

# OR64: OR for a better world together

The Operational Research  
Society's Annual Conference

**13-15 SEPTEMBER 2022**

University of Warwick

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# ABSTRACTS BOOK

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## PLENARY SPEAKERS

### Connect with your customers – ML Ops in action

Dr Betty Schirrmeister (PhD)

Betty Schirrmeister, LT OC1.05, September 13, 2022, 3:30 PM - 4:30 PM

#### *Biography:*

Betty is currently Head of Data Science at MoneySuperMarket.

With a team of exceptional scientists, she is using agile and lean methods to deliver data-driven and actionable solutions to predictive problems. Her main goal focuses on creating innovative data science products using statistical models that are scalable and maintainable thanks to clean code- and test driven development - techniques.

Following her PhD in Evolutionary Genetics in 2012 (University of Zurich), she has received funding for several research projects in the field of Bioinformatics and Evolutionary Biology at the University of Bristol. In 2016, she started her work as a Data Scientist for Royal Mail, being promoted to Head of Data Science at the start of 2021.

*In her time at Royal Mail, she has been leading end to end delivery and A/B testing, of several projects, including prediction of delivery windows for RM customers, mail traffic forecasting for Royal Mail's vast infrastructure, revenue prediction and other machine learning projects in the commercial and operational space.*

At MoneySuperMarket we have made it our mission to help Britain's households save money. We operate leading UK price comparison sites for Insurance, Money, Home Services and other products, where we offer households free access to online tools that enable them to switch and buy products.

Fusing advanced data capabilities, we are following the business's strategy to make marketing more efficient and build engaged relationships with our customer base.

We want to ensure that our customers not only keep their money, but also a cool head, hence making the right communication with the right customers an absolutely essential step in our customer interaction.

With the help of our newly built feature store and our customized state-of-the-art MLOps pipeline we have been utilizing >5000 features to optimally support our 10M customers. Personalising messages and design of all our communication channels email, app or website. And the journey continues... While we have been building offline prototypes, the future of online on the fly recommendations awaits.

# Applying systems approaches in Defra

Daniel McGonigle

Daniel McGonigle, LT OC1.05, September 15, 2022, 1:30 PM - 2:30 PM

## *Biography:*

*Dan McGonigle is head of Systems, Innovation and Futures in the Chief Scientific Adviser's Office at Defra. He has been working over the last three years to build a systems research function in Defra to provide insights on interdependencies and complexity in environmental, agricultural and food policy. Prior to this he has 15 years' experience working in Government, research and conservation organisations on sustainable agriculture and environmental management in the UK and overseas. Dan's plenary at OR64 will introduce the audience to the growing and increasingly influential role of systems thinking in government policy making in the UK.*

As we face the dual crises of biodiversity loss and climate change, the stakes for environmental, agricultural and food policy have never been higher. Global events such as the Covid-19 pandemic, Russian invasion of Ukraine and recent heatwaves have highlighted just how interconnected our food, environment and natural resource systems are: how events in one part of the world can cause unexpected cascading outcomes in others, and how impacts can cascade across different sectors of the economy. The socioecological systems that form Defra's policy remit often behave in ways that are complex and unpredictable, and the policy challenges wicked and intractable. Solutions are often contested and actors have conflicting goals. Policymaking in areas like land use, waste management, biodiversity conservation, pollution prevention, food security and fisheries often needs to be based on interrelationships that are only partly understood and evidence that is fragmented. There is frequently a call for systems approaches to shed light on such situations but, until relatively recently, familiarity with such techniques was relatively patchy in Government.

Defra's Systems Research Programme was launched in 2019 to provide insight into complex situations and interacting policies. At the time, the department was undergoing rapid policy development across its remit in response to Brexit and there was wide recognition of the risk of unintended consequences and unexpected trade-offs arising from parallel policy development in interrelated areas. A mixed team of civil servants and seconded academics was established to help identify critical interdependencies. Since then, the team has been on a journey: applying various systems approaches and learning about what works in a Government setting. Defra hasn't been alone in embarking on this journey into systems thinking. GO-Science, Defra and others have recently released a package of tools and guidance on systems thinking for civil servants, and there is a strong and growing network of systems thinkers across Whitehall. In my talk I will discuss the journey that we have been on and the various emerging roles for systems thinking in Government.

# Analytics for a Better World

Dick den Hertog

Dick den Hertog, LT OC1.05, September 14, 2022, 9:00 AM - 10:00 AM

## ***Biography:***

*Dick den Hertog is professor of Operations Research at University of Amsterdam. His research interests cover various fields in prescriptive analytics, in particular linear and nonlinear optimization. In recent years his main focus has been on robust optimization, and recently he started research on Optimization with Machine Learning. He is also active in applying the theory in real-life applications. In particular, he is interested in applications that contribute to a better society. He received the INFORMS Franz Edelman Award twice: in 2013 for his research on optimal flood protection, and in 2021 for his research on optimizing the food supply chain for the UN World Food Programme. Currently, he is doing research to develop better optimization models and techniques for cancer treatment together with researchers from Harvard Medical School and Massachusetts General Hospital (Boston, USA), and he is involved in research to optimize the locations of health care facilities in Timor-Leste and Vietnam together with the World Bank. He has been Visiting Professor at MIT for several years now. He is Science-to-Impact Director of the Analytics for a Better World Institute, that he co-founded in 2022.*

In this talk I will describe two Analytics applications that contribute to one or more of the 17 Sustainable Development Goals (SDGs) of the United Nations. The first application is an optimization model to optimize the food supply chain for the World Food Programme. This application received the INFORMS Franz Edelman award in 2021. The second application is an optimization model to optimize health care facility locations in Timor-Leste and stroke center locations in Vietnam. This project is carried out in collaboration with the World Bank. If time permits I will shortly describe current and future activities of the recently initiated Analytics for a Better World Institute ([analyticsbw.org](http://analyticsbw.org)).

# PRESIDENT'S MEDAL

## A Consumer Healthcare AI Inventory Planner

Dr Gueorgui Mihaylov<sup>1</sup>

<sup>1</sup>GSK Consumer Healthcare

President's Medal, September 14, 2022, 1:00 PM - 2:30 PM

### *Biography:*

Gueorgui Mihaylov (GM) is a Principal Data Scientist at GSK Consumer Healthcare. His expertise lies mainly in geometrical and topological methods in data science, manifold learning techniques and theory of complex systems. GM had a series of research and teaching positions at Polytechnic University of Turin and Polytechnic University of Milan (Italy), and worked on significant industrial research projects in collaboration with AgustaWestland, Tetra Pak and other companies. In 2016-2017 GM had a visiting professorship in applied mathematics at the Silesian University of Technology within the research programme "Smart engineering applications of modern data science". In 2017, GM joined Royal Mail as Senior and later as a Principal Data Scientist. GM contributed to multiple industrial and academic research projects on different research areas including mail flow modelling, maintenance optimisation for the largest van fleet in Europe, fraud detection, optimal industrial scheduling, original manifold learning approach to multiple vehicle routing, geometric techniques for change point detection, financial mathematics etc. GM joined GSK Consumer Healthcare in 2020 as a Principal Data Scientist with focus on the CH global supply chain, currently developing a wide spectrum of strategic initiatives in smart manufacturing, Inventory and logistics optimisation, quality control, CH industrial AI strategy etc. GM is a Visiting Research fellow at the Department of Mathematics of King's College London and a member of the EPSRC Strategic Advisory Team for Mathematical Sciences.

Efficient management of global supply chains is progressively becoming more and more relevant for various reasons including service resilience, sustainability etc. The increasing digital visibility on industrial processes creates interesting opportunities for development of innovative solutions also in traditional operational research areas such as inventory modelling, management and optimisation.

GSK Consumer Healthcare (soon to become Haleon) is a world-leading company in the CH sector. GSK CH develops, manufactures and delivers a broad portfolio of products, including pain relief/anti-inflammatory medicines, oral healthcare products, nutrition supplements, respiratory health and digestive health etc. Some specific characteristics of the consumer healthcare products (compliance with quality regulations, dynamical demand, formulation stability) determine high level of complexity in the management of CH supply chains.

In this talk we describe a bespoke inventory management tool developed by the GSK Consumer Healthcare Data Team in collaboration with the Lancaster University Management School. The tool is a highly integrated ensemble of several components, an ML demand forecasting algorithm, an ML supply forecasting algorithm that leverages the direct digital visibility on the upstream supply operations (manufacturing, release, international logistics etc), a scenario simulation component and an optimisation model, which based on the information provided by the other components, determines the optimal inventory management policy. The tool implements a complex set of real-world operational constraints and recommends optimal order patterns in different commercial scenarios determined by the requested service levels. The complete tool relies on robust data pipelines that source the necessary data from core enterprise systems and includes a sophisticated end-user interface.

Consistent evidence on the high optimisation performance of the AI Inventory Planner in the specific GSK CH industrial reality has been collected.

# Clearance Pricing Optimisation for UK's Largest Supermarket Chain

Ekaterina Arafailova, Francesco Bucci, Tim Butler, George Dikas, Sivaji Doguparthi, Ramon Fuentes, Ross Hart, Akshay Kishan, Can Kocer, Aleksandar Kolev, Sebastian Lautz, Stephen Logan, Fabio Milano, Edwin Reynolds, Himanshu Singh, Stephen Spurrier, Hamish Teagle, Benjamin White, Da Wei Wong

*Tesco PLC*

President's Medal, September 14, 2022, 1:00 PM - 2:30 PM

## ***Abstract:***

We developed a novel multi-stage Clearance Pricing Optimization system and deployed it across all Tesco stores in the UK where it is applied to 100,000s of unique products annually. The objectives of this solution are to (1) clear excess stock by a specific date (either expiry or new product roll-out date), (2) increase revenue by finding the optimal discounts, and (3) reduce operational costs and provide further insights of in-store processes. Our models reduced the number of fresh food items going to waste by 5%, and increased the revenue generated by 1.5-13% across multiple food and non-food product lines.



# Enabling efficient and scalable recipe box fulfilment using symbiotic algorithms for warehouse configuration and order routing

Daniel Paddon, Dominic Wigmore-Shepherd

*Gousto*

President's Medal, September 14, 2022, 1:00 PM - 2:30 PM

## *Biography:*

Gousto is a recipe kit delivery company, offering a choice of over 75 unique recipes per week. In order to ship millions of meals to customers each week, Gousto operates several fulfilment centres. Each factory consists of one or more production lines, split across chilled and ambient sections. Each line has a number of "pick-by-light" stations, with each station holding a number of unique Stock Keeping Units (SKUs).

Gousto's fulfilment requirements have grown rapidly as its customer base has increased. In part this growth is driven by the company's strategy of increasing recipe range. As these two business metrics increase, so too does the requirement to optimise the configuration of Gousto's fulfilment sites.

The problem discussed here is therefore: given the set of SKUs on the menu, the available space on the production line, and a forecast of customer orders, what is the most efficient way to pick this week's orders?

## APPLICATIONS IN STRATEGY

### Using analytics to facilitate strategies

Prof Martin Kunc<sup>1</sup>

<sup>1</sup>Southampton Business School

Parallel Session 6 -Applications in Strategy, OC1.04, September 15, 2022, 11:00 AM - 12:30 PM

***Biography:***

*Professor in Management Science. Research interests in strategic planning using system dynamics. Author of "Strategic analytics: integrating management science and strategy"*

How to integrate Analytics to the Strategic Planning process? This talk is a discussion on the issues and possibilities of using analytics within the strategic development process.

## Reviewing the strategy process within organisations

Dr Frances O'Brien<sup>1</sup>, Ms Eleanor Reynolds

<sup>1</sup>University of Warwick

Parallel Session 6 -Applications in Strategy, OC1.04, September 15, 2022, 11:00 AM - 12:30 PM

### ***Biography:***

*Frances O'Brien is an Associate Professor of Operational Research at Warwick Business School. Her main research interests cover the use of methods to support strategy with a particular focus on the development and use of scenarios to explore future uncertainty.*

This research explores the issue of reviewing an organisation's strategy process. It considers a diagnostic tool proposed originally by Dyson in his book *Strategic Development: Frameworks, methods and models* formed from the strategic development process presented in that and later works. This paper illustrates the deployment of the diagnostic tool in two organisations and compares its less formal use within a third organisation.

# Embedding OR methodology within a business strategy module using an Authentic Business Learning approach

Dr Giles Hindle<sup>1</sup>

<sup>1</sup>University of Hull

Parallel Session 7 - Applications in Strategy, OC1.06, September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

Giles is an analyst with research, teaching and consulting experience at the very highest levels. He is particularly interested in data analytics, problem structuring methods, strategic thinking and systems thinking. His action research programme explores the value of analytics and systemic thinking in supporting management decision making, strategic thinking and business management.

Giles is a member of the General Council of the Operational Research Society, Centre for Systems Studies at Hull University Business School and a Senior Teaching Fellow at Warwick Business School. Previous posts include Associate Director at Health Consultancy Services Ltd, Assistant Professor at Warwick Business School, Senior Data Analyst for Tribal plc and Business Consultant at The Institute for Entrepreneurship and Enterprise Development, Lancaster University.

Research interests include analytics, strategic thinking, applied systems thinking, business modelling, service system innovation, executive coaching and complex problem solving. Giles has led consultancy and research projects for a wide range of clients including the RCUK-funded NEMODE project, NHS Scottish Executive, County Councils Network, Secta Health Group, Countryside Agency, Department for Transport, Department for Health in N. Ireland, Birdseye, Network Rail, Tornado Wire Ltd, Northern Hi-Tec Ltd, and many others.

*Giles provides mentoring and training to government analysts, is an award winning teacher on the Warwick Executive and Online MBAs. He has taught strategic thinking and data analytics on the Hull, Warwick and Lancaster MBA programmes and has developed masters programmes in Business Analytics at Hull and Warwick universities.*

As module leader of a large core Level 6 module on Business Strategy, I've tried to embed OR methodology where possible. The University of Hull has adopted an Authentic Business Learning approach, which means we try to make modules as close to real-world practice as possible. So the first key aspect of the module is the use of a realistic case - where the students must deliver realistic outputs for a realistic client. Although we do use real external collaborators like Cinch for some modules, we prefer to use a fictional case written by myself for strategy and SoftOR modules. This is so we can control the level of complexity, the balance of information and anticipate the likely analytical outputs. Information is presented to the students through a combination of documents, data and stakeholder interviews (delivered through role-play videos). Our approach is based upon the mainstream view of strategy making, which balances an analysis of the external environment with an internal investigation of business model, resources and competitive advantage – it's mostly analytical. We add to this by including stakeholder views and a requirement for innovation and creativity. The students are required to base their approach on a methodology derived from the Business Analytics Methodology (Hindle and Vidgen, 2018) and we encourage the use of tools such as Rich Pictures, Causal Mapping, Business Model Canvas, Strategy Canvas and so on. We find the discipline of OR provides valuable methodological sophistication for strategy projects and, of course, effective analytical tools.

# A multi-methodological framework to enhance the design and implementation of a systemic intervention

Prof Alberto Paucar-Caceres<sup>1</sup>

<sup>1</sup>Manchester Metropolitan University

Parallel Session 7 - Applications in Strategy, OC1.06, September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

Professor Alberto Paucar-Caceres

Professor Alberto Paucar-Caceres is systems scientist, specializing in the field of Systems Thinking, Creative problem solving, Management science and Systems Science. Experience in application of systemic thinking and systemic methodologies to: sustainability and environmental management; transition to the CE; recycling; reducing and managing food waste and sustainable consumption. Alberto's research interest is in the area of application of systems thinking. In particular: (1) application of systems methodologies (Problem-structuring methods, and 'Soft' Operational Research to problematic situations in organisations; and (2) application of systemic management science methodologies to environmental management and sustainability. Publication record includes 150+ academic articles in refereed journal papers, and more than 200 conference papers. Portfolio of research outputs in international journals: European Journal of Operational Research; Journal of Operational Research; OMEGA; Systems Research and Behavioural Research; Systemic Practice and action Research.. All of these articles are supported by a substantive corpus of other work.

## Current projects:

- 1) Applying Circular economy systemic principles to Food Waste management
- 2) Promoting ecological and environmental awareness in HEIs
- 3) The role of higher education stakeholder networks for sustainable development: a systems perspective
- 4) Literacy Health and Planetary Health in Latin America

Multi-methodology in Operational Research (OR) practice has become increasingly popular amongst OR practitioners. Based on Mingers' framework for mapping OR methodologies/methods/techniques and his three notional systems, this paper advances a systemic framework to enhance the design and implementation of a systemic intervention. We report on the challenges posed when using the notional systems in a real-world as well as the cultural and psychological barriers that could prevent feasibility of a multi-method and multi-paradigm intervention. The proposed enhanced framework provides insight as to how to overcome these barriers at both strategic and operational levels. Using Mingers' multi-methodology map, an initial range of soft/hard OR methodologies and operation management tools were then selected. Corroboration on the adequacy of the initial design and selection of methods deployed was achieved by reflecting on the questions arising from the relationships between the three notional systems. This article contributes to the debate about the burgeoning multi-methodological practice of mixing methods in OR-practice by proposing a novel framework and, by reporting the results of a real-world application.

Keywords: Problem Structuring Methods, Operation Management, Hard OR, Multi-methodology, Systemic Intervention.

# Contributions to a new edition of the book Supporting Strategy: Frameworks, Methods and Models

Prof Martin Kunc<sup>1</sup>

<sup>1</sup>Southampton Business School

Parallel Session 7 - Applications in Strategy, OC1.06, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*Professor of Management Science at Southampton Business School. His interests reside on the intersection between strategic planning, behavioural science and simulation (system dynamics and hybrid)*

This year is the 15th anniversary of the publication of the book “Supporting Strategy: Frameworks, Methods and Models”, editors: Frances O’Brien and Robert Dyson, publisher Wiley & Sons. The book has been widely used as a text in courses teaching OR methods applied to strategy. The framework depicting “The Strategic Development Process” integrates the role of OR methods within traditional strategic development process and originates from lively discussions among the two editors, Jim Bryant and John Morecroft. The book has 14 chapters organised in six parts.

The editors have invited Martin Kunc and Giles Hindle to edit together a new edition of the book. Potential authors, who can be academics, practitioners or users of the book, are invited to the inaugural workshop in order to share your ideas for new chapters or updates to the original chapters with their recent research. We aim to develop the book through a series of workshops in-person and online to discuss ideas in order to shape the content of the chapters.

## APPLIED ARTIFICIAL INTELLIGENCE

### Open-Source Crime Data Mining And The Impact of COVID-19 Lockdown on Crime across England and Wales

Mr Tom Turner<sup>1</sup>, Ms Haeshiya Sivakumaran<sup>1</sup>

<sup>1</sup>Decision Analysis Services Ltd.

Parallel Session 3 - Applied Artificial Intelligence, OC1.04, September 13, 2022, 4:30 PM - 6:00 PM

#### ***Biography:***

*Having completed degrees in Mathematics and, Data and Decision Analytics, Tom is now working for DAS Ltd as a Data Science Consultant. He is currently deploying machine learning solutions within the cyber security space.*

Data mining and its applications is an area of machine learning and AI that is yet to be used widely within Police Forces across England and Wales, although it is being trialled by a number of forces.

This project aimed to investigate the availability of open-source crime data, gain insights, and conduct predictive analytics which could aid Police Forces across England and Wales. Throughout this project, machine learning was used to generate predictive models and their results analysed.

Different geographical descriptors were also included alongside historic crime data to improve the accuracy of the final model. The final model produced was able to obtain an average  $R^2$  score of 93.6% across England and Wales. Further research could have been conducted to identify more features to improve the accuracy of the model.

The UK government responded to the unprecedented, rapid spread of the COVID-19 pandemic with national lockdowns. The imposed mobility restrictions changed many aspects of society, with crime and policing being no exception.

The project went on to investigate how crime trends evolved during the COVID-19 pandemic. Additionally, data availability about the COVID-19 response by the UK government and impact of lockdown were also identified, reviewed, and summarised. Regression techniques were used to investigate statistical relationships between the impact of lockdown and crime data.

The level and composition of crime was affected by the national lockdowns. Although an overall decline in recorded crime is observed in England and Wales, certain crime types (public order, drug, and anti-social behaviour offences) increased during lockdown periods. Anti-social behaviour offences remained high post-lockdown.

The incentive to commit crime increased due to the lockdowns as there were decreased returns to legal activities. However, this was offset by shift in people's movement patterns - increased mobility in residential areas made committing some types of crime more difficult e.g. robbery.

# General Predictive Preparedness: Are embeddings and pre-training the new feature engineering?

Dr Michael Mortenson<sup>1</sup>

<sup>1</sup>University of Warwick

Parallel Session 3 - Applied Artificial Intelligence, OC1.04, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Dr Michael Mortenson is an Associate Professor in Data Science and the course leader for the MSc in Applied Artificial Intelligence at the University of Warwick. He has extensive academic and professional experience in data science and artificial intelligence. He is currently working on vision models based on software defined radios.*

In recent years the dominance of custom trained discriminatory models in AI literature and practice has declined in favour of first transfer learning, more recently via self-supervised pre-training models. This talk will make the case for the role of embeddings and vector databases in modern ML practice. Pre-trained, or doubly pre-trained models offer the potential to replace feature stores and complex data pipelines and offer a range of benefits for the modern business. These include the automated contextualisation of business data, reducing the speed to deployment of downstream predictors and providing greater robustness to production models. This talk will review this emerging area with some examples from current projects and considerations on how the space may develop in the future.



# Agile AI Projects: Re-evaluating the Agile Manifesto in the Age of AI

Mr Mark Bonnett<sup>1</sup>, Armaghan Khan

<sup>1</sup>The University Of Warwick

Parallel Session 3 - Applied Artificial Intelligence, OC1.04, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Mark is an Assistant Professor specialising in agile projects in a range of fields*

Agile principles have dominated software development for many years. Its key concepts - such as building iteratively to a minimum viable product, welcoming changing requirements and continuous delivery of features - are now well established goals and practices for the modern software development lifecycle. However, many of these elements are challenging when building AI-powered applications and software where stages often cannot begin before the previous has finished (e.g. modelling the data before it has been prepared for analysis). This talk, drawing on theoretical and technological developments as well as real-world projects, will evaluate the Agile Manifesto as it applies to the AI domain and consider ways in which practitioners can seek to realise the value of agile in AI projects

# BEHAVIOURAL OR

## Mixing intuition and analysis

Prof Konstantinos Katsikopoulos<sup>1</sup>

<sup>1</sup>University Of Southampton

Parallel Session 1 - Behavioural OR, OC0.05, September 13, 2022, 11:00 AM - 12:30 PM

### *Biography:*

I am a professor at the University of Southampton and the deputy head of the Business School. My research connects behavioural science with analytics: I employ experiments to understand lay and expert decision making under conditions of radical uncertainty; harvest this understanding to build models of how such decisions should be made; and test multiple models using machine learning methodologies. This approach is enjoying a rare success—the models are accurate and at the same time transparent, as detailed in

our book "Classification in the Wild: The Science and Art of

Transparent Decision Making" (MIT Press). I am a fellow of the Psychonomics Society (US), chair of the behavioural OR group at the OR Society (UK), and have received a German Science Foundation fellowship for young researchers.

Before joining Southampton, I worked at the University of Massachusetts, Naval Postgraduate School, MIT, and the Max Planck Institute for Human Development. I am currently working on a new book, "Cognitive Operations: Models that Open the Black Box and Predict our Decisions" (Palgrave Macmillan).

Firefighters, emergency paramedics, and airplane pilots are able to make correct judgments and choices in challenging situations of scarce information and time pressure. Experts often attribute such successes to intuition and report that they avoid analysis. Similarly, laypeople can effortlessly perform tasks that confuse machine algorithms. OR should ideally respect human intuition while supporting and improving it with analytical modelling. We utilize research on intuitive decision making from psychology to build a model of mixing intuition and analysis over a set of interrelated tasks, where the choice of intuition or analysis in one task affects the choice in other tasks. In this model, people may use any analytical method, such as multi-attribute utility, or a single-cue heuristic, such as availability or recognition. The article makes two contributions. First, we study the model and derive a necessary and sufficient condition for the optimality of using a positive proportion of intuition (i.e., for some tasks): Intuition is more frequently accurate than analysis to a larger extent than analysis is more frequently accurate than guessing. Second, we apply the model to synthetic data and also natural data from a forecasting competition for a Wimbledon tennis tournament and a King's Fund study on how patients choose a London hospital: The optimal proportion of intuition is estimated to range from 25% to 53%. The accuracy benefit of using the optimal mix over analysis alone is estimated between 3% and 27%. Such improvements would be impactful over large numbers of choices as in public health.

# News vendor stockout aversion revisited: the role of option discriminability

Dr Ilkka Leppanen<sup>1</sup>

<sup>1</sup>Aalto University

Parallel Session 1 - Behavioural OR, OC0.05, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*I am an Assistant Professor in Management Science at Aalto University School of Business, focusing on computational decision science. Previously I worked as a Lecturer at Loughborough University School of Business and Economics.*

Various studies have proposed that the news vendor pull-to-center behavior can be explained by decision biases, but there is not general agreement on which biases are the most relevant ones. One prominent explanation draws on the news vendors' tendency to avoid stockouts. We use a novel method of measuring decision times in conjunction with choice data to study the stockout aversion motive, and derive predictions from evidence accumulation models in decision making. We hypothesise that the news vendor decision making environment has lower option discriminability, that causes the pull to center effect, than a normatively identical decision making environment framed as choice between lotteries. We conduct multiple treatments varying the size of the decision space and saliency of audience effects, and include mouse tracking as a process measure. Our results indicate various interesting patterns concerning decision times and problem framing and behaviour after stockouts. We propose that the results are due to the lower option discriminability between the motives of demand satisfaction and profit maximization in news vendor environments. Evidence for this explanation is corroborated by analyses of the relationship between decision times and utility difference, and by additional measures of social value orientation and self-reported decision motives. Our results strengthen the view that the current understanding of operational decision biases should take into account nonpecuniary motivations such as stockout aversion.

# Cognitive Ability and Suboptimal Behaviours in Risky Decision Making: The Perspective of Decision Inconsistency

Mr Tianqi Hu<sup>1</sup>, Dr Ilkka Leppanen, Professor Alberto Franco

<sup>1</sup>Loughborough University

Parallel Session 4 - Behavioural OR, OC0.05, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*I am a doctoral researcher at Loughborough University. My research concerns about the relationship between intelligence and risk preference.*

Individuals with high cognitive abilities are less prone to suboptimal behaviours in risky decision making, but it is unclear whether this behavioural pattern reflects individual differences in risk literacy for informed assessment of risky prospects, or attentional effort devoted to finding optimal responses. The present study explores this issue by investigating a particular case of suboptimal behaviours – decision inconsistency. Studies suggest that decision inconsistency can be caused by two latent factors, namely, cognitive uncertainty and response caution. While low cognitive uncertainty implies superior risk literacy in processing and integrating risk-related information, low response caution reflects a lack of attentional effort, but not ability for thorough, analytical assessment of risky prospects. We examine whether cognitive ability relates to cognitive uncertainty, response caution, or both factors. In our experimental study, we measure the cognitive ability of participants by psychometric tests and decision inconsistency by preference reversals in a series of risky decisions. We then model each participant's preference formation process using the Drift Diffusion Model (DDM), which decomposes and quantifies the effects of cognitive uncertainty and response caution in causing the observed inconsistency in risky decisions. Our results show that cognitive ability with respect to the tendency of engaging in effortful and analytical thinking is negatively related to cognitive uncertainty, but no measurement of cognitive ability is associated with response caution. These findings suggest that it is risk literacy, but not attentional effort contributing to the correlation between cognitive ability and decision inconsistency, and possibly to a broader range of suboptimal behaviours.

## A case study in failure

Mr Dennis Sherwood<sup>1</sup>

<sup>1</sup>*The Silver Bullet Machine Manufacturing Organisation Limited*

Parallel Session 4 - Behavioural OR, OC0.05, September 14, 2022, 10:30 AM - 12:00 PM

### *Biography:*

I have been a practitioner since I was first introduced to systems thinking in the early 1980s, when I was a consulting partner in Deloitte. I now run my own business, specialising primarily in creativity and innovation, within which I see systems thinking as a most valuable component.

*Over the years, I've written 15 books on a variety of subjects, including two specifically on systems thinking, and one on the story which forms the basis of this contribution to OR64: "Missing the Mark: Why so many school exam grades are wrong, and how to get results we can trust" will be published in August 2022 : <https://www.canburypress.com/collections/frontpage/products/copy-of-how-britain-broke-the-world-by-arthur-snell-isbn-9781912454600?fbclid=IwAR0qdRqoeWeoslc8g67A-XBJ6wx8q2AwlFhJM0mpk3aYz5N5UbhUdzzoA7E>*

Case studies presented at conferences tend to be about success. Clever analysis; insightful use of data; nifty maths; clear solutions; ecstatic client. Great!

This presentation is different.

It's about failure.

Abject failure.

It's the story of an assignment I carried out nine years ago, in 2013. I'd like to think that my analysis wasn't bad, that I interpreted the data sensibly, that my inferences 'saw the wood for the trees'. But what happened next was that the client didn't like the answer. In a big way. Not, I believe, because the answer was wrong, but because the answer was organisationally embarrassing - for the answer threw a spotlight on a systemic error that the organisation had been making for years. Not only did the client not like the answer, the action they took was - to me - surprising. Rather than fixing the fundamental problem, they covered it up, and then denied its existence. For years.

And it's (I think) an important issue too. The client was the exam regulator, Ofqual, and my analysis suggested that the grades actually awarded were much more unreliable than their internal measures were suggesting. That turned out to be true: the internal measure was an error rate of around 1%. The actual turned out to be 25%. Or, in more every-day language, 1 GCSE and A level grade in every 4 is wrong. That's about 1.5 million wrong grades a year. Which Ofqual covered up when, in 2016, they changed the rules for appeals to make it (much) harder to get a re-mark, so (intentionally) suppressing the discovery of grading errors and their correction. And this summer, now that "real" exams are back, 1.5 million wrong grades will be "awarded" again. But no one will know which grades, in which subjects, awarded to which students.

So my assignment failed. And I'm still puzzled by that. What did I do wrong? What can you do when a client doesn't like the truth?

This is, I think, a behavioural rather than a technical issue, which is why I have submitted this suggestion to this stream...

# Behavioural approaches to Grand Challenges

Prof Martin Kunc<sup>1</sup>

<sup>1</sup>Southampton Business School

Parallel Session 4 - Behavioural OR, OC0.05, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Professor of Management Science. Research interest in behavioural decision making applied to strategic problems. Co-editor of two books on Behavioural Operational Research*

Grand Challenges are special problems that face the whole humanity. As such, there is no experience on how to tackle them so well-known behavioural approaches may not be appropriate to deal with them given their special characteristics. In this presentation, I discuss the limitations of traditional behavioural approaches and suggest potential solutions to tackle Grand Challenges using novel methods and/or novel combinations of existing methods.



# CHALLENGES AND OPPORTUNITIES IN FACILITY LOCATION. THEORY AND APPLICATIONS

## Network Restructuring and the Addiction to Growth: addressing locational complexity in distribution networks

Dr DIEGO RUIZ-HERNANDEZ<sup>1</sup>, Dr Jesús María Pinar-Pérez

<sup>1</sup>Sheffield University Management School

Parallel Session 7 - Challenges and Opportunities in Facility Location. Theory and Applications, OC0.05, September 15, 2022, 2:30 PM - 4:00 PM

### *Biography:*

Diego Ruiz-Hernández holds a PhD in Operational Research from the Universitat Pompeu Fabra in Catalonia. He is currently Senior Lecturer in Management Science at Sheffield University Management School and Director of the MSc Management programme.

He has developed his academic career at: Universitat Pompeu Fabra (1998-2009), Universidad de Navarra (2006-2009), and the University College for Financial Studies (2009 to 2018).

He has been visiting scholar at the universities of Edinburgh, Strathclyde and Lancaster in the United Kingdom; and has been visiting lecturer at Kedge Business School and NEOMA Business School, both in France, for several years.

His research covers, but is not limited to, fields in the areas of mathematical programming, combinatorial optimisation, discrete and network location, stochastic scheduling and dynamic resource allocation.

He has published scientific articles in international journals as *Advances in Applied Probability*, *Computers and Operations Research*, *European Journal of Operational Research*, *Expert Systems with Applications*, *International Journal of Production Economics*, and *Transportation Research B*, among others.

Diego is member of the the Operational Research Society of the United Kingdom (ORS); the Spanish Association of Statistics and Operational Research (SEIO); the European Working Group on Locational Analysis (EWGLA); and the Spanish Network on Locational Analysis and Related Problems (RedLoca).

*He is currently lead for Sheffield University Management School of two Catapult Projects at the Advanced Manufacturing Research Centre in Rotherham.*

This work addresses the problem of locational complexity and its inclusion in network design problems. We define “locational complexity” as the intricate set of interactions and decisions that emanates from a company's territorial strategy. The rationale is that an ever-growing number of facilities and a constant expansion into new markets introduces unpredictable costs that hinder the capacity of the company to generate profits. Early work by the same authors reveals that standard location problems (in particular Median and Set Covering formulations) tend to generate oversized networks, inducing what other authors have called “an addition to growth”.

Using an entropy-based measure for supply chain structural complexity (pars-complexity), we develop a theoretical framework for addressing the effects of locational complexity on the profitability of service/manufacturing networks, and provide a mechanisms for efficient network restructuring. This results



in a highly combinatorial and nonlinear problem referred to as the K-MedianPlex problem. A maximum-ascent greedy heuristic is proposed for solving large instances of the problem.

# The Quickest Evacuation Location Problem (QELP) in Humanitarian Operations: Introduction, Applications and a Matheuristic Approach

Mrs Xiaochen Feng<sup>1</sup>, Dr DIEGO RUIZ-HERNANDEZ<sup>1</sup>, Dr Antonino Sgalambro<sup>1</sup>

<sup>1</sup>Sheffield University Management School, The University Of Sheffield

Parallel Session 7 - Challenges and Opportunities in Facility Location. Theory and Applications, OC0.05,  
September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

Doctoral Researcher in OR at Sheffield University Management School.

*My research interests are concerned with the study of novel discrete optimisation problems with real-world applications in Humanitarian Operations and Logistics Management and the design and implementation of efficient algorithms for Location and Network Design problems arising in this context. From an application perspective, I focus on planning disaster relief and evacuation problems in humanitarian logistics.*

Our work is concerned with supporting decision-making in humanitarian operations and emergency management, by considering the problem of finding the optimal locations for emergency facilities, such as shelters, places of safety, and assembly points within the design and planning of evacuation processes. We introduce the Quickest Evacuation Location problem (QELP), a novel optimisation approach aimed at supporting evacuation design and planning in humanitarian operations by combining quickest flows on networks and discrete facility location problems. The main goal is to enhance evacuation network design and planning by identifying which shelters among a finite set of candidates would allow the quickest possible evacuation process for a given set of demand points.

The QELP is first modelled by developing an ad-hoc network tool referred to as QELP-Time Expanded Network (QELP-TEN), which accounts for the lack of a predetermined set of sink nodes - as these need to be selected among the candidate sinks as part of the optimisation problem. Then, in order to secure flexible and realistic decision support, an original multi-objective mixed-integer programming mathematical model is introduced to find the optimal shelters locations such that the overall makespan for the evacuation process is minimised. As the installation of each shelter presents a required set-up cost, and the quality of the evacuation plan depends on an even distribution of evacuees flows over the network, we consider the budget required to install and operate the facilities and the maximum load of evacuees for each shelter throughout the time-horizon as two further - yet conflicting - objectives to be considered for minimisation besides the makespan.

A tailored Matheuristic approach is developed, exploiting linear relaxations and approximations of the original MIP model to identify high-quality solutions in reasonable computational times. In order to explore the Pareto Set efficiently, this is framed within a multi-objective scheme based on the Robust Augmented Epsilon-constraint (AUGMECON-R) method. Computational results on a set of realistic size instances confirm the suitability of the modelling and solution approach to support decision-making for practical applications in Humanitarian Operations.

# Facility Delocation Problem under Demand Uncertainty

Dr Nalan Gulpinar<sup>1</sup>, Dr DIEGO RUIZ-HERNANDEZ<sup>2</sup>

<sup>1</sup>Warwick Business School, The University of Warwick, <sup>2</sup>Management School, Sheffield University

Parallel Session 7 - Challenges and Opportunities in Facility Location. Theory and Applications, OC0.05,  
September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*Will be added later*

Firms need to deal with demand fluctuation or sudden changes in customers' needs and preferences in various industries. This requires to focus on novel technologies and to make important managerial and operational changes in order to maintain their profits or to restore loss profitability in an adverse economic environment. Among these changes, facility delocation has become widely accepted as a valuable mechanism for reducing costs, recovering competitive advantage and, in general, dealing with an unfavourable business environment. In this paper, we consider the capacitated facility delocation problem under demand uncertainty. We introduce a scenario-based stochastic programming formulation of the facility delocation problem where the decision maker should decide either to close certain facilities and/or to modify the capacity of others in order to deal with changing market conditions. We design numerical experiments using a real case study and present the computational results to illustrate performance of the model and derive some managerial insights.

## COMBINATORIAL OPTIMISATION

### Recent developments in the FICO-Xpress Solver.

Mr Michael Perregaard<sup>1</sup>

<sup>1</sup>FICO

Parallel Session 2 -Combinatorial Optimisation, OC0.05, September 13, 2022, 1:30 PM - 3:00 PM

***Biography:***

*Team leader of Xpress Solver development at FICO.*

We will present some of the recent developments of the FICO-Xpress Solver for solving challenging mixed integer programming problems, with a focus on recent work on the efficient use of cutting planes.

# Graph Theory and Cost-Benefit Analysis for Optimizing and Evaluating Networked-Infrastructures Transitions: A Case Study on Wastewater Infrastructure's Mergers in England

Mrs Yasmin Jaaron<sup>1</sup>

<sup>1</sup>Loughborough University

Parallel Session 2 -Combinatorial Optimisation, OC0.05, September 13, 2022, 1:30 PM - 3:00 PM

## ***Biography:***

*Yasmin Jaaron is currently a third year PhD student at the School of Business and Economics (SBE) at Loughborough University. In 2013, she received her bachelor's degree in Industrial Engineering from the Industrial Engineering Program of An-Najah National University in Palestine. She also received her master's degree in Engineering Management from the same university in 2019. Her PhD research is being now conducted in the Economics discipline at the SBE school, working with her supervisors on a multidisciplinary project which requires both economics and engineering knowledge and backgrounds. The goal of her PhD research is to develop models for understanding and developing the efficiency of wastewater infrastructure/system. Yasmin's research considers employing hybrid methodologies from engineering and economics for developing exploratory and optimization models, mainly involves Structural Equation Modelling (SEM), Cost-Benefit Analysis (CBA) and mathematical optimisation modelling based on Graph theory. Accordingly, as wastewater industry is not only affected by economical changes, but is also related to environmental and social challenges, the research will have an impact on the three lines of sustainability. Previously, Yasmin has worked on developing an optimization model for eco-friendly vehicle routing problem. Her research has published in the leading Journal of Cleaner Production.*

This research focuses on applying a hybrid methodology of mathematical optimisation and economic analysis, seeking to develop an optimisation and evaluation tool to be used in infrastructural transitions planning. In particular, the concepts of graph-theory and Cost-Benefit Analysis (CBA) have been applied on facilities mergers of wastewater infrastructure, to demonstrate a proof-of-concept of an effective decision-making tool. The study has involved modelling sewerage systems considering the main two components of collecting and transporting sewage (pipelines and pumping stations) and wastewater treatment facilities. Graph-theory principles are adopted to simulate and solve a whole-system optimization model representing sewage collection and treatment. Accordingly, a heuristic greedy algorithm is developed and applied to find optimum/optimal solutions for two specific mergers scenarios. These are spokes-and-hubs and cascading mergers; both aim at reducing the number of sewage treatment plants by merging treatment facilities looking for long-term savings. The optimization approach involves solving the two merger scenarios heuristically in two stages, to find and compare optimal solutions referring to optimal merger structures. Subsequently, results of the optimization models are complemented by CBA to evaluate their feasibility on a long-term period, by analysing the Net Present Value (NPV) of suggested merger structures over a twenty-five-year timeline.

# Communication-aware Drone Delivery Problem

Dr Cihan Tugrul Cicek<sup>1</sup>, Dr Cagri Koc, Dr Hakan Gultekin, Prof Gunes Erdogan

<sup>1</sup>Microlise Limited

Parallel Session 3 - Combinatorial Optimisation, OC0.05, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Cihan Tugrul Cicek received his Ph.D. degree in Industrial Engineering from TOBB University of Economics and Technology, Ankara, Turkey, in 2019. He is currently a Data Scientist at Microlise Limited. His research interests include mathematical optimization and algorithms with applications in wireless communications, non-terrestrial communication networks, facility location and smart grids.*

The drone delivery problem (DDP) has been introduced to include aerial vehicles in last-mile delivery operations to increase efficiency. However, the existing studies have not incorporated the communication quality requirements of such a delivery operation. This study introduces the Communication-aware DDP (C-DDP), which incorporates handover and outage constraints. In particular, any trip of a drone to deliver a customer package must require less than a certain number of handover operations and cannot exceed a predefined outage duration threshold. We develop a Mixed Integer Programming (MIP) model to minimize the total flight distance while satisfying communication constraints as well as the time windows of customers. We present a Genetic Algorithm (GA) that can solve large instances, and compare its performance with an off-the-shelf MIP solver. Computational results show that the GA can outperform the MIP solver for solving larger instances and is a better option. The computational study supports our theoretical findings that ignoring the communication constraints would result in operational disruption risk, which can be easily mitigated by sacrificing slightly from total flight distance. In particular, the handover and outage performance can be improved by up to 24% and 31%, respectively, in return of up to 7% increase in total flight distance.

# Multi-Step Integer Linear Programming in Fibre-To-The-Home Network Design

Mr Danny Yen<sup>1</sup>, Mr Tim Glover<sup>2</sup>

<sup>1</sup>University Of Warwick, <sup>2</sup>British Telecom

Parallel Session 3 - Combinatorial Optimisation, OC0.05, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Danny Yen is a 4th year PhD Candidate in Operational Research at the University of Warwick (Warwick Business School). His PhD project investigates Integer Linear Programming methods to solve Fibre-To-The-Home Network Design Problems in collaboration with British Telecom.*

We address the Fibre-To-The-Home Network Design problem with Integer Linear Programming (ILP) and compare with a current Simulated Annealing method. The search for a solution is split into multiple steps to be able to tackle large real-life problem instances with high effectiveness.

Linear Programming is usually considered inadequate for large problem instances, particularly for one as complex as Fibre Network Design. Either the model is simplified, or a random search algorithm is used instead. We develop a novel ILP formulation of the Fibre Network complete with equipment levels, container costs and fibre constraints. The branch and bound algorithm from CPLEX is found to solve small instances to optimality, faster and more consistently than Simulated Annealing. Large instances cannot be fully solved in reasonable time, so the optimisation is divided into 2 or 3 ILP steps to be solved in succession. This involves optimising the network with the exclusion of Splitter-to-Splitter cables, then re-optimising Splitter cables while keeping the equipment fixed. The first step can further be split into optimisation of the lower level of the network followed by the upper level.

The ILP methods and Simulated Annealing method are tested on real-life problem instances for a fixed length of time. The 2-Step method produced the best results across the range of network sizes, only beaten by the 3-Step method on the largest test problem. The solutions produced by the ILP methods are substantially superior to those produced by Simulated Annealing. This may be due to the random search struggling to find efficient configurations in order to reduce the number of equipment required. In comparison, ILP can optimise details effectively as long as the large problems get broken down carefully.

# Multi-stage Heuristic for Facility Management

Mrs Arezoo Vejdani<sup>1</sup>, Dr Andre Maravilha<sup>2</sup>, Dr Felipe Campelo<sup>1</sup>, Dr Aniko Ekart<sup>1</sup>, Dr Randa Herzallah<sup>1</sup>  
<sup>1</sup>Aston University, <sup>2</sup>Federal de Minas Gerais University

Parallel Session 3 - Combinatorial Optimisation, OC0.05, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Early career data researcher, with experience of working in academia (at PhD level) and industry (as a KTP associate in Arcus FM). Our KTP project is in the area of operational research and I am very interested to talk about it in the OR society.*

We consider a complex real-world Facility Management (FM) problem requiring generating and updating schedules for approximately 1,000 engineers to attend around 10,000 daily job sites executing maintenance tasks, under numerous constraints related to skills matching, job deadlines and geographical location. The problem is modelled as a Mixed Integer Programming (MIP) problem with binary variables. Given the size and complexity of the problem, we propose a multi-stage heuristic solution strategy, with (i) a pre-filtering stage to select valid engineer-task pairs; (ii) an allocation stage where tasks are attributed; (iii) a route refinement stage for each engineer, modelled as multiple small-scale Travelling Salesperson Problems with Time Windows (TSP-TW); and (iv) a final refinement using a general solution polishing strategy. The pre-filtering is needed to ensure that domain specific constraints such as engineer skills matched for the job are satisfied. In the allocation stage a greedy shortest transit time rule is used, until the engineers' available time is exhausted. Since the number of allocated tasks to each engineer per day is limited (e.g., < 10), the multiple TSP-TW in the route refinement stage can be solved to optimality with simple algorithms. The results of the proposed heuristic are compared to CPLEX time-limited Branch-and-Cut strategy using data provided by a partner FM industry. Preliminary results indicate that the proposed heuristic provides good feasible solutions and scales well up to the required problem sizes within reasonable amount of running time. The future work in this regard is to compare solutions of the multi-stage heuristic to the partner FM industry solutions in terms of solution quality and running time.



