average system cost by assigning the future demands to stock and/or print. We model the problem as a second-order cone program and obtain an optimal solution through a decomposition algorithm. This modeling framework is flexible and extends to many settings, including among others, the dual sourcing in which each product could be both stocked and printed.

WA14

34th FI-Cypress

Optimization I

Contributed Session

Chair: Bahareh Mosadegh Sedghy

University of Lethbridge

2 - Task Allocation Optimisation of Workforce with Dynamic Performance

Negin Asadayoobi, PhD Candidate, Ryerson University, Toronto, ON, Canada, negin.asadayoobi@ryerson.ca

Sharareh Taghipour, Mohamad Y. Jaber

Factors relating to workers and tasks have a combined effect on system performance. Disregarding the variations in performance levels, especially in emergency operations, may lead to erroneous planning decisions causing irreparable damage. This study optimises task allocation/scheduling plans using a Markov decision process while considering two performance measures, speed and accuracy. It allows for dynamic fluctuation of workers' performance over time, affected by their time-varying learning, fatigue, and stress levels.

3 - Optimal Sizing of a Hybrid Solar Power Plant

John Cox, Colorado School of Mines, Golden, CO, United States

The design of a hybrid renewable energy plant, including multiple generation and storage systems, is difficult due to the many degrees of freedom. To analyze the economic performance of hybrid renewable energy plants, we utilize the System Advisory Model (SAM) software, and dispatch systems according to a revenue-maximizing mixed-integer linear program. We develop an execution framework which supports optimization of system sizing according to various performance metrics. We present a case study considering multiple configurations of utility-scale photovoltaic and concentrating solar power plants with storage, and contrast optimal sizing in different locations and electricity markets.

4 - Applying Synergistic Relationships Between Projects for Project Portfolio Optimization

Carolyn Chen, Defence Research and Development Canada, Ottawa, ON, Canada

Michael Petryk, Kendall Wheaton

Strategic planning for long-term capital investments in defence aims to tackle the challenging problem of selecting the best set, or portfolio, of investments for equipping future forces. A project portfolio optimization approach using a 0-1 knapsack algorithm has typically been employed. We will present recent research into the inclusion of synergistic relationships between projects in the algorithm. These relationships determine whether there is added or reduced value to a pair of projects when they are included together within a portfolio. An example will be presented demonstrating the methodology.

5 - System Reliability Optimization throughout Product Life Cycle

Aliakbar Eslamibaladeh, Ryerson University, Toronto, ON, Canada

Sharareh Taghipour

The reliability of a product is affected by various decisions in different phases of product development, such as part selection, system configuration, maintenance, and inspection planning. However, as they are not taken simultaneously, and some uncertain parameters are realized during the progress of product development, integrating all these decisions is a challenging task for system engineers. This presentation introduces a multi-stage stochastic programming model to integrate all reliability-related decisions by considering the realization of information by product development.

6 - Optimization and Coordination of Organic Product Supply Chains Undercompetition: An Analytical Modeling Perspective

Bahareh Mosadegh Sedghy, University of Lethbridge, Lethbridge, AB, Canada, bahareh.sedghy@gmail.com
Alireza Tajbakhsh, Mohammadreza Nematollahi

This study explores competition and coordination-based scenarios driving conventional and organic markets under contract farming mechanisms. The investigated supply chain includes an agribusiness enterprise, an organic farmer, and a conventional farmer. The agribusiness enterprise as the Stackelberg leader offers the price and the farmers set their production quantity. We explore the effects of competition and the main characteristics of organic farming on the players' optimal strategies. We analytically compare the optimal strategies under centralized and non-centralized settings while proposing a synergistic trilateral contract farming that ameliorates societal welfare.

Wednesday, 10:15–11:45am

WB03

2nd Fl-Plaza A

Facility Location

Contributed Session

Chair: Masoud Amel Monirian

Concordia University

2 - Elderly Care Facility Network Design in Response to Climate Change Disasters

Mahsa Madani Hosseini, Ryerson University, Toronto, ON, Canada, mahsa.madani@ryerson.ca

Manaf Zargoush

This paper highlights the importance of (re-)designing an emergency care plan in response to climate change disasters aiming to maximize the number of covered senior people who need support during disasters. We model and solve the Elderly Care Facility Network Design Problem (ECFNDP), considering demand, current and potential facility sites, along with capacity/resource constraints.