# Large Scale Real-Time Dispatching Problem for Freight Trains

Mr. Md Tabish Haque, Dr Faiz Hamid<sup>1</sup>

<sup>1</sup>Indian Institute of Technology Kanpur

Parallel Session 6 - Combinatorial optimisation, OC0.05, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Dr. Faiz Hamid is an Assistant Professor in the Department of Industrial and Management Engineering at Indian Institute of Technology Kanpur. He holds a Bachelor of Technology in Computer Science and a doctorate in Operations Research from Indian Institute of Management Lucknow. After receiving his Ph.D., he was engaged as a Post-doctoral Research Fellow at University of Paris. He served as a Functional Architect at JDA Software for a project on Revenue Management for Railways. His research interests include Combinatorial Optimization and Data Science. His research work has been published in several reputed international journals.*

Train operators often provide timetables for passenger and freight services operating periodically or acyclically. However, due to complex network structure and large number of daily activities, the railway network is susceptible to disruptions leading to delays or cancellations of train service. Under these circumstances, the original timetable, rolling stock circulation and crew schedules are no longer feasible and must be revised. The revision of all three phases is contingent on the severity and impact of the disruption. In this paper, we address the real-time scheduling of freight services whose operation is primarily impacted by the unavailability of crews, locomotives, and yards. Due to an acyclic timetable, rapid changes in demand patterns, and a greater number of requests with short-term train routes, the application of real-time rescheduling in freight services is invariably unique from passenger services, necessitating special consideration.

We model this real-time dispatching problem for freight trains using a mixed integer linear program with the objective of minimizing the delay of trains at each service station. To enhance the computational performance, several preprocessing steps have been proposed. Further, we develop an iterative solution algorithm based on a time decomposition approach. Numerical experiments have been carried out on a real-world dataset obtained from NS and ProRail. The dataset includes 423 trains, 60 stations and a combination of single and double tracks throughout the network. This problem is significantly larger than those solved in the literature, where exact solutions are obtained for no more than 50 trains. The strengthened formulation and iterative approach can solve large problem instances using the branch-and-cut algorithm of CPLEX in a reasonable amount of CPU time.

# The truck-porters routing problem

Mr Mohammed Alammar<sup>1</sup>

<sup>1</sup>University of Southampton

Parallel Session 6 - Combinatorial optimisation, OC0.05, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*I am Mohammed Alammar, a PhD student at the University of Southampton. I am interested in the last-mile delivery problems.*

The truck-porters routing problem (TPRP) arises when undertaking deliveries within urban areas where vehicle access to some customers is impossible. Thus, some of the deliveries are undertaken by porters who walk to the customers, while a truck is driven to perform deliveries to the other customers. In the TPRP, a single truck and a limited number of identical porters are available at the depot. For the customers, some must be visited by the truck, some must be served by a porter, and the remainder can be visited either by the truck or by a porter. Porters are limited by the total weight of items that they can carry and by a total working time constraint. However, a porter can revisit the depot to collect further items for delivery. The TPRP problem consists of designing a set of minimum-cost routes, where each route starts and ends at the depot and satisfies capacity and travel time constraints. We introduced two mixed-integer programming formulations for this problem and several families of valid inequalities which are used within a branch-and-cut algorithm. A tabu search algorithm is designed and used for the separation procedure. Our branch-and-cut algorithm is tested on randomly generated instances. Computational results show that it solves to optimality instances with up to 19 nodes within a reasonable amount of computational time. Furthermore, for larger size instances, we propose a variable neighbourhood search heuristic for the TPRP problem.

# A Mixed Integer Linear Programming model for the Home Health Care Routing and Scheduling Problem

Dr Consuelo Parreño-Torres<sup>2</sup>, Dr Miguel Reula<sup>3</sup>, Dr Toni Martínez-Sykora<sup>1</sup>, **Dr Carlos Lamas-Fernandez<sup>1</sup>**

<sup>1</sup>University Of Southampton, <sup>2</sup>University of Valencia, <sup>3</sup>Universidad Carlos III de Madrid

Parallel Session 6 - Combinatorial optimisation, OC0.05, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Carlos is a Lecturer in Business Analytics/ Management Science in Southampton Business School. In his research, Carlos is interested in using optimisation techniques in areas such as health care, transportation and logistics. He has developed both heuristic and exact methods for cutting and packing, vehicle routing and facility location problems.*

In the health and social care sectors it is common for some specialised teams to travel to patient homes to provide care. These teams are typically integrated by a number of staff members with varying skills, starting locations and working hours. Patients require different types of care, during specific time windows, and might have special requirements, such as needing two staff members, or multiple visits with some sort of temporal dependency between them. This means that these teams need to decide which staff member will visit each patient, as well as the routes they will take to do so. Of course, these decisions have an impact on the total time required to see all patients, as well as the timeliness of the visits or the ability of maintain preferred staff-patient assignments. This kind of planning problem is known in the literature as the Home Health Care Routing and Scheduling Problem (HHCRSP), and has been extensively studied under different variants to model the requirements of different care providers. In this talk, we present a novel Mixed Integer Linear Programming formulation for the HHCRSP which considers a wide range of practical aspects of the problem, and generalises previous models. We show that our formulation can be easily adapted to solve more specific variants published in the literature and that, using the same computing set-up, we are able to obtain more optimal solutions, feasible solutions and better lower bounds for benchmark instance sets.

# COMMUNITY OR: ORGANISING COMPLEXITIES AND RESPONDING TO COMMUNITY CHALLENGES

## Linking OR and public engagement. The Challenge-Based Learning approach

Dr Eliseo Vilalta-Perdomo<sup>1</sup>, Ms Rosario Michel-Villarreal<sup>2</sup>

<sup>1</sup>Aston University. Aston Business School, <sup>2</sup>Royal Agricultural University.

Parallel Session 3 - Community OR: Organising complexities and responding to community challenges,  
OC1.08, September 13, 2022, 4:30 PM - 6:00 PM

### *Biography:*

Eliseo Vilalta-Perdomo holds a BSc in Industrial and Systems Engineer (1987) and a MSc in Manufacturing Systems (Automation and Control) (1989) from the Tecnológico de Monterrey. His PhD was focused on developing a theory for the design of interfaces ("What Keeps Us Together and Makes Us Effective? A collective action approach to the study of Information Systems", University of Lincoln, 2005). His research focuses on how to improve individual and collective performance, in those cases where the alignment of aims and preferences is not possible, unattainable or even unnecessary. He currently studies the development of sustainable communities of micro-producers, to become more resistant to global and/or local logistical challenges, using diverse human and technological interfaces, within different supply arrangements, that may increase the propensity of individuals to collaborate. In short, his current research is at the intersection of issues such as human performance, technology and sustainable operations. At the Tecnológico de Monterrey he was part-time Lecturer (1993-1999) and full-time since 2000, where he was Associate Professor, Head of the Department of Industrial & Systems Engineering (Guadalajara), and Dean of Higher Education (Irapuato). At University of Lincoln (2011-2020) he was Associate Professor and Programme Leader of the MSc in Logistics and Global Operations.

*He has professional experience in Government and the Private Sector. In the Office of the Speaker for the President of Mexico, he was Documentation Deputy Director; in Aeropuertos y Servicios Auxiliares, Advisor for the Operations Deputy Director; in PEMEX Gas y Petroquímica Básica, General Superintendent of Natural Gas Sales, and in the Mexican Secretary of the Interior, Advisor to the Secretary. In the private sector he collaborated as Associate in Consultores y Promotores Asociados, S.C.; in Desarrolladora Metropolitana, S.A. de C.V. as Assistant of the General Director, and in Grupo Tribasa, as Evaluation Advisor for the International Vice-president.*

Since Rosenhead's inaugural address as President of the OR Society (1986) many things have happened in our discipline. At that time, Rosenhead was trying to answer "who O.R. works for ('custom'), as well as what we do and how we do it ('practice')". What at that time was not at the focus of OR was: how to teach OR? But this question does not seem clearly bounded and can be answered with a poor answer: "do it as usual". In this presentation, we will focus on answering the question on how to teach OR, but with a particular twist. To teach OR in such a way that students learn, not just the techniques, but also become aware of the impact that they may have when using OR for finding "solution of problems in the management of complex systems that enables decision makers to make better decisions."

This presentation will show different OR perspectives that can be used to improve communities through public engagement, under a multidisciplinary teaching and learning approach that aims to increase students understanding of OR to solve real-life problems. This approach is known as Challenge-Based Learning. Examples of its use will be presented and discussed with the audience.

# Supporting development through community-based research; researching community systems

Dr Rebecca Herron<sup>1</sup>

<sup>1</sup>University Of Lincoln

Parallel Session 3 - Community OR: Organising complexities and responding to community challenges, OC1.08, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Rebecca is an Associate Professor in Management at the Lincoln International Business School, (University of Lincoln, UK). Her main teaching and research interests are Community Organisation and Non-profit management. She leads the Community Operational Unit within the School - and over the past 20 years has engaged with numerous community-based research activities and championed community research within management and business and across the University. Becky's academic background is Maths and O.R. and her PhD was within both the Centre for Nonlinear Studies and the Centre for Computational Geography (University of Leeds). As well as her interest in community-based research and community development, Becky is interested in how ideas of complexity and systems thinking can help inform community research. She was a co-founder and the academic partner of the community-led 'Social Issues in South Lincolnshire' Network in 2011 and has been a joint facilitator of their network meetings over the decade since. She has also led numerous research projects and supported the development of many community-based doctoral studies.*

Communities often work together in a variety of ways to try to improve their own local (or global) situations. These improvements may be to residents' own quality of life, to the environment the communities they live or work in, or they may relate to wider conceptual issues such as social justice or addressing inequalities. The ways that communities operate may be quite diffused and hard to define and observe – but often involve a web of relationships and interactions as well as the sharing and development of a wide range of resources (money, time, knowledge, history and culture, connections, property, imagination, experience and sense of humour; to name just a few). Community Operational Research seeks to develop and articulate ways for researchers to support communities in these endeavours. It can do this through a number of means including community-based research, participatory development activities and the evaluation of community activities and projects. This talk presents a few University-Community partnership activities – including the 'Social Issues in South Lincolnshire' Network and the 'We Are Sincil Bank' Place-Based Social Action Project. In doing this, reflections are made and invited on the ideas of systemic thinking that shape and inform these activities and the challenges and opportunities for this kind of research.

# The impact of supply chain operations on the sustainability of cities and their communities.

Dr David Ernesto Salinas-Navarro<sup>1</sup>

<sup>1</sup>Aston University

Parallel Session 3 - Community OR: Organising complexities and responding to community challenges,  
OC1.08, September 13, 2022, 4:30 PM - 6:00 PM

## *Biography:*

Dr David Ernesto Salinas-Navarro was born in Mexico. He received a BSc degree (Hons) in Aeronautical Engineering from Instituto Politécnico Nacional in Mexico City, an MBA from Tecnológico de Monterrey, and a PhD degree in Business/Management Systems from the University of Lincoln, UK.

From August 2021, he is a Senior Teaching Fellow at the Operations and Information Management Department, Aston Business School, Aston University, UK. Before, he worked at Tecnológico de Monterrey as Associate Professor and Regional Head of Department at the Industrial Engineering Department, Mexico City Region. He is the author of one book in management systems and papers in supply chains and logistics, lean systems, and industrial engineering education. His research work explores the footprint of logistics and supply chains on the sustainability of cities and communities.

*Dr Salinas-Navarro is a senior member of the Institute of Industrial and Systems Engineers (IESE) and a fellow of the MIT SCALE Network Latin America, coordinating the Education Innovation initiative. He also directs education leadership initiatives such as the Healthcare Engineering Management Lab, the Lean Thinking Learning Space (LTLS), the Social Lab for Sustainable Logistics (SLSL), and the Community Resilience and Sustainability Education Lab (CoRSEL) to enrich Industrial Engineering and Operations Management education. His innovative work has obtained the Silver Award for Presence Teaching and Learning at the 2019 QS Reimagine Education competition.*

Supply chains affect the sustainability of cities and their communities by creating a footprint alongside their operations going from producers, manufacturers, wholesalers, distributors, and retailers to the final consumers of products and services in urban settings. Some traditional views on the topic emphasise improving economic and environmental aspects under the concept of sustainable supply chains. Examples of these cases are the reduction of carbon footprint and gas emissions by minimising fossil fuel consumption or the optimal allocation of logistic vehicles in supply networks or last-mile logistics. Other works shed light on the idea of the circular economy to reduce or eliminate the generation of solid waste and maintain its economic value through repairing, reconditioning, reusing, or recycling. However, to improve the sustainability footprint, supply chains should consider the triple bottom line of economic, environmental, and social performance, which also involves additional elements such as the use of land, urban mobility, noise generation, traffic accidents, and the accessibility and availability of the products and services, among others. This view takes into account social aspects such as health and wellbeing, inclusion, and equity, which allow for doing good by doing well. Therefore, this work explores how the notion of sustainability in supply chains should go beyond economic and environmental requirements by tangibly contributing to the urban contexts where they operate, involving comprehensive daily life aspects of people in their cities and communities. Accordingly, a conceptual framework is proposed to observe and reflect upon relevant supply chain situations in urban contexts and their sustainability impact according to the Sustainable Development Goals (SDG). This work also presents instances concerning the retail landscape of nanostores across different socioeconomic levels, traffic disruptions in cargo loading and unloading operations, and the interruption of supply chains in the distribution of food products over the COVID-19 pandemic. The main contribution of this work consists of conceptualising sustainability in supply chains to consider the integration of economic, environmental, and social aspects and their contextual impact on cities and communities in line with the SDG.

# CONTINUOUS OPTIMISATION

## Bilevel hyperparameter optimization for RFB Kernel support vector machines

Mr Anthony Dunn<sup>1</sup>, Dr Alain Zemkoho<sup>1</sup>, Stefano Coniglio<sup>1</sup>

<sup>1</sup>University Of Southampton

Parallel Session 3 - Continuous optimisation, OC1.01, September 13, 2022, 4:30 PM - 6:00 PM

### *Biography:*

*I am a PhD student at the University of Southampton specializing in ML applications and optimization in ML*

The problem of tuning the hyperparameters of a Support Vector Machine (SVM) model via cross validation is intuitively a bilevel problem. Methods for solving this problem have been presented in the literature however these papers have addressed only the linear kernel SVM. The Radial Basis Function (RBF) or Gaussian kernel affords SVM models the ability to capture more complex relationships between the variables of our data. This however comes with the drawback of the primal form of the training problem containing the function  $\mathbb{R} \rightarrow \mathbb{R}^\infty$ . To avoid this, we consider instead the dual formulation of problem. Typically, when gridsearch, randomsearch or Bayesian optimisation are used to approximate a solution for this bilevel problem, the upper level problem involves maximising the accuracy of the model's predictions for the testing set. This choice of upper level objective function is non-smooth and hence, would render any gradient based approach to solving the bilevel problem useless. We propose an upper level objective function in which we minimize a loss function derived from the lower level SVM training objective. However, this loss function utilizes parameters of the primal problem and, as such, we have to construct robust methods for deriving the primal parameters from the dual parameters. We perform the KKT single level reformulation and apply the Sholtes relaxation. The relaxed problem is then solved using `fmincon` in MATLAB, the relaxation of the original problem is then reduced and the solution reached by the solver on the previous iteration is used as a starting point. We evaluate this method by performing on 3-fold CV on 10 commonly datasets and provide a comparison of this methods performance with that of gridsearch.

# Bilevel hyperparameter optimization for support vector classification: theoretical analysis and a solution method

Dr Alain Zemkoho<sup>1</sup>

<sup>1</sup>University Of Southampton

Parallel Session 3 - Continuous optimisation, OC1.01, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*I am an associate professor in operational research at the School of Mathematical Sciences within the University of Southampton where I am affiliated to the OR Group and CORMSIS. Prior to joining the University of Southampton, I was a Research Fellow at the University of Birmingham and had previously worked as a Research Associate at the Technical University of Freiberg. I am a Fellow of the Alan Turing Institute for Data Science and Artificial Intelligence, a Fellow of the Institute of Mathematics & Its Applications, and a Fellow of the Higher Education Academy.*

Support vector classification (SVC) is a classical and well-performed learning method for classification problems. A regularization parameter, which significantly affects the classification performance, has to be chosen and this is usually done by the cross-validation procedure. In this talk, we discuss a formulation of the hyperparameter selection problem for support vector classification as a bilevel optimization problem, where the upper-level problem minimizes the average number of misclassified data points over all the cross-validation folds, while the lower-level problems are the  $l_1$ -loss SVC problems with each one associated to a fold in T-fold cross-validation. The resulting bilevel optimization model is then converted to a mathematical program with equilibrium constraints (MPEC). To solve this MPEC, we propose a global relaxation cross-validation algorithm (GR-CV) based on the well-know Sholtes-type global relaxation method (GRM). It is proven to converge to a C-stationary point. Moreover, we prove that the MPEC-tailored version of the Mangasarian-Fromovitz constraint qualification (MFCQ), which is a key property to guarantee the convergence of the GRM, automatically holds at each feasible point of this MPEC. Extensive numerical results verify the efficiency of the proposed approach. In particular, compared with other methods, our algorithm enjoys superior generalization performance over almost all the data sets used in the study.

This talk is based on joint work with Qingna Li and Zhen Li, School of Mathematics and Statistics, Beijing Key Laboratory on MCAACI/Key Laboratory of Mathematical Theory and Computation in Information Security, Beijing Institute of Technology, Beijing, 100081, P. R. China.



# A practical comparison of direct reformulation of the M-stationarity and the relaxation techniques for pessimistic bilevel optimization problems

Dr Lateef Jolaoso<sup>1</sup>, Dr Alain Zemkoho<sup>1</sup>

<sup>1</sup>University of Southampton

Parallel Session 3 - Continuous optimisation, OC1.01, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Lateef Jolaoso joined the University of Southampton in 2021 as a postdoctoral fellow. Prior to that, he was a postdoctoral researcher at the Sefako Makgatho Health Science University, Pretoria, South Africa. He completed his PhD at the University of KwaZulu-Natal, Durban, South Africa on efficient iterative methods for solving nonlinear optimization problems which include equilibrium problems, variational inequalities and fixed point problems. Lateef is an active researcher who have published several articles in high impact factor journals and gained more than a thousand citations globally. He currently enjoyed working on pessimistic bi-level optimization problems and its applications.*

In this talk, we focus on the so-called pessimistic version of bi-level optimization program which, of focus, is challenging to handle because it assumed that there is no cooperation between the leader and the follower in contrast to the popularly treated optimistic version. Though the pessimistic version is more realistic from a practical point of view, it has scantily been addressed in the literature. In this paper, we first considered the direct reformulation of the Mordukhovich (M)-stationarity of the problem as a system of nonsmooth equations which can be solved by a semi-smooth Newton method under appropriate regularity conditions. Furthermore, we study the relaxation of the mathematical program with complementarity constraint (MPCC) associated with the pessimistic bi-level optimization programs in the sense of Kanzow and Scholtes. Some theoretical and numerical comparison of the solution methods will be provided under certain regularity conditions.

This is a joint ongoing work with L. Lampariello, P. Mehlitz, S. Sagratella and O. Stein.

# Stackelberg Games for Adversarial Learning

Mr David Benfield<sup>1</sup>, Dr Alain Zemkoho<sup>1</sup>, Dr Vuong Phan<sup>1</sup>

<sup>1</sup>University of Southampton

Parallel Session 7 - Continuous Optimisation, OC1.04, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*David Benfield is a postgraduate research student in the Operational Research Group within the School of Mathematical Sciences at the University of Southampton. He is in his first year, studying Adversarial Machine Learning.*

Adversarial machine learning concerns the situation where data miners face attacks from active adversaries. In particular, the underlying distribution of the data used by the data miner to train machine learning models is vulnerable to significant changes made by the adversary. The interactions between the data miner and the adversary can be modelled as a game between two players. While many game theoretic models exist, some of these assume that the players act simultaneously. However, in the case of adversarial learning, a perhaps more appropriate assumption is that players can observe their opponent's actions before making their own. For example, spam email senders might probe an email filter by sending test emails before deploying their final products. We explore the Stackelberg Game model where the players act sequentially, allowing for such an assumption. In this Stackelberg model of two players, there are two levels, the leader at the top and the follower below. The leader acts first followed by the follower, creating two possible approaches to modelling our adversarial scenario, depending on who takes on these roles. We focus on the case where the data miner takes the role of the leader and develop and test a method to solve the resulting pessimistic bilevel optimisation problem.

# On RLT vs RLT-SDP Relaxations of Box Constrained Quadratic Programs

Mr Yuzhou Qiu<sup>1</sup>

<sup>1</sup>University Of Edinburgh

Parallel Session 7 - Continuous Optimisation, OC1.04, September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

(Currently) PhD student at the University of Edinburgh studying Operational research.

Postgraduate student at the London School of Economics and Political Science studying MSc Operations Research & Analytics.

*Undergraduate student at the University of Liverpool and Xi'an Jiaotong-Liverpool University studying BSc Mathematics with Finance.*

In this talk, we focus on RLT (Reformulation-Linearisation Technique) and RLT-SDP (Reformulation-Linearisation Technique - Semidefinite Programming) relaxations of nonconvex box-constrained quadratic programs (Box-QPs). Such convex relaxations provide lower bounds on the optimal value of Box-QPs in minimization form. A convex relaxation is said to be exact if the lower bound arising from that relaxation matches the optimal value of the Box-QP. We investigate characterizations of exact and inexact RLT and SDP-RLT relaxations of Box-QPs. We provide several necessary and/or sufficient conditions in order for a given relaxation to be exact and inexact. We illustrate our findings with several numerical examples.

## DATA ENVELOPMENT ANALYSIS

Making open data go further: Creating household data from aggregated open data that anyone can use.

Dr Colin Stewart<sup>1</sup>

<sup>1</sup>More Metrics Ltd

Parallel Session 1 - Data Envelopment Analysis, OC1.04, September 13, 2022, 11:00 AM - 12:30 PM

### *Biography:*

*For over 30 years Colin's career has been built around using analytics to solve business problems. Colin has run teams across different sectors of the banking industry. Working independently since 2010 with insurance and other clients Colin has led the development of new ways of using open source data and spatial analysis techniques that underpin More Metric's models.*

Many established organisations have an embarrassment of riches when it comes to data. Timely and high-volume data on customer interactions can be complemented with selected external data to support a wide range of analytical projects.

But what about smaller, less-established organisations who have fewer customers? For them open data is a major help, but it has its limitations. Often it is aggregated data, not specific to an individual, which by necessity leads to an increased reliance and spend on third party data (e.g. from social media platforms) to support business activities.

To address this, we were curious to see if we could create useable household estimates of key census variables from aggregated open data. The idea being that if every UK address has its own estimates for a well-rounded set of geo-demographic variables it could be a game changer for smaller organisations with limited data assets of their own.

Our approach to this problem is described, split into two distinct parts. The first part explains how we create imputed micro data as at census day (2011). These imputed data are “plausible” census records for all UK individuals and households that tally with published census counts at Output Area across all chosen variables when aggregated up. The second part explains how we assign these “plausible” household records to the stock of housing as at the current day (2022) ensuring the assigned records reflect changes since the 2011 census and are averaged to avoid over-specifying the results for each address, without losing sharpness unnecessarily.

Results are presented for real-world examples. The practical aspects of distributing the data are discussed, as are our plans for the 2021 / 2022 census.

# School Dropout and Efficiency of the School Education System in India

Prof Rachita Gulati<sup>1</sup>

<sup>1</sup>Indian Institute Of Technology Roorkee

Parallel Session 1 - Data Envelopment Analysis, OC1.04, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Rachita Gulati is an Associate Professor of Economics at the Department of Humanities and Social Sciences, Indian Institute of Technology (IIT), Roorkee, Uttarakhand. She received the Subir Chowdhury Visiting Fellowship 2017-2018 from the India Observatory, London School of Economics and Political Sciences, London, UK. Her research work relates to the evaluation of financial and social policy interventions by the regulators on the efficiency performance of public and private institutions. She has been working and gaining experience in this area for the past 13 years. She has formulated several mathematical and nonparametric DEA-based benchmarking models to measure efficiency performance, which she has applied to banks, microfinance institutions, investors, insurers, etc. She has published more than a dozen articles in top-ranked (ABDC/Q1/Q2) journals. She is the co-author of a book, "Deregulation and Efficiency of Indian Banks" (Springer). She is serving as a member of several national and international associations, including the International Society of Efficiency and Productivity Analysis, the Indian Econometric Society, International Corporate Governance Society, International Econometric Society, etc.*

This paper examines the dropout-adjusted efficiency and identifies convergence clubs across states and union territories in the elementary education system in India. A non-oriented sequential directional distance function-based metafrontier (NSDDFM) approach is applied to compute reliable efficiency estimates and decompose inefficiency measures. In particular, we explicitly incorporate "school dropout" as an undesirable outcome in the efficiency model. In addition, we account for heterogeneity in education systems across general category states (GCS) and special category states & union territories (SCS&UTs), which is present because of the differences in demographic, fiscal, institutional, and economic environments. Empirical results reveal significant efficiency variations across states and years, and SCS&UTs show higher efficiency in the education delivery process relative to GCSs. We note significant variations across states and years in efficiency levels in the provision of school education from 2011 to 2020. An average efficiency level across all states and years is around 78 percent, implying that a typical regional entity, on average, could potentially reduce undesirable factors (school dropout) and input factors simultaneously and expand the desirable output factors by about 22 percent. This potential adjustment in input and output factors varies across states, UTs, and years. Kerala, Karnataka, and Goa are the three best-performing GCS. While Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh show the lowest efficiency in the school education delivery system. The analysis of the technology gap ratio reveals that SCS&UTs employ best elementary education practices, and GCSs operate farther from the national best-practice frontier. Phillips and Sul's (2007, 2009) convergence test rejects the null hypothesis of parity in the school education delivery process and shows the formation of spatial clubs across states.

# Applying a two stage robust Data Envelopment Analysis model to assess the determinants of organ transplantation efficiency in Brazil.

Dr Alexandre Marinho<sup>1</sup>

<sup>1</sup>Institute for Applied Economic Research / State of Rio de Janeiro University

Parallel Session 1 - Data Envelopment Analysis, OC1.04, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*I have a PhD in Economics. I have been working with data envelopment analysis, stochastic frontier analysis, Malmquist index, queuing theory, econometrics and similar techniques as a professor, researcher and government adviser since the mid 1990s. I have published papers in scientific journals and presented works in Brazil and abroad, including in previous conferences of the DEA society.*

Brazil has the most extensive public program for organ transplantation in the world, and the Brazilian National Health System (SUS) provides full coverage of all costs involved in organ donation, transplants, and post-transplant. Despite the relevance of the subject and the shortage of organs for transplants, transplantation process efficiency assessments are still uncommon in Brazil and abroad. This study aims to evaluate the efficiency of the Brazilian states and the Federal District in transforming potential organ donors into actual donations. We applied Data Envelopment Analysis (DEA) in conjunction with the bootstrap technique, using organ transplantation data from 2018-2019. The bootstrap method allows to obtain a confidence interval for DEA scores and provide greater robustness to studies based on DEA methodology. The bootstrap bias-corrected model indicates that there is significant room for improvement in terms of converting potential donors into actual donors.

Finally, DEA scores are regressed against variables that may portray heterogeneities, such as blood type, gender, causa mortis, income and age in terms of a two-stage procedure by using OLS and also a regression corrected by the bootstrap. The mostly significant results reinforce the plausibility of the initial analysis. The mean corrected score is 0.57, signaling that altogether the Brazilian states could maximize in 43% the number of transplanted organs without necessarily increasing the pool of potential donors.

Keywords: Organ donation-transplantation process, efficiency analysis, Data Envelopment Analysis, bootstrap, Brazil.

# Optimising Risk Mitigation Strategies in Nigerian Petroleum Supply Chain using Data Envelopment

Mr John Asu<sup>1</sup>, Professor Khalid Hafeez<sup>1</sup>, Professor Adel Hatami-Marbini<sup>1</sup>

<sup>1</sup>Department of management and Entrepreneurship, Leicester Castle Business School, De Montfort University

Parallel Session 5 - Data Envelopment Analysis, OC1.04, September 15, 2022, 9:00 AM - 10:30 AM

## *Biography:*

John is a doctoral researcher from the Department of Management and Entrepreneurship, Leicester Castle Business school, De Montfort University.

*John's research area is in operation management and decision support systems with core interest in the application of frontier analytical tools.*

**Purpose:** This paper develops a comprehensive risk management framework to analyse Nigeria's petroleum supply chain. We divide the supply chain into three stages (supply, production, and distribution) to assess the risk in the internal structure.

**Design/methodology/approach:** A data envelopment analysis (DEA)-based approach is used to evaluate the importance of each risk factor and determine the best response strategy. Specific risk priority number (RPN) indicators of the Failure Mode and Effect Analysis (FMEA) are considered as the inputs. In addition, several other significant indicators in the oil industry, are undesirable outputs.

**Findings:** Unique output variables refer to the impact of risk on people, environment, and business continuity. Where the RPN indicators include severity, occurrence, and detection of risks as the input variables. The findings show that the most critical risk factors in the Nigerian oil industry supply chain, in order of priority, include terrorist attacks (27% efficiency), the explosion of road tankers (28% efficiency), logistics (57% efficiency), environmental (64% efficiency), and host community risk (69% efficiency). In terms of mitigation strategies, we have identified transfer, safety planning, alternative energy carriers, improved energy efficiency, expected shortage, diplomatic relations, and emergency rescue plans, are among the best mitigation strategies.

**Research contributions:** This study provides a comprehensive risk management framework of the significant risks in the Nigerian petroleum supply chain. It shows how RPN indicators are applied in a DEA model to analyse the relationship between risks and impact measures simultaneously.

**Originality/value:** This study illustrates how RPN and DEA can be combined to analyse data for better decision-making and management. The use of DEA integrated with RPN data to simultaneously prioritize supply chain risks, and its corresponding mitigation strategies is a novel idea. Although the findings are based on the Nigerian context, these can be readily adopted in other processing supply chains operating in different countries/regions for optimising risk mitigation strategies.

**Keywords:** Risk management; Petroleum supply chain; DEA; FMEA

## key Reference

Amor, R. Ben and Ghorbel, A. (2018) 'The risk in Petroleum Supply Chain: A review and typology', International Journal of Scientific & Engineering Research, 9(2), pp. 141–163.

# Green Supply Chain Recognition by Two-Stage DEA Model

Prof Sahand Daneshvar<sup>1</sup>, Mr. Farzad ZAREE TAJABADI Zaree Tajabadi<sup>1</sup>, Mrs. Fatemeh Abbasi<sup>1</sup>

<sup>1</sup>Eastern Mediterranean University

Parallel Session 5 - Data Envelopment Analysis, OC1.04, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Assoc. Prof. Dr. Sahand Daneshvar is academic staff in department of Industrial Engineering, Engineering Faculty, Eastern Mediterranean University. He took his BS, MS and PhD from Tabriz University and Science and Research branch of Islamic Azad University in 1993, 1996 and 2002 respectively. His main study field is Operations Research. His research fields are optimization, data envelopment analysis, fuzzy mathematical models and recently risk management*

Environmental concerns and their sustainability issues are controversial subjects and have been considered in recent decades. So, firms and manufacturers attempt to keep their productivity and profitability beside responsibilities for environmental effects which is vital to reduce waste and emissions in this age of competition. Even though governments start to legislate laws about environmental issues like global warming, waste, and emissions for companies and force them to obey these principles, otherwise, they will face the consequences. Green Supply Chain Management (GSCM) is a technique for firms that engage with consumers and suppliers to improve efficiency and decline environmental effects. To improve their environmental performance, companies should use green purchasing, green design, green manufacturing, green distribution, green packaging, green marketing, and reverse logistics, according to GSCM dimensions. Recently, Data Envelopment Analysis (DEA) has been applied as a nonparametric method to evaluate the efficiency of supply chains as decision-making units (DMUs). Accordingly trying to obtain the best possible GSCM performance is essential and DEA models can assist organizations to choose the best supplier by imposing green supply chain principles. These principles are crucial for firms to achieve superior performance across the whole supply chain. This study applied a Two-Stage DEA model to evaluate 38 supply chains by considering the green GSCM dimensions and recognizing efficient DMUs as green supply chains. Also, the result compared to the overall efficiency values has been archived by standard DEA models.

Keywords: Green supply chain management, Performance evaluation, Efficiency, Two-stage data envelopment analysis.



# Efficiency of Islamic versus commercial banks: The role of time period and estimation technique

Dr Dennis Olson, Dr. Taisier Zoubi

Parallel Session 5 - Data Envelopment Analysis, OC1.04, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Dennis Olson is a recently retired professor of finance. He is an active researcher living in Oregon, USA. He holds a PhD in economics from the University of Wyoming (USA) and is a Chartered Professional Accountant (CPA) in Canada. He has taught economics, finance, and accounting classes in the US, Canada, New Zealand, Denmark, Colombia, Oman, Kuwait, and the UAE. He has published in the Journal of Banking and Finance, International Journal of Accounting, Journal of Corporate Finance, European Economic Review, International Journal of Forecasting, Economic Inquiry, Energy Economics, Emerging Markets Review, and Financial Review. Several of the papers have been applications of data envelopment analysis and stochastic frontier analysis for measuring the efficiency of conventional versus Islamic banks.*

This paper examines the efficiency of GCC Islamic banks relative to commercial banks for the years 1994-2019. Islamic banks were slightly more efficient than commercial banks for the years 1994-2002. However, in the aftermath of the second Gulf War in 2003, commercial banks have been significantly more efficient than Islamic banks. The intertemporal pattern holds across 16 different data envelopment analysis and stochastic frontier analysis models calculating output and cost efficiencies. Input and output orientations and input and output distance functions yield similar efficiency scores but measuring inputs in terms of monetary costs versus physical units impacts relative efficiency scores. Nevertheless, output and cost efficiency measures of the relative efficiency of Islamic and commercial banks are generally consistent across all years of the data set.

# DATA SCIENCE MEETS OPTIMISATION

## Faster Hyper-Parameter Optimisation via Partial Cross-Validation

Mr Dobromir Marinov<sup>1</sup>, Dr Daniel Karapetyan<sup>2</sup>

<sup>1</sup>Swim.Ai Inc., <sup>2</sup>University Of Nottingham

Parallel Session 5 - Data Science meets Optimisation, OC1.09, September 15, 2022, 9:00 AM - 10:30 AM

### ***Biography:***

*Dr Daniel Karapetyan received his PhD degree in computer science from Royal Holloway, University of London, UK, in 2010. Since 2020, he has been assistant professor of computer science at the University of Nottingham. His research interests include artificial intelligence and data science applied to combinatorial optimisation and decision support.*

It has been observed that machine learning (ML) systems are usually sensitive to the values of the hyper-parameters (HPs), and HP optimisation has been used to set their values. The objective function in HP optimisation is the accuracy of the ML system provided a specific set of HPs. However, the measured accuracy is highly dependent on the training and test datasets; hence cross-validation is commonly used to reduce the amount of noise in the objective function.

We designed an approach to use partial cross-validation for the less successful sets of HPs. The system uses statistical analysis to identify the sets of HPs that are unlikely to achieve the highest performance. We embedded this approach into the Random HP optimisation method and tested it on a large set of small datasets for SVM. We found out that our approach can reduce the Random HP optimisation time budget by about 30%.

# An adaptive parallel evolutionary algorithm for uncapacitated facility location problem

Dr Emrullah Sonuç<sup>1</sup>, Prof Ender Özcan<sup>1</sup>

<sup>1</sup>University Of Nottingham

Parallel Session 5 - Data Science meets Optimisation, OC1.09, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Dr Emrullah Sonuç is a member of the Department of Computer Engineering, Karabuk University, Turkey. He is currently a postdoctoral researcher (fully funded by TÜBİTAK) at the University of Nottingham and working in Computational Optimisation and Learning (COL) Lab. His current research interests are Parallel algorithms, Combinatorial optimization and Meta-heuristic algorithms.*

Metaheuristics provide high level guidelines for heuristic optimisation and have successfully been applied to many complex problems over the past two decades. However, their performances often vary depending on the choice of the initial settings for their parameters and operators along with the characteristics of the given problem instance handled. Hence, there is a growing interest into designing adaptive search methods that automate the selection of efficient operators and setting of their parameters during the search process. In this study, an adaptive parallel evolutionary algorithm, referred to as ABPEA, is introduced for solving % one of the binary-encoded optimisation problems, the uncapacitated facility location problem which is proven to be an NP-hard optimisation problem. The approach uses a unary and two other binary operators. A reinforcement learning mechanism is used for assigning credits to operators considering their recent impact on generating improved solutions to the problem instance in hand. An operator is selected adaptively with a greedy policy for perturbing a solution. The performance of the proposed approach is evaluated on a set of well-known benchmark instances using ORLib and M\*, and its scaling capacity by running it with different starting points on an increasing number of threads. Parameters are adjusted to derive the best configuration of three different rewarding schemes, which are instant, average and extreme. A performance comparison to the other state-of-the-art algorithms illustrates the superiority of ABPEA. Moreover, ABPEA provides up to a factor of 3.9 times acceleration when compared to the sequential algorithm based on a single-operator.

# Automated Algorithm Configuration for the Quadratic Unconstrained Binary Optimisation Problem

Mr Jack Warren, Dr Daniel Karapetyan, Prof Ender Özcan, Dr Andrew Parkes

<sup>1</sup>University Of Nottingham

Parallel Session 5 - Data Science meets Optimisation, OC1.09, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Computer Science and Artificial Intelligence graduate. Currently working on his Ph.D thesis.*

Quadratic Unconstrained Binary Optimisation (QUBO) is a mathematical model that can conveniently represent many combinatorial optimisation problems such as number partitioning, max-cut problem, graph colouring, etc. It is of specific interest as it is the representation used within the "D-Wave Quantum System" for solving optimisation problems. Here, we use the Conditional Markov Chain Search (CMCS) metaheuristic framework to automatically build a metaheuristic combining several low-level heuristics (mutations and local search operators). CMCS is a highly-configurable framework that is flexible enough to model a range of standard and new metaheuristics, yet its behaviour is completely controlled by numerical parameters. We designed an algorithm configuration method to optimise the CMCS configuration. It is a hybrid metaheuristic built specifically for CMCS configuration. The CMCS configuration obtained by our algorithm configuration method performs well across benchmarks and achieves state-of-the-art results on most of the widely used random benchmark instances.

# Modelling and forecasting of exchange rate pairs using the Kalman filter

Dr Janeeta Maunthrooa<sup>1</sup>, Dr Paresh Date<sup>1</sup>

<sup>1</sup>Brunel University London

Parallel Session 1 - Financial modelling, OC1.01, September 13, 2022, 11:00 AM - 12:30 PM

## *Biography:*

I am an ambitious postdoctoral researcher currently working at Brunel University London. My area of expertise as a researcher is in economics and finance with a focus on international finance and investment, and time series modelling explored during my doctoral studies. My current postdoctoral position is in mathematics and statistics, where my research crosses the field of finance with the use of more advanced time series applications.

*I have also acquired significance experience in teaching having led seminars and lectures at the university for various modules including accounting, statistics, financial modelling and time series modelling. In addition to academic work, I am a passionate of the self-development path and becoming a master of self in all areas of life.*

Developing and employing practically useful and easy to calibrate models for prediction of exchange rates remains a challenging task, especially for highly volatile emerging market currencies. In this paper, we propose a novel approach for joint prediction of correlated exchange rates for two different currencies with respect to the same base currency. For this purpose, we reformulate a generalised version of a bivariate ARMA model into a state space model and use the Kalman filter for estimation and forecasting of the underlying exchange rates as latent variables. With extensive numerical experiments spanning 14 different exchange rates (across both emerging markets and developed economies), we demonstrate that our approach consistently outperforms univariate ARMA models as well as the random walk model in short term out-of-sample prediction for various exchange rate pairs. In terms of root mean squared errors in one step ahead prediction over out-of-sample datasets, the improvement ranges from 16 percent to 99 percent across different currencies. Our study fills a gap in the empirical finance literature in terms of robust, explainable, accurate and easy to calibrate models for forecasting correlated exchange rates. The proposed methodology has applications in exchange rate risk management as well as pricing of financial derivatives based on two exchange rates.

# FINANCIAL MODELLING

## Student Loans and Life-Cycle Portfolio Choice

Mr HAOYU Zhang<sup>1</sup>, Dr Nalan Gulpinar, Dr Arie Gozluklu

<sup>1</sup>University Of Warwick

Parallel Session 1 - Financial modelling, OC1.01, September 13, 2022, 11:00 AM - 12:30 PM

### *Biography:*

*Haoyu Zhang is currently a third-year PhD at the University of Warwick. His main research interests are within quantitative macroeconomics and cover household finance, homeownership, and student loan.*

Households' portfolio choice has received considerable attention in household finance. One common conclusion is that young households, no matter how risk averse, should have some equities if the equity premium is positive. But in reality, less than 50 percent of young households in the US participate in the stock market. Nonetheless, given that student debts have become one of the most distinctive financial features of today's young households, it may contribute to the low stock participation.

In this paper, we explore one possible explanation that student debt reduces households' overall disposable wealth and then induces liquidity constraints. With the presence of student debt, we examined whether households invest in stocks (stock participation), the proportion that allocates to stocks (conditional stock allocation), and when they enter the market (stock entry). Our results show that in a certain parameter range of the participation cost, the model delivers a hump-shaped stock allocation pattern over the life span. Moreover, the model explains how various student loan repayment types affect borrowers' investment behaviour beyond the repayment period (age 20-30) in a life cycle. In general, borrowers who choose the income-contingent repayment type (ICT) have lower stock participation and allocate less wealth in the stock market conditional on participation than borrowers who choose the standard consolidation repayment type (SC).

# Optimal Investment, Heterogeneous Consumption and Best Time for Retirement

Prof Hyun Jin Jang, Prof Zuo Quan Xu, Prof Harry Zheng<sup>1</sup>

<sup>1</sup>Imperial College

Parallel Session 4 - Financial modelling, OC1.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Harry Zheng is a professor of mathematics at Imperial College London. His research interest is in the area of stochastic control, convex optimization, applied probability, and mathematical finance.*

We study an optimal investment and consumption problem with heterogeneous consumption of basic and luxury goods, together with the choice of time for retirement. The utility for luxury goods is not necessarily a concave function. The optimal heterogeneous consumption strategies for a class of non-homothetic utility maximiser are shown to consume only basic goods when the wealth is small, to consume basic goods and make savings when the wealth is intermediate, and to consume almost all in luxury goods when the wealth is large. The optimal retirement policy is shown to be both universal, in the sense that all individuals should retire at the same level of marginal utility that is determined only by income, labour cost, discount factor as well as market parameters, and not universal, in the sense that all individuals can achieve the same marginal utility with different utility and wealth. It is also shown that individuals prefer to retire as time goes by if the marginal labour cost increases faster than that of income. The main tools used in analysing the problem are from PDE and stochastic control theory including variational inequality and dual transformation. We finally conduct the simulation analysis for the featured model parameters to investigate practical and economic implications by providing their figures.

# An efficient approach to the pricing of basket options using control variates

Mr Kam Jipreze<sup>1</sup>, Dr Paresh Date

<sup>1</sup>Brunel University

Parallel Session 4 - Financial modelling, OC1.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*I am a mathematics PhD student at Brunel University under the supervision of Dr Paresh Date. My research interests include the pricing and hedging of basket and Asian options, martingale theory and information-based approach to asset pricing.*

We propose two new control variate methods for efficient and accurate pricing of basket options. The first one is a linear approximation to log summation of prices using Hermite polynomial, which leads to a Black-Scholes type closed-form price for a basket option.

The second control variate is an upper bound on the basket option price resulting from the Jensen's inequality.

We observed that the Hermite polynomial approximation provided good estimates for the basket option price in the money.

Through numerical experiments on data with realistic parameters derived from five market indices (FTSE100, FTSE250, S&P 500, NIKKEI 225 and IMOEX), we observe that the use of these control variates lead to fast, accurate and low variance estimates when compared to antithetic variates Monte Carlo simulation and common control variate method, viz. geometric lower bound.

Our control variates have variance reductions between 61-99% for basket options and faster computation times of 45-75% when compared to antithetic variates. However, when compared to the geometric lower bound control variate similar variance reductions are observed with the trivial upper bound control variate and in their computation times. The Hermite polynomial has the fastest computation times but significantly lower variance reduction in comparison to the other control variates.



# Optimal investment in a market with borrowing and random coefficients: an explicit closed-form solution via a BSDE approach

Mr Abdullah Aljalal<sup>1</sup>, Dr Bujar Gashi<sup>1</sup>

<sup>1</sup>The University of Liverpool

Parallel Session 4 - Financial modelling, OC1.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*My name is Abdullah Aljalal. I am a PhD student at the University of Liverpool. I am working on stochastic optimal control problems and my supervisor is Dr. Bujar Gashi.*

We consider the problem of optimal investment in a market with borrowing and random coefficients. This is a market consisting of a bond, a stock, and a bank account. The borrowing interest rate is higher than the bond interest rate. We further assume that the two interest rates, as well as the stock expected return and volatility, are stochastic processes in general. We formulate the optimal investment problems for the power and logarithmic utility from terminal wealth. As it is not reasonable to borrow at a higher interest rate and invest in a bond with a lower interest rate, the resulting optimization problem is an optimal stochastic control problem with a nonlinear system dynamics. Using a certain completion of squares approach and backward stochastic differential equations (BSDEs), we find an explicit closed-form solution to these problems. It turns out that the optimal investment strategies are of a linear wealth-feedback form expressed in terms of a certain nonlinear BSDE with a quadratic growth in the control variable. While these problems have been considered before in a setting of complete markets, no explicit solutions were found in the present setting of random coefficients and possibly incomplete market. This paper is theoretical.