3 - Considering the Impact of Interdictions in the Design of Distribution Networks

Shabnam Mahmoudzadeh Vaziri, Concordia University, Montreal, QC, Canada, shabnam_vaziri@yahoo.com

Onur Kuzgunkaya, Navneet Vidyarthi

We present a tri-level mathematical model to design distribution networks by considering the effects of interdictions. The goal is to locate intermediate facilities with minimum installation cost and flow costs before and after interdictions. Since interdictions are not always successful in real-world settings, we introduce a stochastic model with uncertain interdiction success. We present Benders Decomposition (BD) algorithm to solve the proposed model. The resulting stochastic subproblem is solved with dual decomposition algorithm. We also add valid inequalities to accelerate the convergence of the BD. We examine the effects of key parameters on the algorithm performance and the design.

4 - A Capacitated Multi-vehicle Covering Tour Problem with Intermediate Facilities for Waste Collection

Vera Fischer, University of Fribourg, Fribourg, Switzerland, vera.fischer@unifr.ch

David Schindl, Antoine Legrain, Meritxell Pacheco Paneque

We consider a waste collection problem which consists in identifying locations of collection sites that cover all residential buildings (set cover) and creating collection routes with intermediate facilities for a vehicle at minimum total cost. We propose a mixed-integer linear programming (MILP) formulation that exploits the sparsity of the road network. To efficiently solve practical instances, we decompose the problem as follows: we solve a minimum clique covering problem on chordal graphs to identify the set covers and propose a column generation approach to build the routes for a given set cover.

5 - A Conic Integer Optimization Approach to the Preventive Healthcare Facility Network Design Problem Under Congestion

Masoud Amel Monirian, Concordia University, Montreal, QC, Canada, masoudmonirian@gmail.com

Onur Kuzgunkaya, Navneet Vidyarthi

We study the preventive healthcare facility network design problem under congestion to determine the optimal location of facilities, their capacity levels, and client allocations. Incorporating congestion leads to a nonlinear model. We present nine mixed-integer second-order cone programming (MISOCP) reformulations and improve their efficiency using Polymatroid cuts. We evaluate the performance of the proposed MISOCP reformulations using an extensive dataset and the case study of locating Mammography Clinics in Montreal, Canada. Our results show that two of these reformulations perform significantly better than others and 28 times faster than the cutting plane method.

WB04

2nd Fl-Plaza B

Supply Chain Optimization III

Contributed Session

Chair: Ebrahim Sharifi

Ryerson University

2 - Semiconductor Supply Chain Management Under Demand and Yield Uncertainty

Eghbal Rashidi, San Francisco State University, San Francisco, CA, United States

We study the semiconductor supply chain management under uncertainties due to product demand, and production and process yields. Outsourcing of each processing stage (e.g., fabrication, sort, assembly, and test) is explicitly formulated in our three-stage stochastic programming

model. We carry out numerical experiments on a test case based on a large US-based microelectronics manufacturer to generate managerial insights.

3 - Inventory Optimization for Cloud Assets

Steven Hwang, Microsoft, Redmond, WA, United States, stevenhwang@microsoft.com

As more customers turn to the cloud for their business needs, there is an expectation that capacity will be available at any time, like a utility, where customers can consume as much as they want. For Microsoft Azure to meet this expectation, proper inventory placement is crucial to have the capacity available to not only meet our customer demand, but to also minimize the overall inventory cost in the cloud supply chain. In this talk, we will discuss how we have adapted traditional inventory optimization methods to determine the optimal inventory levels in the cloud supply chain, but also solved for new cloud specific features which are difficult to handle with traditional inventory optimization methods.

4 - Developing a New Hybrid Multi-objective Optimization Model for Soybean Supply Chain Configuration with Sustainable Considerations Under Uncertainty

Ebrahim Sharifi, Ryerson University, Toronto, ON, Canada, ebrahim.sharifi@ryerson.ca

Liping Fang, Saman Hassanzadeh Amin

A novel two-phase approach integrating multi-objective programming and the fuzzy Best-Worst method is presented to design a soybean supply chain with sustainability considerations. Four objective functions representing economic, environmental, social aspects, and suppliers' sustainability scores are defined. First, a sustainability index for suppliers is obtained for using in Phase 2. Then, the developed model is solved in Phase 2 utilizing the augmented λ -constraint method. Finally, the presented model is extended to include uncertainty using a two-stage stochastic approach.

Keywords: Sustainability; Food supply chain; Multi-objective optimization; Decision-making; Uncertainty

2 - A Data-driven Approach to Modeling

Assortment Optimization: The Tractable Case of Similar Substitutes

Nanxi Zhang, Shanghai University of Finance and Economics, Shanghai, China

Nanxi Zhang, University of British Columbia, Vancouver, BC, Canada

Bo Jiang, Christopher Thomas Ryan, Renjie Chen

We propose a data-driven approach to model assortment optimization problem in this work. Our work is motivated by two observations from customers browsing history on Taobao: one is that most customers browse very few items (≤ 5) before they made a purchase; the second is that there exists a sorting of items so that customers consideration set is a small interval on the sorting. Based on these observations, we build a framework of choice models, and show the connection between our framework and some popular choice models. To verify if models under our framework capture reality well, we use the data set from Bodea et al. to estimate different models and compare their performance on the out-of-sample data. The result shows that our model provides a good balance between prediction accuracy and model complexity. Then, we consider the assortment planning and pricing problem under our model and give fixed parameter tractable algorithms for both problems. Finally, we illustrate how to apply our algorithms on real data with customers clicking history data on JD.com.

3 - Dynamic Pricing and Advertising in the Presence of Strategic Consumers and Social Contagion: A Mean-field Game Approach

Jafar Chaab, PhD Candidate, GERAD, HEC Montreal, Montreal, QC, Canada, jafar.chaab@hec.ca

Rabih Salhab, Georges Zaccour

We propose new innovation diffusion model that integrates consumer heterogeneity and social influences at the individual level. Forward-looking consumers belong to two mutually exclusive segments: individualists, whose adoption decision is influenced by the price and reputation of innovation, and conformists, whose adoption decision depends on social influences and on price. We use a mean-field game approach to translate consumer strategic interactions into aggregate social influences. We provide conditions for the existence and uniqueness of equilibrium and a numerical scheme to compute it. We find that innovation diffusion is considerably shaped by consumer heterogeneity."

WB05

2nd FI-Plaza C

Productivity & Competitiveness

Contributed Session

Chair: Jafar Chaab

HEC Montreal

WB06

3rd Fl-Regency A

Operations Management III

Contributed Session

Chair: Kiefer Joe Burgess

University of Waterloo, Waterloo, ON, N2L
0G7, Canada

2 - Pricing Strategies for Online Dating Platforms

Titing Cui, Ph.D. Student, University of Pittsburgh,
Pittsburgh, PA, 15213, United States, tic54@pitt.edu
Michael L Hamilton

Online dating apps have become the most common way for couples to meet. Many of these dating apps use subscription based pricing (SP), where subscriptions to the app are sold at a fixed price. In online dating SP is controversial as it may misalign the incentives of the platform and its users. Another strategy is contract pricing (CP), where the dating app is contracted at a one time price. While less common than SP, CP potentially corrects these incentive issues. We present a novel and natural modeling framework, and use it to study the profit and welfare trade-offs associated with either pricing strategy for online dating platforms.

3 - ***Late Cancellation - Entropy-based Evolutionary Diversity Optimization for the Patient Admission Scheduling Problem

Amirhossein Moosavi, University of Ottawa, Ottawa,
ON, Canada

Computing diverse sets of high-quality solutions has gained increasing attention among the evolutionary computation community in recent years. It allows practitioners to choose from a set of high-quality alternatives. We employ a population-based diversity measure, called the high-order entropy measure, in an evolutionary algorithm to compute a diverse set of high-quality solutions for the patient admission scheduling problem. In contrast to the previous studies, our approach allows diversifying the solution set based on different components of the objective function. Experimental results show that our algorithm can find a set of diversified and high-quality solutions.

- Thinking Beyond Market Share to Achieve Exceptional Growth in Pandemic Recovering Markets

Craig S. Hoke, Sales Leader, Pentair Inc, Chester Springs,
PA, United States, craig.hoke@pentair.com

Most corporations use Market Share analysis to develop strategic planning. However, expanding the view with Share of Market (SoM) analysis can deliver more significant and sustainable growth. This presentation will explain the SoM method, its successful utilization in various Asia markets, and its potential application to boost growth in pandemic recovering western markets.

4 - Contract Design with Auditing at a SaaS Firm

Kiefer Joe Burgess, PhD Candidate, University of
Waterloo, Waterloo, ON, Canada, kjbουργess@uwaterloo.ca

We examine a contracting scenario between a principal and an agent at a Software-as-a-Service (SaaS) firm. Both the principal and agent observe the outputs of the agent's effort: service quality and service time. Only the agent views task difficulty costlessly; the principal can, ex-post, perform a costly audit.