# Utilizing Machine Learning Methods to Represent Complex Relationships in Financial Network Analysis

Mr Daren Purnell

<sup>1</sup>George Washington University, <sup>2</sup>U.S. Department of the Treasury

Parallel Session 5 - Financial Modelling, OC1.01, September 15, 2022, 9:00 AM - 10:30 AM

## *Biography:*

Daren “DJ” Purnell is a former naval submarine officer and nuclear engineer, turned data scientist, with 15 years of leadership experience in systems engineering, product management, and data analytics. After his time with the Navy, he has held positions in consulting and at various Federal Agencies. In his current role as the Associate Director of Data Products at the Office of Financial Research (U.S. Department of the Treasury), he leads the development, production, and maintenance of data products that promote transparency in financial networks. His related academic and professional qualifications include a B.S. in Information Technology (U.S. Naval Academy), M.B.A. (George Washington University), and an M.S. in Data Science (Northwestern University). He also holds professional certifications in nuclear engineering (Naval Nuclear Propulsion Program - NAVSEA08), Nuclear Weapons (Sandia National Laboratory), project management (Project Management Institute), and cloud computing (Amazon Web Services). His research interest is the optimization of financial systems to maximize liquidity and minimize financial risks.

In Financial Stability Network Analysis, directed graphs (digraph) network models are used to understand the complex relationships between banks and the risk they pose, in aggregate, to the system using network analysis. Debt claims, known as the network channel, interconnect banks to one another. In the digraph models, banks are represented as nodes and connected by associations called edges representing this network channel. Typically, these relationships are weighted to describe the amount of debt owed. The market, known as the liquidity channel, bounds the banks when they sell assets to raise cash in distressful situations. The collection of banks within the digraph network represents this liquidity channel. These digraphs are developed and studied to understand financial contagion risk – or the “domino effect” of banks taking down other banks – equivalent to the literature on the spread of infection in epidemiology and cascading component failures in systems engineering. However, traditional linear, directed graph relationships utilized in Financial Stability Network Analysis do not capture the complex, nonlinear, time-varying, and multidimensional relationships between banks, putting financial stability at risk. The measures of contagion risk can be improved by using better-informed relationships between the banks. This research topic proposes developing an improved financial network contagion model, utilizing machine learning feature selection, to better represent the propagation of systemic cascading failures between banks through network and liquidity channels. The improved model builds upon existing financial network analysis models (Eisenberg Noe) and utilizes an ensemble of long-short-term memory neural network (LSTM), Support Vector Regression (SVR), and Random Forest (RF) models for feature selection. The selected features are then incorporated into a linear model for interpretability and added to the network edge between existing nodes. An improved financial network contagion model can inform our understanding of systemic financial risk to mitigate future crises and incorporate additional factors into the cost of capital (cost of borrowing) between financial institutions. Additionally, the novel process of using complex machine learning methods to inform edge relationships between nodes can be utilized in other forms of network analysis where nonlinear, time-varying, multidimensional relationships may exist.

# Interpretable and powerful predictions of personal financial volatility from non-linear transactional patterns

Ms Rui Ying Goh<sup>1</sup>, Dr Galina Andreeva<sup>1</sup>, Dr Yi Cao<sup>1</sup>

<sup>1</sup>University Of Edinburgh

Parallel Session 5 - Financial Modelling, OC1.01, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*She is currently pursuing a PhD in Financial Technology at the Business School of the University of Edinburgh. Her research interest is in the development of predictive financial models, specifically to assess personal financial risk from cash flow transactional patterns.*

Financial circumstances change over time. Capturing potential vulnerability from individuals' fluctuating financial behaviours is important for financial firms to implement effective strategies to protect vulnerable consumers. This study proposes spline regression (SPLINE) to develop a financial volatility predictive model to assess vulnerability risk. We define a financial volatility index as the target variable, which incorporates the fluctuations in income, expenditure, and financial buffer (or balance), to evaluate the degree of uncertainty from cash flow transactions. The key to assessing financial risk relies on model explainability to examine how vulnerability relates to volatility and investigate how the transactional patterns driving (high/low) volatility are linked to potential financial struggles. Hence, the evaluation of SPLINE includes comparing the (i) predictive performance with several state-of-the-art machine learning techniques and (ii) the interpretation of marginal effects with accumulated local effect plots. We conclude that SPLINE has robust predictive performance with a marginal 1% underperformance than the best-performing model and the benefit of being transparent to unveil implicit financial risks from complex transactional patterns. Our findings reveal that volatility steadily increases with vulnerability risk. We should thus monitor the drivers of high volatility to identify harmful behaviours to mitigate vulnerability risk.

# National Audit Office - what makes a quality financial model?

Ms Ruth Kelly<sup>1</sup>

<sup>1</sup>National Audit Office

Parallel Session 5 - Financial Modelling, OC1.01, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Ruth Kelly is Chief Analyst at the National Audit Office (NAO) and has wide experience of applying economics and other analytical approaches to support policy evaluation, investment decisions and risk management. She directed the NAO's 2022 report into Financial Modelling in Government. Prior to joining the NAO, she held business evaluation and risk management roles for a global resources company, and advised clients on carbon and energy issues for a Big 4 economic consultancy practice.*

High-quality modelling is vital to help make good decisions, including on public spending. The National Audit Office shares its insights on using and quality assuring financial models to manage risks to value for money:

Financial modelling is at the heart of how the government understands its spending, performance and risks, and influences decisions that often have major impacts on people's lives. So it's really important that finance professionals who depend on outputs from models can feel confident in the quality and robustness of these models.

Through our extensive Financial Audit work examining government models, we continue to find weaknesses in models such as limited or poor-quality data; unrealistic assumptions and optimism bias; and inadequate sensitivity and scenario analysis. Departments often rely too heavily on best estimates from models which can limit their understanding of uncertainty and limit their ability to manage risks to value for money.

In this presentation, we will highlight the key findings and recommendations of our recent report on Financial modelling in Government. We'll share our Framework to Review Models, a structured approach that model commissioners and users can use to understand if the modelling outputs they are relying on are reasonable, robust and high quality. And we'll discuss what finance professionals should know when it comes to analysing, managing and communicating uncertainty, to support them in making good decisions on spending.

## HEALTH SYSTEMS

### Healthcare digital transformation: systems thinking perspective

Mrs Natalia Kapralova, Mrs Natalia Kapralova<sup>1</sup>

<sup>1</sup>University of Glasgow, Adam Smith Business School

Parallel Session 2 -Health Systems, OC1.02, September 13, 2022, 1:30 PM - 3:00 PM

#### *Biography:*

*BSc, MSc, MBA, PhD Candidate at the Adam Smith Business School, University of Glasgow*

To date the processes around digital transformation have been widely studied by the scholars from the information systems and management science subject areas. However, it could be argued that the phenomenon of digital transformation is broader than the information systems adoption and implementation. Scholarly views of digital transformation have been largely fragmented, which has been particularly critical and challenging in terms of its application within healthcare systems. Using the holistic systems thinking approaches, the paper aims to enhance the understanding of the digital transformation phenomenon in the health system and to create bridges across multiple disciplines, such as information systems, health policy, integrated care, management science, operations management. The paper attempts to uncover the practical implications and benefits of applying holistic systems thinking approaches, such as soft systems methodology and causal mapping. The discussion in the paper is contextualised within the integrated care pathway perspective on the digital transformation processes in NHS Scotland. The effectiveness of the digital transformation processes in this context is viewed from multidimensional perspectives of a wide range of the stakeholders, such as policymakers, clinicians, patient representatives, clinical guidelines developers, and e-health leads. The paper reports on the methodological contribution of the systems thinking approaches to the enhancement of the understanding of the digital transformation phenomenon in the health system. The paper concludes by making practical recommendations for the effectiveness of the digital transformation processes in the context of the integrated care pathways.

# The false economy of seeking to eliminate delayed transfers of care: some lessons from queuing theory

Dr Richard Wood<sup>1,2</sup>, Dr Alison Harper<sup>3</sup>, Dr Zehra Onen-Dumlu<sup>2</sup>, Dr Paul Forte<sup>1</sup>, Prof Martin Pitt<sup>3</sup>, Prof Christos Vasilakis<sup>2</sup>

<sup>1</sup>National Health Service (BNSSG ICS), <sup>2</sup>University of Bath, <sup>3</sup>University of Exeter

Parallel Session 2 -Health Systems, OC1.02, September 13, 2022, 1:30 PM - 3:00 PM

## ***Biography:***

*Richard Wood is Head of Modelling and Analytics at NHS Bristol, North Somerset and South Gloucestershire Integrated Care System (BNSSG ICS), which oversees the organisation of healthcare services across a one million resident population in South West England. He has a background in O.R. and has applied various O.R. techniques to a number of settings from mathematical biology to credit risk capital modelling. He has particular interests in working at the interface of academic theory and practical application.*

It is a stated ambition of many healthcare systems to eliminate delayed transfers of care (DTOCs) between acute and step-down community services. This study demonstrates how, counter to intuition, pursual of such a policy is likely to be uneconomical. Some standard results from queuing theory are used to provide a model of patient flow from the acute to community setting. While queuing models have a track record of application in healthcare, they have not before been used to address this question. Results show that “eliminating” DTOCs is a false economy: the additional community costs required are greater than the possible acute cost saving. While a substantial proportion of DTOCs can be attributed to resource mismanagement, the remainder are economically essential. For England’s NHS, our modelling suggests the former account for approximately 88% with the latter representing just 12%. Annual cost savings of £117m could result from reducing DTOCs to their optimal level. This study discourages the use of ‘zero DTOC’ targets and instead supports an assessment based on the specific characteristics of the healthcare system considered.

# Descriptive analysis of COVID-19 vaccine adopters and hesitant among social media users

Tianjie Gu, Mr Anthony Dunn, Emmanuel Kagning Tsinda, Dr Alain Zemkoho

<sup>1</sup>University Of Southampton

Parallel Session 2 -Health Systems, OC1.02, September 13, 2022, 1:30 PM - 3:00 PM

## *Biography:*

*I am a PhD student at the University of Southampton, co-sponsored by DAS Ltd, specializing in ML applications and optimization in ML.*

COVID-19 has seriously impacted the health of hundreds of millions of people around the world, killing millions among those infected. The vaccine roll-out has played a critical role in getting the COVID-19 pandemic under control and is progressing successfully in many countries. Beyond protecting those most vulnerable to the effects of COVID-19, mass vaccination may contribute to herd immunity, which in turn can slow the spread of the virus and provide protection to those who cannot take the vaccine. However, one significant factor which may greatly impede progress towards herd immunity is vaccine hesitancy. Analysing public opinions shared on social media may be helpful in identifying geographical and cultural trends in both those who display positive sentiment towards COVID-19 vaccination compared with those who display negative sentiment. For this analysis, 200,000 tweets related to COVID-19 vaccination (together with their associated metadata) were collected from Twitter using a social media web. A subset of 57,271 of these tweets had hashtags which gave a very strong indication as to the sentiment towards the vaccine present in the tweet e.g. #GetVaccinated and #KillerVaccines. Using this labelled data, we formulate a supervised learning problem and build a classification model capable of 90% classification accuracy which utilizes a number of natural language processing techniques including sentiment analysis, tokenization, lemmatization and TF-IDF vectorization. This model enables us to label all of the remaining tweets. Having determined the sentiment of each tweet, we use a LDA model to analyse the topics which are prevalent in tweets which showing particular sentiment towards vaccination. Finally, an analysis of these topics has provided evidence of some potential reasons why people (among the English speakers considered in the analysis) display negative sentiment toward COVID-19 vaccine. These reasons include belief in conspiracy theories and rumours, mistrust towards the government and health organizations, and concerns over a lack of trials and side effects of the vaccines. A geographical analysis of sentiment towards vaccines and a temporal analysis of which topics were most prevalent within tweets are also conducted as part of this study.

## Co-designing Digital Self-care in later life

Dr Sarfraz Iqbal<sup>1</sup>, Sofi Fristedt<sup>2</sup>, Ryoko Asai<sup>3</sup>, Caroline Fischel<sup>4</sup>, Professor Kazue Sako

<sup>1</sup>Linnaeus University, <sup>2</sup>Jönköping University, <sup>3</sup>Uppsala University, <sup>4</sup>Jönköping University, <sup>5</sup>Waseda University

Parallel Session 6 - Health Systems, OC1.09, September 15, 2022, 11:00 AM - 12:30 PM

### ***Biography:***

*Dr. Iqbal is currently working as Assistant professor at Linnaeus University. He has received his Phd in the field of Computer and Systems Science from department of Computer Science, Electrical and Space Engineering at Luleå University of Technology (LTU). Dr. Iqbal has experience of pedagogical development of different courses and E-learning platforms to teach Master Programs. He has been teaching at Master level courses for Information Systems and Information Security programs. His research interest is in the realm of Information Systems including Information Management, Health informatics, Information Security, Information and Communication Technologies for development (ICT4D) and E-learning. Currently, working on a project regarding Sustainable Healthcare Systems. The research work focuses on promoting good health and well-being, empowering lifelong learning as well as fostering health care innovation that is responsive to the needs of older adults, their families, and their communities.*

The discipline of Digital health is devoted to the accumulation of sociotechnical aspects which includes running digital care programs, healthcare technologies, sharing health related experiences, providing support for the people with chronic diseases and healthcare needs of the society to deliver the healthcare services in an effective manner. This is a special project which is focused on older persons' health (range 65 to 79 years) in the home setting from the perspectives of design science, information ethics, systems thinking, information technology, and occupational science/therapy. Older people represent a particular community which is very focused on self-care to maintain and enhance health, prevent disease and cope with illness, as well as keep themselves social and participate in their community. However, generally, it is thought that the elderly community is reluctant to adopt new technologies and are seldomly included in the development of new technologies. Therefore, it is relevant to ask: How can emerging technologies support older person's self-care and social participation? Implementation and use of technology at home is not only important for the older persons and their families, but it also impacts other stakeholders including care personnel, municipal health and social care managers as well as health sector policymakers. Overall, aim of the project is to establish the sustainable process of capturing and describing the self-care requirements and specifications for older people in Sweden and Japan through the development of a digital self-care tool together with older people. Following goals are set for this project:

- To establish close collaborations with the technology industry (e.g., medtech start-ups from Sweden and Japan).
- Applying ELSI framework.
- Seeking partners from researcher and practitioners' community, industry, end-users.
- To explore the needs of community-dwelling older persons for self-care and participation in their communities and society.
- To explore available technologies to support older persons' self-care and digital engagement in the communities and society.

Keywords: self-care, co-designing, ethics by design, ELSI, participatory design



# A watershed moment: health inequalities and vaccine prioritisation in the NHS

Miss Shamim Rahman<sup>1</sup>, Hannah Keys<sup>1</sup>

<sup>1</sup>Department Of Health And Social Care

Parallel Session 6 - Health Systems, OC1.09, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Shamim Rahman is an operational researcher and Deputy Director at the Department of Health and Social Care who leads the Mental Health and Disabilities Analysis Team. The team delivers analysis to support priorities to improve mental health; support those with mental health problems or neurodiversity, disability and learning disability conditions; and support people who are immunosuppressed during the COVID-19 pandemic.*

The risk of serious illness and death from COVID-19 was not uniform across populations.

At the outset of the COVID-19 pandemic in the UK, the Shielded Patient List was established on expert clinical consensus. It was comprised of clinically extremely vulnerable patients considered likely to be at high risk of serious health outcomes from COVID-19. As evidence emerged, it showed that COVID-19 risk was influenced also by socio-demographic factors, including age, sex, deprivation, and ethnicity.

England's Chief Medical Officer commissioned a predictive model for a data driven approach to COVID-19 risk assessment. Policy, clinical and analytical teams across the Department of Health and Social Care, the University of Oxford, NHS Digital, and many others produced a model (QCOVID) to estimate the risk of COVID-19 mortality, taking into account both demographic and clinical risk factors.

QCOVID was implemented in the NHS as a COVID-19 Population Risk Assessment to identify, protect and prioritise vaccination for high-risk people. Implementation was pioneered at pace across multiple organisations working within a highly complex clinical, epidemiological, technical, information governance, and legal framework.

Find out how the first precision public health intervention of this nature in the world helped mark a 'watershed moment' in recognising the intersectional nature of health inequalities.

# HEALTHCARE OPERATIONS MANAGEMENT - SIMULATION MODELLING

## Using Operations Research to Improve the Provision of Human Donor Milk

Mrs Marta Staff<sup>1</sup>, Prof Nav Mustafee<sup>1</sup>

<sup>1</sup>University Of Exeter, Business School

Parallel Session 1 - Healthcare Operations Management - Simulation Modelling, OC1.09, September 13, 2022,  
11:00 AM - 12:30 PM

### *Biography:*

*Marta Staff is a PhD student at University of Exeter, Business School with interest in OR techniques to improve decision making in supply chains and operations management in healthcare. Her current research focus is on operations of human milk banking in the UK.*

WHO recommends an exclusive human milk diet for the initial six months of life. When mother's milk is unavailable, e.g., delayed lactation, donor human milk (DHM) is recommended. Human Milk Banks (HMBs) provide DHM to hospitals. Their operational scope includes donor recruitment, collection, processing, storage, quality-assurance and dispatch. Despite HMBs widely practising the cost recovery method, the upfront cost for hospitals is high, contributing to the non-universal hospital provision of DHM in England and Wales (E&W).

The priority target for DHM are premature infants in hospitals, however the policy of DHM entitlement/duration is generally unstandardised. DHM could also benefit infants discharged from the hospital, the so-called community demand, for which HMBs have a significant role in prioritising potential recipients.

The application of OR tools and techniques related to HMB operations is an unexplored area. The research aims to investigate how DHM provision policy, and operations and inventory management of HMBs, can be optimised considering hospital and community demand. The study will be conducted with stakeholders (predominantly Human Milk Foundation and neonatal units). The research objectives are presented below. The first objective is to estimate the potential scale of hospital DHM demand in E&W for (primarily) premature infants, as a function of different stakeholder-agreed policy models, and will include the impact of uncertainty arising from statistical variation of birth characteristics through Monte-Carlo simulation. The second objective is to develop a multi-criteria decision-making (MCDM) model to support the prioritisation of community DHM provision, considering influencing aspects, such as infant/maternal health, and family situation (e.g., bereavement, adoption). A multi-stakeholder engagement process will facilitate the associated model building.

The third objective is to investigate HMB operations optimisation using Discrete-event Simulation (DES), focussing on inventory management and system resilience. DES model is thus expected to incorporate aspects related to provision priority (hospital over community), choice-making during the production process (e.g., packaging sizes) and different donor milk grade constraints ('community-only' or suitable for both demand populations).

The research trajectory thus aims to create OR tools for HMBs to facilitate the evaluation of different policy options for DHM provision and inform decisions on developing milk bank infrastructure.

# Informing Cancer Services in the Wake of the Covid-19 Pandemic Using Discrete Event Simulation

Miss Amalia Gjerloev<sup>1</sup>, Prof Sonya Crowe<sup>1</sup>, Prof Christina Pagel<sup>1</sup>, Dr. Yogini Jani<sup>2</sup>, Dr. Luca Grieco<sup>1</sup>

<sup>1</sup>Department of Mathematics, University College of London, <sup>2</sup>School of Pharmacy, University College of London

Parallel Session 1 - Healthcare Operations Management - Simulation Modelling, OC1.09, September 13, 2022,  
11:00 AM - 12:30 PM

## ***Biography:***

*Amalia has a background in both physics and mathematics. After completing her BSc at the University of Richmond, she took time off from academia and worked at a healthcare software company for two years. There, she worked closely with several health care organizations in regards to patient movement and financial assistance. In 2020, she completed her MSc in physics at Imperial College of London with a focus on astrophysics. During her PhD, she hopes to combine her knowledge of electronic health record systems (EHRS) with operational research techniques to improve NHS services.*

With the Covid-19 pandemic, healthcare systems have seen a huge influx of patients, a strain on hospital resources and increased pressure to operate efficiently in order to save patient lives. Cancer services have been particularly impacted and face a large backlog and long waiting times following a dramatic fall in referrals at the start of the pandemic. In order to improve resource allocation, scheduling and understanding of the pandemic's impact on patient care, we are developing a model of the cancer pathway, focusing initially on lung cancer. This will inform the framework for a Discrete Event Simulation, a useful tool in characterising what-if scenarios and analysing patient flow. From discussions with operational staff at a large teaching hospital, we have established that the lung cancer pathway has many possible paths that each patient can take, which presents challenges for the modelling and for finding a holistic solution for improving patient care services. In this presentation, I will expand on how we have parameterised our model, how we have engaged with clinicians and operational leaders, and how we have overcome some of the difficulties with data extraction.

# Modelling study to explore the role of flexible use of bed capacity in acute stroke pathways

Prof Christos Vasilakis<sup>1</sup>, Dr Richard Wood<sup>1,2</sup>

<sup>1</sup>University Of Bath, <sup>2</sup>NHS BNSSG ICB

Parallel Session 1 - Healthcare Operations Management - Simulation Modelling, OC1.09, September 13, 2022,  
11:00 AM - 12:30 PM

## ***Biography:***

*See first authors bio*

Good quality and evidence-based decision making on bed capacity options along patient pathways is essential to avoid pressure building in different parts of the healthcare system, and to help ensure best patient outcomes and financial sustainability. Yet, routine decision support methods typically use only average arrival rate and lengths of stay, which are well known to underestimate the number of beds required. This study investigates the extent to which averages-based estimates can be augmented by a robust assessment of additional 'flex capacity' requirements, to be used at times of peak demand. The setting is a major healthcare system in England, which has been working towards a centralised acute stroke pathway. Numerical experiments using an open-source pathway simulation tool recently developed by our team (PathSimR) showed that, to ensure delay for only 1% of presentations at the hyper-acute stroke unit, flex capacity would be needed at 45%, 45% and 36% of the allocated averages-based bed requirement for the hyper-acute, acute and rehabilitation units respectively. Some amount of flex capacity would be required 30%, 20% and 18% of the time. This study demonstrates the importance of appropriately capturing variability within capacity plans, and provides a practical and economical approach which can complement commonly-used averages-based methods. Results of this study have directly informed the healthcare system's new configuration of stroke services.

# HEALTHCARE OPERATIONS MANAGEMENT - DECISION MAKING IN HEALTHCARE

## Linking Predictive and Prescriptive Analytics for Healthcare Services: The Case of Frail and Elderly Patients

Miss Elizabeth Williams<sup>1</sup>, Daniel Gartner<sup>1</sup>, Prof Paul Harper<sup>1</sup>

<sup>1</sup>Cardiff University

Parallel Session 3 - Healthcare Operations Management - Decision Making in Healthcare, OC1.09, September 13, 2022, 4:30 PM - 6:00 PM

### ***Biography:***

*Elizabeth Williams is a PhD student in Operational Research at Cardiff University. Her research applies predictive and prescriptive modelling techniques to hospital admissions to NHS Wales, specifically focussing on elderly and frail patients.*

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 utilise a variety of predictive modelling techniques, including optimal clustering and CART, to determine homogeneous clusters of patient attributes. By incorporating the associated length of stay distributions into deterministic and two-stage stochastic models, we provide novel insights for capacity planning of hospital beds and staffing requirements. We apply this to a case study of a network of 11 hospitals in South East Wales across 29 specialties for elderly and frail patient admissions. Indicative results show that the value of the stochastic solution saves an approximately 15.8% in staffing and bed costs. This results in more staff being planned upfront to reduce the additional costs associated with agency and bank nursing staff. 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.

## Decision making in South Australia's pre-hospital and retrieval medicine service MedSTAR

Dr Laura Boyle<sup>1</sup>, Mr Matthew RYAN<sup>2</sup>, Mr Trevor Matthews<sup>2</sup>, Dr Melissa Humphries<sup>2</sup>

<sup>1</sup>Queen's University Belfast, <sup>2</sup>The University of Adelaide

Parallel Session 3 - Healthcare Operations Management - Decision Making in Healthcare, OC1.09, September 13, 2022, 4:30 PM - 6:00 PM

### ***Biography:***

*Laura Boyle is a lecturer of Data Analytics in the Mathematical Sciences Research Centre at Queen's University Belfast, N. Ireland. Her research interests are in discrete event simulation modeling with applications in healthcare.*

South Australia has a dedicated, centralised pre-hospital and retrieval medicine service (MedSTAR) affiliated with the South Australian Ambulance Service (SAAS). SAAS MedSTAR has multiple, 24-h, doctor-led PHRM teams operating by road, rotary and fixed-wing platforms. The service undertakes both primary (roadside) trauma and inter-facility retrieval of critically unwell adults. SAAS MedSTAR keeps a database of all patients utilising the service. MedSTAR collects information on a large set of variables for each patient encounter. In this research, we utilise the MedSTAR database to develop a mathematical model which can predict the on-scene and total turnaround time of the crew for each emergency mission. The model is embedded in an R Shiny application so that it can easily be used by MedSTAR staff. This tool will assist MedSTAR in planning and allocation of resources. It will further allow them to benchmark turnaround times against previous missions to reflect on improvements which could be made to their operations.

## Operational research in congenital heart disease

Dr Qi Huang<sup>1</sup>, Dr Dan Dorobantu<sup>2,3,4</sup>, Dr Ferran Espuny-Pujol<sup>1</sup>, Dr Rodney Franklin<sup>5</sup>, Deborah Ridout<sup>6</sup>, Dr Serban Stoica<sup>4</sup>, Prof Christina Pagel<sup>1</sup>, Prof Sonya Crowe<sup>1</sup>, Dr Kate Brown<sup>7</sup>

<sup>1</sup>Clinical Operational Research Unit, University College London, <sup>2</sup>Children's Health and Exercise Research Centre, University of Exeter, <sup>3</sup>Population Health Sciences, University of Bristol, <sup>4</sup>University Hospitals Bristol and Weston National Health Service Foundation Trust, <sup>5</sup>Royal Brompton and Harefield National Health Service Foundation Trust, <sup>6</sup>Institute of Child Health, University College London, <sup>7</sup>Great Ormond Street Hospital Biomedical Research Centre and Institute of Cardiovascular Science

Parallel Session 3 - Healthcare Operations Management - Decision Making in Healthcare, OC1.09, September 13, 2022, 4:30 PM - 6:00 PM

### **Biography:**

*Qi Huang is a research fellow working in the Clinical Operational Research Unit, University of London. She has a PhD in engineering and has been interested in developing and applying statistical methodologies to health care data since 2016. Currently she is working on the long-term outcomes of survival and re-operation amongst children born with congenital heart disease (CHD), and applying OR methods to improve the quality of CHD services in UK.*

We bring an operational research approach to analysing national data sets to improve health care delivery for congenital heart disease (CHD) in England. We have linked several routinely collected national data sets to generate understanding about the CHD services. We worked with clinicians to describe patients' trajectories through treatment procedures, analyse long-term survivals and identify useful metrics for driving quality improvement. Our work combines statistical analysis and detailed work with clinical teams, patients, families and audit bodies to understand, improve and communicate outcomes for patients living with CHD. Challenges include the complexity of the large linked dataset and lack of consensus on appropriate outcomes.

### Key features

- We worked with clinicians to identify patients in England with a complex and severe condition called functionally single ventricle (f-SV) CHD. These babies cannot survive without several surgeries starting in the first month of life. We described their healthcare resource utilisation by ages and treatment stages, and investigated the impact of potential risk factors. This work can be used to provide information and counselling to families of babies with f-SV disease, as well as a framework for planning healthcare resource allocation.
- CHD services in England are highly centralised. Research in the US (where CHD services are non-centralised) found post-operative outcomes for f-SV patients were worse for lower volume centres. We evaluated the relationship between centre-volume and long-term survival in f-SV children, and found no evidence that f-SV centre-volume was linked to longer-term survival in England. This work offers supportive evidence for a centralized model of care of f-SV CHD.
- Ongoing work with clinicians, families and national audit to select other representative diagnoses and establish how to routinely report their mid- and long-term outcomes including survival, treatment pathway, additional interventions every year. This work will support quality improvement in CHD services.

# HEALTHCARE OPERATIONS MANAGEMENT -WORKSHOP

## The (highly) complex world of the GP

Mr Dennis Sherwood<sup>1</sup>

<sup>1</sup>The Silver Bullet Machine Manufacturing Organisation Limited

Parallel Session 5 - Healthcare Operations Management -WORKSHOP - Dennis Sherwood, OC1.07, September 15, 2022, 9:00 AM - 10:30 AM

### ***Biography:***

*I have been a devotee of systems thinking for over 30 years, having first learnt about it when I was a consulting partner in Deloitte in the early 1980s. And having been an Executive Director at Goldman Sachs and also MD of the UK operations of SRI Consulting, I now run my own consulting business. And a few months ago, I was commissioned by GPDF Limited - which is owned by Local Medical Committees - to carry out a systems thinking study of GP practices: hence this presentation, which also features as a chapter in one of my latest books, "Strategic Thinking Illustrated - A visual guide to applying systems thinking", to be published by Taylor & Francis in September 2022.*

This is a systems thinking case study of a 'typical' GP practice, presenting a causal loop diagram showing how workload, stress, government policies, demographics, practice culture and a host of other variables are inter-related as a (highly) complex system.

With your approval, I'd like to run this session more as an interactive workshop, rather than as a 'lecture'. One reason for that is because that style is, I think, more engaging for those present, for rather than sitting there listening (or not!), with a few questions at the end, I think it would be good for everyone to be actively engaged throughout.

Secondly, the CLD I'll present is my mental model, my view of the world. Which is inevitably limited - so it would be very interesting to explore how it might be enriched.

Thirdly, the CLD is a description of the status quo, how things are now. Which, as we all know, is not a good place. So how might things be better? How should the system be changed to all our benefits? Those questions would, I trust, stimulate a lively discussion...



# HEALTHCARE OPERATIONS MANAGEMENT

## Rolling Horizon Scheduling of Biopharmaceutical Therapies via a Two-Step Lookahead Heuristic

Dr Siamak Naderi<sup>1</sup>, Prof Juergen Branke

<sup>1</sup>Warwick Business School

Parallel Session 7 - Healthcare Operations Management - Healthcare Operations Management, OC1.09,  
September 15, 2022, 2:30 PM - 4:00 PM

### **Biography:**

*Siamak is a research fellow at Warwick Business School, working on real-time supply chain logistics for personalised medicines as a part of an EPSRC funded Future Targeted Healthcare Manufacturing Hub, a network of six leading UK universities and 40+ industry partners working on innovative manufacturing research for the targeted biopharmaceutical supply chain. Prior to joining WBS, Siamak worked as an Assistant Professor of Industrial Engineering at MEF University, Istanbul, Turkey. MEF University is the first university in the world to adopt the flipped-classroom educational model university-wide. Siamak received his Ph.D. degree from the Industrial Engineering program of Sabanci University under the direction of Prof. Kemal Kilic and Prof. Abdullah Dasci. His research interests are largely related to developing algorithms for large scale Mixed Integer Programming (MIP) models. Siamak is particularly interested in models motivated by real-life problems. He has advanced education in Operations Management and Operations Research that has provided him with superior creative problem solving skills and analytic and conceptual abilities. He has also developed his communication and business skills by leading teaching assistants and collaborating with a fashion retailer as a consultant. In addition to this experience and due to his commitment and success in teaching undergraduate students, he received a teaching award in 2017-2018 academic year as the Best Teaching Assistant of the Year. In addition, Siamak has advanced knowledge of Python to use in optimization algorithms and data science problems.*

We address the scheduling of Chimeric Antigen Receptor (CAR) T-cells manufacturing under uncertain process durations and patient drop-outs. As a general practice in pharmaceutical manufacturing, CAR T-cell manufacturing is subject to no-wait constraint. We address the problem of maximising throughput by assigning equipment and operators to tasks for a CAR T-cell manufacturer. The underlying problem, a flow shop scheduling problem under uncertainty with no-wait constraint and multiple resources is formulated as a mixed-integer linear programming model. Because of the complexity of this problem a two-step lookahead heuristic using a rolling horizon is developed and its efficiency is evaluated in a simulation.

# Optimised extended red blood cell matching for transfusion dependent sickle cell patients

Dr Folarin Oyebolu<sup>1</sup>, Jennifer Martin<sup>1</sup>, Prof Simon Stanworth<sup>2</sup>, Dr Sara Trompeter<sup>3</sup>, Dr Nicholas Gleadall<sup>1</sup>, Dr William Astle<sup>1</sup>

<sup>1</sup>University Of Cambridge, <sup>2</sup>University of Oxford, <sup>3</sup>University College London Hospital

Parallel Session 7 - Healthcare Operations Management - Healthcare Operations Management, OC1.09, September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

Folarin is a Research Associate in Operational Research at the MRC Biostatistics Unit in the University of Cambridge.

Previously, Folarin completed a Knowledge Transfer Partnership (KTP) at the University of Manchester to research and implement a custom Bayesian Optimisation tool for Biopharm Services' software suite. There, he worked with Dr Richard Allmendinger, Dr Jonathan Shapiro and the team at Biopharm. Folarin subsequently worked for a couple of years at Biopharm in a product design and project management role to develop the requirements for and supervise the delivery of software development projects.

*Folarin did his PhD at the University of Warwick under the supervision of Prof Jürgen Branke and Prof Suzanne Farid. His research was on the application of novel heuristics to optimise capacity planning and scheduling for biopharmaceutical manufacturing facilities. His undergraduate degree was an MEng in Biochemical Engineering at UCL.*

People with sickle cell disorder (SCD) are heavily dependent on blood for prevention or treatment of complications. Current matching practices for red blood cell (RBC) transfusion cause avoidable harm to patients in the form of alloimmunisation to non-self RBC antigens. Alloimmunisation increases risk of: inadequate blood availability; life-threatening transfusion reactions; and at worst, death due to no available blood. This disproportionately affects those with SCD - people with no other treatment options.

Recently, rapid cost-effective genotyping technology has been developed, allowing the complete antigen profile across the donor cohort to be determined routinely. Knowledge of this should allow provision of routine extended matching to reduce alloimmunisation, and improve the ability to transfuse blood for those where compatible blood could previously not be sourced.

In this work, we build upon previous models for matching extensively typed RBC units to extensively typed patients by formulating a Hitchcock transportation problem where the objective is to minimise the costs associated with allocating available RBC units to patients requiring RBC transfusions. These costs include the risk of alloimmunisation, wastage of expired units, and the opportunity cost of allocating rare and valuable units.

We subsequently carry out simulation optimisation studies by simulating daily RBC stock and patient demand, and solve a series of daily transportation problems over an extended time horizon. Novel to previous work, we focus on simulating demand from patients with SCD. This means the transfusions are generally elective, and includes patients who are already alloimmunised. Furthermore, the antigen frequencies in England vary dramatically between patients with SCD (>90% African ancestry) and donors (>96% European ancestry). We demonstrate that extended antigen matching reduces the incidence of alloimmunisations. Finally, we investigate the impact of anticipatory matching in the model by incorporating forecasts of future RBC supply and patient demand when solving the daily transportation problem.

# HYBRID MODELLING AND SIMULATION

## Democratisation of Simulation within Manufacturing Engineering

Mr Joe Young<sup>1</sup>, Dr Emile Glorieux<sup>1</sup>

<sup>1</sup>The Manufacturing Technology Centre (MTC)

Parallel Session 2 -Hybrid Modelling and Simulation, OC1.03, September 13, 2022, 1:30 PM - 3:00 PM

### *Biography:*

*As part of the Digital Engineering team at the MTC, Joe helps businesses in making evidence-based decisions; using modelling and simulation techniques to optimise the performance of factories, supply chains, products and technologies. Joe has spent 8 years in engineering roles, and prior to the MTC, worked at Alstom Power and GE Power Digital, supporting design engineers in the application of mathematical and statistical tools. He has a Masters Degree in Mathematics and Physics from the University of Durham.*

Over the past decades, process models and production system simulations have proven to be impactful for the manufacturing industry. However, using these tools is typically restricted to engineers with specialised skills. Consequently, simulation technologies are kept siloed, away from decision-makers, limiting their potential impact as well as efficiency to facilitate improvements. Additionally, lack of awareness of simulation capabilities often means that organisations miss opportunities to use simulation to drive informed decision making. Democratisation of simulation, as a concept, drives the deployment of simulation tools beyond simulation engineers to empower more people within a manufacturing organisation to take advantage of these technologies. By transferring some analysis tasks, democratisation reduces the burden on scarce, specialist simulation skillsets and provides end-users with greater freedom to experiment and problem solve. A next step could be to extend this to external stakeholders (e.g., suppliers, customers, technology partners, etc.) on a Software-as-a-Service basis provided on a digital marketplace to facilitate collaboration, accelerate innovation, and improve traceability. This presentation shows the various aspects involved with democratisation of simulation; including levels of democratisation, deployment modes, as well as identifying democratisation opportunities and challenges. The presentation will also cover when democratisation is an appropriate solution and associated risks and limitations. Specific requirements for successfully developing democratised simulation tools, particularly related to usability and reliability, which have been refined over multiple simulation democratisation case studies in manufacturing engineering are discussed. This presentation describes three key ingredients required for kick-starting simulation democratisation development: (1) standardised modular deployment, (2) intuitive user interfaces and (3) automated data-management. The lifecycle for democratised simulation technologies is described to highlight the difference with conventional simulation technologies in manufacturing engineering. This includes opportunities to make tools more accessible by using advanced Information Technology (IT) environments and cloud-based architectures to remove existing IT barriers. Furthermore, several commercial case studies of simulation democratisation will be presented related to Additive Manufacturing (AM) and assembly systems for electrification. The presented work will cover different model types including factory simulations, cost modelling as well as physics simulations (e.g. Computational Fluid Dynamics).

# Analysing the dilemma between lithium-ion battery recycling and second use: A system dynamics perspective

Dr Krishna Mohan Thazhathu Valiyaveetil<sup>1</sup>, Mr Bhanu Pratap, Dr R K Amit, Dr Shankar Venugopal

<sup>1</sup>University Of Exeter Business School

Parallel Session 2 -Hybrid Modelling and Simulation, OC1.03, September 13, 2022, 1:30 PM - 3:00 PM

## *Biography:*

Krishna Mohan joined the University of Exeter Business School as Full Time Postdoctoral Research Fellow in February 2022. He works for the Research in Theme 4 of the UKRI Interdisciplinary Circular Economy Centre for Technology Metals (Met4Tech CE). His research interests are primarily in circular economy, sustainable operations management, and simulation (system dynamics and agent-based).

He obtained in PhD from the Indian Institute of Technology Madras in 2019. His thesis focused on the dynamic modelling of end-of-life vehicle recycling markets in emerging economies.

*Prior to joining the University of Exeter, he worked as an Assistant Professor of Operations Management and Quantitative Techniques area at the Indian Institute of Management Bodh Gaya, India for two years.*

Rapid growth in the share of electric vehicles (EVs) in the mobility sector is imperative, to meet the global targets for reducing greenhouse emissions set by the Paris agreement. However, the growing share of EVs in the transportation sector presents a challenge in handling end-of-life (EOL) lithium-ion batteries (LIB) that serve as the primary power source of electric vehicles (EVs). The proposed EU regulatory framework for batteries put forward extended producer responsibility for LIB manufacturers making them liable for end-of-life management of batteries. The EOL LIB can be recycled to obtain strategic raw material contained in them by using different recycling methods, or it can be used as stationary energy storage applications. This brings the dilemma for the battery manufacturers regarding the choice between recycling and LIB second use. We present a systematic approach for analysing the trade-off between LIB recycling and LIB second-use by applying system dynamics simulation modelling. Model results indicate that while cascading use of lithium-ion batteries for stationary storage applications reduces the battery material demand, the extended life of LIB limits their availability for recycling and material availability in the long term. While poor collection rates and battery quality limit the scope of repurposing, limitations in process efficiency hamper recycling profitability. We aim to provide recommendations for LIB manufacturers to identify effective end-of-life management practices and regulators to identify suitable instruments for effective policy decisions.

# Potential Role of Hydrogen Storage Technology in the UK Electricity Grid

Mr Saheed Bello<sup>1</sup>

<sup>1</sup>Loughborough University

Parallel Session 2 -Hybrid Modelling and Simulation, OC1.03, September 13, 2022, 1:30 PM - 3:00 PM

## *Biography:*

Saheed Bello is a Doctoral Researcher in School of Business and Economics at Loughborough University, UK. His research focuses on the optimal mix of technical, economic, and regulatory factors of attaining low-carbon electricity system using hybrid quantitative tools from network science, simulation, and econometrics.

Prior to that, Saheed worked as a research analyst in reputable international organisations such as MacArthur Centre for Petroleum, Energy Economics and Law(CPEEL), Centre for Public Policy Alternatives (CPPA).

Saheed holds a first degree in Economics from the University of Ibadan, Nigeria. He went on to graduate from Surrey School of Economics, where he received a Master of Science degree in Energy Economics and Policy.

This paper quantifies and values the hydrogen storage required for the UK future electricity system transition. Unlike in the previous literature, the study develops an agent-based model that integrates wind electricity generation penetration in the UK electricity grid to quantify the amount of hydrogen storage required to address the problem of wind curtailment. In addition, it provides an economic evaluation of the hydrogen storage investment using an uncertainty-augmented discounted cashflow approach that allows for interactions between power plants and storage facilities in an agent-based setting.

Its findings show that about 5.5 GW of hydrogen capacity is required to solve the electricity curtailment problem in the UK electricity grid by 2050. In addition, the cost associated with hydrogen storage is £5.24millions. The substantial NPV (about £2,000 Millions) compared to its investment cost (about £5.24millions) suggests high returns on investment when hydrogen is used to solve the problem of electricity curtailments. It also finds that about 57% of CO<sub>2</sub> emissions is reduced by deploying the hydrogen storage technology. Therefore, any government measures to stimulate private investment in green hydrogen storage technology, which is economically viable, environmentally friendly, and socially worthwhile, needs urgent implementation.

# Agent-based Modelling for Public Policy: Where Things Stand and Aspirations

Dr Kavin Narasimhan<sup>1,2</sup>, Professor Nigel Gilbert<sup>1</sup>, Dr Eugene Chang<sup>2</sup>, Andy Jones<sup>2</sup>, Rudi Narendran<sup>2</sup>

<sup>1</sup>University of Surrey, <sup>2</sup>Department for Business, Energy & Industrial Strategy

Parallel Session 3 - Hybrid Modelling and Simulation, OC1.03, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Dr Kavin Narasimhan is a Research Fellow at the Centre for Research in Social Simulation (CRESS) at the University of Surrey and a Data Social Scientist (Secondee) at the Department of Business, Energy & Industrial Strategy. Kavin has a PhD in Computer Science from Queen Mary University of London. She has worked on various interdisciplinary research projects, leading on the development and application of computational models to explore issues of policy relevance, e.g., energy demand management, water management, climate resilience and adaptation. She has significant experience working with diverse groups of stakeholders for knowledge co-creation to inform, provide data and evaluate the effectiveness of computational models, making them relevant and useful for the needs of stakeholders. Agent-based Modelling (ABM), Participatory Systems Mapping (PSM) and analysis, and energy data analysis are research methods that Kavin uses regularly.*

Agent-based modelling (ABM) is popular in academic disciplines such as social sciences, biology, and ecology. But examples of ABM to steer public policy are less prevalent. This is unfortunate because examining the impact of public policy on individual entities (e.g., people, businesses, and industries) is important for evidence-based policy development, and ABM affords the methodological rigour to explore these interactions in silico. On the other hand, the strengths of ABM in simulating individual heterogeneity, bottom-up behaviours and interactions, and complex, non-linear, emergent phenomena are accompanied by challenges for policy applications related to computational processing speed, detailed individual-level data to calibrate and validate models (which may not be available or easy to collect), and limited predictive capabilities. Secondly, ABM is distinct from other modelling approaches commonly used to inform policy, e.g., econometric modelling, linear optimisation, microsimulation, etc. This presents conceptual, cognitive, and capacity barriers for wider uptake. Lastly, a model developed for a specific policy problem risks becoming outdated or incapable of being extended or adapted to other problems without regular code maintenance.

Considering these challenges, we are primarily motivated to explore examples and improve the understanding of where ABM is and could be useful for public policy. We are further interested to explore ways to improve the visibility, accessibility, and usefulness of ABM for public policy. Our suggestions include: (1) Promoting model reusability by turning fundamental or foundational aspects of models into reusable components and make their documentation and code open source. The ambition here is to grow the user base and encourage the development of standards for ABM for public policy. (2) Reproducible Analytical Pipelines (RAPs) are used in Government to improve quality and promote transparency and trust in analytical processes. Packaging ABM simulation experiments, data, and analysis into RAPs, and implementing them using popular languages like R or Python would promote trust in models and modellers. Where policy-relevant data cannot be shared due to confidentiality or ethical reasons, options for generating synthetic data to calibrate and validate agent-based models should be explored. (3) Co-creating and evaluating agent-based models with policy stakeholders, using short-term sprints to improve agility.