We identify four candidate optimal contracts, based on our wage form that incentivizes higher service quality and lower service time while incorporating auditing. We then discuss a number of operational changes that impact these candidates and provide a thorough numerical description of these impacts.

WB07

3rd Fl-Regency B

Multi-stage Optimization under Uncertainty

General Session

Chair: Haoxiang Yang

Ph.D., The Chinese University of Hong Kong,
Shenzhen, The Chinese University of Hong Kong,
Shenzhen, Shenzhen, 518172, China

2 - Stochastic Mixed-Integer Programming Approach to Integrated Protection and Restoration Planning for Interdependent Infrastructure Networks

Haoxiang Yang, The Chinese University of Hong Kong,
Shenzhen, Shenzhen, 518172, China, yanghaoxiang@
cuhk.edu.cn

Jinzhong Yu

This study formulates a two-stage mixed-integer stochastic program to improve the integrated protection and restoration of interdependent infrastructure networks. The first stage considers the decisions about which components to fortify, while the second stage considers decisions about the schedule of repair crews, network flow, etc. To solve this stochastic program, we propose a tri-level decomposition algorithm, with a reformulation of the repairing process as a

2D scheduling problem. Synthetic interdependent networks are employed to illustrate the proposed stochastic program and the solution method.

3 - Multi-period Power System Risk Minimization Under Wildfire Disruptions

Hanbin Yang, The Chinese University of Hong Kong, Shenzhen, Shenzhen, 518172, China, hanbinyang@link.cuhk.edu.cn

Electric grid faults can cause severe wildfires; however, electric utilities often have few options to reduce wildfire risk, leading to disruptive measures such as the use of active blackout equipment. These sudden power cuts had a significant impact on customers. This work constructs a multi-stage model to express the trade-off between serving more load and avoiding wildfire. The model plans the first stage of decisions making until the first fire disruption, and then the second stage will deal with whether some electric components should be shut down. We address this problem by implementing SDDiP algorithm using the level-set method.

4 - The Curse of Passive Data Collection in Batch Reinforcement Learning

Ilbin Lee, University of Alberta, School of Business, Edmonton, AB, T6G 2R6, Canada
Chenjun Xiao, Bo Dai, Dale Schuurmans, Csaba Szepesvari

In high stake applications, active experimentation may be considered too risky and thus data are often collected passively. Compared to active data collection, the price of passive sampling can be substantial when controlling a dynamic system. The main focus of the paper is characterizing this price. For example, when learning in episodic finite state-action Markov decision processes, we show that the number of episodes necessary (and sufficient) to obtain a near-optimal policy is exponential in the number of states and the problem horizon. A remarkable feature of our result is the sharp characterization of the exponent, which is critical for understanding what makes passive learning hard.

5 - Risk-averse Regret Minimization in Multi-stage Stochastic Programs

Mehran Poursoltani, HEC Montreal, Montreal, QC, H3S1W4, Canada, mehran.poursoltani@hec.ca
Erick Delage, Angelos Georghiou

Within the context of optimization under uncertainty, a well-known alternative to minimizing expected value or the worst-case scenario consists in minimizing regret. In a multi-stage stochastic programming setting with a discrete probability distribution, we explore the idea of risk-averse

regret minimization, where the hindsight decisions benefit from getting access to the realizations of a certain number of stages ahead. We provide theoretical and numerical insights about this paradigm under popular risk measures and shed light on the effect of the length of the period used by the decision-maker when evaluating regret.

WB08

3rd Fl-Regency E

Decision Analysis

Contributed Session

Chair: Jun Ma

University of Calgary, Calgary, AB, T3B2V3, Canada

2 - Performance Measurement of Service Providers

Majid Azadi, Deakin University, Melbourne, Australia

The implementation of the SPC is a major challenge in most companies, and a very few studies have carried out modelling of different aspects of the SPC (Kamakura et al. 2002).

To this end, the current study employs data from all dealers of a single automotive brand in Australia to extend the SPC framework. Specifically, the study aims to examine relationship between service delivery investments and customer satisfaction in unstable environments and in the presence of uncontrollable factors such as market size, government legislation and economic climate.

3 - Measuring Efficiency of Multiple Groups of Production Units

Jafar Sadeghi, Ivey Business School, Western University, London, ON, Canada, jsadeghi@ivey.ca

Fredrik Odegaard, Mehmet A Begen

Many DEA applications include a grouping of DMUs. This enables DMUs sufficient flexibility to efficiently meet their requirements within their group assignments and environmental limits. The existing literature does not measure efficiency of these groups in a satisfying and rigorous way. We present a novel approach to analyze group efficiency with and without reallocation of available resources. We also create dual formulations with meaningful interpretations.

4 - Coordination Mechanisms in Decentralized Autonomous Organizations

Jun Ma, University of Calgary, Calgary, AB, Canada, jun.ma2@ucalgary.ca

Jian (Ray) Zhang, Barrie R Nault

We develop a general-form analytical model for decentralized autonomous organizations (DAO) to analyze the impact of two coordination mechanisms considering global and local investments. We consider three features in a general DAO: (i) both global and local investments are made by the members because there is not a central authority in a DAO; (ii) network externalities for end users in a DAO depend on the DAO size; and (iii) each member has an expected profit to join a DAO based on their member size and the DAO size. Furthermore, we derive the conditions for how to use the coordination mechanisms.

WB09

3rd Fl-Regency F

Transportation II

Contributed Session

Chair: Tareq Abu Aisha

University of Quebec at Trois-Rivieres

2 - The Electric On-demand Bus Routing Problem with Partial Charging and Nonlinear Function

Ying Lian, University of Antwerp, Antwerp, Belgium, ying.lian@uantwerpen.be

Flavien Lucas, Kenneth Sørensen

This research extends the existing work on EVRP to an On-Demand Bus Routing Problem (EODBRP) which transports passengers with bus station assignment, in specific, each passenger can have more than one stations to board or alight, and the ones with smaller total user ride time are chosen. In EODBRP, frequent intermediate visits to CSs are considered. Moreover, nonlinear charging functions are in use and partial charging strategy is applied. To solve the EODBRP, a greedy insertion method with "charging first, routing second" strategy is developed, followed by a large neighborhood search which consists of local search operators to further improve the solution quality.

3 - Routes' Interactions in Consolidation-based Transportation Networks

M. Saleh Farham, Wilfrid Laurier University, Waterloo, ON, Canada

Borzou Rostami, Michael Haughton

We study route interactions in a consolidation-based transportation network with a given set of hubs and a set of origin-destination demands. The objective is to find an optimal-cost solution to determine the assignment of demand nodes to hubs, vehicle routes for pickup and delivery, and the flow between the hubs. We formulate the problem as a mixed-integer quadratic program and

develop an exact solution method based on Benders decomposition and column generation techniques. We address consolidation-based economies of scale and provide a detailed computational analysis.

4 - Simulation and Optimization Based Models for Sea Rail Intermodal Transportation Planning Systematic Literature Review

Tareq Abu Aisha, University of Quebec at Trois-Rivieres, Trois-Rivieres, QC, Canada, tareq-ali-issa.abu-aisha.1@ens.etsmtl.ca

Jean-Francois Audy, Mustapha Ouhimmou

The rail connectivity with the seaport is an essential connection for efficient cargo flow from the port to the hinterland. It can be a cost-efficient and green alternative to unimodal road transportation. Inefficient sea-rail connectivity in the seaport results in slowing down cargo flow and affecting the port capacity. This systematic review focuses on connectivity between rail and sea modes of transportation at the seaport as the intermodal system. The review aim is to categorize and analyze previous research contributions on the sea-rail intermodal transportation system, to identify the research trends, investigate the strategies that are used to improve the efficiency of this connectivity.

WB10

3rd Fl-Balmoral/Windsor

Simulation Techniques in Quantitative Finance

General Session

Chair: Gabriel Power

Ph.D., Université Laval, Université Laval, Québec City, QC, G1V 0A6, Canada

2 - One Simulation is All You Need, One Simulation to Price Them, One Simulation to get the Greeks and Forever Hedge Them

Lars Stentoft, PhD, Western University, London, ON, Canada, lars.stentoft@uwo.ca

Pascal Letourneau

This paper brings together two recent contributions for American option pricing and proposes a unified method for pricing large panels of options and for obtaining their sensitivities with respect to all state variables using one simulation and state of the art methods for pricing early exercise options. The method uses nothing but homogeneity of the option price, a property of most option pricing models, and initial dispersion of state variables to achieve this. Compared to pricing one option individually the cost of pricing additional options is negligible and

involves at most a simple cross sectional regression and evaluation of the resulting function approximation at relevant moneyness ratios.