# A Hybrid Decision Support System to Facilitate Industrial Symbiosis in the Food Processing Industry

Dr Barry Evans<sup>1</sup>, Dr Mehdi Khoury<sup>1</sup>, Dr Lydia Vamvakieridou-Lyroudia<sup>3</sup>, **Prof Nav Mustafee<sup>2</sup>**, Prof Albert Chen<sup>1</sup>, Dr Otto Chen, Prof Slobodan Djordjević<sup>1</sup>, Prof Dragan Savić<sup>3</sup>

<sup>1</sup>Centre for Water System, University Of Exeter, <sup>2</sup>Centre for Simulation, Analytics and Modelling, Business School, University of Exeter, <sup>3</sup>KWR

Parallel Session 3 - Hybrid Modelling and Simulation, OC1.03, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Nav Mustafee is a Professor in Analytics and Operations Management at the University of Exeter Business School. His research focuses on Modelling & Simulation methodologies and their application in Healthcare Operations Management, Supply Chain, Sustainability and the Circular Economy. A particular interest is in Hybrid Modelling and Simulation. Nav is the Founder and the Co-Director of the Health and Care IMPACT Network, which is a collaboration between health and care organisations and universities, primarily in the South West of England. He is a Joint Editor-in-Chief for the Journal of Simulation and Vice-President of Publications for The Society of Modeling and Simulation International (US). He is a Member of the EPSRC Associate Peer Review College.*

Food processing industries (FPIs) such as tinned vegetables, juices, and ketchup productions consume a significant amount of water, as well as release considerable wastewater. The wastewater may be generated only in certain months of the year as the products link with the seasonal harvest of fruits and vegetables. As these FPIs discharge wastewater for a limited time of the year, the businesses may be averse to setting-up costly treatment facilities. Furthermore, as these facilities are often scattered across agricultural areas (close to the produce), it is challenging for environmental authorities to monitor wastewater discharge. This research, as part of the EU H2020 ULTIMATE project (GA869318), tests an innovative solution of industrial symbiosis whereby the wastewater of the FPIs is treated locally, with opportunities for additional value generation during the treatment process. The primary objective is wastewater treatment and water reuse to mitigate water deficit. Another objective is extracting valuable compounds (e.g., antioxidants) to generate extra benefits.

Our case study is related to FPIs of Greece, mainly the eastern Peloponnese, which is one of the most productive regions in Greece (also in Europe) in terms of citrus fruit. A rental service provider is offering Mobile Treatment Units (MTUs) and technicians for on-demand wastewater treatment. The innovative solution is expected to lead to an industrial symbiosis that brings win-win advantages to local industries. However, the operation involves a high level of complexity and uncertainty as the FPIs have various patterns of seasonal demands.

These make it difficult for the service provider to plan for future investment and operations. As the new business model is lacking experience and data in practical context to support the estimations, a decision support system based on computer simulation could benefit the service provider for the experimentation of scenarios as what-if questions. Therefore, we have developed a hybrid modelling framework for symbiotic water cycle (F-SWC) to facilitate industrial symbiosis in the FPIs in Greece through simulation. The F-SWC features the integration of the hybrid simulation approach of Operational Research (i.e., Agent Based Simulation (ABS), Discrete Event Simulation (DES), and System Dynamic (SD)) with multiple criteria decision analysis (MCDA).

# Predicting the natural history of metabolic syndrome with a Markov-System Dynamics model: a novel approach

Dr Esmail Morasae<sup>1</sup>, Dr Pezhman Bagheri<sup>1</sup>

<sup>1</sup>University Of Exeter

Parallel Session 3 - Hybrid Modelling and Simulation, OC1.03, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*I am a research fellow in complex systems and policy at the Exeter University Business School. I am coming from a public health/social sciences background with a Ph.D. in Complex Systems Science. I am engaged in a couple of projects at Exeter that take a systemic approach to health, social, inequalities, and circular economy.*

**Background:** A hybrid Markov-System Dynamic (MSD) model has rarely been used in medical studies. The aim of this study was to evaluate the performance of an MSD model in the prediction of the natural history of Metabolic Syndrome (MetS), as a very complex, multi-component (i.e. obesity, hypertension, etc.), and hard-to-manage, deadly chronic disorder.

**Methods:** Data gathered by the Tehran Lipid & Glucose Study (TLGS) over a 16-year period from a cohort of 12,882 people was used to conduct the analyses. First, transition probabilities (TPs) between 12 components of MetS as well as control and failure rates of relevant interventions were calculated by a Markov model. Then, the risk of developing the components and the syndrome over the next two decades was simulated once by the Markov model and then by an MSD model. Finally, the two models were validated and compared to assess their performance and advantages. Mean differences, mean SE of matrices, fit of the graphs, Kolmogorov-Smirnov two-sample test, and R2 index (as a model fitting index) were used for model comparisons.

**Results:** Both Markov and MSD models were shown to be adequate for the prediction of MetS trends. But the MSD model predictions were closer to the real trends when comparing the output graphs. The MSD model was also, comparatively speaking, more successful in the assessment of mean differences (less overestimation) and SE of the general matrix. Moreover, the Kolmogorov-Smirnov two-sample test showed that the MSD model produced equal distributions of real and predicted samples ( $p = 0.808$  for the MSD model and  $p = 0.023$  for the Markov model). Finally, R2 for the MSD model was higher than the Markov model (73% for the Markov model and 85% for the MSD model).

**Conclusion:** The hybrid MSD model showed a more realistic natural history than the Markov model which highlights the importance of paying attention to this method in planning for therapeutic and preventive procedures when managing MetS patients.

**Keywords:** Metabolic Syndrome, Markov-System Dynamics, Natural History



## MAKING AN IMPACT

### Systems Stream Pre-brief for MAI Workshop 2 pm 14 Sep

Mr Gordon Dyer<sup>1</sup>

<sup>1</sup>Retired (Open University)

#### *Biography:*

I had a first career in the Royal Air Force and held a variety of operational flying, training, and staff appointments. Following a brief period of part-time teaching at the OU, I was appointed as Technology Staff Tutor, based in London. I contributed to several courses produced by the Systems Department: writing course and examination materials and acting as a course team chair. I also taught courses offered by the OU Business School. In 1985, appointed Deputy Regional Director for the East Anglian Region and was tenured as Senior Lecturer in this post till 1999. My affiliation with the OU continued to 2007 through various teaching and consultancy contracts.

My publications cover contributions to books and 40 articles in 10 different academic journals. These are primarily to the field of systems thinking and its practice through a different style of dialogue, termed, "conversation". This style, literally "turning together", remains a key driver in my research as a basis for groups/teams to co-create an improving and evolving future, particularly in our post-Covid world of threats.

This session is intended as a pre-brief for my Workshop in the Making an Impact MAI stream "Experience an evolutionary, conversation-based methodology for improving a group's future" and which follows at 2pm.

The aim of this session is to provide a description of the conversation methodology that you will use in the MAI workshop. This will mean that the actual workshop can begin with a short introduction. This will enable participants to engage with in the trigger questions I will provide as soon as possible. The conversation process as presented here will be a new learning experience from which the benefits can only be appreciated by "doing it."

I am not expecting that everyone who intends to come to the 2pm Workshop will be free to attend this briefing session. I am aware of the attraction of other paper sessions.

However, it will be useful if some do attend, and these then spread themselves between the 3 groups for the workshop.

# Experience an evolutionary, conversation-based methodology for improving a group's future

Mr Gordon Dyer<sup>1</sup>

<sup>1</sup>Retired (Open University)

MAI 2 Systems Thinking - Co-creating an Evolutionary Protocol for a New Group Future, OC1.09, September 14, 2022, 3:00 PM - 6:00 PM

## *Biography:*

I had a first career in the Royal Air Force and held a variety of operational flying, training, and staff appointments. Following a brief period of part-time teaching at the OU, I was appointed as Technology Staff Tutor, based in London. I contributed to several courses produced by the Systems Department: writing course and examination materials and acting as a course team chair. I also taught courses offered by the OU Business School. In 1985, appointed Deputy Regional Director for the East Anglian Region and was tenured as Senior Lecturer in this post till 1999. My affiliation with the OU continued to 2007 through various teaching and consultancy contracts.

My publications cover contributions to books and 40 articles in 10 different academic journals. These are primarily to the field of systems thinking and its practice through a different style of dialogue, termed, "conversation". This style, literally "turning together", remains a key driver in my research as a basis for groups/teams to co-create an improving and evolving future, particularly in our post-Covid world of threats.

Join this taster of conversation-based methodology enabling a social group/work-team to co-create their own "improving/evolving" future. Drawing on heuristics from some twenty IFSR and ISI conversation events, and albeit limited action-research, I offer a four-stage methodology to OR colleagues, especially those interested in softer systems concepts. The methodology is intended for small groups of size 6-8(max10). Sharing interim outcomes via plenary allows for larger numbers.

Adaptive methodology caters for the spectrum of (in)formality in social groups and work-teams. It involves sequences of design and reflective conversations interspersed by new group experiences. Methodology is dynamic, meeting underpinning ethics of encouraging genuine participation, and equal opportunities for current and evolving membership, and stakeholders. Guidelines are offered on how conversations – disciplined inquiries - can be conducted to sustain creative synergy. Conversation allows for challenge and exploration of ideas avoiding the acrimonious style of debate.

The workshop simulates a context where group members have difficult recent experiences. Assume little 'team spirit' to build on – a new future should be created, and some guiding protocols are desirable. Each group will explore shared values, create a common vision of an improving future, and define proxy measures/indicators to judge how well their intentions are met as they next work/go forward together.

1.Introduction - explore common key values e.g., welcoming diversity. Express key values in a vision statement/protocol expressing intention to embed them in their (hypothetical) group's future behaviour. (I'll offer example)

2.Development -plenary share groups' views/protocols evolve?

3.Incorporation – Extend protocol; develop measures/indicators for evaluating progress towards their vision. Sharing previous good/ bad group experiences, when expected 'freedoms/rights' were recognised/ ignored respectively, will help. (I'll offer an example approach). Plenary share outcomes/protocols evolve?

4.Review – without follow-up experience, review isn't simulated.

By participating you will have experienced conversation-dialogue and its lexicon and have methodology useable with groups in your own context.

#### Notes

1. Adaptable template developed with and for the members of the International Systems Institute (ISI).
2. Though individual experiences will be different, in context of OR64 membership you share some common values/ aspirations. These may be like key values you share with others 'back home'.

# Introduction to the Alliance for Data Science Professionals

Mr Gavin Blakett<sup>1</sup>

<sup>1</sup>*Operational Research Society*

MAI 2: Practice - Alliance of Data Science Professionals, LT OC0.03, September 14, 2022, 3:00 PM - 4:30 PM

***Biography:***

*Gavin Blakett is the Executive Director of the Operational Research Society. He has worked in operational research throughout his career, working as a consultant with British Coal, Hoskyns and Capgemini, and has headed the OR Society staff for over 15 years. He is a Fellow of the OR Society.*

The OR Society is one of four learned societies, along with NPL and the Alan Turing Institute, who make up the Alliance. The Alliance was formed as a response to one of the recommended actions in the Royal Society's report 'Dynamics of data science skills'. It seeks to define standards of professional competence and professional behaviour, and to certify both individuals and degree courses against these standards. This talk will discuss the Alliance, the standards and the certification processes.

# The Beer Game: Exploring the dynamics of a logistic supply chain

Dr Siôn Cave<sup>1</sup>, Dr Dave Exelby<sup>1</sup>, Mr Tom Turner<sup>1</sup>, Ms Haeshiya Sivakumaran<sup>1</sup>

<sup>1</sup>Decision Analysis Services Ltd

MAI 2: Systems - Beer Game, OC1.01, September 14, 2022, 3:00 PM - 6:00 PM

## ***Biography:***

*Head of the DAS Analytics + Foresight Hub.*

The Beer Game, is a hands-on, interactive and fun board game based simulation representing the dynamics of a typical supply chain. The workshop pits teams against each other to see who can run the most efficient supply chain, resupplying beer from a brewery to shops. The purpose of the workshop is to demonstrate how systems cause the behavior they exhibit, and how unintended consequences can result from system design. The lessons from the beer game are relevant to anyone who relies on supply chains for delivery, from manufacturing industries, technology companies to workforce planners.

# Emergent Design: An embodied approach to making sense of complex adaptive systems using SenseMaker

Mr Paul Ader<sup>1</sup>

<sup>1</sup>ThinkClarity

MAI 2: Systems Thinking - Emergent Design, OC1.06, September 14, 2022, 3:00 PM - 6:00 PM

## *Biography:*

I am a director at ThinkClarity, a specialist consultancy that works with teams, organisations and communities to inform, nudge and navigate adaptive change in complex situations. This work is based on the use of SenseMaker® and the widely cited Cynefin Leaders Framework for Decision Making.

Since 2013, I have worked with colleagues and client teams to use SenseMaker® on projects in Lebanon, Papua New Guinea, Pakistan, Afghanistan, the Horn of Africa, South Sudan, the USA and the UK. These projects have been designed to discover actionable insights into governance, legitimacy, service delivery, anti-corruption, ways of coping with drought and migration, social engagement and conflict resolution.

*I moved into this specialist area in 2014 after 30 years' experience in analytic decision-support and programmatic change management in Unilever, Duracell, Coopers & Lybrand, Oracle and the NHS. While most of my work is currently focused on enabling adaptive change in complex situations, I also have experience and expertise in designing, planning and managing programmatic change; financial modelling; developing and delivering training; design and facilitation of workshops; monitoring and evaluation (M&E); and the use of Tableau®, a leading tool for data visualisation.*

SenseMaker® enables decision makers to map a landscape of diverse stakeholder experiences in the context of complex adaptive systems. It can be deployed in small enquiries based on 50-100 stakeholder stories, or it can be used in large and/or longitudinal enquiries capturing many thousands of such stories. It is possible for decision makers to pre-define sense-making questions. However, this 'top-down' approach arguably misses an important first level of sense-making, when stakeholders critically engage with the questions that should be asked. I have distilled my experience of designing questions for a SenseMaker® enquiry into a process that I have called "Emergent Design". This participatory process does not create a complete design – rather it provides a launch pad for further work, as well as a landing platform for input from experts and stakeholders. Emergent Design makes use of embodiment to ensure that participants are able to use all their senses to design and test ideas for questions. This testing is essential, because relatively few questions can be asked out of an almost endless array of possibilities. Embodiment is enabled by drawing large triangles (and, in some cases, other shapes) on the ground, so ideas for questions can be placed at the corners, and members of the design group can step into and move around the triangle to say how the question at each corner feels in relation to a relevant experience. Embodiment enables effective use of a technique referred to as "stress-testing", in which ideas for questions are checked to ensure that results clustered near them are likely to have meaning and impact, and enable action. Steps in the Emergent Design process and the way it uses embodiment will become clear during the workshop.

# The Zen Business Model: facilitating organizational awareness and sustainable development through Eastern-based systems approaches

Dr Josep Coll<sup>1</sup>

<sup>1</sup>*Eada Business School*

MAI 2: Systems Thinking - Zen Business Model, OC1.04, September 14, 2022, 3:00 PM - 4:30 PM

## *Biography:*

Josep M. Coll is a professor of Strategy, Sustainability and Innovation at EADA Business School, visiting professor at Yonsei University in South Korea, and research associate at Maastricht School of Management. He works as an independent consultant for a wide range of private and public organizations, such as the European Commission and the United Nations. In the United Nations system, he co-led the first corporate developmental evaluation and adaptive management movement in UNFPA. As an initiate in Taoist metaphysics and Zen practitioner, he applies East Asian perennial philosophies into practical systems approaches and methods for regeneration. He regularly speaks internationally on systems leadership and sustainable transformation and coaches organizations, managers and entrepreneurs in transitioning to the new sustainable, regenerative and inclusive business paradigm. He is the author of "Buddhist and Taoist Systems Thinking: the natural path to sustainable transformation" (Routledge, 2021), recognized as an important contribution to systems sciences by the International Society of Systems Sciences in 2022.

Management science has ignored, since its inception, learning from Eastern systems approaches. These approaches bring a wealth of natural wisdom grounded in hundred of years of inquiry and practice. The Zen Business Model is one of these approaches. As such, the main purpose of this workshop is to introduce this model as a systemic bio-model useful in facilitating and guiding sustainable organizational development for organizations that seek to increase the generation of value and impact across the triple bottom line. This workshop is targeted to management consultants, researchers and executives that are interested in exploring and facilitating new systems approaches that integrate the personal, organizational and sustainable development in purpose-driven organizations that are transitioning to the new regenerative and inclusive business paradigm. The workshop will cover the following contents. First, it will introduce and explain the model, focusing on the five corporate stars, its interdependent relations, and the value generation and control cycles that characterize the model's dynamics. Second, it will explore the utilization-focused application in different domains of organizational development (design, strategy, sustainability practice and evaluation). And third, it will explore ways of introducing and facilitating the model into the audience's own case studies. More information about the model can be found in the book "Buddhist and Taoist Systems Thinking: the natural path to sustainable transformation" (Routledge), chapter 5: the Zen Business Model: <https://www.routledge.com/Buddhist-and-Taoist-Systems-Thinking-The-Natural-Path-to-Sustainable-Transformation/Coll/p/book/9780367478964>

# Interactive Data Science: From Data to Results

Dr Judit Guimera Busquets<sup>1</sup>, Mr James Watkinson<sup>1</sup>, Dr Jeremy Bradley<sup>1</sup>

<sup>1</sup>Datasparq

MAI 2: Techniques - Data Science – From Data to Result, OC1.08, September 14, 2022, 3:00 PM - 4:30 PM

## ***Biography:***

*Judit graduated in Aeronautical/Air Transport Engineering in 2013 at City, University of London, where later on she pursued her PhD studies. Her research focused in developing a modelling framework that looked at city-pair generation, route demand assignment and air traffic estimation, while taking into account network evolution. Judit has worked for Virgin Atlantic and Royal Mail in the past and is now a Senior Data Scientist at Datasparq. As a data scientist she has contributed to the development and continuous improvement of predictive models for classification, customer segmentation as well as schedule optimisation problems.*

We will run an interactive data science session on building and refining a typical data science model. We will walk participants through a structured notebook that takes you through all the stages of a data science project. The end-goal will be for participants to try their hand at ingestion, refinement and model iteration and see how the wider data product is created.

At each stage, participants will have the opportunity to craft their own solution in python, before moving on to the next stage.

From this session you will have an understanding of the basic data science project lifecycle as executed using python and how you can use it to help you Make an Impact in your work. A notebook with full answers will be provided at the end of the session.

Prerequisites: A core knowledge of python will be very helpful. Please bring your own laptop to the session with an up-to-date web browser.

Sign up for this session is required so that we can get you set up on the platform. To sign up please visit the link below:

<https://datasparq.ai/or64-mai>



# An introduction to DEA and use of efficiency methods in economic regulation with case study on a German court case and demonstration of Oxera's Performance App

Dr Ali Emrouznejad, Dr Srin Parthasarathy<sup>1</sup>

<sup>1</sup>*Oxera*

MAI 2: Tools - An introduction to DEA, OC1.07, September 14, 2022, 3:00 PM - 4:30 PM

## *Biography:*

Ali Emrouznejad is a Professor and Chair in Business Analytics at Surrey Business School, UK. His areas of research interest include performance measurement and management, efficiency and productivity analysis as well as data mining and big data. He holds an MSc in applied mathematics and received his PhD in operational research and systems from Warwick Business School, UK. Dr Emrouznejad is editor / associate / member of editorial boards of several scientific journals. He has published over 200 articles in top-ranked journals and authored / edited several books (<http://emrouznejad.com/ali/>)

Srin is an expert in performance management in the context of competition and regulation, and he heads Oxera's Performance, Productivity and Efficiency practice.

For more than 15 years, while at the London School of Economics and Oxera, Srin has led on expert reports and testimonies for regulators, industry associations, and corporates in over ten European member states, focusing on the energy, water and transport sectors. He has provided expert advice as part of regulatory due diligence, regulatory incentive design, price control reviews, competition investigations, and price appeal and merger inquiries.

*Srin has previously taught in the Economics and Business faculties at the University of Warwick, London School of Economics and London Business School. He acts as an ad hoc reviewer for peer-reviewed academic journals in performance management: OR Spectrum, Annals of Operations Research, Journal of the Operational Research Society and Annals of the Brazilian Academy of Sciences.*

DEA (Data Envelopment Analysis) is an optimization method for measuring efficiency and productivity of decision-making units with multiple-inputs/ multiple-outputs which was developed by Charnes, Cooper, Rhodes (1978). DEA has rapidly extended and used in many applications. This session comprises of two parts.

The first part provides an introduction to Data Envelopment Analysis following by demonstration of feature of the Performance Improvement Management Software (PIM-DEA). The focus on the second part is on the use of efficiency methods in economic regulation. Efficiency and productivity methods are commonly used to set revenues or prices in the economic regulation of utilities. Several important and difficult trade-offs need to be addressed when using these methods. For example, a primary objective is consumer protection (e.g. keeping tariffs to an efficient level while delivering outstanding service), which needs to be balanced with incentivising timely investment and long-term resilience. Recent macroeconomic developments, the move to net zero, and climate change effects pose additional challenges in making such trade-offs. In this session, we will cover three topics briefly: first, on the general use of efficiency methods in regulation, the main building blocks involved and importance of expert judgement; second, on a recent regulatory application in the German energy sector that myself and several academics were involved in and which was examined by the German Court of Appeal (Oberlandesgericht Düsseldorf); and lastly, on Oxera's innovative

Efficiency App launched last year to enable energy companies to prepare for anticipated changes to the German energy law.

# Increasing transformational leadership thanks to the Transformative Management Canvas

Dr Gianni Di Marco<sup>1</sup>

<sup>1</sup>Freelance

MAI 3 Systems Thinking - Transformative Management with the Q Matrix, OCO.04, September 14, 2022, 3:00 PM - 4:30 PM

## ***Biography:***

*Gianni Di Marco is a Specialist in Transformational Management and Leadership from the University of Lausanne (HEC). He is a qualified practitioner in PCM® Adaptive Communication, B Leader affiliated with B Lab Switzerland, for supporting companies in the assessment of their social and environmental responsibility (CSR) using B Corp's Business Impact Assessment tool, and Certified Specialist in Transformational Leadership Development using the VLD-GLP approach from Global Leadership Associates. Consultant, Coach and Trainer, Gianni Di Marco also holds a doctorate in geology and has more than 25 years of experience in marketing, management, project management and change management. He was CEO and founder of a start-up in the 2000s and created his consulting agency in 2022 to provide advice and support in transformational management. He is the author of the concept of the Q method, of the Transformational Management Canvas (CMT) and of publications on resistance to change and systemic change (in prep.)*

We don't always realize that life is a constant transformative process. We gather things that we collect from the past to produce something new in the future. Management, and especially change management, requires mastering this transformation process properly. Incomplete project design, inappropriate leadership, and inadequate process sequence lead to project failure, dysfunctions, and resistance to change. In this session, you will discover the Transformative Management Canvas, based on the Q method, two innovative frameworks to improve systems designs, project planning and leadership in ways that they become more transformative, sustainable, and regenerative.

## Ritual in systemic/soft operational research practice: An exercise

Dr Jose-Rodrigo Cordoba-pachon<sup>1</sup>

<sup>1</sup>Royal Holloway, University Of London

MAI 3: Systems Thinking - Ritual in Systems and OR Practice, OC1.04, September 14, 2022, 4:30 PM - 6:00 PM

### ***Biography:***

*Associate professor in technology and information management, Royal Holloway, University of London*

This session introduces ideas about ritual, with the aim of informing how we could conduct our systemic/soft operational research practice in new and possibly richer ways. After an introduction (helped by some personal memories of ritual), the session will present basic features of ritual as per Han (2020, The disappearance of Rituals ) and Seligman et al (2008, Ritual and its Consequences). After, we will invite participants to identify and reflect on their own 'rituals' in practice.

A short role play exercise of how rituals are firmed up in and beyond a systemic/soft operational research intervention is performed. Examples to help this performance are using Midgley (2000)'s description of unemployment benefits sign off and others. Discussion of 'stages' of ritual (awakening, assembling, dispersing) and implications for future practice could follow.

# How to be (even more) creative!

Mr Dennis Sherwood<sup>1</sup>

<sup>1</sup>*The Silver Bullet Machine Manufacturing Organisation Limited*

MAI 3: Techniques - Creativity Workshop – How to be Creative, OC1.08, September 14, 2022, 4:30 PM - 6:00 PM

## *Biography:*

For the last 20 years - and after having been a consulting partner in Deloitte and an Executive Director at Goldman Sachs - I have been running my own consulting company specialising in organisational creativity and innovation. So that's from way before "design thinking" being fashionable! And the tools and techniques I use haven't been copied from somewhere else - I developed them myself. And they work - as I'll show at this workshop.

*You can read about them too, if you wish - I've written 15 books on a variety of subjects, including two on systems thinking, five on creativity, and one on them both. Most recently, "How to be Creative - A Guide for the Mathematical Sciences", which I've co-authored with Manchester's Professor Nicholas Higham FRS, was published by SIAM in May 2022; "Creativity for Scientists and Engineers" has just been published by the Institute of Physics; and "Strategic Thinking Illustrated - A visual guide to applying systems thinking" by Taylor & Francis.*

So, you've done your OR analysis, and run some forecasts. The results don't look good. What next?

What next is creativity. If the future doesn't look good, something has to change. Perhaps something needs to be designed differently. Perhaps there needs to be a significant change in the context in which a system is operating. Perhaps someone (or some people) need(s) to change his/her/their mind(s). These changes won't happen by themselves - they can happen only if the corresponding ideas are tabled first. And having good ideas requires creativity.

But how does creativity actually happen? What, fundamentally, is creativity anyway? Can you have great ideas 'on demand'? Do you have to be a 'design thinker'? Or can an 'ordinary' person be creative? These are important questions, and answering them is what this session is all about...

The session will be led by Dennis Sherwood, an expert in creativity, modelling and systems thinking. Dennis now runs his own business, having been a consulting partner with Deloitte, and Coopers & Lybrand; an executive director at Goldman Sachs; and UK MD of Stanford Research Institute (SRI). He is also the author of numerous journal articles and 15 books.

# What makes a quality model? The National Audit Office shares its insights on using and quality assuring models to manage risks to value for money

Ms Ruth Kelly<sup>1</sup>

<sup>1</sup>National Audit Office

MAI 3: Tools - What makes a Quality Financial Model?, OC1.07, September 14, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Ruth Kelly is Chief Analyst at the National Audit Office (NAO) and has wide experience of applying economics and other analytical approaches to support policy evaluation, investment decisions and risk management. She directed the 2022 Financial Modelling in Government report. Prior to joining the NAO, she held business evaluation and risk management roles for a global resources company, and advised clients on carbon and energy issues for a Big 4 economic consultancy practice.*

Financial modelling is at the heart of how the government understands its spending, performance and risks, and influences decisions that often have major impacts on people's lives. So it's really important that decision makers who depend on outputs from models can feel confident in the quality and robustness of these models.

Through our extensive Financial Audit work examining government models, we continue to find weaknesses in models such as limited or poor-quality data; unrealistic assumptions and optimism bias; and inadequate sensitivity and scenario analysis. Departments often rely too heavily on best estimates from models which can limit their understanding of uncertainty and limit their ability to manage risks to value for money.

In this interactive discussion session, we will highlight the key findings and recommendations of our recent report on Financial modelling in Government. We'll share our Framework to Review Models, a structured approach that model commissioners and users can use to understand if the modelling outputs they are relying on are reasonable, robust and high quality. And we'll discuss what decision makers and finance professionals should know when it comes to analysing, managing and communicating uncertainty, to support them in making good decisions on spending.

# Basic forecasting with Python

Dr Alain Zemkoho<sup>1</sup>

<sup>1</sup>University Of Southampton

Making an Impact 1 - Basic Forecasting with Python, OC1.07, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*I am an associate professor in operations research at the school of mathematics within the university of southampton. I lead the mathematical programming and forecasting modules and conduct research on nonconvex and nonsmooth optimization techniques for bilevel optimization problems. Areas of applications interest of my research include transportation, data analysis, and forecasting. I also supervise postgraduate research on academic and industrial projects, e.g., with major uk airline and defense companies.*

The aim of the workshop is to introduce a few Python-based tools to develop forecasts using time series data sets. There is a wide range of forecasting methods in the literature, as well as in opensource and commercial software packages. However, our focus will be on one of the most basic statistical one (exponential smoothing), yet very powerful in generating forecasts for data exhibiting clear patterns such as trends and seasonality. The workshop is planned to be handy, with participants taking part by trying the tools as we proceed. Nevertheless, efforts will be made to provide a digestible background of the mathematics behind the methods. Clearly, no particularly advanced mathematics, statistics, or Python knowledge is required for the workshop. Access to relevant data, codes, and notes, which will serve as base for the workshop are made available (see [github.com/abzemkoho/forecasting](https://github.com/abzemkoho/forecasting)) for anyone interested in going further in developing some familiarity with the tools and mathematical background of relevant methods.

It is expected that at the end of the course, anyone attending should be able to generate forecasts on their own with time series data. The preliminary schedule of the session will be as follows:

1. Basic python tools – software installation, etc. (10 min)
2. Basic data analysis tools (15min)
3. What is forecasting (10min)
4. Break (5min)
5. Exponential smoothing methods
  - ☐ High level mathematical background (10min)
  - ☐ Implementation with Python (35 min)
6. Other methods (e.g., ARIMA) if time allows it (5min)

## Reference

Zemkoho, A., 2022.

A basic time series forecasting course with Python, Operations Research Forum, in press, available at <https://arxiv.org/abs/2205.10941>

# A tutorial on engaging clients in OR projects

Dr Antuela Tako<sup>1</sup>

<sup>1</sup>Loughborough University

Making an Impact 1 - Engaging Clients in OR Projects, OC1.01, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Antuela is a Reader in Operational Research at the School of Business and Economics, Loughborough University. She is an expert in developing quantitative and qualitative modelling approaches to support organisations in their decision-making processes. Her research interests focus on simulation modelling and more specifically participative and facilitated simulation, comparison of alternative simulation approaches, hybrid simulation, behavioural operational research and problem structuring methods, applied primarily in healthcare. Antuela is the co-founder of PartiSim ([www.partisim.org](http://www.partisim.org)) and supported Leicestershire County Council in the development of integrated community-based care services as part of the Simulation for Greater Care project ([www.simtegr8.org](http://www.simtegr8.org)). Antuela is an Associate Editor of the Journal of the Operational Research Society, Journal of Simulation and the Health Systems Journal. Her email address is: [a.takou@lboro.ac.uk](mailto:a.takou@lboro.ac.uk) and twitter account @AntuelaTako.*

This talk will be an interactive workshop where delegates will learn about and get a flavour of facilitated modelling. Facilitated modelling consists of a carefully designed process, which involves modelling activities undertaken in workshops with a group of stakeholders (service providers, commissioners, and even service users). This talk draws from the facilitator's experiences of developing facilitated modelling processes to support stakeholder groups in evaluating their services using a collaborative approach. The workshop will include discussion points and activities for delegates to participate in. No prior knowledge is required, however experienced facilitators are also welcome to join and share their own experiences.



# Grand Challenges and OR: the Cost of Living Crisis

Dr Miles Weaver<sup>1</sup>

<sup>1</sup>Edinburgh Napier University Business School

Making an Impact 1 - Grand Challenges and OR: The Cost of Living Crisis, OCO.04, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Miles is an Associate Professor of Systemic Sustainability and Supply Chain Management at Edinburgh Napier University Business School. He leads the Business School efforts towards PRME (the Principles for Responsible Business in Management) and at a university level, Societal Impact. Miles is passionate about empowering young people to make a difference as Trustees on charity boards and supporting purpose-driven business to accelerate progress towards the Sustainable Development Goals, including the transition to net zero. He does this, in part through his research to bring about meaningful engagement between business and communities to bring about more impact and place-making. As Programme Director of the "Governance Matters" CPD Programme and as a Founding Trustee of "Everyone's Edinburgh".*

To upload by 18.7.

# Identity, Social Justice and Capitalism- A Systems Perspective

Mrs Helen Sanson<sup>1</sup>

<sup>1</sup>Forcera

Making an Impact 1 - Identity, Social Justice and Capitalism, OC1.06, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Helen is the founder of Forcera CIC, a consultancy that aims for change by using her passion for learning, systems and complexity thinking to build capacity and foster agency for social transformation and impact whilst appreciating the practical challenges. She believes in exploring ways to make power inclusive, so people's voices are part of the decision-making process and they belong. Her interests lie in how societal structures and systems exacerbate existing inequalities by conceptualising how they occur to create social change. She brings various skills and experiences, including lived, to empower organisations and individuals through awareness-based systems thinking based on social science, active learning and participatory approaches. She enjoys facilitating space for engaging in generative conversations that explore the complexities of wicked problems that create uncertainties by reframing frustrations and disrupting issues to realise new ways of thinking, seeing, doing and being and reaching the root cause.*

If systems thinking is a way of looking at problems in society as a whole and how they are interconnected. Why does it have so little to say about what I call the "isms," i.e. racism, sexism, disablism, sexualism, genderism etc., especially since 2020 and the explosion of the term systemic, which has been thrust into the spotlight due to social injustice rhetoric.

This presentation and workshop will explore if current social justice ideology upholds the reductionist notion that a system can be understood by the sum of its isolated parts. By overly focusing on the 'isms' as the whole and their outcomes as symptoms, so the remedies given to cure them, such as allyship, education and figurative theories, are reductive. The discussion will argue that the 'isms' are behaviours, and the sum of their symptoms is not the whole system. The presentation will examine that the key to understanding is to identify how these behaviours are produced by debating that they are a historical creation and commodities of capitalism; therefore, they are doing what they are designed to and are doing it very well.

The discussion will assert that the socio-economic disconnects and divides are not symptoms of the 'isms' as they are often positioned. Instead, they are outcomes due to the interconnectedness of the three pillars of capitalism: wealth (not just from bottom to top but within groups and subgroups at all levels), economics and politics, which intersect with codified class categories that include identities. These work together to create or decrease power regardless of identity, which cannot be eradicated by social justice advocacy alone; only when we situate the 'isms' in relation to capitalism can their true nature be understood and solutions found.

# How High-Impact Organizations Are Using Systems Thinking to Develop Cultures That Transform The Workplace And Deliver Extraordinary Customer Value

Mr Daniel Edds<sup>1</sup>

<sup>1</sup>Praxis Solutions

Making an Impact 1 - Leadership – It's a System, not a Person, OC1.09, September 14, 2022, 10:30 AM - 12:00 PM

## *Biography:*

For over twenty-five years Daniel B Edds has been a practicing management consultant serving state, and local government, healthcare, K-12 education, and higher education. His focus has been to bring the most innovative tools to assist these essential organizations in their operational, financial, and strategic operations.

Founder, Praxis Solutions

The mission of Praxis Solutions is to help our client organizations "bridge the gap between strategy and execution." Therefore, the focus of Praxis is the application of tools and methodologies that will fully execute the mission of our client organizations. This includes both the development of winning business strategies, but even more, the development of the best organizational cultures and systems of leadership to execute those strategies. The result of these are cultures of deeply empowered and engaged employees and the delivery of extraordinary customer value.

## Education

Dan Edds holds a Masters of Business Administration, International Business, the Albers School of Business and Economics at Seattle University.

## Certifications and training

- Baldrige Quality Criteria Team Lead and Senior Examiner (WSQA);
- Kaplan Norton Balanced Scorecard Certified Graduate™
- Certified strategic planner;
- Certified facilitator; and
- Lean Green Belt.

## Publications: -books

1) The Genetics of Leadership: Cracking the Code of Sustainable Team Performance, (Nov 2020, AVIVA Publishing, Lake Placid NY). A revolutionary new look at organizational leadership. This book documents how high-impact organizations approach the discipline of leadership systemically to create cultures that deliver both an extraordinary employee experience but also extraordinary customer value. The research and case studies include healthcare, manufacturing, education, and groups as diverse as an NFL Super Bowl Champion, the New York Mafia, and the Salvation Army.

2) Transformation Management, (2003 by Spiro Press, London, England). This is a practical "how-to" guide on the application of Activity Based Costing & Management to transform organizational performance.

The Gallup organization has calculated that the lack of employee engagement worldwide costs employers \$7 Trillion annually. Or nearly the combined economies of Germany and Japan. In the U.S., 67% of all employees are either nonengaged (meaning they contribute little to innovation) or actively sabotaging their employers. Worldwide, this number is 87%.

While executives understand the value of employee engagement, they also recognize the challenge of developing organizational cultures that will engage their employees. Their challenge has two parts. First, there are over 160 different definitions of culture. The result is confusion about the very nature of culture. Second, too many organizations have approaches to leadership (which is responsible for culture) that have not changed since Henry Ford introduced the first moving assembly line in 1908.

Culture is the mirror image of the leadership system. A systems approach to leadership and culture formation provides several advantages for executives who desire to transform their organizational cultures, 1) clarity of each culture element, 2) the integration of structure, 3) processes to build a high-impact culture, and 4) where to begin the journey. The results of this approach are consistently high employee engagement, retention of top talent, thriving employees that enjoy both professional and personal growth, and corporate success in the marketplace.

Daniel B Edds, MBA is the author of, *Leveraging the Genetics of Leadership*, cracking the code of sustainable team performance. This is the first book that documents through case studies and interviews with key leaders in healthcare, manufacturing, education, small business, and the U.S. Military on how to build high-impact organizations with systems design and thinking. Beginning with a systemic approach to leadership, these unique organizations are generating value greater than their size would indicate is possible. By removing personality from leadership and replacing it with an integrated leadership system, organizations of any size can transform their workplace and deliver unparalleled customer value.

# Machine Learning for Discrete Event Simulation: A tutorial on our experience at Simul8 with integrating Supervised Learning methods in simulation models

Dr Christoph Werner<sup>1</sup>

<sup>1</sup>Simul8 Corporation

Making an Impact 1 - Machine Learning for DE Simulation, OC1.08, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Christoph Werner has an MSc and PhD in Operational Research from the University of Strathclyde. Since 2018, Christoph has been working as part of Simul8's Simulation Excellence team where he has helped Simul8 users with numerous simulation projects ranging from automotive, defence and energy industries to healthcare and other service sectors.*

Machine Learning (ML) is becoming an ever more important tool for simulation modellers – at Simul8, we often notice this through the discussions we have with our users. Integrating ML in a simulation can assist them to better understand how complex decisions are being made in a process and implement these directly into their simulation.

Often, the rules underlying a modelled process, e.g., regarding timing and routing, depend on complex factors, such as multiple attributes of the entities going through a simulation, together with several system states, such as the time of the day or the current state of a particular simulation object, for instance the length of a certain queue. These complexities can be difficult to outline and implement. Even further, they might be unknown to an organization.

Methods in the area of ML, especially Supervised Learning, are able to derive such rules from a given dataset and hence, provide a modeller with a powerful tool to integrate this level of complexity in a simulation if desired.

In this tutorial, we show you how you can implement Supervised Learning directly in a simulation for timing and routing decisions through Simul8's new ML feature.

We present two case studies, one from the healthcare sector and another from manufacturing. In the first, we show how implementing a common Supervised Learning algorithm for a triage decision in an ER simulation helps to include complex logic about which patients are admitted as urgent cases, which ones can go to a waiting room, and finally, which ones are transferred to a different ward.

The second case study presents how Supervised Learning is integrated in a model to allow for the consideration of multiple system states and attributes of produced car parts when deriving the conditional timing for a quality check task in the production line.

# Computer supported techniques for running problem structuring sessions online

Mr Karthik Suresh<sup>1</sup>

<sup>1</sup>University of Hull

Making an Impact 1 - Online Strategies for Problem Solving, OC1.04, September 14, 2022, 10:30 AM - 12:00 PM

## *Biography:*

Karthik Suresh is a Management Consultant who helps customers with energy, utility, sustainability, research, innovation and knowledge management projects. His experience includes working with large and small organisations to select and implement strategic decision systems, improve and develop management capability and deploy risk management, IT, communications and information systems projects.

Problem structuring methods such as Soft Systems Methodology (SSM) use techniques that have traditionally been carried out in face to face environments. Free/Open Source software and commercial equivalents are capable of supporting techniques such as Rich Pictures, enabling participants to carry out problem structuring workshops in online videoconferencing sessions, reducing the time taken to set up such sessions. This workshop will demonstrate the use of such tools for Rich Picturing and also introduce Rich Notes, a technique that uses the advantages of software tools to develop a rich note taking method that seeks to understand the “story” the client has to tell about the situation. The ability to draw Rich Picture and Rich Notes is illustrated through a demonstration of the tools and approach used in practice and other tools that practitioners may wish to consider.

Applying a novel Soft Systems approach (PrOH Modelling) to improve manufacturing and service operations

## Note: This is for an experiential workshop on the 15th September 2022

Prof Ben Clegg<sup>1</sup>, Dr Krishna Balthu<sup>1</sup>

<sup>1</sup>Aston University

Parallel Session 6 - PrOH Modelling (Systems Thinking-Ben Clegg), OC1.07, September 15, 2022, 11:00 AM - 12:30 PM

### *Biography:*

Ben is a professor of operations management at Aston Business School, Aston University. He is Head of the Operations and Information Management Department, which has approximately 70 faculty, 60 research students and 50 visiting staff. The OIM Department has teaching foci in business analytics, IS/ICT, and operations and supply chain management; it has research foci in advanced services for manufacturing, cyber security, business/data analytics, circular economy, and humanitarian crisis management. Ben's individual research focuses on the application of systems thinking to operations improvement: strategic change, digitalization, leanness, quality improvement, efficiency, productivity and effectiveness in manufacturing and services. His teaching focuses on post graduate education to MBAs, businesses and short professional courses. His research has led REF impact cases in 2014 and 2021. Ben has published hundreds of research papers (conference and top journals), won more than £2m of research funding, been elected to the European Operations Management (EurOMA) committee, has organised international conferences, and has served on the IET fellowship panel. He has a leading textbook 'Operations Management' from McGraw-Hill (2e, 2021). He has also been Associate Dean for Business and Community Engagement.

Soft Systems Methodology (SSM) is a contrasting approach to so-called 'hard systems methodologies'. SSM can improve human activity system problems that are complex in nature and difficult to optimise (Checkland, 1981; Senge, 1990; Ackoff, 2006).

In this workshop we explore how a novel Soft Systems Methodology called Process Oriented Holonic (PrOH) Modelling has been used to investigate and improve complex organizational problems, such as those found in strategic operations management, within both manufacturing and service organisations (Clegg, 2007; Balthu & Clegg, 2021). Built on the principles of Checkland's SSM PrOH Modelling in Action Research contexts engages with the problem situation / system under observation and delivers practical changes. PrOH modelling is for strategic operations management improvements but can also provide new insights to systemic thinking.

The philosophy and mechanics of PrOH Modelling Methodology will use real-life case studies. Using examples from both manufacturing and service organisations, this workshop will explain change journeys of organisations that have used this novel approach. Discussion will combine research rigour and industrial relevance based on high-quality journal publications and REF impact case studies (2014 and 2021).

Using a gamified approach, this workshop will allow delegates to learn the principles of the PrOH Modelling Methodology in an innovative and engaging manner. This workshop will appeal to researchers who would like to develop their, presentations skills, soft modelling, change management and action research skills. It will also appeal to practitioners / consultants who would like to lead impactful transformational change programmes in their organisations as PrOH Modelling can be used as a systemic Problem Structuring

Method (PSM) to broaden perspectives of participants and facilitate discovery of emergent (and hidden) systemic strategies and actions (Midgeley et al., 2013).

note: references did not fit in word count.



## OPTIMAL LEARNING AND APPLICATIONS

### Integrating the multiobjective ranking and selection algorithm into the multiobjective evolutionary algorithm

Dr Wen Zhang<sup>1</sup>

<sup>1</sup>University of Bristol

Parallel Session 2 -Optimal Learning and Applications, OC1.06, September 13, 2022, 1:30 PM - 3:00 PM

#### *Biography:*

Wen Zhang is a Lecturer in Business Analytics. She obtained her PhD in Operations Research and Management Science from Warwick Business School in 2019. Her current research focuses on AI for social good (such as legal, insurance, CSR, etc.) and simulation optimisation.

*She is a recipient of the 2014 Warwick Business School Scholarship for PhD and the 2016 Winter simulation conference diversity award. She is a Fellow (D2) of the Higher Education Academy (FHEA).*

Simulation optimization has been proven to effectively improve simulation efficiency. In this research, we integrate the multi-objective evolutionary algorithm with different M-MOBA variants for the simulation budget allocation stage for fitness evaluation. Initial computational results show that the M-MOBA method could effectively improve the simulation efficiency.

# Constrained Bayesian Optimization

Juan Ungredda, Prof Juergen Branke<sup>1</sup>

<sup>1</sup>Warwick Business School

Parallel Session 2 -Optimal Learning and Applications, OC1.06, September 13, 2022, 1:30 PM - 3:00 PM

## ***Biography:***

*Juergen Branke is Professor of Operational Research and Systems at Warwick Business School, University of Warwick (UK). His main research interests include metaheuristics and Bayesian optimisation applied to problems under uncertainty, such as simulation optimisation, dynamically changing problems, and multi-objective problems. Prof. Branke has published over 180 papers in international peer-reviewed journals and conferences. He is Editor of ACM Transactions on Evolutionary Learning and Optimization, Area Editor of the Journal of Heuristics and the Journal of Multi-Criteria Decision Analysis, as well as Associate Editor of IEEE Transactions on Evolutionary Computation and the Evolutionary Computation Journal.*

Many real-world optimisation problems such as hyperparameter tuning in machine learning or simulation-based optimisation can be formulated as expensive-to-evaluate black-box functions. A popular approach to tackle such problems is Bayesian optimisation (BO), which builds a response surface model based on the data collected so far, and uses the mean and uncertainty predicted by the model to decide what information to collect next. In this talk, we present a novel variant of the well-known Knowledge Gradient acquisition function that allows it to handle constraints. We then empirically compare the new algorithm with four other state-of-the-art constrained Bayesian optimisation algorithms on deterministic as well as noisy problems.