3 - Time Series and Machine Learning Volatility Forecasting

Pascal Letourneau, PhD, University of Wisconsin, Whitewater, Whitewater, WI, United States

Lars Stentoft

This study revisits forecasting of equity volatility for option trading. We find that selecting a best model and hyper parameters depends on the metric used. In particular, results show that for simple models, a compromise as to be made in the size of the estimation sample, whereas more complex models do not suffer from using larger estimation samples. Contrary to general beliefs, a very flexible GARCH specification does not suffer from over fitting and provides equal or better out-sample forecasts. We combine time-series forecasting under ensemble bagged trees to further improve the forecasting quality. Finally, we show how improved volatility forecasting can be used in option trading strategies.

4 - Bias Correction in the Least-Squares Monte Carlo Algorithm

François-Michel Boire, Western University, London, ON, Canada

Lars Stentoft, Mark Reesor

In the Longstaff-Schwartz Least-Squares Monte Carlo (LSM) method for American option pricing, the early-exercise strategy is based on a regression of future option values on current state variables. This introduces dependence between continuation values and future cash flows and results in potential model overfitting generating positive foresight bias. In this paper, we first obtain an expression for the impact of overfitting on the bias of option values. Next, assuming that continuation values are normally distributed we derive a local foresight bias approximation. Finally, we propose a bias-corrected LSM estimator that holds true for general asset price processes and option payoffs. Numerical results show that our proposed method reduces overall estimator bias across a wide range of option characteristics. The relative importance of these improvements increases with the frequency of exercise opportunities, and when continuation value estimates use a small number of sample paths with a large number of basis functions.

5 - Performance of Jump Models to Price Commodity Options

Gabriel J. Power, Full Professor, ULaval, Quebec City, QC, Canada, gabriel.power@fsa.ulaval.ca

We investigate stochastic volatility (SV) models to price commodity options, including a novel double-jump model. We assess their performance in terms of pricing errors and hedging. Using futures options for major commodities, we find meaningful improvements generated by the new model. Particular attention is paid to how jumps relate to seasonality and stochastic volatility. They help account for heavy-tailedness of the distribution. Other models that are assessed include those of Brooks and Prokopczuk (2013), Trolle and Schwartz (2009), and Trolle (2014). As a control, we also fit the model to options on the S&P 500 e-mini and find no improvement from using models that account for seasonality.

WB11

3rd FI-Oxford/Prince of Wales

Finance II

Contributed Session

Chair: Liyuan Lin

University of Waterloo

2 - Are Disclosures of Pandemics as a Source of Risk Informative? Evidence from Changes in Equity Risk Before and After the Covid-19 Pandemic

Keno Theile, Kühne Logistics University, Hamburg, Germany, keno.theile@the-klu.org

Kai Hoberg, Vinod R Singhal

Gathering information on risks in a supply chain is still a significant challenge for firms. However, firms are requested to disclose their material risks in 10-K reports, leading to a substantial amount of information on their risk status. It remains an unanswered question whether the information is informative. Using the COVID-19 pandemic as a natural experiment, we analyze firms' equity risk to answer the question. Our analysis provides evidence that firms disclosing pandemics as a source of risk experience a positive abnormal increase in equity risk. Hence, risk disclosures are informative because firms disclosing the risk of a pandemic are indeed perceived riskier when the risk materializes.

3 - E-Backtesting Risk Measures

Qiuqi Wang, University of Waterloo, Waterloo, ON, Canada, q428wang@uwaterloo.ca

Ruodu Wang, Johanna Ziegel

Expected Shortfall (ES) is the most important risk measure in finance and insurance. One of the most challenging tasks in risk modeling practice is to backtest ES forecasts provided by financial institutions, based only on daily realized portfolio losses without imposing specific models. Recently, the notion

of e-values has gained attention as potential alternatives to p-values as measures of uncertainty, significance and evidence. In this paper, we use e-values and e-processes to construct a model-free backtest of ES using the notion of universal e-statistics, which can be naturally generalized to many other risk measures and statistical quantities.