# Approximate Dynamic Programming for Pharmaceutical Portfolio Management

Dr Xin Fei<sup>1</sup>

<sup>1</sup>University Of Edinburgh

Parallel Session 6 - Optimal Learning and Applications, OC1.06, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*I joined the University of Edinburgh as the role of University Lecturer (teaching and research) in 2022. Before that, I was a Lecturer in Business Analytics at the University of Bristol and a Fellow of Bristol Digital Futures Institute. I received a PhD degree in Operations Research & Management Science from Warwick Business School in June 2019. My PhD research dealt mostly with efficient information collection, but stochastic optimisation is also an important part of my research.*

A pharmaceutical research and development pipeline can be composed of multiple pharmaceutical projects which await evaluation in clinical trials with static designs and unknown outcomes. Advancing the pipeline presents challenges in managerial decision-making and computation, as the projected profit of a pharmaceutical product during the market exclusivity period depends on the factors such as the lead time, the outcome and the cost of clinical trials. We present a tactical decision support tool that allocates budget among clinical trials such that the static designs are cost-effective and the predicted pipeline revenue is maximised. A dynamic programming framework is applied to formulate the problem of pharmaceutical product portfolio management and to search for the optimal tactics, but the fast increasing dimensions of state space when scaling up the pipeline are likely to place a computational challenge. We develop a look-ahead approach in which a base policy is used to approximate the post-decision value function to identify the best action at each state. In such an approach, the post-decision function values induced by various actions need to be estimated by simulation, leading to a problem of information exploration. The statistical racing exploiting the techniques of correlated sampling and empirical Bernstein's inequality is proposed to maximise the time-efficiency of the simulation process. The numerical results show that the proposed statistical racing with correlated sampling outperforms the state-of-the-art methodology in terms of exploration efficiency, and the look-ahead approach finds better decision policies within a reasonable computational time.

# An index policy to the promotion allocation problem in a crowdfunding platform

Mr Chenguang Wang<sup>1</sup>, Dr Dong Li<sup>1</sup>, Prof Baibing Li<sup>1</sup>

<sup>1</sup>Loughborough University

Parallel Session 6 - Optimal Learning and Applications, OC1.06, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Chenguang Wang is a 2nd-year PhD candidate in the Management Science and Operation Group, School of Business and Economics, at Loughborough University. He holds an MSc in Applied Math from the University of Manchester and a BSc in Applied mathematics from XJTLU. Chenguang's PhD project explores the application of Multi-armed bandit problems and index heuristics in the Crowdfunding business.*

This study concerns a reward-based crowdfunding platform where multiple projects compete for the investment from individual backers over a finite time horizon. Backers visit the platform following a Poisson process. Upon arrival, they either choose one of the projects to invest or leave without any investment. The choice behaviour is modelled as a Multinomial Logit Model. The platform charges a commission as a percentage of the final funds raised for each project at the end of the time horizon. At each time point, the platform could choose to promote a single project to boost its chance of being backed, and the objective is to maximise the overall commissions. We model this problem as a stochastic dynamic program, which is however computationally intractable. To this end, we decompose the problem into single project subproblems based on the Whittle's restless bandit approach. We prove the indexability of single project subproblems, calculate the index values (that are both state and time dependent), and propose an efficient index policy. Extensive numerical experiments show that the index policy outperforms many other strategies in most scenarios considered.

# OPTIMISATION UNDER UNCERTAINTY

## Robust Optimization Approaches for Sustainable Energy Infrastructure

Dr Aurelie Thiele<sup>1</sup>, Hao Jiang

<sup>1</sup>Southern Methodist University

Parallel Session 1 - Optimisation under Uncertainty, OC1.06, September 13, 2022, 11:00 AM - 12:30 PM

### ***Biography:***

*Aur lie C. Thiele is an Associate Professor in the department of Operations Research and Engineering Management at Southern Methodist University. Prior to joining SMU, she was an Assistant Professor and (tenured) Associate Professor of Industrial and Systems Engineering at Lehigh University in Bethlehem, PA, where she also served as the co-director of the Master of Science in Analytical Finance. She has received first prize in the George Nicholson paper competition, an IBM Faculty Award and multiple National Science Foundation grants for her research in decision-making under high uncertainty. Two of her research papers have been cited more than 500 times. Further, Dr. Thiele was twice a Visiting Associate Professor at the University Paris-Dauphine in Paris, France. At SMU she has also served as President of the Faculty Senate (2020-2021). Dr. Thiele received her "diplome d'ing nieur," summa cum laude, from the Ecole Nationale Sup rieure des Mines de Paris (Mines ParisTech) in France and her M.S. and Ph.D. in Electrical Engineering and Computer Science from M.I.T.*

In this talk we present robust optimization approaches for sustainable energy infrastructure. First, we develop robust portfolio models of clean and renewable energy production over time to meet local and state governments' short-term and long-term clean energy goals, incorporating concepts from project finance to finance the building of critical new infrastructure in the presence of demand uncertainty and price uncertainty. We model and mitigate a wide range of risks both pre-completion and post-completion to create a comprehensive strategy to achieve renewable energy goals. Second, we also design tractable, robust approaches for vehicle fleets to achieve portfolio-wide emission goals in line with the new Greenhouse Emissions Standards put forward by the U.S.'s Environmental Protection Agency in December 2021. We use customer choice models to create portfolios of new vehicles that best allow car manufacturers to fulfill the preferences of various customer segments while addressing the climate crisis. Further, we investigate various financial incentives. Our models are relevant for state and local policymakers as well as individual customers.

# Stochastic Optimisation Approaches for Truck-Drone Tandems in Humanitarian Applications

Dr Melih Celik<sup>1</sup>, Hannan Tureci Isik<sup>1</sup>, Dr Ece Sancı<sup>1</sup>

<sup>1</sup>University Of Bath

Parallel Session 1 - Optimisation under Uncertainty, OC1.06, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Melih Celik is an associate professor at the School of Management, University of Bath. He holds BSc and MSc degrees in Industrial Engineering from Middle East Technical University (Ankara, Turkey), as well as an MSc in operational research and a PhD in Industrial Engineering from the Georgia Institute of Technology (Atlanta, USA). His research is broadly centered around applying operational research tools and techniques on supply chain management and logistics problems. More specifically, he works on developing exact and heuristic solution approaches for real-world problems in areas including, but not limited to disaster relief, not-for-profit logistics, warehouse management, and material handling. His work has appeared in Operations Research, Production and Operations Management, European Journal of Operational Research, IIE Transactions, Naval Research Logistics, and International Journal of Production Research, among others. He currently serves on the Executive Committee of NATCOR and as the treasurer of the EURO Working Group on Humanitarian Operations.*

The use of drones to overcome network inaccessibility in the aftermath of a disaster can increase the timeliness of humanitarian aid operations. In this study, we consider simultaneous and independent truck and drone deliveries for post-disaster relief distribution of light-weight aid items such as packages containing first aid kits, vaccine or hygiene kits in the aftermath of a large-scale disaster. We formulate a two-stage stochastic programming model to locate depots prior to the disaster considering the subsequent post-disaster relief distribution by routing ground vehicles and drones simultaneously, considering uncertainty on the disruption to the road network. Due to the intractable nature of the model, we propose a heuristic approach that decomposes the problem into the location, allocation and routing subproblems.

## Data-Driven Robust Optimization with Cluster-Based Anomaly Detection

Dr Aakil Caunhye<sup>1</sup>

<sup>1</sup>The University Of Edinburgh

Parallel Session 1 - Optimisation under Uncertainty, OC1.06, September 13, 2022, 11:00 AM - 12:30 PM

### ***Biography:***

*Dr Aakil Caunhye is a Lecturer at The University of Edinburgh. His main research area is Robust Optimisation and Stochastic Programming, with applications to Humanitarian Logistics and Energy Planning.*

We propose a data-driven robust optimization approach where cluster Voronois are used to identify (via sparsity) and discard anomalous regions of the uncertainty set. The Voronois are built using perpendicular bisecting hyperplanes and form a geometrical characterisation of data clusters. Combined with a geometrical formulation of the uncertainty support, our data-driven uncertainty set is equipped with a comprehensive geometrical intuition, with enough generality to allow decision makers to tailor supports based on the problem at hand. With the recognition that not all anomalous data result in anomalous decisions, we also develop a method to maximize the size of the non-anomalous regions, such that decisions remain non-anomalous. Our anomaly-based models show marked improvements in performances over the classical robust optimization with polyhedral uncertainty on a disaster response model that uses real data from the last 18 years of impacts of floods and landslides in Brazil.

## An efficient computational method for large scale surgery scheduling problems with chance constraints

Dr Mahdi Noorizadegan<sup>1</sup>, Prof Abbas Seifi

<sup>1</sup>Northumbria University

Parallel Session 3 - Optimisation under Uncertainty, OC1.06, September 13, 2022, 4:30 PM - 6:00 PM

### ***Biography:***

*Mahdi is interested in decision making under uncertainty in particular mathematical modelling and algorithm design aspects.*

We propose an efficient solution method based on a set-partitioning formulation for an integrated surgery planning and scheduling problem with chance constraints. The underlying problem is characterized by a set of identical operating rooms (ORs), a set of surgeries with uncertain durations, a set of surgeons, and surgery dependent turnover times. The decision variables include the number of ORs to open, assignments of surgeries and surgeons to ORs in admissible periods, and the sequence of surgeries to be performed in a period. The objective is to minimize the cost of opening ORs and the penalties associated with turnover times. In the proposed formulation, the column generation subproblem is decomposed over ORs and time periods. The structure of the subproblem is further exploited and transformed to a shortest path problem. A search algorithm has been devised to efficiently solve the resulting subproblem, subject to some optimality and feasibility conditions. The proposed computational method outperforms the standard chance constrained model and reduces the solution time significantly. Furthermore, extensive simulation experiments have been carried out to compare the performance of three variants of the underlying formulations and evaluate the sensitivity of the decisions to the probability of exceeding a session length.



# A Generalized Risk-averse Stochastic Optimization Framework to Promote Diversification and Fairness in Decision Making for Applications with Heavy-tailed Distribution of Losses

Dr Nasrin Mohabbati<sup>1</sup>, Dr Alexander Vinel<sup>2</sup>

<sup>1</sup>California State University San Bernardino, <sup>2</sup>Auburn University

Parallel Session 3 - Optimisation under Uncertainty, OC1.06, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Dr. Nasrin Mohabbati is an Assistant Professor in Information and Decision Sciences Department at California State University San Bernardino. She received her Ph.D. in Industrial and Systems Engineering from Auburn University in the U.S. in 2019. Her research interests include decision-making under uncertainty, large-scale optimization, and operations research and machine learning interface. Dr. Mohabbati received several awards and recognitions for excellence in teaching, research, and leadership such as the Outstanding Research, Scholarly, and Creative Contribution Award; Frank Sturm Memorial Fellowship; and 100+ Women Strong Leadership Award.*

The concept of Risk Parity has been widely used in financial portfolio management to enforce diversification by ensuring equal contribution from each asset to the total volatility of a portfolio. Besides finance, several application areas can be found in engineering and operations research to utilize the risk parity concept for effective decision-making under uncertainty. In these settings, the Risk Parity condition can be interpreted as enforcing the fairness of a decision or as a way to balance between a number of candidate solutions. In this research, we considered Risk Parity in conjunction with modern risk-averse stochastic optimization, studied a generalized Risk Parity model, and proposed a combined two-stage diversification-risk framework. We assessed the performance of the proposed model based on a case study in hazardous materials transportation. The results show the effectiveness of the solutions in terms of fairness and risk equity for decision-making under uncertainty in the presence of a heavy-tailed distribution of losses.

# Asset management for multiple assets with multiple maintenance actions

Prof Thomas Archibald<sup>1</sup>, Prof Jake Ansell<sup>1</sup>

<sup>1</sup>University Of Edinburgh Business School

Parallel Session 3 - Optimisation under Uncertainty, OC1.06, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Thomas Archibald is Professor of Business Modelling at the University of Edinburgh Business School. His research focuses on applications of stochastic modelling to problems in business and management.*

The large sums of money spent on physical assets mean even minor improvements in the approach to asset management can result in substantial savings. Many models have been proposed to optimize the maintenance or replacement of single items or components with stochastic failure types and times. However, these models do not generally extend to larger systems where resource constraints are important. This paper focuses on systems of multiple assets with a range of potential maintenance actions. Using decomposition, a method to determine a prioritization index for combinations of assets and maintenance actions is developed. These indices can be used to help asset managers design near-optimal maintenance strategies subject to budget constraints. Numerical examples are presented to illustrate the approach.

# A simheuristic method for airport runway scheduling

Dr Robert Shone<sup>1</sup>, Prof Kevin Glazebrook<sup>1</sup>, Prof. Konstantinos G. Zografos<sup>1</sup>

<sup>1</sup>Lancaster University

Parallel Session 5 - Optimisation under Uncertainty, OC1.06, September 15, 2022, 9:00 AM - 10:30 AM

## *Biography:*

*Dr. Rob Shone is currently a Lecturer in Operational Research at Lancaster University.*

Runway scheduling (also known as aircraft sequencing) involves controlling the sequence of aircraft landings on a runway in order to optimise delay-related performance measures. In practice, air traffic controllers might use a 'first-come-first-served' policy so that aircraft land in the same order that they arrive in the terminal area, but this is not always the most efficient approach, as the separation requirements between consecutive aircraft pairs also depend on aircraft weight classes – with larger gaps usually required if the leading aircraft is in the 'heavy' class.

In the academic literature, this type of problem has been formulated as a multi-objective combinatorial optimisation problem. Some classical formulations assume that the problem is both static (i.e. the landing sequence only needs to be determined once, without any subsequent updating) and deterministic (i.e. all relevant information is known, without any uncertainty). However, in reality, the problem is both dynamic and stochastic.

In this talk we consider a dynamic, stochastic runway scheduling problem in which the system state at any point in time is high-dimensional and includes the latest estimated times of arrival (ETAs) of planes due to land at the airport, the latest positions of aircraft that have already been 'queued' for landing, and also the weather conditions and latest forecast. The ETAs and weather forecasts vary according to continuous-time stochastic processes. The problem is too complicated to be solved using exact methods and we therefore introduce a novel simheuristic method, which involves continuously simulating the performances of various possible landing sequences and using a ranking and selection method to update the hypothesised 'optimal' sequence. Preliminary results suggest that our simheuristic method can outperform alternative heuristics that use 'expected value' estimates based on the latest system information and treat the problem as if it were deterministic.

# Incorporating declared capacity uncertainty in optimizing airport slot allocation

Dr Aleksandr PIROGOV<sup>1</sup>, Prof. Konstantinos G. Zografos<sup>1</sup>

<sup>1</sup>Lancaster University Management School

Parallel Session 5 - Optimisation under Uncertainty, OC1.06, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Aleksandr Pirogov is Research Associate of the Centre for Transport and Logistics (CENTRAL), at Lancaster University Management School (LUMS). His research interests include Computer Science and Robust Optimisation techniques for real-world Transportation and Industrial applied problems.*

Slot allocation is the mechanism used to allocate capacity at congested airports. A number of models have been introduced in the literature aiming to produce airport schedules that optimize the allocation of slot requests to the available airport capacity. A critical parameter affecting the outcome of the slot allocation process is the airport's declared capacity. Existing airport slot allocation models treat declared capacity as an exogenously defined deterministic parameter. In this presentation we propose a new robust optimization formulation based on the concept of stability radius. The proposed formulation considers endogenously the airport's declared capacity and expresses it as a function of its throughput. We present results from the application of the proposed approach to a congested airport and we discuss the trade-off between the declared capacity of the airport and the efficiency of the slot allocation process.

# A Hybrid Spanning Trees Enumeration and Best-Worst Method for Decision-Making under Uncertainty

Dr Amin Vafadarnikjoo<sup>1</sup>, Dr Konrad Maliszewski<sup>2</sup>

<sup>1</sup>Sheffield University Management School, University Of Sheffield, <sup>2</sup>Atheon Analytics

Parallel Session 7 - Optimisation under Uncertainty, OC1.01, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*Dr Amin Vafadarnikjoo is a lecturer in Operations Management and Decision Sciences at Sheffield University Management School. He gained his PhD from Norwich Business School, University of East Anglia. Prior to joining the University of Sheffield, he worked as a Research Associate at Manchester Metropolitan University Business School. His research contributed to operations, supply chain management and decision sciences fields in various contexts such as supply chain risk management, green supply chain management, closed-loop supply chain, logistics, healthcare, energy, construction, insurance, and sustainability. His articles have appeared in leading journals including International Journal of Management Reviews, Annals of Operations Research, Expert Systems with Applications, Socio-Economic Planning Sciences, Applied Soft Computing, Industrial Management & Data Systems, International Journal of Operational Research, Sustainability, Journal of Cleaner Production, Measurement, Automation in Construction, and Mathematical Problems in Engineering. Amin is a member of the British Academy of Management, Decision Sciences Institute, European Operations Management Association, International Society in MCDM and Operational Research Society. He holds a Postgraduate Certificate in Learning and Teaching in Higher Education and is a Fellow of the Higher Education Academy.*

In the Best-Worst Method (BWM), a decision maker selects one decision-making criterion as the best criterion and another decision-making criterion as the worst one. The real-world decision-making process necessitates dealing with subjective judgements of human beings and circumstances of the decision-making context. As a result, there might be a set of potential best and a set of potential worst criteria with some level of hesitancy that might make the decision maker unable to confidently choose only one single best or worst criterion. This is likely due to decision makers encountering uncertainty, hesitancy, or lack of information. In this study, a Spanning Trees Enumeration (STE) method is integrated with the BWM to deal with this type of uncertainty. In the proposed hybrid approach, STE offers an opportunity for decision makers to suggest more than one best or worst criteria. The STE concludes which criterion is actually the best or worst one among the given set of potential best and worst criteria. The STE analysis is based on the data already provided in the form of pairwise comparisons by decision makers. The result of STE then feeds into the BWM to calculate the final weights and prioritised order of criteria. In order to validate the performance of our proposed hybrid method, we have conducted a set of Monte Carlo simulations under various defined numerical experiments. The simulation analysis has been carried out by running numerical analyses in Python. The results indicate a satisfactory success rate of the STE in identifying the unique best or worst criterion in various experiments. In addition to the numerical analysis, we have also shown the applicability of the proposed STE-BWM in one real-world application. The application was a case study in the UK energy supply chain risk management. In this case study, the six already identified UK energy risks including natural disasters, climate change, industrial action, affordability, political instability, and sabotage/terrorism are prioritised using the STE-BWM.

# Maximizing Profit in Hub Location Problems Under Price-dependent Uncertain Demand

Mr Dung Tran<sup>1</sup>, Assoc Prof. Nader Azizi<sup>1</sup>, Prof Thomas Archibald<sup>1</sup>

<sup>1</sup>University Of Edinburgh

Parallel Session 7 - Optimisation under Uncertainty, OC1.01, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*Dung is currently a PhD candidate in Management Science and Business Economics at the University of Edinburgh. He is particularly interested in Operational Research, especially prescriptive analytics with mathematical programming and business analytics with heuristics. His research focus lies on the area of logistics and supply chain management, under the uncertainty.*

This research considers the capacitated single assignment hub location problems with profit oriented objective and demand uncertainty. Motivated by the strategic importance of network management, especially in freight delivery, the problem is first formulated as a two-stage stochastic programming model in which price is exogenous. The model is further extended by introducing price variables and price-dependent demand to investigate the joint effects of pricing, location and allocation decisions on profit within a hub and spoke paradigm. We propose both exact and heuristics solutions to solve the instances of AP data set, then present and discuss the results from computational experiments.

# Ranking robustness in multiplicative pairwise comparisons

Dr Jiri Mazurek<sup>1</sup>

<sup>1</sup>Silesian University In Opava, Czech Republic

Parallel Session 7 - Optimisation under Uncertainty, OC1.01, September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

Jiri Mazurek was born in 1974. He received the B.S. and M.S. degrees in physics from the Faculty of Mathematics and Physics, Charles University, Prague, and the Ph.D. degree in theory of education in physics from the Faculty of Science, University of Ostrava, in 2009. Since 2009, he has been an Assistant Professor with the School of Business Administration in Karvina, Silesian University, Opava, Czech Republic. His research focuses mainly on decision theory and the pairwise comparisons methods in particular.

The author published papers on the topic in top journals in the field of Operations Research such as European Journal of Operational Research or Journal of the Operational Research Society. In total, the author published over 100 papers and has more than 400 citations at Google Scholar.

Pairwise comparisons constitute a fundamental part of many multiple-criteria methods such as the analytic hierarchy process (AHP), where the goal is to find a ranking of compared objects called alternatives with respect to a given set of criteria. Though pairwise comparisons methods are rather sophisticated, what they lack is a post-hoc analysis of the robustness of acquired outcomes. Human judgments, such as pairwise comparisons, are seldom fully consistent or accurate, and even very small errors in judgments can distort the results significantly. Therefore, the aim of the paper is to introduce a new measure of ranking robustness called the delta-robustness in the multiplicative pairwise comparisons framework. The delta-robustness is defined as a smallest error in one element of a pairwise comparisons (PC) matrix such that the original PC matrix and the PC matrix with the delta-error produce a different ranking of compared objects. The application of the delta-robustness approach is illustrated on numerical examples and real-world studies.

# POST-PANDEMIC ADVANCES IN TEACHING AND LEARNING OR AND ANALYTICS

## Designing Business Analytics Programmes: A Critical Reflection

Dr Matthew Higgs<sup>1</sup>

<sup>1</sup>University of Bristol

Parallel Session 6 - Post-pandemic advances in teaching and learning OR and Analytics, OC1.08, September 15, 2022, 11:00 AM - 12:30 PM

### ***Biography:***

*Matthew is a Lecture in Business Analytics in School of Management at the University of Bristol. Previously, Matthew worked as a Lecturer at Northumbria University, Head of Product in the Peterson and Control Union group, Data Scientist at The Data Lab Innovation Center, and a Post Doctorate researcher at the University of Glasgow, after receiving his PhD in Computational Statistics and Machine Learning from UCL.*

I reflect on the design of Business Analytics programmes at the University of Bristol. I consider the contextual influences and related needs for such programmes as well as their vision and values, curriculum models, aims and outcomes, organisation and structure, learning and assessment strategies, and the implications for unit design. Through conscious examination of such influences and constraints, and the resulting choices we and others have made, I hope to surface learning from the experience to inform future iterations of our programme; encourage a wider discussion of ideas, experiences, and opinions on the design of Business Analytics programmes; and challenge the status quo.



# Gamification in Teaching for Deep Learning

Dr Nicholas Dacre<sup>1</sup>

<sup>1</sup>University Of Southampton

Parallel Session 6 - Post-pandemic advances in teaching and learning OR and Analytics, OC1.08, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Nicholas Dacre is an Associate Professor of Project Management, a leading 'ITS Complex' scholar, DAR's Director of the Advanced Project Management Research Centre (APROM) at the University of Southampton Business School, is a Fellow of the Chartered Association for Project Management (FAPM), and Vice Chair of the British Academy of Management Project Management Special Interest Group. With over 20 years of executive experience spanning academia and industry, Nicholas has developed a significant track record of developing high-impact research by actively collaborating with international partners, industry experts, and the UK government on emergent 'ITS Complex' research topics, focused on Innovation, Technology, and Sustainability in Complex Projects. As a passionate transformative academic and a Senior Fellow of the Higher Education Academy (SFHEA), Nicholas Dacre has also received multiple awards for his innovative approach to teaching and learning by delivering highly engaging project management sessions, in order to provide the skills, knowledge, and expertise required for future project professionals.*

Engaging students and sustaining stimulating creativity in the classroom through practice-based learning can be challenging, but can also be highly rewarding for both students and the wider academic community. In this session I will illustrate and present how elements of gamification, serious games, and lego serious play have been successfully applied with a one of the largest and diverse cohorts of final year undergraduate project management students facing unique future career aspiration challenges.

Final year students tend to be acutely focused on their upcoming transition from academia to industry, and therefore it is vitally important that Universities and academics offer the framework and eco-system to support engaging, meaningful, and creative problem solving, decision making, team working, and communication skills that permeate across different disciplines, for their future careers. Nonetheless this session is also applicable to a wide range of higher education settings, individual students, and academics wishing to embrace highly dynamic approaches to teaching and learning.

The concepts of gamification, serious games, and lego serious play, will be compared and contrasted with emergent digital technologies such as VR, AR, and Digital Whiteboards in order to examine and understand their application in an increasingly digital world.

The session will conclude with a period of self-reflection in order to illustrate some of the benefits and challenges in gamifying elements of teaching and learning, and will encourage participants to share their experiences, and challenges towards building momentum in introducing and implementing some of these across different modules, programmes, and disciplines.

# Co-designing Data Analytics Courses with Industry Partners

Dr Ali Owrak<sup>1</sup>, Dr Chris Smith<sup>1</sup>

<sup>1</sup>The University of Manchester

Parallel Session 7 - Post-pandemic advances in teaching and learning OR and Analytics, OC1.08, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*Dr Ali Owrak is a Senior Lecturer in Service Systems and Digital Business at Alliance Manchester Business School. Dr Owrak holds a PhD in Computer Science from The University of Manchester. His research interests focus on digital transformation for organisations and how they can bring digital technologies and platforms to improve decision making at an organisational level. Dr Owrak leads several major collaborative partnerships with multinational IT service providers in digital transformation on behalf of Alliance Manchester Business School. Ali was recently awarded the University of Manchester teaching award for Educational Leadership and Inclusive Education.*

At the Alliance Manchester Business School, we have redeveloped our IT Management for Business UG programme with student and industry as partners to modernise content, mode of delivery and assessment. We have developed three core course units sponsored by industry partners who provide real world problems and data to give students insight into a career in data analysts. Moreover, we have developed two integrated core course units which bring together core learning outcomes from analytics, and integrate these with other core units, which include, business analysis, software development, digital strategy, UX design. Assessment for these course units now includes a group competition delivered at our bi-annual industry showcase where our partners from industry provide support and feedback that aims to develop our students.

Teaching data analytics at its heart is about developing students who solve problems through an analytical and structured process. Course units teaching data analytics traditionally lend themselves to programmes where the need to understand technical content is aligned with the expectations of the participants that it is intended for. However, data analytics content is increasingly included in a variety of university disciplines/programmes where the intended recipient does not always have the technical background to digest the content. Our engagement was to understand the role of industry as a partner in curriculum design with focus on how this engagement could enrich pedagogies applied to the delivery of technical course units and programmes.

Key findings considered the:

1. Motivations for faculty and employers engaging in partnership;
2. Pedagogical case for partnership in curriculum design;
3. Strategic and sustainable practices of engaging employers as partners delivery of Data Analytics to Management School students;
4. Development of a partnership learning community to guide and sustain practice in curriculum design and delivery; and
5. Challenges brought about by such a partnership.

# Employability and student engagement: the case of the “Advanced Management Science” unit

Dr Marios Dominikos Kremantzis<sup>1</sup>

<sup>1</sup>*School of Management, University of Bristol*

Parallel Session 7 - Post-pandemic advances in teaching and learning OR and Analytics, OC1.08, September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

Marios Kremantzis is a Lecturer in Business Analytics at the University of Bristol. In addition to his current position, Marios is a doctoral researcher (viva passed) in Management Science at the University of Southampton. He also holds an MSc in Business Analytics (University of Lancaster) and a BSc in Business Administration (University of Macedonia).

Marios’ research interests lie in the fields of Data Envelopment Analysis (DEA), efficiency measurement, and multi-criteria decision analysis. He has substantial experience in building and applying mathematical programming models to solve real-world problems and make well-argued decisions. He is also competent to evaluate the performance of production and operations systems with network structures under the DEA technique. Thanks to various cross-disciplinary research collaborations, his work has already been published in Expert Systems with Applications and in RAIRO-Operations Research. He has been a referee for a number of prestigious journals such as the Journal of the Operational Research Society and the OR Spectrum. He has also chaired a session for the internationally renowned conference of the Operational Research Society (OR63). During his doctoral studies, he received funding from the EPSRC and the BAE Systems, and he has taken part in internationally renowned conferences in the UK, Greece and South Korea. He is currently acting as the Lead Guest Editor of the special issue titled “Fairness in the evaluation and ranking of DMUs within network DEA structures” in Mathematical Modelling and Applications.

Marios is also a member of the Operational Research Society and a Fellow of the Higher Education Academy (FHEA). He has been nominated for 2022’s Bristol Teaching Awards in the categories: “Inspiring and Innovative Teaching Award – Individual” and “Outstanding Personal Tutoring Award – Individual”.

In recent years, it has been identified that stakeholders and industry put more pressure on the higher education institutions towards ensuring the student’s development to enhance their employability skills. Employability has received increasing attention from higher institutions due to globalization, government regulations, depreciation of university qualifications, and deficiency of skills. It has been highlighted that universities mostly equip their graduates with disciplinary-oriented knowledge, leading to the employers’ disappointment regarding students’ lacking several soft skills such as teamworking and self-learning. The purpose of this presentation is to explore how the employability and work readiness concepts contribute to the upgrade of the higher education environment and in turn to the support of sustained learning and the improvement of student engagement. To this end, the author intends to reflect upon their current and future teaching and learning practices (e.g., design teaching curricula, support learners, design and use assessment & feedback approaches) related to the elective unit, "Advanced Management Science", offered to third-year undergraduate business and economics students at University of Bristol School of Management.

## REINFORCEMENT LEARNING

### An introduction to Thompson Sampling for dynamic pricing of quality differentiated products

Miss Kaidi Shi<sup>1,2</sup>, Dr Huan Yu<sup>1,2</sup>, Dr Toni Martinez-Sykora<sup>1,2</sup>

<sup>1</sup>Department of Decision Analytics and Risk, Southampton Business School, University of Southampton, <sup>2</sup>Centre for Operational Research, Management Sciences and Information Systems (CORMSIS), University of Southampton

Parallel Session 5 - Reinforcement Learning, OC1.03, September 15, 2022, 9:00 AM - 10:30 AM

#### ***Biography:***

*A PhD student from the University of Southampton, whose research interests are in reinforcement learning and revenue management.*

Motivated by some online grocery platforms, we consider the problem of dynamic pricing, in a multi-armed bandit model, for a retailer who sells substitute products with differentiated qualities. In this environment, the customers arrive sequentially and make purchasing decisions following a Multinomial Logit (MNL) choice model. The parameters of the choice model are not known a priori but can be learned through interactions with customers. We dynamically set the selling price to maximise the expected total revenue over a finite selling horizon. We are based on the Thompson Sampling framework to balance the trade-off between individual demand learning and revenue and evaluate the performance of the algorithm using regret. We prove that our algorithm is efficient in learning the model parameters, and our numerical results show that Thompson sampling performs well compared with the benchmark model which knows the parameters in advance.

# A Inverse Reinforcement Learning Approach to Weaning of Mechanical Ventilation in Intensive Care Units

Dr Huan Yu<sup>1,2</sup>

<sup>1</sup>Department of Decision Analytics and Risk, Southampton Business School, University Of Southampton, <sup>2</sup>Centre for Operational Research, Management Sciences and Information Systems (CORMSIS), University of Southampton

Parallel Session 5 - Reinforcement Learning, OC1.03, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Huan joined the Southampton Business School as a Lecturer in September 2019. Before Huan joined the University of Southampton, she completed her PhD in Management Science and Engineering from the School of Management at the University of Science and Technology of China in May 2019. During her PhD, she was also a Visiting Researcher at IESEG School of Management in 2014-2016 and National University of Singapore in 2018.*

Weaning patients from mechanical ventilators is a critical decision in intensive care units (ICUs). In this study, we aim to develop a reinforcement learning-based weaning decision support tool to improve the extubating decision for ventilated patients. We use inverse reinforcement learning to extract the reward function from the real medical data and compare the results with the current policy given by clinicians.

# RELIABILITY AND APPLIED STOCHASTIC PROCESSES

## Keynote: Performance Centred Maintenance

Prof Tim Bedford<sup>1</sup>

<sup>1</sup>University of Strathclyde

Parallel Session 1 - Reliability and Applied Stochastic Processes Incl. KEYNOTE: Prof Tim Bedford, OC1.08,  
September 13, 2022, 11:00 AM - 12:30 PM

### *Biography:*

*Professor Tim Bedford works in Risk Analysis and Decision Making at the University of Strathclyde and is also Associate Principal for Research and Innovation at the University. He is a Fellow of the Safety and Reliability Society and also of the Royal Society of Edinburgh.*

Performance Centred maintenance (PCM) was introduced in [1] in order to enable us to model situations where there is a dynamic interplay between operating decisions and maintenance decisions. Operating decisions include ones where the short term need for higher production can include operating in a way that delivers higher production at the cost of increased deterioration rates. This would bring forward the need for additional types of mitigating maintenance actions. Hence there is a need to model how different operating decisions for production impact on requirements for maintenance actions. As maintenance actions normally require at least a reduction of production and often a temporary stop to production, it is clear that optimisation requires a good understanding between production and maintenance decision-makers.

In this talk we shall discuss the key elements of the theoretical approach used in [1], including the distinction between operating and degradation states and the way that production value and maintenance cost vary through time. The specific example used in the paper was from the electricity sector where the price of energy can vary considerably from hour to hour depending on supply and demand, and the cost of not meeting obligations has to be met. However, we discuss other examples in which the PCM approach is relevant, and we compare the framework to more conventional maintenance modelling approaches to consider when this type of approach gives value to decision makers.

[1] E.Barlow, T.Bedford, M.Revie, J.Tan L.Walls "A performance-centred approach to optimising maintenance of complex systems", European Journal of Operational Research, 292, 2021, p 579-595

# Life Cycle Cost Optimisation of Industrial Equipment

Prof Yuchun Xu<sup>1</sup>

<sup>1</sup>Aston University

Parallel Session 2 -Reliability and Applied Stochastic Processes, OC1.08, September 13, 2022, 1:30 PM - 3:00 PM

## ***Biography:***

*Prof Yuchun Xu is Chair in Manufacturing, leader of Smart and Sustainable Manufacturing group at Aston University. His research lies in the areas of Smart Manufacturing, Life Cycle Engineering, and Circular Economy.*

Industrial equipment is an important element of manufacturing process, and they are subject to failure and deterioration due to the effect of wearing and fatigue etc. There is a need to adopt effective maintenance planning to keep equipment well-functioning so that they can produce high-quality products continuously. At the same time, manufacturers are continuously trying to reduce the cost including production and maintenance cost.

This talk will introduce an on-going work on developing a digital technology based framework for life cycle cost (LCC) optimisation of industrial equipment. The framework includes multiple models to obtain optimised maintenance schedules for the industrial equipment with minimum life cycle cost, including a reliability model to continuously rate the deterioration of the equipment; a cost model that estimates the cost of different types of maintenance strategies; a model of constraints that considers budget limits, minimum acceptable reliability on both component and equipment levels, and expected improvement in equipment reliability; and an optimisation model that uses Genetic Algorithm (GA) to generate numerous maintenance plans and select the best one that minimise the LCC and maximise the reliability of the equipment. An Excel-based VBA tool has been developed to implement the proposed framework.

# Genetic Programming Hyper-heuristic for Evolving a Maintenance Policy for Wind Farms Considering Wind Condition and Inventory Policy

Miss Yikai Ma<sup>1</sup>, Dr Wenjuan Zhang<sup>1</sup>, Prof Juergen Branke<sup>1</sup>

<sup>1</sup>Warwick Business School, University of Warwick

Parallel Session 2 -Reliability and Applied Stochastic Processes, OC1.08, September 13, 2022, 1:30 PM - 3:00 PM

## *Biography:*

Yikai Ma is a final year PhD student from the Operations group, Warwick Business School, University of Warwick.

*Before coming to Warwick, she earned MSc from the University of London (UCL), majoring in Statistics in 2017, and a BSc from the University of Liverpool, majoring in Mathematics with Finance in 2016. Her research interests span the fields of multi-objective optimisation, hyper-heuristics and maintenance schedule. Her current research mainly focuses on the application area, the optimal maintenance strategy for wind farms.*

Reducing the cost of operating and maintaining wind farms is essential for the economic viability of this renewable energy source. This study applies hyper-heuristics to design a maintenance policy that prescribes the best maintenance action in every possible situation and minimises the overall cost, which includes maintenance cost, inventory cost of spare parts and the cost of production loss. Genetic programming is used to construct a priority function that determines what maintenance activities to conduct and the sequence of maintenance activities if there are not enough resources to do them simultaneously.

The priority function may consider the health condition of the target turbine and its components, the characteristics of the corresponding maintenance work, the workload of the maintenance crew, the working condition of the whole wind farm, the possibilities provided by opportunistic maintenance, the wind speed during maintenance and the current spare parts inventory level. The wind speed and inventory level both restrict the maintenance activities. At the same time, considering wind also provides opportunities for maintenance activities. In this study, the importance of each attribute is fully considered and demonstrated, especially for wind speed and inventory level of spare parts.

Empirical results using a simulation model of the wind farm demonstrate that the proposed model can construct maintenance policies that perform well in training and test scenarios, which show the practicability of the approach. Furthermore, the proposed maintenance policy offers significant advantages compared with previous strategies.



# A methodology for data-driven preventive maintenance planning

Prof Sanja Petrovic<sup>1</sup>, Dr Thalita Obal, Prof Marjorie Bellinello, Huixuan Qiu, Dr Gilberto Martha de Souza

<sup>1</sup>Nottingham University Business School

Parallel Session 5 - Reliability and Applied Stochastic Processes, OCO.05, September 15, 2022, 9:00 AM - 10:30 AM

## *Biography:*

Sanja Petrovic has conducted and led multi-disciplinary research into development of models, heuristics and algorithms for a variety of real world optimisation and scheduling problems, including radiotherapy planning, scheduling of radiotherapy patients, nurse rostering, production scheduling, and university timetabling. Her research areas include the theory and practice of case-based reasoning, multicriteria decision making, modelling of uncertainty by using fuzzy sets and fuzzy logic, optimisation methods and meta-heuristics, and multi-agent systems. Prof Petrovic has been the principal investigator on 3 projects funded by Engineering and Physical Sciences Research Council (EPSRC) that deal with real-world scheduling and planning problems and principal investigator in Nottingham on a project funded by Technology Strategy Board. She has been also a co-investigator on 12 other externally funded grants. Sanja was a Vice-president of the UK Operational Research Society in two terms (2013-2018), Chair of the Committee of Professors of Operational Research in the UK COPIOR, 2018-2021, and a Co-ordinator of the EURO (European Association of Operational Research Societies) Working group on Automated Timetabling (WATT) since 2006. She was Chair of the OR53, UK Operational Research conference, Nottingham, September 6-8, 2011

More details at <https://www.nottingham.ac.uk/business/people/pszsxp.html>

The failures occurrences in machinery and equipment of a food production process have serious impact on the product quality. Non-availability of the machine and loss of quality increases the cost of the food production cycle, directly affecting the competitiveness of the company. Consequently, it is essential to establish the appropriate maintenance strategy for the food industries to increase the reliability and safety level of their machines with a reasonable cost. We collaborate with a food company in Brazil, who provided us with failure records and the corresponding maintenance activities together with the incurred cost collected in a 5-year period. A k-means algorithm is used to group historical failure records with similar characteristics of failures. The created clusters are ranked by the multicriteria decision making method TOPSIS combined with Critical Method, which uses the inter-criteria correlation to calculate the criteria importance. Criteria used in ranking express the availability of the machine, the time to failure (TTR), the cost incurred by the maintenance activities that were performed to rectify the corresponding failures and the estimated loss of profit during the time the machine is switched off. The ranking makes a trade-off between the availability and TTR and the company profitability. The engineer uses the rank of clusters to prioritise maintenance activities and construct a preventive maintenance plan starting with the cluster with the highest criticality. All the failures are also ranked by TOPSIS to validate the clustering. The results obtained on the available data records are analysed and discussed in collaboration with the engineer.

# Data-driven production management under random yield

Miss GUO SHI<sup>1</sup>, Dr Bin Liu<sup>1</sup>, Professor Lesley Walls<sup>1</sup>

<sup>1</sup>University Of Strathclyde

Parallel Session 5 - Reliability and Applied Stochastic Processes, OCO.05, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Guo Shi is a first-year Ph.D. student from the Management Science Department, University of Strathclyde. Before that, she obtained a Master's degree from Shanghai Jiao Tong University in China. Currently, her research interests include intelligent maintenance management, decision models, and machine learning algorithm.*

We focus on the multiperiod production management problem with random yield in a data-driven setting. In this problem, the manufacturer's objective is to maximize its total expected profit during the multiperiod by deciding the optimal quantity to produce at each period. Existing research implicitly assumes that the yield rate follows a given distribution, e.g., uniform distribution. It is the so-called full information problem with an accurate distribution function. However, in practice, the true distribution function of yield rate is difficult to obtain. In addition, the yield rate is highly related to the quantity to produce. To leverage the history yield rate data that is relatively easy to collect, we propose a data-driven algorithm to approximate the real function between the production quantity and yield rate. The true yield rate function can be represented by non-negative combinations of potential functions in a hypothesis set according to the least square error approach. With the approximated yield function, the production quantity for each period can be decided by using myopic heuristic methods, which aim to maximize single-period profit first and then solve the dynamic programming recursively using backward induction for multiple periods. We will theoretically investigate the sample complexity bound for each period in the proposed data-driven approximation for the yield rate function. Through a numerical study, the effectiveness of the approach will be illustrated by comparison with existing approaches and the benchmark full-information policy.

# Reliable Fault Diagnosis with Uncertainty Quantification through Evidential VGG Neural Networks

Ms HANTING ZHOU<sup>1,2</sup>, Mr Huiming Sun<sup>1,2</sup>, Dr Min Xia<sup>2</sup>

<sup>1</sup>Nanjing University of Science and Technology, <sup>2</sup>Lancaster University

Parallel Session 5 - Reliability and Applied Stochastic Processes, OCO.05, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*I am currently as a visiting Phd student at the Engineering, Lancaster University with the guidance of Dr. Xia. At the same time, I am a PhD student at Nanjing University of Science and Technology, China. I have received B.S. degree (2016) and M.S. degree (2019) from China Jiliang University, China. My research interests include smart manufacturing, signal processing, machine diagnosis and prognostics, and trustworthy AI.*

In the open-world scenarios, deterministic neural networks can provide the accurate prediction results, but unreliable due to the occurrence of new classes and model inference errors. How can we trust the output of the neural networks? Uncertainty quantification (UQ) plays an important role in preventing the overconfident behaviour and providing reliable fault diagnosis results. In this paper, we develop an evidential VGG (EVGG) method integrated with evidence theory and an improved convolutional neural network. This approach allows a minimal modification of the state-of-the-art neural network by using a novel evidence loss function and applying a Dirichlet distribution to the class probabilities. The testing samples that are the out-of-distribution (OOD) to the training samples can be detected with the uncertainty value of the prediction. The proposed method is verified by using fault diagnosis datasets and is suitable for open set recognition. The experimental results show that the proposed EVGG model achieves good performance for the known classes and can detect unknown samples with high uncertainty values. Then, with the unknown testing samples, the parameters of the EVGG model can be adaptively optimized and reduce the model uncertainty. The proposed method indicates pivotal potential in detecting OOD samples from new classes and provides trustworthy prediction results in practical environments.

## RETAIL OPTIMISATION

### Improving Quality of Service with HEADS (Highways England Automatic Diversion System)

Miss Louise Kirkham<sup>1</sup>

<sup>1</sup>Datasparq

Parallel Session 5 - Retail optimisation, OC1.02, September 15, 2022, 9:00 AM - 10:30 AM

***Biography:***

*Started as a research scientist at MOD research lab DSTL; moved into AI as a data scientist at Royal Mail; more recently joined Datasparq as an AI engineer, helping clients use AI and data to things faster, cheaper and smarter.*

Overnight roadworks undertaken by Highways England in the past seven years as part of their Road Investment Strategies I and II have caused major disruption to Royal Mail's backbone network. To mitigate their effect on quality of service, a system was built that learns from all the previous journeys undertaken by HGVs in order to recommend the quickest safe route around any set of arbitrary closures on a daily basis.

# A resource optimisation tool for resource planning at a sorting centre of a major postal provider

Dr Judit Guimera Busquets<sup>1</sup>, Dr Jeremy Bradley<sup>1</sup>

<sup>1</sup>Datasparq

Parallel Session 5 - Retail optimisation, OC1.02, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Judit graduated in Aeronautical/Air Transport Engineering in 2013 at City, University of London, where later on she pursued her PhD studies. Her research focused in developing a modelling framework that looked at city-pair generation, route demand assignment and air traffic estimation, while taking into account network evolution. Judit has worked for Virgin Atlantic and Royal Mail in the past and is now a Senior Data Scientist at Datasparq. As a data scientist she has contributed to the development and continuous improvement of predictive models for classification, customer segmentation as well as schedule optimisation problems.*

Resource planning is a vital aspect of any logistics company and has a direct impact on the performance of the company, which tends to depend on successful on-time deliveries. Over-resourcing will lead to an excellent delivery performance but comes at a financial cost if the resources are not optimally utilised. Under-resourcing will lead to a poor performance which might in turn drive losses through, for example, government fines and also, and more importantly, on the reputation of the company itself and future business. None of these situations is ideal, especially in times where there are many uncertainties, such as employee absences and fluctuations in demand amongst others. Coupling the high uncertainty with the complexity of the problem makes resource planning a difficult and lengthy process that management teams need to go through.

With the objective of optimally utilising the resources available, we have worked with a major postal provider to discover more efficient ways to optimise the resources in their sorting centres. We have built a tool that can generate a resource schedule of the number of people that are needed at each time of the day and area of the centre based on a forecast of the volumes that are expected to go through. The complexity of such a problem scales up when the problem is not only observed at the granular level of time of day and location but also needs to meet a certain level of smoothness at the aggregate level, i.e. fluctuations of total number of resources over time must be minimised. We present the concept of a resource optimisation tool that takes into account the forecasted volumes, the leftover volumes and the smoothness at the aggregate level.

# Riding the wave(s): improved delivery scheduling with 3-stage metaheuristic search

Mr Jack Solomon<sup>1</sup>

<sup>1</sup>Imperial College London

Parallel Session 5 - Retail optimisation, OC1.02, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Jack Solomon is an MSc Computing student at Imperial College London. He is currently working on a metaheuristic optimisation problem using ALNS under Professor William Knottenbelt (Imperial) and Jeremy Bradley (Datasparq, ex Imperial). He previously completed a BA Philosophy, Politics, Economics at the University of Oxford.*

Creating delivery schedules is a notoriously difficult problem facing logistics, fulfilment, and even consumer companies. For most commercial applications, there exist trillions of ways of matching drivers, routes, and deliveries - far too many to test individually. It is also an increasingly competitive and high-stakes problem. Each extra mile or minute that a schedule requires comes with significant financial, environmental, and regulatory costs.

For over two decades, various metaheuristic approaches have been developed to address this problem. In particular, many flavours of a metaheuristic approach called Large Neighbourhood Search (and, more recently, Adaptive LNS) have been employed commercially with quite some success.

In this talk, I will do three things. First, I will give some background to these existing metaheuristic approaches to the delivery problem; and I will show why they are inconsistent across data sets and suboptimal in their solutions. Second, I will describe a novel 3-stage approach to metaheuristic search, which introduces an infeasible search and then infeasible repair stage. This approach, as I'll show, can be cleanly 'retrofitted' to many existing metaheuristic scheduling algorithms. Finally, I'll show how this approach works by escaping the all too familiar local extrema trap to achieve upwards of a 2% improvement on an existing LNS/ALNS implementation.

# Storage Location Assignment with Varying Demand Patterns: An E-Grocery Retailing Business Case

Mr David Winkelmann<sup>1</sup>, Mr Michael Römer<sup>1</sup>

<sup>1</sup>Bielefeld University

Parallel Session 7 - Retail optimisation, OC1.02, September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

I am working on my PhD considering the combination of OR and Data Science in economic issues. My research focuses on logistics operations and business applications. Currently, we are working on an inventory management optimisation project for e-grocery retailing. Additionally, we consider heuristic and optimal solution approaches for the article placements in a picking-loop. Third, vehicle routing problems with stochastic capacity constraints are part of my current research.

Furthermore, I am interested in sports economics. When considering the (in)efficiency of betting markets in top European football, we recently published an article on the impact of the Covid pandemic on these markets. In current projects we also focus on a more psychological and *behavioural perspective by discussing the presence of a hot hand effect, namely persistence of underlying short-term abilities, in various sports.*

E-grocery retailing enables customers to order goods online while the retailer delivers the purchase within a determined time slot. At the same time, retailers are faced with the additional fulfilment processes picking and delivery. To satisfy a convincing service at low costs within a competitive market environment, a key challenge for retailers is the strategic decision of allocating stock keeping units (SKUs) to storages within their distribution warehouses. While a re-allocation is cost-intensive, depending on the assortment of the retailer, the allocation have to meet several requirements, e.g. SKUs with a high weight have to be assigned to early stations. To avoid congestion and delay leading to a dissatisfying service for customers, the allocation should address a balanced demand across stations within the warehouse. However, a balanced demand is not only required on average but for each individual day taking into account seasonality as well as within-week variation in demand. Using real-world data provided by a European e-grocery retailer, we use MIP-based approaches to optimise the SKU assignment for the business case under consideration.

# Anticipating and mitigating pick line hotspots in the food services industry

Dr Kiko Rul-Ian<sup>1</sup>, Dr Jeremy Bradley<sup>1</sup>

<sup>1</sup>Datasparq

Parallel Session 7 - Retail optimisation, OC1.02, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*Kiko is a Senior Data Scientist at Datasparq. He works on metaheuristic optimisation of vehicle routing and planning, dynamic pricing and statistical learning with industrial applications. He completed his PhD in Medical Imaging at Centre for Medical Imaging Computing at UCL. While at UCL he was Vice president at UCL's Consulting Society. At Datasparq, he co-created the interactive ML visualisation platform PlayML.*

In the food industry, increasingly meals are being prepared with ingredients pre-picked and packed for the consumer. These manufacturing or pick lines required people to service boxes as they move down a conveyor belt. As with any manufacturing line, the component being assembled has to visit various stations where the ingredients are added as needed. We present a queueing driven approach to get a high level map of such a production line and anticipate for given demand levels where hot spots in the production process might emerge and at what level of demand. We will also talk about possible mitigations and design changes that this might require to permit a more scalable process line.



# A Unified Analysis for Assortment Planning with Marginal Distributions

Dr Xiaobo Li<sup>1</sup>

<sup>1</sup>National University of Singapore

Parallel Session 7 - Retail optimisation, OC1.02, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*I am an assistant professor in the Department of Industrial Systems Engineering and Management at National University of Singapore. I received my Ph.D. in Industrial Engineering from the University of Minnesota in 2018. My research mainly focuses on online learning and robust optimization, with applications in revenue management, supply chain management, transportation planning and sharing economy.*

We study assortment problems under the marginal distribution model (MDM), a semiparametric choice model that only requires marginal error information without assuming independence. We characterize the marginal distributions under which a profit-nested assortment is optimal. Moreover, we prove that the best profit-nested assortment is a 1/2-approximate solution for all MDM. These results either generalize or improve existing results on the assortment optimization under the multinomial logit (MNL) model, multiple-discrete-choice (MDC) model, and the threshold utility model (TUM). Lastly, we focus on the marginal exponential model (MEM) as an alternative to capture heteroscedasticity. Our results in this case yield significant computational advantages compared to other choice models that are also designed to capture heteroscedasticity, including Heteroscedastic Extreme Value (HEV) choice model and Heteroscedastic Exponential Choice (HEC) model. Our numerical studies using synthetic and real-world data sets show that MEM provides a competitive predictive and prescriptive performance in capturing heteroscedasticity despite its simple and parsimonious structure.

## REVENUE MANAGEMENT AND PRICING

### Choice-based availability controls for urban carsharing revenue management

Miss Richlove Frimpong, Dr Dong Li, Professor Jiyin Liu, Dr Wendy Jiao

<sup>1</sup>Loughborough University

Parallel Session 2 -Revenue Management and Pricing, OC1.01, September 13, 2022, 1:30 PM - 3:00 PM

#### *Biography:*

Richlove Frimpong is a 3rd year doctoral researcher in the Operations and Management Science discipline group in the Loughborough University School of Business and Economics.

She holds an Msc in Operations Research and Management Science from Lancaster University and a BSc in Electrical/Electronics Engineering from Kwame Nkrumah University of Science and Technology. She also has two years working experience in Vodafone Ghana, first as a Graduate Management Trainee and later as a financial analyst.

Her PhD focuses on the development of revenue management models and algorithms for the carsharing industry. She is supervised by Dr Dong Li, Professor Jiyin Liu and Dr Wendy Jiao.

Urban carsharing schemes provide flexible, affordable and green mobility services where customers can pick up a car from one station and return it to the same station (round trip) or any other station in the car-sharing network (one-way). While one-way car-sharing service offers a higher degree of mobility flexibility to customers, it may cause operational challenges such as fleet unbalance between multiple rental outlets and increased management costs. Due to this, carsharing operators employ various vehicle relocation techniques to ensure the availability of sufficient vehicles across rental stations.

In this study, we adopt the user-based relocation strategy where customers are offered incentives such as fare discounts to drop off the vehicles in proposed alternative destinations. We estimate a multinomial discrete choice model using collated responses from a discrete choice experiment implemented in a survey. We then formulate a dynamic program model based on this choice model to determine the optimal destination-fare discount combinations to offer which maximizes the total expected revenue given a customer's booking request.

To address the computational complexity of the dynamic program, we approximate it with a deterministic linear program. The effectiveness of the proposed strategy and the performance of the models are tested in a numerical study.

## Postal Platform Pricing with Limited Consumer Attention

Dr Robert Edwards<sup>1</sup>, Dr Christian Bach, Dr Christian Jaag

<sup>1</sup>University Of Nottingham

Parallel Session 2 -Revenue Management and Pricing, OC1.01, September 13, 2022, 1:30 PM - 3:00 PM

### *Biography:*

Robert is an economist, currently appointed as Assistant Professor of Industrial Economics at the University of Nottingham Business School.

Robert's research expertise lies primarily in pricing and competitive strategy. His research is driven by collaboration with external institutions and economic consultancies in areas of firm pricing and competitive strategy.

More broadly, his research interests include Microeconomics, Game Theory, Industrial Economics, Behavioural Economics, Competition Policy and Regulation.

His work has been published in a range of journals including Oxford Economic Papers, Journal of Mathematical Economics and Theory & Decision. He also participates in a range of international conferences and serves on the scientific committee for the Association of Southern European Economic Theorists.

This paper introduces limited consumer attention into a two-sided market model to investigate optimal pricing in the postal mail sector. Two types of mail senders: advertisers and non-advertisers, derive value from the attention paid to their mail. Consumers pay more attention to each mail item when they receive less mail, and pay more attention to advertising mail when they receive more non-advertising mail. We show that a postal monopolist subsidises non-advertising prices to stimulate demand, which increases the value of mail to advertisers, inflating advertising prices. Advertisers that are most nuisance or attention-consuming for consumers face higher prices. Competitive entry for delivering advertising mail cannibalises the advertising mail market and the cross-subsidisation of prices is shut down. However, if the entrant price-matches rather than competes, all postal operators, mail senders and recipients can benefit. Competition amongst postal operators does not necessarily benefit consumers, especially if the entrant is more efficient. Universal Service Obligation policies are not as demanding as traditionally viewed.

# Generalized rank pricing problem in networks

Mr Aaditya Bhardwaj<sup>1</sup>

<sup>1</sup>Lancaster university

Parallel Session 2 -Revenue Management and Pricing, OC1.01, September 13, 2022, 1:30 PM - 3:00 PM

## ***Biography:***

*I am a full-time PhD Student at STOR-i CDT (Centre for Doctoral training) of Lancaster University. STOR-i is not only among the best CDTs established by the Engineering and Physical Science Research Council (UKRI), but it is a world-renowned research centre in the field of Statistics and Operational Research as well. As a part of my research, I am working on a pricing project with TESCO, the largest retail supermarket chain in the United Kingdom, and my PhD supervisors are Christopher Kirkbride and Trivikram Dokka.*

Traditionally, PFS pricing was done on outlet/station level due to its ownership structure. In recent times, the dealership model of distribution has been overtaken by large retail chains, owning many petrol stations over a network. Although it is known that petrol demand is inelastic over a network, traditional methods imbed an inherent bias in demand estimation by ignoring its network structure. In our upcoming paper, we will introduce a network-driven demand estimation, and data-driven pricing model by incorporating different price elasticities, within the network influenced by consumption patterns and the convenience of motorists to mitigate those prediction biases. In doing so, under mild assumptions, we formulated the problem as max revenue Min-Network-Pricing-Problem (MNPP), by connecting it to the developing literature on multiproduct pricing.

To solve MNPP optimally, we devised two mixed integer-programming (MIP) formulations. An extensive empirical study and theoretical results concluded that these formulations can not be trusted for larger instances because of time complexity. We have also shown that the complexity of MNPP problem lies in finding the optimal price ladder (ranking of outlets based on their expensiveness which provides maximum revenue) among outlets, if the price ladder is available then optimal prices can be found in polynomial time by using dynamic programming. Therefore, to solve larger instances, five heuristics have been proposed to learn the underlying price-ladder using LP relaxations, Greedy, and Insertion techniques. An extensive simulation study has shown that these heuristics can produce up to 3% of optimality gap in a fraction of minutes when compared to MIPs. To understand its effectiveness and applicability, a case study in association with a large retail-chain conglomerate is in process.

# SOFT OR AND PROBLEM STRUCTURING METHODS: ADVANCES IN PSM METHODOLOGY

## Exploring an alternative dominant logic within purposeful activity modelling in SSM

Dr Giles Hindle<sup>1</sup>

<sup>1</sup>University of Hull

Parallel Session 1 - Soft OR and Problem Structuring Methods: Advances in PSM methodology, OC0.01, September 13, 2022, 11:00 AM - 12:30 PM

### *Biography:*

Giles is an analyst with research, teaching and consulting experience at the very highest levels. He is particularly interested in data analytics, problem structuring methods, strategic thinking and systems thinking. His action research programme explores the value of analytics and systemic thinking in supporting management decision making, strategic thinking and business management.

Giles is a member of the General Council of the Operational Research Society, Centre for Systems Studies at Hull University Business School and a Senior Teaching Fellow at Warwick Business School. Previous posts include Associate Director at Health Consultancy Services Ltd, Assistant Professor at Warwick Business School, Senior Data Analyst for Tribal plc and Business Consultant at The institute for Entrepreneurship and Enterprise Development, Lancaster University.

Research interests include analytics, strategic thinking, applied systems thinking, business modelling, service system innovation, executive coaching and complex problem solving. Giles has led consultancy and research projects for a wide range of clients including the RCUK-funded NEMODE project, NHS Scottish Executive, County Councils Network, Secta Health Group, Countryside Agency, Department for Transport, Department for Health in N. Ireland, Birdseye, Network Rail, Tornado Wire Ltd, Northern Hi-Tec Ltd, and many others.

*Giles provides mentoring and training to government analysts, is an award winning teacher on the Warwick Executive and Online MBAs. He has taught strategic thinking and data analytics on the Hull, Warwick and Lancaster MBA programmes and has developed masters programmes in Business Analytics at Hull and Warwick universities.*

SSM uses purposeful activity models within element two of the methodology (Checkland and Poulter, 2006). Originally, this modelling was based upon a concept named a 'human activity system', which drew upon systems ideas from Jenkins (Jenkins 1969) and Churchman (Churchman 1971). Over time Checkland changed the name of the systems concept to a 'purposeful activity system' and prefers to talk about purposeful activity models in the latest descriptions of SSM. However, the basic nature of the systems modelling has remained largely the same – to construct a logical systems model of purposeful activity from a declared worldview. This presentation examines the utility of the notion of purpose within the purposeful activity system concept. Checkland argues purposeful activity can always be described as a transformation process – one in which some entity is transformed into a different state. But this schema may not be the most appropriate for some modelling referents, especially when viewed through a particular theory of business. For example, a purposeful activity system operating under a service dominant logic (Vargo and Lusch, 2004).

# Rich Notes: A technique for supporting problem structuring sessions online

Mr Karthik Suresh<sup>1</sup>

<sup>1</sup>University of Hull

Parallel Session 1 - Soft OR and Problem Structuring Methods: Advances in PSM methodology, OC0.01,  
September 13, 2022, 11:00 AM - 12:30 PM

## *Biography:*

Karthik Suresh is a Management Consultant who helps customers with energy, utility, sustainability, research, innovation and knowledge management projects. His experience includes working with large and small organisations to select and implement strategic decision systems, improve and develop management capability and deploy risk management, IT, communications and information systems projects.

Problem structuring methods such as Soft Systems Methodology (SSM) and Strategic Options Development and Analysis (SODA) have developed techniques to collect data and engage stakeholders when initiating an engagement with clients, such as Rich Pictures and Cognitive / Group Causal Maps. SSM has traditionally been carried out in person while SODA has used computer software packages, both with in-person sessions and, more recently, with the use of online multi user software. Rich Notes are a novel approach to initial engagement that use Free/Open Source software during video conferencing meetings to facilitate a low-friction, transparent and accessible approach to note taking and problem structuring discussions. Rich Notes have similarities with Rich Pictures and causal mapping while avoiding the imposition of structure or rules early in the discussion process, seeking instead to understand the “story” the client has to tell about the situation. The Rich Notes approach will be illustrated through a demonstration of the tools and approach used in practice.

# A comparative action research study of Initial Client Interactions: A comparison of Rich Pictures and Rich Notes.

Dr Chris Smith<sup>1</sup>, Dr Giles Hindle<sup>2</sup>, Mr Karthik Suresh<sup>2</sup>

<sup>1</sup>University of Manchester, <sup>2</sup>University of Hull

Parallel Session 1 - Soft OR and Problem Structuring Methods: Advances in PSM methodology, OC0.01,  
September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Dr Smith is a Senior Lecturer at the University of Manchester who has been researching PSMs and Soft OR for over 10 years.*

This project develops a comparative action research strategy to explore two different qualitative approaches for structuring initial client interactions and project development, Rich Pictures and Rich Notes. Rich Picturing is a well-established approach that was predominantly known as part of the 'Finding Out' element of Soft Systems Methodology. Rich Notes is a novel approach that draws inspiration from Rich Pictures capturing rich textual representations of the initial client meeting by modelling the narrative and mental terrain explored while maintaining the chains of argument. After modelling the initial meeting an action oriented second order analysis of the initial model identifies common ground and actions which is translated in the day-to-day language of the organisation and presented as a project proposal for future work.

The comparative action research study makes meaningful comparisons between the two approaches by considering specific a version of each approach that have been developed over independent long standing action research programmes. The comparison using the Area of concern (A), Methodology (M) and Framework of ideas (F) framework to identify discussion points that are extrapolated to existing PSMs and what this means for wider practice.

The contributions from this paper are 3-fold, first, we present the highly novel Rich Notes approach. Second, we present a new research strategy of comparative action research. Third, we theorise beyond rich notes and rich pictures to consider key learning points about PSMs more generally.

# SOFT OR AND PROBLEM STRUCTURING METHODS

## Keynote Soft OR/PSMs through six decades

Prof Robert G. Dyson<sup>1</sup>

<sup>1</sup>University of Warwick

Parallel Session 2 -Soft OR and Problem Structuring Methods incl. KEYNOTE - Prof. Robert Dyson, OC0.01,  
September 13, 2022, 1:30 PM - 2:30 PM

### *Biography:*

Initially a research mathematician and senior systems technologist at Pilkington Plc (1964-70). Joined the University of Warwick School of Industrial and Business Studies (now Warwick Business School) in 1970 as a lecturer. Chairman of WBS 1978-81 and Dean 1998-2000. Visiting Fellow at Technische Hogeschool Twente, Enschede (1977) and Visiting Professor at the University of Texas, Austin (1982). Pro-Vice Chancellor of the University 1989-95 and 1999-2005. Chair of the Committee of Professors of Operational Research (1995-7) and President of the Operational Research Society (1998 and 99). Elected a Companion of Operational Research (2007). Board Member of the Coventry Partnership (1998-2005). Governor of Kenilworth School 1989-98, Chair of Governors (1993-97) and Chair of Trust (2008-2012). An Editor of the European Journal of Operational Research 2006-2020. Chair, Warwick Retired Staff Association, 2017-. Robert has published in the fields of cutting stock problems, stochastic programming, capital investment appraisal, strategic development, data envelopment analysis problem structuring and performance management.

The talk covers Robert's engagement with soft OR/PSMs through six decades. The first encounter involved an introduction to soft OR at an OR Society meeting at Shell in the 1970s. Also in the 70s a project was carried out at Chat Moss peat bog using qualitative modelling. In the 80s the first version of a course at Warwick on OR and strategy was developed which included both hard and soft methods and the course continues to this day delivered by Frances O'Brien. Over the years three edited texts were published to support the course. In the 90s PSMs were used to support strategy at Warwick at corporate and departmental (business school) levels. Robert was an editor of the European Journal of Operational Research from 2006 – 2020 and was responsible for soft OR/PS submissions. In the late 2010s Robert and Frances developed a paper linking soft OR/PS to 34 founders of OR which was published in the journal Operations Research. The talk ends with a discussion of conclusions and future directions.



# SOFT OR & PROBLEM STRUCTURING METHOD: DESIGN THINKING AND HUMAN EXPERIENCE

## Design thinking in Operational Research

Dr Christina Phillips<sup>1</sup>

<sup>1</sup>Liverpool John Moores University

Parallel Session 3 - Soft OR & Problem Structuring Method: Design thinking and human experience, OC0.01,  
September 13, 2022, 4:30 PM - 6:00 PM

### ***Biography:***

*Christina is a director of the OR Society and co-chair of the Problem Structuring Methods SIG. Her interests span across analytical methods such as forecasting and simulation to soft OR techniques such as SSM and VSM. Her specialism is Human Centric Analytics (HCA), bringing together analytical tools and the humans whose work they are meant to augment in ways which are useable, useful and which gain traction in use.*

Although rarely acknowledged by those who do Operational Research (OR) there are strong links between OR and design. Design regularly nods to these historical and current links but OR is behind the curve. We have much to learn and to gain from understanding how OR links to design and how design can help us in our OR endeavours.

In this talk I will look at the history of design and OR and explore the links. I will draw out the proponents of OR and design and show how this journey is continuing to evolve. I will compare and contrast existing OR methods and design science and design thinking and discuss how these differentiate and where they overlap.

I will also look at recent research that illustrates how design is necessary for us to do OR well and make some first steps in illustrating how we might study and research this subject in the future with an acceptable level of rigour and ways to move theory forward in both OR and design.

## Co-Design – Aspirational Vapourware?

Mr Martin Russell<sup>1</sup>

<sup>1</sup>Fujitsu

Parallel Session 3 - Soft OR & Problem Structuring Method: Design thinking and human experience, OC0.01,  
September 13, 2022, 4:30 PM - 6:00 PM

### ***Biography:***

*Following many years in retail management, Martin joined Fujitsu more than 20 years ago and has enjoyed a variety of roles. More recently, as part of the Global Co-design Programme, he has worked as a Design Lead focussed on designing, managing and delivering hundreds of customer collaborative sessions based on Fujitsu's Design Thinking methodology (HXD – Human Centric Experience Design). This has included working across all sectors with multiple customers, partners and stakeholders to generate tangible solutions to business imperative challenges. Martin has helped develop the approach and more recently has been involved in the generation and delivery of a virtual immersive environment to orchestrate the sessions.*

The digital world thrives on inspiration and innovation. Fujitsu have developed Human Centric Experience Design (FUJITSU HXD) methodology, our unique iteration of design thinking that helps our customers harness the power of collaboration to deliver unique digital transformation by driving ideation. Harnessing decades of experience from Japan and around the world, we have worked with customers, exchanged perspectives, ideas, and information in a highly focused and innovative way, applying the process to real world issues with hundreds of customers.

The approach is based on simple, collaborative engagement. We bring multiple perspectives together using digital technologies. By incorporating Academic relationships (such as the University of Manchester) into our wider ecosystem, our business and our customers benefit. We ask customers to identify their key business decision makers as well as people from across their enterprise to help generate a rich understanding of the strategic needs of the business. At Fujitsu, we think that an inclusive ecosystem is the key to success for our business, and our customers, both now and in the future.

Fujitsu's talented and experienced experts facilitate their collaborative engagement to achieve a dynamic mix of knowledge, creativity, ideation, concept development and create a momentum to build prototypes which can be tested, modified, and turned into proofs-of-business focused on delivering tangible outcomes. It's done at pace to focus people's minds and enables four key things:

- Understanding the business challenge within the context of the business strategy
- Looking at the issues through different lenses
- Combining business, academic and technology expertise to develop rapid outline concepts
- Developing joint working plan for immediate experimentation

Join us to discover the story of how we have arrived where we are, examples of activities we undertake with our customers and some detail around how the methodology has modified over time.

# Problem structuring in OR practice

Prof Mike Yearworth<sup>1</sup>

<sup>1</sup>University of Exeter

Parallel Session 3 - Soft OR & Problem Structuring Method: Design thinking and human experience, OC0.01,  
September 13, 2022, 4:30 PM - 6:00 PM

## *Biography:*

Mike Yearworth is Professor of Management Science in the Centre for Simulation, Analytics and Modelling (CSAM) at the University of Exeter Business School. His research is grounded in Soft OR and focussed on the development and use of Problem Structuring Methods (PSMs). Recent applications of his research have been in municipal decision-making around energy and transport planning. He is currently working on the use of PSMs via online Group Support Systems (GSS). He is Co-Editor-in-Chief of the European Journal of Operational Research (EJOR).

We are conducting a novel analysis of the OR literature with a view to understanding something of the breadth of approaches to problem formulation that are found in published OR work. We make use of probabilistic topic modelling to construct a classifier that can identify texts that are strongly associated with the fields of Problem Structuring Methods, Community OR and Behavioural OR – even if not labelled as such through keywords, titles or abstracts – as exemplars of work that address key problem formulation concepts. We draw on Callon’s notion of problematisation as the theoretical basis for our analysis because it sits outside of OR and thus provides a different perspective on problem formulation and insight into the “abundance of problematisations” that face any OR practitioner engaging with real-world problems.

# SOFT OR & PROBLEM STRUCTURING METHODS: MIXED AND MULTI METHODOLOGY FOR SOFT OR AND PSMS. METHODOLOGICAL AND PHILOSOPHICAL DEVELOPMENT

## Using Problem Structuring Methods with Quantitative OR: Six Methodological Designs

Ms Jane Christie<sup>1</sup>, Professor John Mingers<sup>1</sup>, Dr Kathy Kotiadis<sup>1</sup>

<sup>1</sup>University Of Kent

Parallel Session 4 - Soft OR & Problem Structuring Methods: Mixed and multi methodology for soft OR and PSMS. Methodological and philosophical development, OC0.01, September 14, 2022, 10:30 AM - 12:00 PM

### ***Biography:***

*Jane Christie is a doctoral candidate in Operational Research at the University of Kent, UK, investigating the use of multimethodology by analysts supporting strategic decision-making in government. She has degrees in Economics and Management (Oxford), Operational Research (LSE), and Psychology (Open), and is a Fellow Chartered Accountant (ICAEW). She has extensive international consulting experience, has directed large-scale strategic global business transformation programmes, and served as Deputy Chair of the Board of Trustees of a large UK charity.*

There is renewed interest – amongst practitioners and academics – in using soft OR and problem structuring methods with quantitative OR for addressing complex issues and facilitating better decision-making. There have again been calls for well-documented case studies for practitioners, for guidance on combining methods in theoretically sound ways, and for the highlighting of benefits realized for clients from this mixed OR practice. In this study, we review the use of problem structuring methods (PSMs) with quantitative OR in practice over the last thirty years, as reported in surveys of practitioners and systematic literature reviews. We compare results with the survey for the UK Heads of OR and Analytics Forum (HORAF) presented at OR63. We then propose a new set of six multimethodological designs compiled specifically for using PSMs with quantitative OR. As far as we are aware, this is the first study to focus specifically on the different ways in which PSMs are used with quantitative OR across OR practice. We present examples of these designs from well-documented case studies across public, private, and third sector organizations. Together they illustrate a range of typical and innovative designs across different countries, industry sectors, subject matters, and methods. We highlight the ways in which practitioners can extend their practice beyond the use of methods and tools from PSMs for generic problem structuring at the outset of an OR intervention to the use of PSMs in other multimethodological designs, and describe benefits realized for clients. We conclude with current and future research directions.

# Value Realisation, Problem Structuring and Multimethodology in Practice

Dr Rebecca Casey<sup>2</sup>, Dr Adrian Small<sup>1</sup>, Professor David Wainwright<sup>3</sup>

<sup>1</sup>Northumbria University, <sup>2</sup>Newcastle University Business School, <sup>3</sup>Sociotechnical Design Ltd

Parallel Session 4 - Soft OR & Problem Structuring Methods: Mixed and multi methodology for soft OR and PSMs. Methodological and philosophical development, OC0.01, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

Adrian is an Associate Professor of Operations Management. His main research activities are focused around the area of process improvement, continuous improvement, Lean and Lean implementation in both manufacturing and service contexts. Adrian also undertakes research in problem structuring methods (PSM), information systems, and Industry 4.0.

*Adrian has completed numerous collaborative research projects with a variety of different organisations. Adrian completed a feasibility study with North Tyneside council in 2021 that looked at the Development of an Intertrading Tool. The work concluded that the development of a collaborative intertrading tool would help the businesses of North Tyneside due to business-to-business (B2B) buying being complex and buyers are looking at the totality of the relationship rather than on one specific product/service. The collaborative tool would allow businesses to develop more organic buying relationships. Adrian completed work on a Knowledge Transfer Partnership (KTP) with Benfield Motors in 2016. Adrian's main role was the knowledge base supervisor supporting the KTP associate undertake transformational change throughout the dealership network to increase productivity and improve customer service. The project enacted a holistic approach linking strategy, operations and HR management. The project enabled dealerships to achieve transformational change throughout the organisation versus point improvements through the application of Lean tools. The project received the classification of 'outstanding' from Innovate UK, the grant funding body for Knowledge Transfer Partnerships and features as an ESRC Impact Case Study: <http://www.esrc.ac.uk/news-events-and-publications/impact-case-studies/lean-car-service-boosts-profits/>. Other work Adrian has been involved in includes the implementation of Lean within five small-and-medium sized organisations within the North East. The second project evaluated the North-East Transformation System (NETS). The project is utilising Lean as a method to help hospital Trusts in National Health Service North-East (NHSNE) become more efficient, effective and provide better quality care to patients.*

Despite a multitude of hard and soft OR problem structuring and management methods available, there are relatively few that are specifically orientated to the problem of realising more comprehensive value and benefits from complete digital technology systems projects and implementation. Previous work has developed a multimethodology that bridges the soft and hard OR methodological systems divide-focusing on combining a soft systems methodology (SSM) approach for problem exploration and structuring, learning theories for problem diagnosis, and technology management for designing and implementing solutions. Extension of this work aims to develop this theme further by utilising a multi paradigmatic approach that adds a more holistic definition of digital value comprising: social, economic, cultural and empirical dimensions. These dimensions are essential considerations for digital technology project conception, business core development, and eventual systems design through to implementation. The realising digital value playbook (RDVP) is the first encapsulation of this multi-method approach directed at end users, managers, and commissions of digital systems transformation projects – especially with a focus on public and third sector organisations. Rather than a tool used after a decision is taken to implement new technologies, the RDVP is utilised by stakeholders to identify problems or opportunities, agree objectives, explore potential technology enablers, and develop a plan for realising value prior to investment in, or development of digital technologies. The RDVP will be piloted using live case studies, one a social enterprise and innovative community bakery initiative and the other a roll out of an electronic medical record system at a large NHS hospital Trust. This paper presents our initial findings from the problem definition phases.

# In Search of a Meta-Methodology: the VIPLAN Methodology?

Dr Stephen Harwood<sup>1</sup>

<sup>1</sup>University Of Edinburgh

Parallel Session 4 - Soft OR & Problem Structuring Methods: Mixed and multi methodology for soft OR and PSMs. Methodological and philosophical development, OC0.01, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Former practitioner now pursuing research at the intersection of emerging technology, sustainability and complex situation through the lens of cybersystemics. Research projects include the development of the VIPLAN Methodology and explorations in technology futures*

The VIPLAN Methodology (VM), established by Raul Espejo (1988, 1992), offers a heuristic for dealing with complex (wicked, messy) situations. The VM is grounded conceptually in second order cybernetics as well as draws upon Peter Checkland's Soft Systems Methodology. Its distinctive attribute is the explicit focus upon the organisational conditions that shape conversations relating to complex situations. This paper presents a revised version of the VM and explores the underlying concepts. It proposes that the VM can accommodate both qualitative and quantitative approaches. In conclusion, the question is asked: Is it a meta-methodology?

# SOFT OR & PROBLEM STRUCTURING METHODS: THEORETICAL ADVANCEMENT OF VSM

## Complexity and variety management in viable systems operating in volatile environments

Dr Ayham Fattoum<sup>1</sup>, Dr Chris Smith

<sup>1</sup>University of Manchester

Parallel Session 5 - Soft OR & Problem Structuring Methods: Theoretical advancement of VSM, OC0.01,  
September 15, 2022, 9:00 AM - 10:30 AM

### ***Biography:***

*Lecturer in soft operating management and systems thinking. I use systems thinking and soft OR principles and approaches to enhance systems' resilience, efficiency, and viability when operating in volatile environments. My research has involved community engagement during major floods in the UK and the response and recovery from COVID-19.*

The Viable System Model (VSM) uses the concept of variety as a measure of complexity. Despite being different, complexity and variety are often used interchangeably in the literature. While variety is defined by VSM, the confusion of use suggests a need for an in-depth analysis of the conceptual underpinnings of complexity and variety and to study the impact of this confused use of the two concepts. To close the theoretical and practical gaps, this study explores the concepts of complexity and variety conceptually and empirically. Conceptually, it proposes distinctive and operationally meaningful definitions of complexity and variety based on an in-depth analysis of how complexity and variety are conceived and used in the OR literature. Empirically, the study analyses how complexity and variety are processed in a system operating in a highly complex environment. The data was collected from interviews and field observations of two case studies of multi-agency response systems operating in simulated responses to disasters. This paper contributes to the literature on VSM's complexity management by providing clarity of the use and the difference between the key concepts – complexity and variety. It also provides an insight into the operational implications of understanding complexity and variety on decision making and efficiency.

# Benefits, pitfalls and question marks in the application of the VSM in the design and analysis of policy surveillance.

Dr Pedro Pablo Cardoso Castro, Dr Carlos Augusto Paez Murillo, LTC. Dr. Andres Fernandez

<sup>1</sup>Leeds Beckett University

Parallel Session 5 - Soft OR & Problem Structuring Methods: Theoretical advancement of VSM, OC0.01,  
September 15, 2022, 9:00 AM - 10:30 AM

## *Biography:*

Pedro Pablo got a BA in Marine Biology from the Jorge Tadeo Lozano University (Colombia). After working in research for a couple of years, he got his title as Merchant Marine Officer, and he finished his MSc in Environmental Auditing and Business Planning at the Centre for Ecological Studies in Malaga (Spain). Then, motivated by his practice as a business consultant, he decided to do a Master in International Commerce (Complutense University – Spain) and participated in international business research programs. In 2005 he was lecturing at MSc and MBA programs in some of the best-ranked universities in Bogota - Colombia. Simultaneously, he led a technical advising team on environmental services for the preparation of the ALCA - Free Trade Agreement of the Americas - negotiations. After this, he led a research team exploring the internationalization of Hi-Tech SMEs, creating and conducting the Colombia-Japan Hi-Tech SMEs business match program. Also, leading one of the most successful courses of Management for sustainability in Colombia.

In 2007 he started his Ph.D. on Organizational Cybernetics and Self-organization in communities at the University of Hull, UK, Obtaining his Ph.D. in 2010.

Since 2012 he has been working as Senior Lecturer at the Leeds Beckett University, leading research in social business and the use of complexity in Management. Also collaborating with universities on the UK and abroad in the teaching of Systems Thinking and Organisational Cybernetics.

His research and consultancy interests are focused on applying Organizational Cybernetics, Systems Thinking, and Complexity Management in fields such as Strategy, Security, Sustainability, Innovation, Technology Management, Dynamic Networks, and the study and development of Management Systems inspired in Co-evolving and Transition Management principles. Developing various consultancy projects in different fields in UK, Ukraine, Belarus, Poland, Lithuania, Latvia, Colombia, Brazil and Mexico.

The paper analyses the use of the VSM for policy surveillance in two major cities in South America. It compares the use of the VSM self-transformation methodology in Mexico D.C. and Bogota (Colombia). The results show that similar benefits in terms of comprehensive and inclusive surveillance designs can be obtained, despite divergences in the path dependence of the cases considered. The diagnostic also identifies similarities and the particularities of each case study in terms of their profile of organizational pathologies. The study invites a broader conversation and critical analysis of the use of systemic tools in security and defence.



# Future resilience using VSM and Other Soft Operational Research and Problem Structuring Methods

Prof Martin Parr<sup>1</sup>, Dr Maya Vachkova<sup>2</sup>

<sup>1</sup>Guided System Solutions, <sup>2</sup>University of Exeter

Parallel Session 5 - Soft OR & Problem Structuring Methods: Theoretical advancement of VSM, OC0.01,  
September 15, 2022, 9:00 AM - 10:30 AM

## *Biography:*

Maya Vachkova is a systems thinker and a facilitator with a passion for social issues and participatory organisational transformations. Maya holds an LLM, an MA in Peace, Conflict and Development and a PhD in Systems Thinking.

She is the Programme Director for the MSc Systems Thinking in the Public Sector - an applied Apprenticeship for civil servants.

Her external engagements are a membership and support of Metaphorum and a visiting fellowship at the Centre for Systems Studies at the University of Hull.

Martin Parr is an honorary professor at the University of Kent and has a passion for encouraging complex organisations to transform and be more successful. Martin runs his own consultancy company using Systems Thinking methods to solve complex technology and transformation problems within government and commerce. Martin has worked for many years as a strategic advisor for UK government programmes that have annual budgets in excess of £1 billion, including the Ministry of Defence test and evaluation programme. Martin has advised on governance of the UK Major Projects Portfolio which currently has a whole life cost in excess of £500Bn. Martin regularly teaches at the Defence Academy and on the University of Kent's MBA programme. Martin is a Chartered Engineer, a Fellow of the IET and a Fellow of the ORS.

The viable system model (VSM) provides a way of evaluating a governance system to assess fitness for purpose for an organisation (Beer, 1972,1979). The role of VSM System 4 (S4) is to prepare the organisation by considering future scenarios and assessing how the organisation might adapt to potential changes in the environment. To do this research must be conducted, within S4, into the benefits and costs of adaptations such as: additional training and upskilling of staff, investment in new machinery or ways of working and potentially in overall development of organisational capabilities.

Evidence from a number of consulting assignments, that range from small start-up businesses through to multi-billion pound public sector activities, highlights that S4 is often weak and sometimes completely overlooked. Anomalies in System 4 (and its linkage with System 3 and System 5) can lead to an organisation failing to thrive within its environment. In cybernetic terms, this can be due to an imbalance between the internal variety of the system and the external variety of the environment. Variety being the number of different states that an entity may be in.

Problems with S4 may be due to (1) variety imbalances (the organisation cannot make sense of what is going on in the environment e.g Kodak failing to see how digital technology would change their business), (2) problems with organisational cohesion or both.

The question driving our enquiry is: How can SORPS improve S4's ability to tackle the environmental challenges faced by today's organisations?

## SOFT OR & PROBLEM STRUCTURING METHODS: INCREASING STAKEHOLDER ENGAGEMENT THROUGH SOFT OR AND PSMS

How do we meaningfully evaluate systems methodologies been used to integrate different types of knowledge and values within complex low resource contexts?

Miss Maimanah Idris<sup>1</sup>

<sup>1</sup>University College London STEaPP

Parallel Session 6 - Soft OR & Problem Structuring Methods: Increasing stakeholder engagement through Soft OR and PSMS, OC0.01, September 15, 2022, 11:00 AM - 12:30 PM

### *Biography:*

Maimanah Idris is completing a PhD in Science, Technology, Engineering and Public Policy at University College London through a 4-year studentship funded by the UCL Engineering and Physical Sciences Research Council (EPSRC) Doctoral Training Partnership (DTP). Her research interests are interdisciplinary and systems thinking approaches, monitoring and evidence evaluation, participatory tools and stakeholder engagement initiatives across Africa, Asia and the Middle East. She holds a BSc (Hons) in Geography and Environmental Management, a MSc in Environmental Technology: Health and Global Environment and a MRes in Urban Sustainability & Resilience also funded by the UCL EPSRC DTP. In the past she has worked at Imperial College London, in the School of Public Health and has volunteered her time for environmental, social and educational development projects in the UK, Sudan and Malaysia. She has carried out quantitative and qualitative data collection and analysis as well as monitoring, evaluation and evidence reporting in these projects. She has also worked for a supply chain and training consultancy in Khartoum, Sudan, where she coordinated and delivered the Young Professional Development Programme (YPDP) collaborating with Omdurman Ahlia University.

This paper is based on the project 'Innovation for Cancer Care in Africa (ICCA)', an East Africa-India-UK research collaboration led by The Open University, investigating ways to link innovation in the industrial and health sectors to improve access to cancer care in Kenya and Tanzania (<https://www.open.ac.uk/researchprojects/innovation-cancer-care-africa/>).

The need for meaningful evaluation approaches of systems methodologies and methods within systemic, multi-sectoral, complex innovation projects is essential to understand knowledge production, synthesis & use within specific contexts. Midgely and Lindhult (2021), raise the importance of this by stating that those working in the systemic innovation research field need to "independently test the utility" of methodologies in action research. This can be done through "facilitating systemic innovation initiatives and assessing their impacts, for this purpose, the evaluation of methods will be essential" (Midgely and Lindhult, 2021). The authors also add that "evaluation will reveal both further insights to enhance systemic innovation, and issues (such as barriers to using particular systems ideas and methods) that have to be addressed through new conceptual and methodological developments" (Midgely and Lindhult, 2021).

One of ICCA project core themes is the use of embedding systems methods into established analytic processes to achieve transformative change of practice and therefore implementing meaningful engagement with diverse policy stakeholders within the project and post-project. Through the final phases of the ICCA project, the aim is therefore to evaluate how systems methodologies (and their associated methods) have been used for knowledge production, synthesis, and systemic learning within a specific context. This project aims to use both propositional research & action-research, to evaluate the "what, why and how" of systems tools, techniques and approaches used in ICCA. This work will be published in the OR64 paper.

## Online facilitation of problem structuring workshops

Dr Antuela Tako<sup>1</sup>, Dr Kathy Kotiadis

<sup>1</sup>Loughborough University

Parallel Session 6 - Soft OR & Problem Structuring Methods: Increasing stakeholder engagement through Soft OR and PSMs, OC0.01, September 15, 2022, 11:00 AM - 12:30 PM

### ***Biography:***

*ANTUELA A. TAKO is a Reader in Operational Research at the School of Business and Economics, Loughborough University. She holds a PhD in Simulation and an MSc in Management Science and Operational Research from the University of Warwick. Her research interests include the comparison of simulation approaches, facilitated and participative simulation modelling, conceptual modelling and health care modelling. She is Associate Editor of the Journal of the Operational Research Society, Health Systems Journal and Journal of Simulation. Her email address is a.takou@lboro.ac.uk.*

This talk provides an overview of our experience of participative problem structuring in the synchronous online workshop environment. In 2020, due to the outbreak of the Covid19 pandemic and government-imposed restrictions, where possible many organisations moved to remote working. This rendered all face to face workshops and meetings a health hazard. It has meant that we had to adapt our facilitation practice to support stakeholder groups in the online environment. At the time, many organizations needed to make crucial decisions in remote environments but lacked the expertise to manage the process and interactions in an effective way. We discuss our experience as facilitators in working with organizations involving key workers in the online environment. Based on our experience we offer guidance to those interested in transitioning to online facilitation.

# Revisiting pragmatism in Soft Operational Research

Dr Jose-Rodrigo Cordoba-pachon<sup>1</sup>

<sup>1</sup>Royal Holloway, University Of London

Parallel Session 6 - Soft OR & Problem Structuring Methods: Increasing stakeholder engagement through Soft OR and PSMs, OC0.01, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Associate professor, Royal Holloway, University of London*

This presentation of early work in progress aims to enrich the incorporation of pragmatism as an underpinning philosophy for Soft OR. This philosophy has been already explored by Ormerod and Ulrich, directing it to account for professional OR / citizen practice. A complementary presentation of pragmatism is made by looking at how this philosophy has made inroads in the field of creativity. It is proposed to reconsider, if possible within the limits of pragmatism, how we could unlink human experience from its potential orientation to future action. To do that, it might be necessary to focus on the ritualistic aspects of experience.

# SOFT OR & PROBLEM STRUCTURING METHODS: CASE STUDIES OF SOFT OR/PSMS

## Enhancing Systemic Thinking by sharing experiences on reading literary fiction using Causal Mapping

Mrs Leila Abuabara, Prof Alberto Paucar-Caceres<sup>1</sup>, Dr. Katarzyna Werner-Masters, Dr Daniela Simonini  
Teixeira Villas Boas Uni

<sup>1</sup>Manchester Metropolitan University

Parallel Session 7 - Soft OR & Problem Structuring Methods: Case studies of Soft OR/PSMs, OC0.01,  
September 15, 2022, 2:30 PM - 4:00 PM

### *Biography:*

Professor Alberto Paucar-Caceres is systems scientist, specializing in the field of Systems Thinking, Creative problem solving, Management science and Systems Science. Experience in application of systemic thinking and systemic methodologies to: sustainability and environmental management; transition to the CE; recycling; reducing and managing food waste and sustainable consumption. Alberto's research interest is in the area of application of systems thinking. In particular: (1) application of systems methodologies (Problem-structuring methods, and 'Soft' Operational Research to problematic situations in organisations; and (2) application of systemic management science methodologies to environmental management and sustainability. Publication record includes 150+ academic articles in refereed journal papers, and more than 200 conference papers. Portfolio of research outputs in international journals: European Journal of Operational Research; Journal of Operational Research; OMEGA; Systems Research and Behavioural Research; Systemic Practice and action Research.. All of these articles are supported by a substantive corpus of other work.

### Current projects:

- 1) Applying Circular economy systemic principles to Food Waste management
- 2) Promoting ecological and environmental awareness in HEIs
- 3) The role of higher education stakeholder networks for sustainable development: a systems perspective
- 4) Literacy Health and Planetary Health in Latin America

Cognitive mapping (CM), a methodology from Operational Research (OR) has been broadly used in problem-structuring interventions in making sense of complex situations. Systems thinking advocates the importance of making a conscious effort to appreciate other people's perspectives: a well-intentioned required task but difficult to achieve in practice. Great works of fiction in literature seems to mirror life and its complexity. In this article, we explore the interplay of sharing experiences when we read fiction and systems thinking awareness. Underpinning our approach are two main strands: (i) Literature Fiction reading as a way of exploring new perspectives; (ii) recording reading experiences of books of by using an organized program of reading/discussing fiction called Reading Labs (RL) - we use the 'Portrait of Dorian Gray' by Oscar Wilde and applied CM to organize the final discussion to try to understand the different views generated by each of the participants. We assess the benefits of the using reading fiction to tease out the potential gains of enhancing systemic thinking amongst the participants. Findings suggest that the exercise can: (i) enhance systemic thinking by producing a synthesis and shared views on what was meaningful and useful for the participant during the reading; and (ii) translate (using CM) the subjectivity produced by the shared reading experience into new actions enhanced by systemic thinking awareness. The article's findings will interest of Soft/OR practitioners/academics using CM and systems practitioners working on encouraging the use of systems thinking in systemic interventions.