4 - Supply Chain Finance Contract: A Data-Driven Method

Seyyed Hossein Alavi, PhD Candidate, McMaster University, Hamilton, ON, Canada, alavis1@mcmaster.ca
Manish Verma

Loans can cause the bankruptcy risk in capital constrained businesses. This study presents a data-driven contract that enables us to capture the trade credit and bank credit risks by a non-convex quadratic mixed-integer programming. We study cooperation of Ford automotive company and an independent retailer. The supplier loses assets in cooperation with a highly profit margin retailer. Surprisingly, borrowing trade credit is not always the best financing scheme for the retailer. However, supplier benefits from offering more trade credit.

5 - New Diversification Measures Based on VaR and ES

Liyuan Lin, University of Waterloo, Waterloo, ON, Canada, l89lin@uwaterloo.ca

Xia Han, Ruodu Wang

In this paper, we propose the diversification multiplier (DM) as a new diversification index based on a class of risk measures indexed by a parameter. The DM satisfies three natural properties -- non-negativity, location invariance, and scale invariance. We focus on the theoretical properties for DM on Value-at-Risk (VaR) and Expected Shortfall (ES) and provide a clear interpretation of the values. Two special models including the elliptical model and the multivariate regular variation model are further studied. DM can also be applied to the optimal portfolio selection problem and the dependence uncertainty problem. Finally, we calculate DM on VaR and ES based on real financial data.

6 - Stress Testing Behavioural and Macroeconomic Risks in Credit Portfolios

Viani Djeundje Biatat, University of Edinburgh & Credit Research Centre, Edinburgh, United Kingdom

Banks are required to stress test their credit portfolios annually under Basel II. Stress testing credit portfolios to macroeconomic shocks at account level involves parameterising a model predicting probability of default followed by hypothesising specific shocks or by simulation to derive a value at risk (VaR) or expected

shortfall(ES) 12 months into the future. Simulation requires that the simulated values of the macroeconomic variables are mutually consistent. But the probability of default is also correlated with time-varying behavioural variables, which in turn are correlated with the macroeconomy. Simulation studies have estimated the VaR when mutually consistent macroeconomic values have been simulated or when behavioural variables have been simulated but not when both are simulated. In this paper we present a method to simulate both behavioural and macroeconomic variables into the future whilst maintaining the correlation structure between them to derive a more comprehensive simulation methodology to stress test a credit portfolio.

WB12

34th FI-Seymour

Sustainability

Contributed Session

Chair: Amirmohsen Golmohammadi

Laurentian University, Sudbury, ON, P3E 2C6, Canada

2 - Aviation Security Process Simulation Analysis Using Artificial Intelligence X-ray

SungChan Jun, Korea University, Seoul, Korea, Republic of, kaikai95@korea.ac.kr

Min Gyu Sang, Chulung Lee

This study proceeds with simulation analysis reflecting the development in the aviation security process. Utilizing the hourly passenger data generated at the airport, we conducted simulations based on different scenarios including improvement in security checkpoint performance, change in the number of security checkpoints, and change in the number of passengers considering the future airport environment. This study considers changes in the aviation security process taking into account advanced technology in the security process, and therefore would serve as a basic research to establish future airport strategies according to the development of security checkpoints.

3 - The Effects of Competition on Fair Trade Operations

Daehun Chung, Yonsei University, Seoul, Korea, Republic of, hooney@yonsei.ac.kr

Seung Jae Park

In this study, we explore the effects of competition on fair trade operations. Specifically, as a benchmark, we explore a model with one fair trade organization (FTO), i.e., the monopoly FTO. We then consider two competing FTOs, i.e., the duopoly FTOs. We show that the benefit to farmers per

unit of product sold is greater with the monopoly FTO, but the aggregate benefit to farmers is greater with the duopoly FTOs due to higher consumer demand. We also show that utilizing blockchain technology further benefits farmers and alleviates the effects of competition because consumers directly connect with farmers through the blockchain.

4 - A Three-player Game Theory Model for Carbon Cap-and-trade Mechanism with Stochastic Parameters

Hossein Mirzaee, University of Saskatchewan, Saskatchewan, SK, Canada

Hamed Samarghandi, Keith Willoughby

The cap-and-trade mechanism is a widely used tool by the governments to reduce the emission of greenhouse gases. Naturally, businesses operating under a cap-and-trade scheme adopt strategies to ensure profits maximization and emission minimization. Effectiveness of such strategies depend on mutual interaction of external and internal factors. This article develops a stochastic game theoretical model consisting of a manufacturer, a third-party carbon emission verifier, and the government to study the necessary trade-offs to maximize the stated objectives. The proposed model is validated using a numerical example. Furthermore, it is demonstrated that the proposed model maximizes social welfare by finding the best penalty for bribery and violating the assigned carbon emission quota through advising a re-verification strategy to detect possible collusion between the manufacturer and verifier.