Keywords: systems thinking, reading groups, cognitive map, literature, operational research, fiction

# Framing business schools as a socio-technical system: issues around complexity and emergence.

Prof Denis Fischbacher-Smith<sup>1</sup>, Mrs Natalia Kapralova

<sup>1</sup>University of Glasgow, Adam Smith Business School

Parallel Session 7 - Soft OR & Problem Structuring Methods: Case studies of Soft OR/PSMs, OC0.01,  
September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

Research Professor of Risk and Resilience

University of Glasgow Business School, University of Glasgow

BEd, BSc, MSc, MBA, MPH, MLitt, PhD, DLitt, MIIAI, MIEnvSc, FEPS, FSyl, PFHEA, FIEHF, C.ErgHF, CGeog, CMgr, CSyP, CFCIPD, CPsychol, FAcSS, CCMI

The paper reports on the application of soft operational research methods to a real-world case of re-designing the management of a large academic department in a higher education institution. The paper proposes the framework and the analysis of the challenges facing by the leadership within a business school and, by extension, can be applied to any other academic department or school. The discussion in the paper is contextualised within the academic experiential background of the lead author of the paper and provides reflections on managerial roles held over a 30-year period as a Dean or a Head of a Business School. The proposed framework is grounded in a socio-technical systems approach and combines the use of Checkland's Soft Systems Methodology with the elements of Chern's Systems Design Thinking and Hollnagel's Functional Resonance Analysis Model. The paper conceptualizes the elements of the framework, starting with the processes around developing consensus, then progresses to the challenges of obtaining a minimum critical specification of the strategic direction. It highlights the difficulties of variance control associated with issues around boundary location and the complexity of the information flows. The findings suggest that by framing the business school within a system perspective, it illustrated how many of the challenges within the management of HEIs were a function of the inability to address variety within the system across the different levels of organisational structure. The paper concludes by highlighting the practical implications of managing within universities.

# Five OR prisms to unfold complexity. A systems thinking perspective

Dr Eliseo Vilalta-Perdomo<sup>1</sup>

<sup>1</sup>Aston University. Aston Business School

Parallel Session 7 - Soft OR & Problem Structuring Methods: Case studies of Soft OR/PSMs, OC0.01,  
September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*My research focuses on how to improve individual and collective performance, in those cases where the alignment of aims and preferences is not possible, unattainable or even unnecessary. I am currently studying the development of sustainable communities of micro-producers, so that they are more resistant to global and /or local logistical challenges. Therefore, I am exploring different human and technological interfaces, within different supply arrangements, that may increase the propensity of individuals to collaborate. In short, my current research is at the intersection of issues such as human performance, technology and sustainable operations.*

Five vignettes on OR implementations will be presented. In these illustrations rather than discussing where OR boundaries are, or if they are instances of soft or hard OR, the focus will be on showing that OR is a wide church for people interested in better informing decision making. An integrative OR strategy will be presented. Its aim is to enhance the quality of interactions among different actors, in addition to optimising physical resources available.

## SUPPLY CHAIN AND LOGISTICS ANALYTICS

### Supply chain OR in practice - optimisation, simulation and machine learning

Mr Emile Naus<sup>1</sup>

<sup>1</sup>*Bearingpoint*

Parallel Session 1 - Supply Chain and Logistics Analytics, OC1.02, September 13, 2022, 11:00 AM - 12:30 PM

#### *Biography:*

Emile is a supply chain professional with 30 years experience in strategy, design and implementation. He deploys data and analytics to support this, including optimisation, simulation and machine learning. Emile leads the Operations team for BearingPoint in the UK and was previously Head of Logistics Strategy for Marks and Spencer and Long Term Planning Manager for Tesco. *He holds an MSc from Cranfield and a BSc from Fontys University of Applied Science.*

There are many elements of OR in use in supply chain and logistics. This talk will focus on the practical application of these elements and how they can be deployed. The perspective is that blending different methodologies will get a better results.

The focus will be on optimisation, simulation and machine learning. The talk will describe 2 real life examples where a blend of different techniques were deployed.

In the first instance, a mixture of optimisation and machine learning was used to assess the impact of shopping habit changes on the number of stores that were required. This required machine learning and statistical analysis to create profiles that were then fed into a mixed-integer optimisation model.

In the second instance, simulation was used to test a series of algorithms to optimise the flow of materials inside an E-commerce fulfilment centre, which had a combination of manual and automated operations.



# The Mixed Fleet Vehicle Routing Problem with Low Emission Zones

Maurizio Bruglieri<sup>1</sup>, Bülent Çatay<sup>2</sup>, **Dr Merve Keskin**<sup>3</sup>, Simona Mancini<sup>4</sup>, Ornella Pisacane<sup>5</sup>

<sup>1</sup>Dipartimento di Design, Politecnico di Milano, <sup>2</sup>Faculty of Engineering and Natural Sciences, Sabanci University,

<sup>3</sup>Sheffield University Management School, <sup>4</sup>Alpen-Adria-Universität Klagenfurt, <sup>5</sup>Dipartimento di Ingegneria dell'Informazione, Università Politecnica delle Marche

Parallel Session 1 - Supply Chain and Logistics Analytics, OC1.02, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Merve is a Lecturer in Operations Management and Decision Sciences at Sheffield University Management School. Her research interests are modelling optimisation problems, especially related to logistics operations and applying operational research methodologies to solve them.*

Due to the increasing effects of greenhouse gas emissions to climate change, several attempts have been made to reduce these emissions. As road transport is a major contributor, many countries are implementing policies to reduce the use of fossil-fuel powered traditional vehicles (TV) and to promote electric vehicles (EV) to establish a more sustainable transportation. Low Emission Zones (LEZ) are introduced as one of these policies, defined as urban areas, in which the EVs are free to enter, but the TVs are required to pay a toll for their first entrance. In this study, we address the problem of efficiently routing a mixed fleet of TVs and EVs in the presence of LEZs, such that the customers are served within their time windows with a minimum total operating cost. This cost includes the energy costs for EVs, fuel costs for TVs as well as the tolls paid by TVs to enter the LEZ. The EVs depart from the depot with a full battery and can recharge partially en-route. We refer to this problem as the Mixed Fleet Vehicle Routing Problem with LEZ (MFVRP-LEZ) and formulate it as an arc-based Mixed Integer Linear Program by allowing multiple visits to a station without cloning it and by identifying a-priori the set of non-dominated stations between each pair of customers. We solve small-size instances using the commercial solver XPRESS and we design an Adaptive Large Neighborhood Search (ALNS) algorithm to tackle the large-size instances. The experimental study presents results on a set of benchmark instances, derived from those already presented in the literature by adding LEZs and arcs avoiding LEZs. Numerical results validate the effectiveness of the proposed ALNS and provide managerial insights to the transportation companies for transitioning their TV fleets by including EVs.

# A multi-modal and variable-echelon delivery system for last-mile logistics

Dr Christopher Bayliss<sup>1</sup>, Prof Tolga Bektas<sup>1</sup>, Vernon Tjon-Soei-Len<sup>2</sup>, Remo Rohner<sup>2</sup>

<sup>1</sup>University Of Liverpool Management School, <sup>2</sup>Darwin Evolution Technologies

Parallel Session 1 - Supply Chain and Logistics Analytics, OC1.02, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*I received a PhD in Industrial Engineering from Bilkent University in 2005 and subsequently completed a postdoctoral fellowship at CIRRELT at the University of Montreal in Quebec. Prior to joining the University of Liverpool Management School in September 2018, I was Professor of Logistics Management and Head of Department of Decision Analytics & Risk at the Southampton Business School, where I worked for 11 years. My research interests are in the application of mathematical modelling and optimisation techniques to problems arising in freight transportation and distribution planning, and in supply chain networks, with a particular focus on improving the environmental performance of such systems. I have been investigator in a number of externally funded projects on railway timetable optimisation, maintenance planning in sea vessels and last-mile distribution in cities.*

We describe a last-mile logistics delivery system which consists of multiple localised storage depots and multi-modal delivery options that include traditional vehicles, such as vans, as well as alternative vehicle types, such as electric cargo bike and porters. The latter can be useful for performing deliveries where there may be vehicle access restrictions, and prove more cost-effective where demand density is sufficiently high and parcel sizes small. The system allows for vehicles to rendezvous at kerbside locations (mobile satellites) where parcels can be transferred between vehicles. No fixed echelon or hierarchical structure is imposed on the sequence of vehicles transporting a parcel. The resulting problem is modelled as a mixed-integer linear programming formulation and a heuristic algorithm is described. Computational results will be presented that validate the mathematical model and the heuristic on a set of instances derived from real sales data in London, whose results demonstrate potential benefits from using the proposed delivery concept.

# Long Term Multi-Product Multi-Region Supply Chain and Crop Rotation Planning for Seasonal Crops

Mr Harry Sisley<sup>1</sup>

<sup>1</sup>Queensland University Of Technology

Parallel Session 3 - Supply Chain and Logistics Analytics, OC1.02, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*I am a PhD student at the Queensland University of Technology. I started my doctorate in 2020 and my main focus of research has been agricultural supply chain optimisation.*

We present a model for long-term planning of a multi-region, multi-product seasonal agri-fresh supply chain with crop rotation. Agri-food farming businesses make great efforts to safeguard the health of their soil, as damage can take years to repair. Crop rotation is a powerful tool for increasing the soil health of farmland; however, it requires careful planning. Moreover, crop rotation must not interfere with the continual production required to satisfy the demand for seasonal crops. There is demand for seasonal crops in supermarkets across Australia even when they are out of season for the local area. To meet this demand, production must be shifted to climates that are in season throughout the year. Including crop rotation as a constraint to this supply chain will restrict what crops can be planted on a farm based on what type of crop was previously harvested. We have developed a deterministic Mixed Integer Linear Program (MILP) to determine which sequences of crops should be planted at each farm across all the growing regions. A sequence for a given farm will include when crops are to be planted and harvested across the entire time horizon and what order the crops are to be planted in to abide by the crop rotation requirements. To best solve this model decomposition solution methods were applied to deal with the large number of decision variables. This model will be used as a decision support tool for production managers at a major national grower within Australia. A case study of their business across multiple years will be used to test the effectiveness of this tool.

# Two-dimensional vehicle loading and dispatching problem with incompatibility constraints in freight logistics

Dr Eda Yucel<sup>1</sup>, Prof Sibel Salman<sup>2</sup>, Prof Gunes Erdogan<sup>3</sup>

<sup>1</sup>TOBB Economy and Technology University, <sup>2</sup>Koc University, <sup>3</sup>University of Bath

Parallel Session 3 - Supply Chain and Logistics Analytics, OC1.02, September 13, 2022, 4:30 PM - 6:00 PM

## ***Biography:***

*Prof Erdogan's research is on exact and heuristic algorithms for integer and mixed-integer optimisation problems and their applications to healthcare and logistics problems. His expertise with exact optimisation methods includes branch-and-cut-and-price and cutting plane algorithms, especially for Vehicle Routing Problems. In terms of heuristic optimisation methods, he has developed and implemented variants of Iterated Local Search, Tabu Search, and Large Neighbourhood Search.*

This study introduces a multi-period, two-dimensional vehicle loading and dispatching problem, called Two-Dimensional Vehicle Loading and Dispatching Problem with Incompatibility Constraints (VLDP). The problem originates from a long-haul FTL transportation problem of a freight transportation company and considers a single lane of the provider between a given origin-destination pair. A set of customer orders are to be transported from the origin to the destination by a heterogeneous fleet of vehicles within a planning horizon and can be consolidated in the vehicles for more efficient use of vehicle capacity. The aim is to prepare a single-origin single-destination multi-period transportation plan of loading required orders to vehicles at the origin and dispatching the vehicles to deliver the orders to the destination within their due dates. The vehicle fleet is formed of owned and outsourced vehicles with each vehicle having a fixed transportation cost per trip, where outsourced ones have higher costs. There are constraints regarding the due dates of the orders, pairwise incompatibility of orders packed in the same vehicle, incompatibility of orders and vehicles, as well as area and weight capacity of the vehicles. An order can be delivered earlier than its due date, incurring an earliness penalty due to storage requirements at the destination. The objective is to minimize the total vehicle usage and earliness penalty costs. A Mixed-Integer Linear Programming model is developed and an Adaptive Large Neighbourhood Search algorithm is proposed for the problem. Computational experiments on instances derived from real-world data show the effectiveness of the proposed heuristic.

# Managing perceived quality during product recalls in a two-echelon supply chain

Satyaveer Chauhan<sup>1</sup>, Arka Mukherjee, Tulika Mukherjee

<sup>1</sup>Concordia University

Parallel Session 4 - Supply Chain and Logistics Analytics, OC1.02, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Dr. Satyaveer Chauhan is a Professor in the Department of Supply Chain and Business Tech. Management at John Molson School of Business. He works in the areas of Operational planning in supply chains, and large-scale optimization. He teaches Simulation and Optimization to both graduate and undergraduate students.*

Efficient crisis management strategies can mitigate the negative effect of a product recall on firms and consumers. We consider a one-supplier-one-manufacturer supply chain prone to a likelihood of a product recall. Considering a differential game framework, we develop a goodwill-based model. Pre-recall and post-recall advertising, quality, and pricing strategies play a significant role in mitigating this crisis on the stakeholders. We extend our basic model by two contractual agreements in which the manufacturer shares the quality improvement and risk-mitigating effort with the supplier. Our results indicate the crossover interaction between pre-recall and post-recall decisions. We find that for a high-likelihood/-impact recall, the supplier and the manufacturer focus more on their respective post-recall quality effort than on the pre-recall period. For such a recall, the manufacturer would try to capture a bigger market by reducing its initial price. Interestingly, by gradual, incremental pre-recall advertising, the manufacturer raises its goodwill before a recall announcement to keep consumers' higher confidence regarding the product's quality even after the recall. Our cooperative contractual agreements benefit all the channel members and consumers. The manufacturer is always better off by sharing a greater quality and risk effort with the supplier in the post-recall period than in the pre-recall period.

# A data-driven approach for maritime fleet management

Dr Çağatay Iris<sup>1</sup>

<sup>1</sup>University Of Liverpool Management School

Parallel Session 4 - Supply Chain and Logistics Analytics, OC1.02, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Dr. Çağatay Iris is a Lecturer at the University of Liverpool Management School. He is the Director of Studies (DoS) for the MSc in Business Analytics and Big Data since 2022. Çağatay has research interests in transportation and logistics (including freight transportation, next-generation ports, shipping, hinterlands, urban logistics, crowdshipping), shared economy, and energy management.*

The global shipping industry has long suffered from high volatilities in freight rates and bunker fuel prices that lead to significant earnings risks. This paper aims to investigate the effectiveness of fleet management strategies of 31 world leading tramp shipping companies through a Bayesian Belief Network (BBN) model using various data sources. Operational fleet management strategies are categorized into long-term (e.g., fleet diversity and fleet age) and short-to-medium-term (e.g., relative trip distance, fleet repositioning flexibility, and trading diversity) strategies. We innovatively quantify the short-to-medium-term fleet management strategies using Automatic Identification System (AIS) data. The results show that financial hedging can effectively reduce bunker fuel price risk exposure but cannot reduce freight rate risk exposure. Meanwhile, companies can use fleet management strategies to effectively reduce both risk exposures. This study provides significant implications for shipping risk management.

## SUSTAINABLE SUPPLY CHAIN MANAGEMENT

### Optimal strategic planning of a multiple level remanufacturing Supply Network in a Circular Economy framework

Miss Azar Mahmoumgonbadi<sup>1</sup>, Prof Andrea Genovese<sup>1</sup>, Dr Antonino Sgalambro<sup>1</sup>

<sup>1</sup>The University of Sheffield

Parallel Session 1 - Sustainable Supply Chain Management, OC1.07, September 13, 2022, 11:00 AM - 12:30 PM

#### ***Biography:***

*Azar MahoumGonbadi is an Early Stage Researcher and a PhD scholar at the University of Sheffield. As an Early Stage Researcher based at USFD, UK, her research is mainly focusing on practical problems arising in closed-loop supply chains (CLSC), where product returns and recovery are possible through several modes. A mathematical model for handling such situations will be developed to design a CLSC based on Circular Economy principles.*

Closed-Loop Supply Chains (CLSCs) can operationalise Circular Economy principles, being aimed at circling back end-of-life products through reusing, remanufacturing, and recycling actions. The literature on CLSC optimisation presents a gap for models addressing the number of remanufacturing levels to consider while concurrently designing a supply network. This study develops a comprehensive CLSC framework, characterised by a compact and multi-objective MIP model, supporting all major strategic design decisions at a supply chain level - supplier selection, facility location, manufacturing, and distribution choices – while determining the number of market channels to be activated in the reverse element of the supply chain. Computational results are illustrated, showing the encouraging potential related to the application of such compact optimisation model.

# Combining fuzzy MCDM with Kano model and FMEA: A novel 3-phase MCDM method for reliable assessment

Dr Shuya Zhong<sup>1</sup>

<sup>1</sup>University of Exeter, Department of Engineering, Faculty of Environment, Science and Economy

Parallel Session 1 - Sustainable Supply Chain Management, OC1.07, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Dr Shuya Zhong is a lecturer in the Engineering Department of the University of Exeter. Her research focuses on applying mathematical modelling and optimisation methods to improve the operations efficiency and sustainability of logistics and supply chain systems. Currently, she is interested in logistics and supply chain decisions in two contexts – renewables like offshore wind or hydrogen, and warehousing and transportation in B2B or B2C markets. Dr Zhong holds a PhD in Management Science and Engineering from Shanghai University. Prior to joining Exeter, she worked as a postdoctoral researcher at the Institute for Manufacturing, University of Cambridge (2018-20) and The Logistics Institute – Asia Pacific, National University of Singapore (2016-18).*

Aiming to improve the reliability of assessment and selection problems in high-investment and long-life cycle projects, this work for the first time, takes the time-based satisfaction and risk factors into consideration simultaneously. To achieve the two reliability factors, we develop a novel 3-phase multi-criteria decision-making (MCDM) method, which combines the fuzzy MCDM, i.e., fuzzy analytic hierarchy process (AHP) and fuzzy technique for order preference by similarity to ideal situation (TOPSIS) approaches with Kano model and failure mode and effects analysis (FMEA) techniques. Specifically, a time-based satisfaction weight is created based on Kano model to differentiate the decision-makers' satisfaction with criteria in short, medium, and long terms, and a risk discounted weight is designed by using FMEA for tuning the criteria scores. This method is applied on a hydrogen storage method selection case for lightweight vehicles. Moreover, a web app with GUI (see in <https://hychain.co.uk/>) is designed for the method to enable decision-makers to use this interactive decision-making tool.



# Exploring Critical Barriers to Adoption of Artificial Intelligence in Shrimp Supply Chain-An Indian Perspective

Dr Soumyajyoti Datta<sup>1</sup>

<sup>1</sup>Xavier Institute of Management, XIM University

Parallel Session 3 - Sustainable Supply Chain Management, OC1.07, September 13, 2022, 4:30 PM - 6:00 PM

## *Biography:*

Soumyajyoti Datta is an assistant professor in Operation Management and Decision Science at Xavier Institute of Management, Bhubaneswar. He has completed his Doctor of Philosophy from Indian Institute of Management Indore in Operations Management & Quantitative Techniques. He has a corporate experience of two and a half years in the information technology industry. His articles have been accepted by several international conferences and journals of repute such as Operations Management Education Review. He has won several recognitions including global awards, and scholarships for his academic endeavours. He has published business cases in Ivey Case Publishing, indexed by Harvard Business Publishing. He has also worked on numerous consulting assignments concerning Public Distribution System in Madhya Pradesh and Indian Army. His current research interests include healthcare operations management, humanitarian supply chain, food supply chain, service operations, MCDM, sustainability, business decision making, data mining and soft computing

In developing countries, like India, which has a long coastline, the shrimp industry plays a very salient role in shaping the economy. The fisheries form one of the chief economic sectors and offer enormous opportunities for development and innovation. In 2020 the Indian shrimp market reached a volume of 0.71 million tons. The Indian Government is promoting sustainable shrimp farming practices to produce high-quality shrimp to make shrimp cultivation cost-efficient and minimize the detrimental environmental effects. The key proponents of the industry are increasing population, disposable incomes, growing demand for convenient and ready-to-eat food, rapid urbanization, population migration, increasing health consciousness, changing food habits, and variety in the availability. The adoption of artificial intelligence in the food supply chains can mitigate food wastage and ensure quality food to the consumers by improving proper coordination, transparency, and traceability. However, the benefits of artificial intelligence are not received by the shrimp supply chain to a substantial extent. The technology adoption literature in the shrimp industry is still in a nascent stage, implying very limited scientific investigations about the critical barriers that could affect the adoption of artificial intelligence in the shrimp supply chain. Hence, this study is one of the early works to identify the barriers to adopting artificial intelligence. A comprehensive literature review has been performed and experts' opinions have been collected to support the study. In this study, a multi-criteria decision-making technique has been used to model the factors and prioritize and rank them effectively. Sensitivity analysis has been carried out to check the robustness of the proposed model of the study. The present study provides valuable research implications which can be used for policy improvements and to make the shrimp supply chain more effective and efficient. This will benefit multiple stakeholders.

# Mitigating Modern Slavery in Supply Chains through Dynamic Modelling

Dr Mahnaz Hosseinzadeh<sup>1</sup>, Mr Amir Salimi<sup>2</sup>, Dr Reza Alikhani<sup>3</sup>

<sup>1</sup>The University of Sheffield, <sup>2</sup>University of Tehran, <sup>3</sup>Montpellier Business School

Parallel Session 3 - Sustainable Supply Chain Management, OC1.07, September 13, 2022, 4:30 PM - 6:00 PM

## *Biography:*

Mahnaz Hosseinzadeh is a Lecturer in Operations Management and Decision Sciences at Sheffield University Management School, University of Sheffield, United Kingdom.

Mahnaz holds a PhD in Operational Research from the University of Tehran.

Prior to joining the Management School, Mahnaz worked at the University of Tehran, initially as a Lecturer and then a Senior Lecturer in Operational Research Management. She has also been a visiting researcher at Linköping University.

*Her research focuses mainly on system dynamics, optimisation, multiple criteria decision making and soft operational research, emphasising social sustainability in supply chains. She is the author of many scientific articles published in peer-reviewed journals in Operational Research and Information Sciences.*

Modern slavery is a complex and hidden crime that includes several forms of exploitation, such as forced labour, child labour, human trafficking, etc. With the advent of global supply chains and complex networks of relationships among different tiers of the chains, the risk of engaging in modern slavery has greatly increased for companies. Therefore, research on different dimensions of modern slavery in supply chains has attracted much attention from academics and practitioners. Many contextual factors have been recognized that encourage modern slavery in supply chains. Many other factors and structures have also been suggested to reduce the risk of labour coercion and increase the awareness, motivation, and capability of detection, remediation, and disclosure of modern slavery in supply chains. Due to the hidden nature of modern slavery and the lack of quantitative indicators as to social factors, some researchers have attempted to define a set of indicators to investigate the linear relationship between the factors involved in the modern slavery context. Yet, the systemic nature of the modern slavery problematic situation has been overlooked in previous studies. The modern slavery problem is a complex socio-economic system involving many variables creating, aggravating, and controlling labour exploitation. This system composes of many nonlinear closed loops. Any intervention to detect, remediate, and disclose modern slavery may aggravate that in another reinforcing loop. An attempt to motivate and make capable entities remediate labour exploitation could be balanced due to policy resistance in complex systems. Before experimentation and simulation of such a complex system, developing dynamic hypotheses on the structure of causal loops is of great importance. Accordingly, this research aims to design the causal-loop-diagram (CLD) of the modern slavery problematic situation in supply chains. To develop dynamic hypotheses in the form of CLD, the literature is extensively investigated, and the opinions of researchers engaged with modern slavery in supply chains are explored. Then, the stock-flow diagram is formulated. Estimating quantitative functions for variables' relationships will be left for future research. The developed closed-loop dynamic model will create a holistic, systemic hypothetical framework encouraging following research on nonlinear estimation and investigation of the dynamic relations.

# Revealing the complexity of a business ecology that keeps the disability employment gap unbridged in Cornwall, UK

Dr Esmail Morasae<sup>1</sup>, Dr Emma Jeanes<sup>1</sup>, Dr Shruti Raghuraman<sup>1</sup>

<sup>1</sup>University Of Exeter

Parallel Session 1 - Systems Thinking, OC0.04, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*I am a research fellow in complex systems and policy at Exeter University Business School. I hold a Ph.D. in complex systems science and am engaged in a couple of projects focused on health and social inequalities and the circular economy.*

Disabled people are significantly under-employed in Cornwall. This is an interesting case for inquiry as Cornwall is geographically dispersed, insulated, and almost all of its business ecology belongs to micro and small businesses, which are normally more risk averse when it comes to disabled people's employment. In a study with a systems approach, a couple of participatory workshops and ensuing face-to-face interviews (36 interviews) were used to map the conditions that shape disabled people's employment in Cornwall. It was hoped that such a participatory inquiry can open up new intervention ideas for policy-makers and practitioners. As the attached map shows, there are a couple of interlocking and self-sustaining loops of practices on the employer and disabled people's side that act as barriers to disabled people's employment. "Benefit trap", "disclosure dilemma", and "disability as incapability" are the loops of practices that sit mostly on the disabled people's side, and "complexity hurdle", "time-off concern", "regulations monster", "costs monster", and "bonus of experience" are the loops of practices that sit on the employer side. As an illustration, the regulations monster is made of the following practices that have knock-on-effects on each other as follows: low awareness about regulations leads to a fear of wrong-doings among small businesses; this fear of regulations consequences then leads to a kind of aversion towards any risk-taking in the employment of disabled people; the following practice among the businesses is then to rely on personal informal networks for employment; this reliance means that almost no or few disabled people are employed by small businesses; this matter leads to less experience of inclusive recruitment and employment among employers and, as a result, awareness about regulations and the associated fear of regulations are not challenged, leading to the repetition of exclusive employment practice. Similar narratives can be repeated for other sustaining loops of practices. But, the most important implication of all these self-sustaining practices is that there is a need for a portfolio of policies in order to address the disability employment gap in Cornwall, a matter that can be of use for other places across the UK too.

## SYSTEMS THINKING

### Towards a method to incorporate ritual in systems inquiry

Dr Jose-Rodrigo Cordoba-pachon<sup>1</sup>

<sup>1</sup>Royal Holloway, University Of London

Parallel Session 1 - Systems Thinking, OC0.04, September 13, 2022, 11:00 AM - 12:30 PM

***Biography:***

*Associate professor, Royal Holloway, University of London.*

Currently our work and educational settings present challenges for individuals in relation to how to make sense of complexities encountered. The influence of proficility (Moeller and D'Ambrosio, 2021) makes us take distance from our identities and to a sense of place, something that the philosopher Byun-Chul Han (2020) decries. To rediscover ritual and therefore valuable relations between people and the natural environment, systems practice offers an alternative but so far it is too focused on future-action, something inherited from the philosophy of pragmatism and might not be fully solved by promoting boundary critique on the (non-naturally driven) boundaries of concern in inquiry. This presentation aims to show progress made so far in studying and incorporating ideas about rituals in systems practice. A generic process to rediscovery of ritual is proposed and some insights obtained are shared

# Systems Thinking Approach for Digital Competence Development

Mr Ali Hamidi<sup>1</sup>

<sup>1</sup>Department of Informatics, Linnaeus University

Parallel Session 1 - Systems Thinking, OC0.04, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*A doctoral student in the Informatics Department of Linnaeus University. His research focus is on developing digital competence and computational thinking (CT) in an educational context from systems thinking (ST) perspective.*

Digital competence development is one of the sub-goals of the digitalisation strategy defined by the Swedish National Digitalisation Council (Wiggberg et al., 2022). Accordingly, different scenarios have been proposed to achieve this goal. Among them, taking a systems thinking (ST) perspective is one of the scenarios developed to consider the role, support, and interaction of different stakeholders from all parts of the society at different levels including the educational sector. Considering that the application of ST to digital competence development in education is rather scarce, the question is from where to begin? In the educational sector, computational thinking (CT) and programming are considered tools for digital competence development (Skolverket, 2021). Therefore, we propose that the application of ST to CT integration into the school curriculum is the initial step toward digital competence development.

Our previous studies on CT and its connection to ST reveal that ST interplays with CT on the conceptual and practical level, however, an ST approach for CT development is very limited. So, this abstract proposes a possible ST approach to stimulate the improvement of the current trend of CT integration into education and to overcome the methodological challenges of CT development. Different ST methods and approaches have been reviewed and the approach of methodological pluralism, which is a feature of systemic intervention (Midgley, 2000) is applied. The strength of this approach is particularly in its initial phase, i.e., Boundary Critique, where the identification of issues and specification of the boundaries related to CT and digital competence take place. Initiating with boundary critique, we get various possible interpretations of the CT integration, in terms of processes and stakeholders, either first-order or second-order agents. The aim is to contribute to the understanding of digital competence and support how this competence is developed in an educational setting. In addition, this research contributes to the designing of complementing methods for CT research from the individual level to the social level and from conceptual cognitions to technological features.

# The truth about balancing loops - from budgets to behavioural economics

Mr Dennis Sherwood<sup>1</sup>

<sup>1</sup>*The Silver Bullet Machine Manufacturing Organisation Limited*

Parallel Session 1 - Systems Thinking 2, OC1.03, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Dennis has been a devotee of systems thinking since 1984. He is the author of "Seeing the Forest for the Trees - A manager's guide to applying systems thinking" (Nicholas Brealey, 2002) and the forthcoming title "Strategic Thinking Illustrated - A visual guide to applying systems thinking", to be published by Taylor & Francis in September 2022.*

What could be simpler than a balancing loop?

The difference between a TARGET and an ACTUAL defines a GAP, and that drives whatever ACTION is required to close the GAP. End of story. OK, time lags might cause some oscillation, but other than that, job done.

That's what I learnt. And that's what I've taught too - the diagram is on page 56 of my 2002 book "Seeing the Forest for the Trees".

But one day, I told - in the nicest way, of course - my teenage son to tidy his room. A few hours later, I returned to his room to find, surprise, surprise, that the socks were still all-over-the-place.

That should not have happened. There was a GAP between the TARGET (a study room) and the ACTUAL (the mess), which should have driven the ACTION (tidying up). But it didn't. The GAP just stayed there, gaping open.

The theory wasn't working.

So that got me thinking - systemically, I trust.

Which led me to realising that the "standard" balancing loop of TARGET - ACTUAL = GAP drives ACTION might apply to an engineering context such as a thermostat, or "Homo Harvard Business School", but it surely didn't to my teenage son, and many other, real, human beings too. People with feelings such as apathy or hostility, people who couldn't care less whether a TARGET is met or not, people who might think that the TARGET is fundamentally wrong anyway.

That led me to compile a much richer, much more realistic, "standard" balancing loop, which had an "interesting" consequence, opening up the world of behavioural economics, of "nudges", and of the identification of "wise" incentives - these being incentives that work, and that don't backfire.

So, if that might be of interest, I'd be very please to share my thinking at the conference...

# The Q matrix and Transformative Management Canvas: powerful frameworks to tackle resistance to change in system design, project planning, and transformative leadership

Dr Gianni Di Marco<sup>1</sup>

<sup>1</sup>Freelance

Parallel Session 1 - Systems Thinking 2, OC1.03, September 13, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Gianni Di Marco is a Specialist in Transformational Management and Leadership from the University of Lausanne (HEC). He is a qualified practitioner in PCM® Adaptive Communication, B Leader affiliated with B Lab Switzerland, for supporting companies in the assessment of their social and environmental responsibility (CSR) using B Corp's Business Impact Assessment tool, and Certified Specialist in Transformational Leadership Development using the VLD-GLP approach from Global Leadership Associates. Consultant, Coach and Trainer, Gianni Di Marco also holds a doctorate in geology and has more than 25 years of experience in marketing, management, project management and change management. He was CEO and founder of a start-up in the 2000s and created his consulting agency in 2022 to provide advice and support in transformational management. He is the author of the concept of the Q method, of the Transformational Management Canvas (TMC) and of publications on resistance to change and systemic change management (in prep.)*

In an earlier conference, we introduced the IOPR sequence of transformative processes in human systems. Evolving human systems, like children, adults, or organizations, have shown to alternate periods of stability, characterized by one specific paradigm (or action-logic), followed by relatively rapid transitions to the next paradigm (Piaget, 1954; Kohlberg, 1969; Graves, 1970; Kegan, 1982; Wilber, 1986; Hy & Loevinger, 1996; Torbert, 2004). We have shown that a cycle of four basic “modes of actions” underpins the sequences: Integrative (I), Organizing (O), Projective (P), and Redefining (R). Human systems appear to grow and thrive through multiple cycles of the IOPR sequence. Each mode of action is linked to specific priorities. Change processes seem to require that those specific priorities are fulfilled to allow the system to evolve from one mode to the next one. Our hypothesis is that the transformative potential of a system relies on its ability to address the requirements of each and all of the basic modes of action of the IOPR cycle.

The Q matrix allows to quickly analyze any situation, project, or organization and check its readiness and ability for transformative processes. The TMC canvas is a management tool built on the Q matrix to support and improve systems designs, project planning, and leadership development so that they become more transformative and regenerative.

# Keynote: Turbulent Times, Wise Choices

Mr Jeremy Bentham<sup>1</sup>

<sup>1</sup>World Energy Council, <sup>2</sup>Shell (retired), <sup>3</sup>World Business Council for Sustainable Development

Parallel Session 2 -System thinking incl. KEYNOTE -Jeremy Bentham, OCO.04, September 13, 2022, 1:30 PM - 3:00 PM

## *Biography:*

Jeremy has led the renowned Shell Scenarios team for over 15 years, as well as being a member of the top leadership team advising the CEO, Executive Directors and Board on the company's global strategy. In total, he has over 40 years' experience in the energy industry, encompassing technical, commercial, research and multiple leadership roles.

During his tenure, the scenario mindset has helped the company anticipate and adapt to momentous events such the Covid pandemic, the turbulent and rapidly transforming global energy system, the escalating climate crisis, and the global financial shocks triggered in 2008.

Successes have been achieved through quiet but persistent and trusted advice and through building transformative collaborations such as the Energy Transitions Commission.

Most recently, he was responsible for developing Energy Transformation Scenarios which explore possible ways the 21st century could unfold, with dramatically different implications for society and the world's energy system (including a pathway for society to achieve the stretched ambitions of the Paris Agreement on Climate). See [www.shell.com/scenarios](http://www.shell.com/scenarios)

On retiring from Shell, Jeremy is now building a portfolio of part-time, non-executive, coaching, advisory and academic positions. He is, for instance, Co-Chair (scenarios) of the World Energy Council, a member of the Imperatives Advisory Board of the World Business Council for Sustainable Development, and a Member of the President's Council of Pathfinders International. He is also contributing occasional seminars at Erasmus and Oxford universities, MIT, and the National University of Singapore.

With a war raging in Europe and a world struggling to emerge from a pandemic, most people would agree that these are turbulent times. These developments actually illustrate and amplify deep structural currents in the world that have long brought us into a particular era of volatility and transitions. Nevertheless, in the face of radical uncertainties, we all still need to make important choices as businesses, policy-makers, researchers or individuals. Yet our natural human instincts and biases can mislead us. In this session, Jeremy will share experience and a system-oriented approach to making wise decisions in such circumstances, founded on a scenario mindset, systems thinking and open enquiry, and illustrated through considering the energy system.



# A Multisystem Approach in Tackling Digital Innovation Process

Dr Sadaf Salavati<sup>1</sup>, Dr Erdelina Kurti<sup>1</sup>

<sup>1</sup>Linnaeus University

Parallel Session 2 -System thinking incl. KEYNOTE -Jeremy Bentham, OCO.04, September 13, 2022, 1:30 PM - 3:00 PM

## ***Biography:***

*Sadaf's interest lies in Systems Thinking, primarily Soft Systems Thinking. She is the leading contact person for the Linnaeus University Systems Community. Sadaf teaches in the undergraduate programs at the Department of Informatics. She also teaches courses at undergraduate and advanced level in Systems Thinking for professionals.*

Digital innovation, an inevitable contemporary phenomenon, consists of several stages, making it a complex endeavor requiring a systemic perspective. According to Nambisan et al. (2017) digital innovation represents both a process and an outcome, and the boundary between them is fluid. Kohli and Melville (2019) report on four stages of digital innovations, which include: initiation, development, implementation, and exploitation. These stages are not manifested uniformly in all digital innovations. They are also not linear and often entangled with one another. Further, digital innovation transpires in an internal and external environment, which contextualizes and at the same time influences each stage and the progression. Multiple systems approaches and methodologies provide a systemic understanding of the different stages but also the process in its entirety. In this line of reasoning, Rich Pictures and Patterns of Strategy could be used for the Initiate stage, which aims to identify and translate opportunities into initiatives. Other methods such as Viable Systems Model could be suitable for the implement stage, which is about organizational changes occurring during digital innovation. A multiple systems approach would be utilized for all the evident stages and the environment. A systemic approach which includes several methodologies and methods has been applied by several systems thinking scholars (e.g. Mingers, 1997; Midgley, 2000) in various areas, including innovation (e.g. Midgley and Lindhult, 2021). However, the combination of digital innovation and systems thinking has been rather limited. Hence, in this work in progress, we propose and advocate the utilization of systems thinking to explain and tackle the dynamic complexity emerging in the digital innovation process and its different stages, taking into account the specific context in which it occurs.

# Learning Systems Thinking: we need the action as well as the ideas

Prof Anita Mirijamdotter

Parallel Session 3 - System thinking incl. KEYNOTE - Prof. Anita Mirijamdotter, OC0.04, September 13, 2022,  
4:30 PM - 6:00 PM

## *Biography:*

Dr. Anita Mirijamdotter is Professor of Informatics at Linnaeus University, Sweden. In that role she serves as Head of Subject, which involves disciplinary responsibility for Informatics research and education, including its development, and leads the Informatics research group. She is also co-founder of the Linnaeus University Systems Community. Research and teaching focus on design and management of information, communication, and decision systems in dynamic organizational settings. Anita's specialization includes Systems Thinking Methodologies and Models, Digital Business Models, embracing design, implementation and evaluation, and Participatory Action Research in relation to change management. Anita has extensive experience delivering higher education across the globe, including countries in the Balkan Region, such as Kosovo and Albania. Additionally, she has been granted Erasmus + International Credit Mobility funds 2018-2023 for exchange of faculty, staff and students with Universities in Kosovo, and University of Tirana, Albania. Another Erasmus + KA2 funded project, 2019-2023, concerns Development and Implementation of National Research School in ICT for Kosovo Education System. A grant by The Knowledge Foundation secures International Visiting Professor focusing on Systems Thinking for Sustainability. The position is held by Professor Gerald Midgley, Hull University. The latest grant concerns EU Horizon 2021 MSCA Doctoral Network, which will start in autumn 2022 and includes financing of ten PhD students placed in five European countries.

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Learning Systems Thinking: we need the action as well as the ideas

# TOWARDS A METHODOLOGY FOR DEVELOPING A SYSTEMIC AND PARTICIPATIVE THEORY OF CHANGE

Mr Lloyd Wilkinson-Cunningham<sup>1</sup>, Prof Gerald Midgley, Ms Esther Hall

<sup>1</sup>East Riding Of Yorkshire Council

Parallel Session 3 - System thinking incl. KEYNOTE - Prof. Anita Mirijamdotter, OC0.04, September 13, 2022,  
4:30 PM - 6:00 PM

## ***Biography:***

*Lloyd Wilkinson-Cunningham is the Evaluation Co-ordinator for Active Withernsea. Lloyd holds a 2:1 undergraduate degree in Forensic Psychology (Hons) from Leeds Trinity University and a Masters degree in Investigative Psychology from The University of Huddersfield. He has had a career in behaviour change, working in substance misuse services and inpatient forensic units before moving on to work in research and evaluation. He has worked on a number of research studies, including investigating the use of Schema Therapy in treating Borderline Personality Disorder; exploring the use of Qbtesting within a youth offenders institute to detect ADHD; Evaluation of SECURE STAIRS and Novax COVID trials.*

Active Withernsea (AW) is an innovative pilot project, run by East Riding of Yorkshire Council (ERYC) and funded by Sport England, aiming to increase physical-activity levels in Withernsea. A systemic community development team supports residents in becoming more physically active in the short term, while simultaneously working for wider system changes to create a more enabling environment for physical activity in the longer term. Sport England requires the theory of change (ToC) underpinning the pilot to be made explicit, so the achievement of that change can be evaluated. Our development of the ToC was grounded in the strategic planning of the pilot, which was facilitated using a participative, mixed-methods, Systemic Intervention approach. A first draft of the ToC was tested for accuracy with the community development team, and then evolved through interviews with a range of internal and external stakeholders. It has therefore become a thoroughly Participative ToC (or PToC, as it has come to be known). The final PToC is now being used as the basis for a systemic evaluation of the pilot. Reflection on this process allows us to retrospectively identify the key methodological stages and systems methods involved in developing the PToC (e.g., boundary critique, rich picturing, system change diagramming, kumu, stakeholder analysis, strategic prioritization, ToC visualization, stakeholder interviews and systemic evaluation design). These stages and methods include the strategic planning that articulated the systemic rationale for the pilot. There is the potential here to work towards a new methodology for designing systemic community development projects with participative theories of change.

# The hidden pattern of transformative processes in human systems, reflecting principles of resistance to change in organizations

Dr Gianni Di Marco<sup>1</sup>

<sup>1</sup>Freelance

Parallel Session 5 - Systems Thinking, OC0.04, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Gianni Di Marco is a Specialist in Transformational Management and Leadership from the University of Lausanne (HEC). He is a qualified practitioner in PCM® Adaptive Communication, B Leader affiliated with B Lab Switzerland, for supporting companies in the assessment of their social and environmental responsibility (CSR) using B Corp's Business Impact Assessment tool, and Certified Specialist in Transformational Leadership Development using the VLD-GLP approach from Global Leadership Associates. Consultant, Coach and Trainer, Gianni Di Marco also holds a doctorate in geology and has more than 25 years of experience in marketing, management, project management and change management. He was CEO and founder of a start-up in the 2000s and created his consulting agency in 2022 to provide advice and support in transformational management. He is the author of the concept of the Q method, of the Transformational Management Canvas (TMC) and of publications on resistance to change and systemic change management (in prep.)*

A regular pattern underpins the sequential transformative processes in human systems. It is built on cycles comprising four successive paradigms which govern the system and produce periods of stability. The first three paradigms are evolutionary steps in a stable system-logic. The process of transformation following the third paradigm requires a complete change in the system-logic, producing at this stage a profound transformation of the system itself.

It is well accepted that the natural evolution of individuals or human systems present themselves more as a succession of stages than as a continuous transformational process (Piaget, 1954; Kohlberg, 1969; Graves, 1970; Kegan, 1982; Wilber, 1986; Hy & Loevinger, 1996; Torbert, 2004). In their attempt to describe each tier of the evolutionary sequences in human systems, authors have expressed periods of stability as being related to specific system-logics (Watzlawick et al., 1974), also called action-logics (Torbert, 2004), constructs of collective action (Crozier & Friedberg, 1977) or more generally systemic paradigms. Paradigms act as stabilizing principles to prevent individuals or organizations from overreacting to any environmental or contextual changes. As such, they also act as resistance factors when system change is “necessary”. Synthetic analysis of the sequences from various human systems reveals that a regular pattern underpins the transformative processes. It produces cycles composed of the following paradigms: Integrative (I), Organizing (O), and Projective (P), and Redefining (R). Each paradigm emerges as a response to unresolvable problematics of the previous one. At the end of the IOP sequence, a major transformative process takes place to move the cycle back to a new Integrative paradigm at a meta-level. This path requires a significant transformation of the system-logic, which is the main characteristic of the Redefining (R) paradigm.

We will show how the INPR pattern is present in all evolutionary sequences of human systems and how understanding this “hidden” pattern of transformation processes can help improve systems designs, project planning, and leadership development so that they become more transformative and regenerative. Finally, we will introduce the Transformative Management Canvas (TMC), based on the IOPR cycle, which we will present in detail in a later conference.

# Using Critical Systems Thinking from a Critical Realism perspective to improve Resource Allocation

Roelien Goede<sup>1</sup>

<sup>1</sup>North-West University

Parallel Session 5 - Systems Thinking, OC0.04, September 15, 2022, 9:00 AM - 10:30 AM

## ***Biography:***

*Roelien Goede, PhD, is President of the International Society for Systems Sciences for the term starting June, 2022. She is a scholar of Critical Systems Thinking in Management Information Systems. She is the director of the research Unit for Data Science and Computing at the North-West University in South Africa.*

Real world problems require real world solutions. The real world is experienced from different perspectives by different individuals. Solutions for real world problems is a fallacy when our focus is on a single solution rather than on improvement from various perspectives. Critical systems thinking promotes holistic thinking from different perspectives aimed at improving the problem situation for both the involved and affected parties.