5 - Improving Supplier Social Responsibility in a Competitive Market

Amirmohsen Golmohammadi, Laurentian University, Sudbury, ON, Canada, agolmohammadi@laurentian.ca
Majid Taghavi, Samira Farivar

In this study, we examine how a firm can improve its supplier's social responsibility (SR) level in a competitive market when the SR level of the supplier is not visible. To do so, we consider two competing supply chains, each consisting of a single firm and a single supplier, who sell products in a market with socially responsible consumers. To capture the effect of socially responsible consumers, we assume the suppliers' SR levels can be revealed by a third party. We explore how the competition and having visibility into the suppliers' SR level affect the firms' and the suppliers' strategies.

WB13

34th Fl-Stanley

Integer Programming II

Contributed Session

Chair: Jean-Francois Landry & Ivado Labs

2 - Using Integer Programming Graph Optimization Models to Understand Partisan Polarization and the Coalitional Structure of the U.S. Congress Based on Bill Co-sponsorship Data

Samin Aref, University of Toronto, Toronto, ON, Canada, sare618@uacklanduni.ac.nz

Zachary P. Neal

A signed graph is one with positive and negative edges and can be used to model political collaboration and opposition (signed edges) between legislators (nodes) based on bill co-sponsorship data. We analyze signed graphs of US Congress legislators through partitioning them into k coalitions by minimizing the intra-cluster negative and inter-cluster positive edges using new integer programming models. We then analyze the optimal coalitions of legislators. This talk provides an overview of new models for network analysis and the empirical findings from a data-driven approach to understand US Congress as a complex system using operations research.

3 - Reverse Logistics at Rent the Runway: Staffing Warehouse Departments Using Network Flow Optimization

Louis Boguchwal, Rent the Runway, New York, NY, United States

As a reverse-logistics operation, Rent the Runway not only ships clothing to its customers, but also ensures that clothing is returned and processed for future rentals. Efficiently processing these returns increases inventory availability. By portraying a warehouse's processing departments as an interconnected network, extended flow-optimization models were developed to generate staff plans that coordinate headcounts across departments and mitigate their backlogs. As a result, Rent the Runway has realized major improvements in warehouse turnaround time and overall throughput.

4 - Optimization of a Pickup and Delivery Problem with Minimal Pattern Re-occurrence

JEAN-FRANCOIS Landry, Sr. Data Scientist, Ivado Labs, Montreal, QC, Canada, jf.landry@ivadolabs.com

Carlos Zetina, Louis-Philippe Bigras, Nabila Remli,

Julien Laferrière, Guy Desaulniers, Jean-Francois Cordeau,

Jorge E. Mendoza, Louis-Martin Rousseau

We have been working on an optimization model where we minimize the costs incurred for full truck load pick-up and deliveries with a hybrid mix of dedicated fleet and common carriers. More precisely, we build a model which will identify interesting delivery routes which re-occur a certain minimum of times to be able to negotiate better rates with common carriers. These routes are then identified and re-generated when doing operational planning and flagged so that they are prioritized and will appear within the daily plans, while still minimizing the overall empty mileage.

WB14

34th FI-Cypress

*****Canceled - Optimization II**

Contributed Session Wednesday, 11:50AM - 12:40PM

WP01

3rd FI-Regency CD

Plenary: AI and OR for Environmental Sustainability

Plenary Session

1 - AI and OR for Environmental Sustainability

Bistra Dilkina, University of Southern California, Los Angeles, CA, 90089, United States

With the increasing anthropogenic pressures of urbanization, agriculture, deforestation, other socio-economic drivers as well as climate change, biodiversity and habitat conservation is a key sustainable development goal. Techniques from AI and OR and their hybridization have an important role to play in providing both predictive and prescriptive tools to inform critical decision making, which can help us do more with less in this important application domain. A prime example of the field of Computational Sustainability, this presentation will give several successful examples of the two-way street of research providing useful domain solutions to real-world problems, while advancing core methodology in AI and OR. Key examples include using deep learning and satellite data for land cover mapping, predicting species distributions under climate change, and optimizing spatial conservation planning, as well as developing data-driven techniques to curb illicit wildlife poaching and trafficking.