The paper present critical systems thinking from a critical realism perspective in the context of traditional operational research methods. Traditionally critical systems thinking is practiced from a critical social theory perspective. The ontological perspective of critical social theory is based on the idea that circumstances create injustices and prevents some individuals from developing their potential. However, the critical social realism paradigm is growing in acceptance in various scientific disciplines where critical systems thinking are practiced. The ontological assumptions of critical social realism focus on the different aspects of reality in terms of structure, events, and experiences. This paper explores the application of critical systems thinking in the context of the ontological assumptions of critical social realism.

It demonstrates how operational research modelling strategies can be used from a critical systems thinking perspective to improve a practical problem in management of a faculty at a university. A Post-Doctoral Fellowship allocation problem in a natural science faculty is used as demonstration. Resource allocation is a traditional operational research problem area. In this demonstration we demonstrate how a multi-stakeholder perspective discloses the complexities of the problem and how traditional allocation of resources used in past, re-enforced injustices. From a critical realism perspective, we distinguish between the objective structure and the subjective experiences of the different stakeholders. The proposed method and its demonstrations make a contribution to the theory and practice of critical systems heuristics.

# Toward data-driven operational risk management: Analysing the temporal effects of causal factors

Ms Nikki Cornwell<sup>1</sup>, Dr Christopher Bilson<sup>1</sup>, Dr Adrian Gepp<sup>1</sup>, Prof Steven Stern<sup>1</sup>, Prof Bruce Vanstone<sup>2</sup>

<sup>1</sup>Bond University, <sup>2</sup>Bangor University

Parallel Session 5 - Systems Thinking, OC0.04, September 15, 2022, 9:00 AM - 10:30 AM

## *Biography:*

Nikki Cornwell is a PhD Candidate within the Centre for Data Analytics at Bond University. Her research focusses on leveraging data through various statistical and machine learning tools to assist organisations more rigorously and efficiently manage their operational risks. In addition, Nikki is an Associate of the Institute of Actuaries of Australia and translates her research into practice as a Risk, Strategy and Technology consultant with KPMG Australia.

*Nikki graduated from her Bachelor of Actuarial Science (First Class Honours) majoring in data analytics and finance with the Steven Johnson Memorial Medal and Queensland Treasury Prize for Actuarial Science. She is also a Member of the Bond University Centre for Data Analytics Committee. Professors from the Centre for Data Analytics and Bangor University have contributed to Nikki's research.*

The consequences of inadequate or failed internal processes, systems and people – operational risks – are costly and disruptive for organisations globally. Understanding the factors contributing to such risks and their causal pathways is key to effective operational risk management. Current approaches predominantly involve individuals reviewing past incidents, investigating their causes and recommending corrective actions to minimise similar occurrences in the future. These manual and qualitative processes are (a) costly, (b) reactive, (c) biased by assessors' subjectivities and experiences, (d) limited by human processing capacity in drawing inferences and similarities beyond a small sample of historical incidents, and (e) provide infrequent and static snapshots of the operational risk environment to decision makers.

Research is emerging using data analytics to identify what factors contribute to incidents, offering a more rigorous and consistent process for causal factors analysis. However, current data-driven approaches do not provide in-depth insights into how causal factors influence the probability of an incident. Further to the individual and collective effects of causal factors, the temporal effect between incident occurrences and causal factors has not been explored.

This study analyses how the temporal dynamics of a system can explain variations in the probability distributions of operational risk incidents. Using lagged terms, dynamic Bayesian networks are developed and empirically evaluated to model the relationships between causal factors and operational risk incidents over time. The optimal time-dependent model is subsequently compared with a baseline time-independent model, a static Bayesian network. The study is applied to aviation safety incidents, using five terabytes of one-secondly data on over one hundred dynamic sensors from the onboard flight monitoring systems of regional commercial aircraft.

While showcased with an aviation implementation, the enhanced data-driven approach to causal factors analysis is generalisable to other industries. Considering the temporal dynamics across an operational risk profile uncovers cumulative and delayed effects of causal factors on the probability of operational incidents. These insights indicate the speed that risky operating conditions can affect an organisation, thus enabling risk managers to efficiently allocate resources and implement mitigation strategies. More proactive management can reduce costly incidents, improve regulatory compliance and increase operational capacity.

# A Model/Framework? for Systems Thinking Practice

Dr Natalie Clewley<sup>1</sup>, Dr Tim Forsyth<sup>1</sup>, Dr Lorraine Dodd<sup>1</sup>, Mr Jeremy Hilton<sup>1</sup>

<sup>1</sup>Cranfield University (Defence and Security)

Parallel Session 6 - System thinking, OC0.04, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Having navigated an unconventional career path that includes a Bachelor of Engineering Degree and a Social Science PhD, Tim studies the relationships and structures formed between people and organisations; and the strategies of governance, leadership and management that contribute to work-related stress, depression and anxiety. In this regard, Tim's principal research interests lie at the interface of sociotechnical systems and peoples' subjective experience of challenge in complex organisational environments.*

This paper provides a novel model/framework for OR practitioners to approach and engage in complex situations. Developed over many years by the Systems Thinking Practice team at Cranfield University, this framework builds upon and complements previous multi-methodology theory (Jackson, 2019; Mingers & Brocklesby, 1997) and draws from new methodological developments in philosophy of science (Blaikie & Priest, 2017). Reflective Practice lies at the heart of good systems intervention (Churchman, 1979; Dodd, 2018; Hoverstadt, 2022; Jackson, 2019). The proposed framework uses Reflective Practice as the conduit that coheres three interrelated and interdependent domains: the practitioner-academic interface; systems tools and methods; and philosophical perspectives.

The intersection of these three domains highlights additional challenge areas that practitioners need to be aware of. At the intersection of Philosophy and Method is a new methodology that links the 'whats' and 'hows' (Checkland, 1999, p. 163). At the intersection of Practitioner and Method, the practitioner must balance the selection of methods in conjunction with their previous experience, skills and preference for individual tools, in such a way as to be mindful of any biases. The intersection between Practitioner and Philosophy is grounded in the lower levels of the Iceberg Model (Hall, 1976) where the practitioner should be mindful of (and potentially surface) any personal beliefs and values that may inhibit the appreciation of other perspectives.

Currently, we apply this model/framework in research in Public Health, Defence and Security and Organisational Resilience; also, in teaching a new generation of systems thinking practitioners who will go on to be active members within the OR community. Going forward, our intention is to generate a set of principles to support practitioners engaging with complex situations within OR.

# Tracing the good regulator: variety management and soft OR

Dr Maya Vachkova<sup>1</sup>

<sup>1</sup>University Of Exeter

Parallel Session 6 - System thinking, OC0.04, September 15, 2022, 11:00 AM - 12:30 PM

## *Biography:*

Maya is a systems thinker and a facilitator with a passion for social issues and participatory organisational transformations. Maya holds an LLM, an MA in Peace, Conflict and Development and a PhD in Systems Thinking.

She is the Programme Director for the MSc Systems Thinking in the Public Sector - an applied Apprenticeship for civil servants. Her external engagements are a membership and support of Metaphorum and a visiting fellowship at the Centre for Systems Studies at the University of Hull.

The good regulator is a foundational theorem in cybernetics, the science of communication and control in natural, social and technical systems. The good regulator is a system that should represent a mini model of the larger system it aims to regulate (Conant and Ashby, 1970). The 'good regulator has been developed by Ashby (2018) to include a critical perspective on ethicality. It was also been applied to understanding competence (Tugushev, 2018) and modelling activities (Stone and Alicea, 2021). Nonetheless, the good regulator theorem has not received much scholarly attention.

While nowadays control theory carries connotations with systems engineering, it is still of relevance to human systems. This abstract aims to invite critical reflection on boundaries and inclusion of relevant perspectives to expand the theorem.

The good regulator theorem can be traced in organisational and operational developments relevant to variety management. Variety is a cybernetic notion that refers to all the states an entity could adopt. Organizations possess horizontal and vertical variety – where the former relates to their ability to tackle environmental variety, and the latter – internal variety.

The conference paper will present examples where the horizontal and vertical variety management of organizations presents regulatory pathologies. Thus, this abstract aims to invite an exploratory discussion and to present a new research agenda inspired by the good regulator theorem. Such a research initiative will be relevant to operational research and cybernetics but also to critical systems thinking, institutional theory, law, organisational and political theory.

## References:

Ashby, M. (2018). How to apply the Ethical Regulator Theorem to crises. *Acta Europæana Systemica*, 8, 53-58.

Conant, R. C., & Ross Ashby, W. (1970). Every good regulator of a system must be a model of that system. *International journal of systems science*, 1(2), 89-97.

Tugushev, M. S. (2018). Competence's Theorem: Solving Problems of Water Utilities. *International Journal of Energy Economics and Policy*, 8(5), 104.

Stone, R., & Alicea, B. (2021). The Foundations of Control and Cognition: The Every Good Regulator Theorem.



# The Build for Purpose Canvas

Dr Miles Weaver, Dr Ana Paula Fonseca, Dr Hock Tan

<sup>1</sup>Edinburgh Napier University Business School

Parallel Session 6 - System thinking, OC0.04, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*Dr Weaver has research interests in Sustainability, Strategy and Supply Chain Management. Particularly, the use of systems-based approaches for cross-sector collaboration to accelerating progress towards the Sustainable Development Goals.*

The paper proposes the “Build for Purpose Canvas” (B4PC) to help organisations to put purpose at the heart of their business, build meaningful relationships with communities and amplify impact by co-creating solutions to common issue(s) of concern when multiple stakeholders share value(s). The B4PC complements the “Build for Purpose Pathway” (See Fonseca et al., in press) that combines the benefits of different systemic approaches to sustainability as reviewed by Weaver et al., (2020). The B4PC can help participants to make sense of sustainability challenges, their complexity and interconnectedness; connect business purpose and value(s) with societal goals; appreciate interdependences within and between oneself, others, and ecological ecosystems; and identify ways to amplify impact by building meaningful engagement with communities in cross-sector partnerships. The paper offers a novel contribution by offering methodological considerations to the underlying systems concept to realise the potential of systems thinking and systems-based approaches to address our grand challenges for a sustainable future (e.g. a just transition to a low carbon economy, accelerating progress to attain the Sustainable Development Goals).

# Methodology to develop a participatory monitoring system on selected Chilean's socio-ecosystems: Bayesian inference and human scale development on wetlands.

Mr Renard Betancourt<sup>1</sup>

<sup>1</sup>Universidad Austral De Chile

Parallel Session 6 - System thinking 2, OC1.03, September 15, 2022, 11:00 AM - 12:30 PM

## *Biography:*

Renard Sergio Betancourt Arellano is a post-graduate from Instituto de Economía, Universidad Austral de Chile. Renard does research in Ecological Economics, Human Scale Development Theory, Sociology and Philosophy of Science.

Assistant professor at Universidad Austral de Chile; researcher at Edáfica.

Institution and department  
Universidad Austral de Chile  
Instituto de Economía

## Skills

*Ecological Economics · Sustainable Development · Sustainability*

There's evidence "beyond any reasonable doubt" on how human health depends on biodiversity and how human economic activities impacts biodiversity (Chivian & Berstein, 2008). This research focus on the development of a monitoring system/device that allows to manage the relationship between economics decisions/practices, driven by a particular economic rationality, and load capacity of specific territory. Rockström et. al, (2009) shown us how biodiversity loss is one of the most affected planetary boundaries by human activities. We also know climate change is impacting most life on Earth, and microorganisms are showing terrible evidence in this regard, especially because this life form supports the existence of all higher trophic life forms (Cavicchioli, R., et al., 2019). Its widely studied how biodiversity loss impact humanity in several ways (Cardinale, B. et al. 2012 ), some of them may include emergence and transmission of infectious diseases (Keesing, F., et al. 2010); the dependence and influence of people on biodiversity across scales (Isbell, F., et al., 2017), as well as the relevance of upgrading protected areas (Pringle, R., 2017) not only to conserve wild biodiversity, also for the sake of human health, or if you will, for the sake of the health of all species: biodiversity conservation as a goal to reach the aim of One health statements (Kim Gruetzmacher, et al., 2021). In this regard, the relationship between humans and its environment could improve if apply a management solution. For that, we rely on critical system thinking framework, using a board game, bioindicators, human scale development index and Bayesian inference, all to visualize thresholds on which citizens -living near wetlands areas- could/should decide if they'll go for a trajectory that's synergic, stable, unstable or collapse between them and their territory.

# Breaking News: Slime Mold Defeats Poverty

Mr Alexander Knapp<sup>1</sup>

<sup>1</sup>University Of Edinburgh Business School

Parallel Session 6 - System thinking 2, OC1.03, September 15, 2022, 11:00 AM - 12:30 PM

## *Biography:*

Alexander Knapp has worked for twenty-five years in international consulting, including strategy, policy, planning, hostage negotiation, fundraising, crisis management, operations, disarmament, and effectiveness. From 1995 to 2012 he served in the United Nations in sixteen peacekeeping, post-conflict reconstruction and humanitarian aid missions around the world including Bosnia, Kosovo, East Timor, Afghanistan, Sierra Leone, Haiti, Angola, Liberia, Eastern Slavonia (it's a real place), Iraq, Democratic Republic of Congo, Tajikistan, Darfur, Central African Republic, and South Sudan.

In addition to consulting, he is a PhD candidate at the University of Edinburgh's Business School, focusing on "Development Jazz: Improving International Development Outcomes through Complexity-Informed Methods and Tools". His applied research focuses on new approaches to wicked problems globally applying biomimetic models from neuroscience, organic chemistry, genetic engineering, ecology, and quantum physics to similarly interdependent and probabilistic challenges like endemic poverty, environmental degradation, infection diseases, representative governance, infant mortality, food scarcity, and climate change.

*He is a Visiting Lecturer in Complexity and International Business at Regent's University in London, and a Visiting Professor of International Development at the American University School of International Service in Washington DC. He holds degrees in international relations, international law, public administration, and Italian culinary arts, has been shot twice, shelled, held at gunpoint more times than he can count, car-bombed, expelled from three autocratic countries, and kidnapped, which has contributed to his calming demeanour under pressure, good sense of humour, and arsenal of amusing anecdotes about the challenges of change management.*

Over the past seventy years, international development and humanitarian aid have saved hundreds of millions of lives, lifted a billion people out of poverty, and improved the quality of life and prospects for half of the world's population. These advances, framed within a mechanistic and linear paradigm, are however delivering diminishing returns as global social, economic, environmental, technological, and political systems become massively more interdependent.

Though well established in the physical sciences, Complex System Theory has only rarely been applied to international development (and then generally anecdotally), yet it has the potential to provide funders, implementors, and local partners with an additional lens through which to understand Wicked Problems such as climate change, sustainable resource management, or public health resilience.

Working with four to eight of the world's leading international non-governmental organisations (INGOs) across different sectors and countries, this research seeks to determine if training in 'complexity' and the provision of non-linear tools and methods to apply to multivariate development programmes quantifiably increase progress toward the United Nations Sustainable Development Goals and their targets.

# On the verge of falling through the cracks of employment system when chronological age ticks towards 60: a systemic approach to the employability of older people in Cornwall, UK

Dr Esmail Morasae<sup>1</sup>, Dr Emma Jeanes<sup>1</sup>, Dr Shruti Raghuraman<sup>1</sup>

<sup>1</sup>University Of Exeter

Parallel Session 6 - System thinking 2, OC1.03, September 15, 2022, 11:00 AM - 12:30 PM

## ***Biography:***

*I am a research fellow in complex systems and policy at Exeter University Business School. I hold a Ph.D. in complex systems science and am engaged in a couple of projects focused on health and social inequalities and circular economy at Exeter University.*

Older people have a unique conflicting figure in Cornwall. The place is well-known as an attractive place for retirement, but at the same time, there are a considerable number of people over 55 living in the county who struggle to get employed and are not able to retire. In a research project called the Inclusivity Project, we aimed to use a systems approach to understand the factors and conditions that shape the employment experience of people over 55 in the county. A couple of group model-building workshops and face-to-face interviews (29 interviews) were conducted to create a co-learning and co-creation space and map the self-sustaining loops of practices that shape the employment of older people in Cornwall, where almost all of the businesses are small and their risk aversion is very high. As the attached map shows, there were a couple of interlocking and self-sustaining practice loops that people identified as follows: “gap as a trap”, “manageability hurdle”, “health hurdle”, “performance hurdle”, “word-of-mouth system”, “inclusivity effect”, “endless pain”, “unemployment begets unemployment”, and “hurdle of location”. As an illustration, most of the sustaining loops of practices act as barriers to employment of disabled people and this creates a gap in the employment history of older people in Cornwall. As a negative consequence, when these people apply for positions, the employers see the gap as another sign of incompetency or lack of performance and do not risk employing older people and prefer to resort to the traditional word-of-mouth system where they can make sure that there is less risk in employment. The repercussion is that the employment gap becomes longer for older people and the employers’ negative attitude to the performance of older people is not challenged or tested, both leading to the sustainment of the practice loop and also the exclusivity of the employment system for older people in Cornwall. The same story can be repeated for other loops, but the main takeaway message from the co-created map of practice loops is that a coordinated, multi-pronged approach to improve older people’s employment is required in Cornwall.

# Dynamic Modelling of Sustainable Balanced Regional Development Theory (Case Study: Deprived Area of Ilam in Iran)

Dr Marzieh Samadi Foroushani<sup>1</sup>, Dr Mahnaz Hosseinzadeh<sup>1</sup>

<sup>1</sup>The University of Sheffield

Parallel Session 7 - System thinking, OC0.04, September 15, 2022, 2:30 PM - 4:00 PM

## *Biography:*

Mahnaz Hosseinzadeh is a Lecturer in Operations Management and Decision Sciences at Sheffield University Management School, University of Sheffield, United Kingdom.

Mahnaz holds a PhD in Operational Research from the University of Tehran.

Prior to joining the Management School, Mahnaz worked at the University of Tehran, initially as a Lecturer and then a Senior Lecturer in Operational Research Management. She has also been a visiting researcher at Linköping University.

*Her research focuses mainly on system dynamics, optimisation, multiple criteria decision making and soft operational research, emphasising social sustainability in supply chains. She is the author of many scientific articles published in peer-reviewed journals in Operational Research and Information Sciences.*

Regional development is a general effort to reduce regional inequalities by supporting economic activities in the regions. The old paradigm of regional development identifies the causes of inequalities in income, infrastructure, and employment and provides temporary compensation for regional deprivations. The new paradigm finds inequalities rooted in the lack of competitiveness and insufficient use of regional potential and exploits regional opportunities and capacities through long-term development planning. Besides, sustainable regional development strategy has received much attention in regional planning systems, based on which the region's economic development must remain at a level that is not beyond the environmental capacity of the region and should finally improve the quality of human life.

Long-term planning demands robust tools capable of assessing the effects of different policy interventions. Accordingly, we applied the system dynamics approach to develop a systemic model of regional sustainable development in deprived regions based on the theories addressed in the new paradigm. As a case study deprived province of Ilam in Iran is investigated.

According to the elements of balanced regional development theory, sustainable regional development, and sensitivity analysis results, individual and combined policies for sustainable development of deprived areas were developed, applied to the model, and simulated, and the results were analysed. According to the results, the selected combined policy includes: economic, say, investing in job opportunities in the energy, agriculture, and tourism industries in the region; social, namely increasing accountability and transparency to fight political corruption and the influence of power in the allocation of governmental resources, and empowering the agricultural, energy, and tourism workforce in accordance with the available job opportunities in the sectors; and environmental, including investing in the efficiency of water resources to manage water demand in the agriculture and energy sectors and increasing the supervision on the implementation of environmental requirements and imposition of environmental fines for the beneficiaries of industrial development in the region and the obligation to publish sustainability reports.

The developed model has a generic nature and can be applied in different regional development planning in deprived areas to investigate the long-term effects of different policies emphasizing exploiting regional capacities.

# The Convergence Point Between Western and Eastern Systems Thinking: An Evidence Synthesis for the Case of E-Governance

Dr Mounia Drissi<sup>1</sup>

<sup>1</sup>Mohammed Bin Rashid School of Government

Parallel Session 7 - System thinking, OC0.04, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*An Assistant Professor of public policy at the Mohammed Bin Rashid School of Government in Dubai. Dr. Mounia Drissi holds a PhD Cum Laude in political science and sociology with a background in psychology. She has an experience within the public and private sector, from teaching, providing research assistance in behavioral science to behavioral consultancies and data analysis for market research. Her current areas of interest are governance, system thinking and collaborative technologies; and behavioral insight for public policy,*

Many gulf countries hold a very high rank in the E-Government Development Index (EGDI), following years of enhancing their service delivery to citizens, businesses and data sharing between governments. However, evidence abounds with projects' failure, lack of service integration and dissatisfactory adoptions. As a complex system by definition, e-government can benefit from well-formulated and forward-looking system thinking approaches. However, would existing western and eastern frameworks meet at this intersection point? This paper achieves two goals. First, it uses meta-research to synthesize the literature specific to the application of system thinking to e-government services. Then, it discusses the application of these findings to the unique make up of the gulf's organizational culture. In doing so, the paper aims to start the discussion towards emergent models that can best serve the e-government process in this region.

# Systems thinking on the rise - Rethinking the structures of subject content in primary teacher education

Dr Maria Svensson<sup>1</sup>

<sup>1</sup>University Of Gothenburg

Parallel Session 7 - System thinking, OC0.04, September 15, 2022, 2:30 PM - 4:00 PM

## ***Biography:***

*Maria Svensson is an Associated Professor in the subject area of technology education at the University of Gothenburg. Her research focus is in the field of technology education with a special interest in teaching and learning technological systems and systems thinking.*

School teachers are central in today's society in developing citizens who have the capability to deal with and understand challenging and complex problems, like social exclusion, poverty, climate change, and ecosystem degradation. The foundation of teaching is a teacher education that prepares teachers with knowledge and skills to engage with these problems. Complex problems require new ways of teaching and understanding the world. Learning systems thinking during teacher education gives student teachers tools to understand and teach about complex problems. This means, for instance, that the traditional way of dividing and describing problems in relation to subjects needs to be challenged and re-evaluated, and complemented with systems thinking. Systems thinking enables understanding a world of continual transformation and evolution; combining components and seeing both parts, interconnections and wholes are critical.

Therefore, the focus of this upcoming project will be on investigating opportunities of systems thinking in subject courses, in science (biology, physics, and chemistry)-technology and social (history, geography, religion, and social science) studies in primary teacher education. We believe that the interdisciplinary nature of the science-technology and social studies courses have specific potential for supporting the development of systems thinking among future teachers, so that they have the capacity to educate students into agents of change.

The purpose is to examine systems thinking in, and across subjects, in subject didactics courses in teacher education, track 4-6. Student teachers' awareness and use of systems thinking is explored using an intervention-study approach in a teacher education context to give student teachers access to systems thinking, and provide opportunities for student teachers to understand, and handle, complex problems.

Research questions:

1. How can higher-level systems thinking be introduced in, and across, subjects in subject didactics courses in primary teacher education?
2. How can awareness of systems thinking support interdisciplinary understanding among student teachers?
3. In what ways can systems thinking strengthen the interdisciplinary basis needed to understand complex problems?

## POSTER PRESENTATIONS

### Towards a consistent evaluative method for facilitated workshops

Miss Zoe Horsham<sup>1</sup>, Dr Kathy Kotiadis<sup>1</sup>

<sup>1</sup>Kent Business School, University of Kent

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

#### ***Biography:***

*Zoe is a PhD Management Science student at Kent Business School. Her focus is examining the impacts of facilitated workshops through a psychological lens. Her current research explores how psychological theories may inform the development and evaluation of facilitation in OR, as well as testing and extending upon current theories in group psychology on biases in group decision making*

Facilitated workshops have gained popularity due to beliefs that stakeholder participation allows more effective decisions to be made. Despite this, there is little consensus on what constitutes “successful” facilitation and whether workshops achieve their intended outcomes. Consequently, there is a growing call for evidence for the impacts of facilitated workshops. Previous attempts at evaluation have been inconsistent; using different methods, evaluating different aspects of workshops and being restricted to particular approaches. Most evaluation is based on anecdotal evidence from facilitators which is prone to bias and not quantifiable. This is problematic for the field, particularly as soft approaches are declining in popularity. Without quantifiable evidence, the efficacy of approaches cannot be formally evaluated and compared, meaning we cannot ascertain which are most effective and indeed, whether they are effective at all. Furthermore, owing to the field stemming from engineering, there is little social scientific theory implemented into facilitation despite being driven by group interaction. To address these issues, we have developed a questionnaire to evaluate facilitated workshops, underpinned by theory and empirical evidence from OR and wider social scientific literature, including social and cognitive psychology. Previous research has advocated for the use of psychological theory to underpin OR research, yet few papers have drawn from the field. We also utilise facilitator competency frameworks to inform our items, praised for their informative nature yet underutilised in evaluation. An extensive literature review encompassing this literature identified key factors to consider in evaluating workshops, forming the variables for our questionnaire. Some examples include co-construction of meaning, procedural justice, trust, and facilitator competencies including conflict resolution, reinforcement of a participative environment and encouraging evaluation of a wide range of options. We believe adoption and further extension of this questionnaire will serve as a strong first step towards more consistent and quantifiable evaluation for the efficacy of facilitation in OR.



# Predicting students at risk of becoming NEET (Not in Education, Training or Employment)

Miss Pranjumrita Kalita<sup>1</sup>, Miss Rachel Humphries, Miss Vanshika Namdev, Mr Abhijeet Mulgund

<sup>1</sup>Warwick Business School

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*I am a Master's student at Warwick Business School, pursuing Business Analytics. I was recently a fellow at Data Science for Social Good (DSSGx UK 2022) where I worked with non-profit organizations to help them solve societal challenges, leveraging Data Science. In my future professional journey, I look forward to optimize business strategies through Data Science and help customers with a seamless product experience.*

This poster idea is from my summer project in association with DSSGx (Data Science for Social Good) UK's Summer Fellowship Program, where I worked with non-profit organizations, helping them address societal challenges through Data Science. Our project partners were the Buckinghamshire Council and EY Foundation.

## **Problem Definition:**

The majority of the students in Buckinghamshire attend good or outstanding schools (88.8%) and overall outcomes at Key Stage 4 (GCSE) are consistently above both national and Statistical Neighbour averages, with 96% of the 18/19 KS4 cohort in a sustained education, apprenticeship or employment destination a year after completing their GCSEs. However, outcomes are not universally high for all pupils or pupil groups, and the reported rate of NEET/not known destinations for 2018-2020 was above 7%. Studies have shown that time spent NEET can have a detrimental effect on physical and mental health, and increase the likelihood of unemployment, low wages, or low quality of work later on in life. Buckinghamshire Council would like to identify students' risk of becoming NEET at the 12 or 13th school year (ages 17-18), by the end of the 10th or 11th school year (ages 14-16) so that they can ensure targeting the right pupils with study or special care programs.

Throughout the summer, we spent time focusing on different data challenges, fuzzy matching of data across different data schemas over different years, building machine learning models, and focusing on data ethics throughout our project journey. We also built a PowerBI dashboard as a final product to help the Council and their stakeholders view NEET predictions, trends from historical data and also focus on schools that need the most attention. We have also made our code public so that this product can be adopted by various other Councils all around the UK.

# Reviewing modelling in government: what makes a quality model?

Catherine Hayes, Hannah Kreczak, Mr Shivam Sood

<sup>1</sup>National Audit Office

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Catherine, Hannah and Shivam are analysts at the National Audit Office (NAO), the UK's independent public spending watchdog. The NAO supports Parliament in holding government to account and helps improve public services through high-quality audits. We lead the modelling network which handles modelling and model review needs across the NAO's work. We are involved in the financial audit of government accounts, in particular to review modelled estimates. We also examine models and contribute analysis to the NAO's reports on the value for money of how public money has been spent.*

Financial modelling is at the heart of government analysis of its risks, spending and performance. It influences decisions that can have major impacts on people's lives. Errors in government models have directly caused significant losses of public money and delays to critical public programmes. Therefore, it's vital that people who depend on outputs from models can feel confident in their quality and robustness.

Nine years on from HM Treasury's major review of quality assurance of government models, we considered how well its principles are embedded and applied to business-critical financial models. Our Financial modelling in government study investigated who is responsible for leading the drive to improve modelling across government, how organisations gain confidence in the quality of their models, and how uncertainty is assessed, communicated, and taken into account when government develops plans. We used 12 case studies across four departments to understand the processes these departments use for managing models. This includes models used to inform debate on the costs of potential policies, as well as models more directly tied to budget bids and financial reporting.

Our study found that government has improved its use of financial modelling in decision making, but we continue to find weaknesses in its models. It is unclear who is ultimately accountable for upholding modelling standards and for driving improvement across government. Although we saw examples of good practice, the level of quality assurance that departments apply to business-critical models remains variable. The analysis of uncertainty in model outputs is often a peripheral activity despite the risks to long-term value for money of not doing so and despite it being extensively recommended in government guidance.

Although we reviewed models used for financial planning, many of the recommendations are sensible principles for all models across government. We used our findings to revamp the NAO's Framework to review models, which provides a structured approach to model review that government departments can use to determine whether the modelling outputs they produce are robust and have a minimal likelihood of errors being made. Its main aim is to help reduce common weaknesses found by our audit work.

# Health inequality Analysis with System Dynamics (focusing on strategies and complementary medicine)

Dr Amin Vahidi<sup>1</sup>

<sup>1</sup>SBU University

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## *Biography:*

*SBU University Assistants Professor*

Inequality in health as described by the OECD is defined by components such as accessibility, affordability and availability of health services (time, personnel, equipment). Inequality in health consists of two components: inequality between groups in a society and inequality between nations. Studies show unfair health conditions even in developed countries. For example, in the United States, the richest Americans live between 10 and 15 years longer than the poorest. So, the Affordable Care Act (ACA), passed in 2010. In India, the two lowest income deciles are 86 percent more likely to die than the two highest income deciles. According to the definition of the World Health Organization, health is the complete physical, mental and social health and not just the absence of disease. According to the Almaty Declaration of 1978, countries were to provide health care for all their people by the year 2000. The most important factors of inequality in health are: poverty, income, race, job, education, housing and a suitable place of work, clean and safe environment, efficient and cost tolerable health services, professional ethics, health services, health governance system, food security and safety, social support and access to proper transportation. Reforming health policies and reviewing the successful experiences of different countries will be effective in eliminating health inequality. Optimizing health policies with soft or semi-soft systemic methods such as System Dynamics is recommended. Among these experiences, we could mention the formation of national health network, integration of medical education in the health services system, the generic drug plan, and the health insurance system. Also, complementary medicine (such as Chinese medicine, acupuncture, Iranian medicine, etc.) could improve accessibility, affordability and availability of health services due to cheaper and more accessible drugs and treatment methods. Even Telemedicine can also make medical services more accessible. Integrating these healthcare frameworks into formal healthcare systems will increase people-centered public healthcare.

# Adoption of a Bayesian Network Model in the Healthcare Safety Context

Ms Salma Albreiki<sup>1</sup>, Dr Mecit Can Emre Simsekler<sup>1</sup>

<sup>1</sup>Khalifa University Of Science And Technology

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Dr Simsekler's research interests span healthcare management and analytics to improve operational and safety outcomes and accelerate risk-based decision-making. Leveraging management science, data science and systems thinking principles, his research explores innovative approaches and emerging technologies to help healthcare organizations transform their operations strategy, risk management process and organizational culture.*

Safety culture involves many organizational factors from management to behavior of people that vary considerably across the literature and no comprehensive study is available regarding their interactions and influences on patient safety. In order to address this, we use hospital-level aggregate survey data to analyze the relationship between various safety culture dimensions and patient safety with the adoption of a Bayesian network model. The proposed model provides significant insights into safety culture components and their relative importance in supporting decision-making and safety improvements in healthcare.

# Using Natural Language Processing To Explore Data Associated With Care Homes in England

Miss Melody August<sup>1</sup>

<sup>1</sup>University Of Southampton

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Melody is currently at the University of Southampton studying MSc Data and Decision Analytics and is completing her dissertation with DAS Ltd. Melody also completed a bachelors in Mathematics with Statistics at Southampton. Her key areas of interest are data mining and machine learning.*

Computation has caused a surge in the amount of available data and it is becoming increasingly difficult to efficiently mine and draw valuable conclusions from large datasets. With many consumers now using information from other members of the public, such as online reviews, to inform decision making, it is imperative that businesses, in this case care homes, ensure they are represented positively. Natural language processing is a useful tool, allowing key insights to be observed about public opinion in textual reviews, using methods such as sentiment analysis and topic modelling. Through analysis of themes within positive and negative reviews, important business insights are found to guide improvements that can be made within care homes. Sentiment analysis of reviews is then compared to audits performed by the government agency, the Care Quality Commission who are responsible for reviewing social care in England, allowing a level of bias in public care home reviews to be measured.

# Towards a facilitated hybrid simulation framework for developing conceptual models in healthcare.

Mrs Vivianne Horsti Dos Santos<sup>1</sup>, Dr Kathy Kotiadis, Prof Maria Paola Scaparra

<sup>1</sup>University Of Kent

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*VIVIANNE HORSTI DOS SANTOS is a PhD student, and she holds a Global Challenge Doctoral Centre (GCDC) scholarship in Management Science at the Kent Business School, University of Kent. Her email address is vh87@kent.ac.uk.*

Conceptual modelling is one of the first and the most critical stages to the success of simulation studies. Scholars argue that the stakeholder's involvement during the concept modelling development enhances the quality of the simulation's outcomes and increases the participant commitment to implementing its findings. While a few studies have put forward frameworks for developing conceptual models to single simulation methods with stakeholders' participation, simulation literature still lacks research focused on adopting facilitated techniques in conceptual modelling for hybrid simulation. Therefore, this research proposes a facilitated conceptual modelling framework for a discrete-event simulation (DES) and agent-based Simulation (ABS) hybrid model. We adapted PartiSim and Soft Systems Methodology (SSM) tools, such as rich picture, analysis one, two, three, and CATWOE to the needs of hybrid simulation modelling. It enabled the participation of a group of stakeholders in the conceptual modelling process.

# Exploring the dynamics of infectious disease spread using the FRED modelling platform

Dr Jessica Aylish McQuade<sup>1</sup>

<sup>1</sup>Epistemix

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Jessica McQuade is a data scientist at Epistemix. She holds a Masters degree in theoretical physics from UCL and a PhD in computational biophysics from Imperial college London. During her doctoral studies she focussed on applying simulation techniques to investigate the role of cellular flows and the design of protein networks in establishing robust cellular polarisation. She then moved to a role as an Operational Researcher at HMRC where she modelled Income Tax and National Insurance receipts to provide insight into the UK tax system for enabling policy makers to make better informed fiscal decisions. Interested in complexity and system dynamics Jessica moved to her current role at Epistemix, where she develops agent-based models to empower leaders to make better decisions by simulating the human impact of the choices they face.*

The Framework for Reconstructing Epidemiological Dynamics (FRED) is an agent-based modelling platform specifically designed to study the complex social dynamics of infectious disease spread. We introduce the FRED modelling procedure, outlining strategies for calibration of models using empirical data from public sources, model scenario design, policy intervention and dynamic visualisation. Using a synthetic population that is representative of the U.S. population, we use FRED to illustrate the dynamics of seasonal influenza in the USA. We show how policy interventions, including school closures and vaccine deployment, can be implemented to explore their impact on public health outcomes.

# Managing The Economy & Society: A Global Comparative Study Into COVID-19 Pandemic Management

Mr Alphaeus Tan Win Syuen<sup>1</sup>

<sup>1</sup>Warwick Business School - MSBA Student

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Alphaeus is your translator of big data, narrator of customer stories and manufacturer of actionable insights. 5 years' work experience in product management and data analytics across E-Commerce, Banking and Fintech.*

Lurking within an ever-increasingly globalised world where hundreds of countries along with their economies, and populations grow intertwined, was a potential pandemic many had anticipated but few, if any had readied for given its scale of disruption to humanity not experienced since almost a century ago from the Great Influenza epidemic which had claimed a devastatingly estimated 50 million lives, or 3% of the world's human population at the time. One epidemic later and since 2020, the COVID-19 pandemic has been wreaking similar havoc at a global scale with countries' pandemic management returning societal and economical damages as collateral.

Previous qualitative studies had attempted to contrast the divergent COVID-19 response strategies but failed to set a quantifiable, proportionate and unified performance metric to evaluate the effectiveness of each response strategy which could have empirically proven similar success across a spectrum of response strategies with respect to differing institutional arrangements and national cultural orientations. This dissertation therefore, attempts to conduct a comparative study into the pandemic management of select countries across continents of the world, and their effectiveness in managing the social and economic consequences associated to the pandemic.

The key outcomes examined are cases, deaths, and trade balances. Expanding from existing literature, this study reviews existing outcomes in a new angle with respect to the number of days since the first reported case of COVID-19 within each select country, and the introduction of Sweden as a baseline measurement given its oddity of an essentially open society throughout the pandemic. The areas explored include Non-Pharmaceutical Interventions (NPIs), COVID-19 vaccinations, COVID-19 vaccine equity and a country's trade balances across several known periods of time (90 days, 180 days and 365 days) each country has lived with the pandemic since the first reported case of person-to-person transmission.

All in all, this dissertation hopes to establish not only a first global comparative study, but also a baseline reference for countries to better respond to future global health crises.



# A heuristic approach to DC optimal transmission switching problem

Mr Juncheng Li<sup>1</sup>, Dr Trivikram Dokka<sup>2</sup>, Professor Guglielmo Lulli<sup>1</sup>, Mr Fabrizio Lacalandra<sup>3</sup>

<sup>1</sup>Lancaster University, <sup>2</sup>Queens University Belfast, <sup>3</sup>The Italian Regulatory Authority for Energy, Networks and Environment (ARERA),

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Juncheng (Liam) Li is a PhD student in Lancaster University, under the supervision of Guglielmo Lulli and Vikram Dokka. His research topic is computational methods for power flow optimization. Prior to joining Lancaster University, he did a Master's degree in operational research and computational optimization in University of Edinburgh.*

The objective of the Optimal Transmission Switching (OTS) problem is to identify a topology of the power grid that minimizes the total energy production costs, while satisfying the operational and physical constraints of the power system.

One of the most popular approaches to solve the OTS problem is to approximate it with an integer linear programming formulation, which comes with big-M inequalities. The big-M values in exact method can hamper MIP solver's ability to find good feasible solution in reasonably short amount of time. To take full advantage of primal heuristics in MIP solvers, we propose a strategy to replace the exact big-M values with carefully chosen "big-M" parameters. Computational experiments show that our strategy can lead to better solution by the solver in given time limit.

# Black women's academics experience in the UK HE

Mr Frederick Kandala<sup>1</sup>

<sup>1</sup>University Of Bradford

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*Frederick Munda Kandala is in second-year PhD student in Social Sciences and Criminal Justice Studies at the University of Bradford. His doctoral study explores Black female professors' lived experiences and their strategies in overcoming the obstacle of discrimination of all forms and promotion. The UK studies highlight the lack of Black female professors, with only 40 fully registered members. He takes a multidisciplinary approach that encompasses the fields of management, human resource, social justice*

My study seeks to explore and understand the perception of Black women's academic lived experiences of navigating in the UK higher education institutions. Your contribution will help capture the often-hidden struggle for their career progression impacted by multiple factors such as discrimination of gender, race, disability, and ethnicity. The study also aligns with the Race Equality Charter (REC), which promotes the widening, progression, and success of Black, Asian and minority ethnic (BAME) staff and students. Within the higher education institutions, where arguably HE policies are regarded ineffective, one of the arguments for the invisibility of Black women in academics. I will use an online survey and semi-structured interviews via Zoom/Teams. Multi-method will be used to help collect empirical and secondary data for this study. The literature review helped to define what is known, gaps, themes, theories and methodologies. I will use an online survey and semi-structured interviews via Zoom/Teams.

Expecting findings might indicate the impact of bullying, lack of mentoring for PhD students, career time consumption, workload and lack of funding.

Early career (lecturers/ PhD students) fixed-term contract.

Competition for funds and Grant and publications is limited by lack of sponsorship.

They are working longer, 60 to 70 hours a week.

Give up family duty or motherhood to help secure occupation.

The comparative finding of the experiences between early-career Black women academia and established Black women academics.

# Nonparametric Predictive Inference for Inventory Decisions

Miss Kholood Alyazidi<sup>1</sup>

<sup>1</sup>Durham University

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*PhD student at Durham university.*

In inventory theory, which is considered one of the main topics in operations research, many scenarios have been studied with the aim of determining an optimal order quantity in order to maximise expected profit. This poster provides an alternative method to inventory problems, where the goal is to base the order quantity on previously observed demands with only a few additional assumptions. Nonparametric predictive inference (NPI) is a way to predict future demand based on data from the past and does not assume any knowledge of the probability distribution of demand.

The scenario of inventory for a two-period independent demands is considered. We present the NPI lower expectation for the profit of the second-period model at the end of the first period to get the optimal order quantity for the second period. Using this quantity to explore the optimal order quantity for the first period of the two-period model.

The performance of the NPI approach is investigated through simulations, which are also used to compare the method to the classical approach, in which the probability distribution of the random demand is assumed to be known. The simulation results indicate that, if the assumptions underlying the classical method are entirely correct, then the classical method performs better, but NPI gets close to the classical method if the number of observations is large. If the classical assumptions are not right, then the NPI starts to perform better.

# Long Term Multi-Product Multi-Region Supply Chain and Crop Rotation Planning for Seasonal Crops

Mr Harry Sisley<sup>1</sup>

<sup>1</sup>Queensland University Of Technology

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*I am a PhD Candidate at the Queensland University of Technology in Brisbane Australia. I started my PhD in 2020 and have been exploring supply chain management of large-scale agri-food supply chains for seasonal crops.*

We present a model for long-term planning of a multi-region, multi-product seasonal agri-fresh supply chain with crop rotation. Agri-food farming businesses make great efforts to safeguard the health of their soil, as damage can take years to repair. Crop rotation is a powerful tool for increasing the soil health of farmland; however, it requires careful planning. Moreover, crop rotation must not interfere with the continual production required to satisfy the demand for seasonal crops. There is demand for seasonal crops in supermarkets across Australia even when they are out of season for the local area. To meet this demand, production must be shifted to climates that are in season throughout the year. Including crop rotation as a constraint to this supply chain will restrict what crops can be planted on a farm based on what type of crop was previously harvested. We have developed a deterministic Mixed Integer Linear Program (MILP) to determine which sequences of crops should be planted at each farm across all the growing regions. A sequence for a given farm will include when crops are to be planted and harvested across the entire time horizon and what order the crops are to be planted in to abide by the crop rotation requirements. To best solve this model decomposition solution methods were applied to deal with the large number of decision variables. This model will be used as a decision support tool for production managers at a major national grower within Australia. A case study of their business across multiple years will be used to test the effectiveness of this tool.

# Mapping Educational Inequality (Opportunities Inequality)

Dr Amin Vahidi<sup>1</sup>

<sup>1</sup>SBU University Assistants Professor

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## ***Biography:***

*SBU University Assistants Professor*

Formulation and implementation of optimal policies and strategies of higher education systems in order to create educational equality and access to equal opportunities for all members of society, is vital and necessary. According to research conducted in many countries, employment and income opportunities between non-medical and medical graduates have been subject to widespread discrimination and inequality. Also, according to studies, educational equality is success bottleneck of the educational system and science and technology. Educational equality has various dimensions such as responding to the needs of society and equal access to opportunities before, during and after education. Also, the mismatch of supply and demand in educational systems due to the needs of communities has made it difficult for people to easily access medical services in many countries and the cost of medical services and staff in many countries is very high, which reduces the level of public health. This inequality has also caused the desire of students fall sharply for studying in non-medical fields. So, these fields will be deprived of elite manpower with high IQ in the long-term. This will weaken the progress of science and education in non-medical fields. In this study, by examining this issue, policies to improve and eliminate educational inequality and inequality in post-training opportunities are surveyed using the System Dynamics methodology. In this methodology firstly the main subsystems and variables of the system are identified. Then by formulating relationships between these variables the simulation will be run and the optimal combination of strategies for facing inequality will be discovered. According to research, if the optimal policy is not implemented, this inequality gap will quickly widen in the coming years and will disrupt social equality, income equality, health equality and disrupt the progress of science and technology in a fair and balanced way.

# Simulation applications in analyzing the trade-off between Climate Change and energy consumption

Dr Amin Vahidi<sup>1</sup>

<sup>1</sup>SBU University

Poster Presentations, LT OC0.03, September 14, 2022, 10:30 AM - 12:00 PM

## *Biography:*

*SBU University Assistants Professor*

The United Nations estimates that 90% of the worst disasters occurred as a result of Climate Change. From an ecological point of view, Global Warming can cause far-reaching changes in the environment, biodiversity and human life. Today, scientists and experts in climatology and environmental sciences believe that one of the causes of global Climate Change in recent years has been the increase in Greenhouse Gases. Human emissions of carbon dioxide come from two main sources: burning fossil fuels and changing land use, such as deforestation. In this research System Dynamics methodology used. System Dynamics method is based on concept of feedback loops. If the loop amplify itself, it is a positive feedback or reinforcing loop. And if increasing in a variable cause itself to decrease so it is a negative or balancing feedback loop. The overall System Dynamics stock and flow model presented based on these concepts. Time horizon of this model simulation of this model is from 2020 to 2100. Simulation if current situation continues in 2050 and 2100, Global Warming will be 2.38 and 5.56 than 2020. It is catastrophic and make earth hardly habitable. Also the simulation shows in 2100 Fossil Fuel Consumption will be 2.1 times of 2020 in an exponential pattern. In 2100 vegetation decreased from 55 percent to 33 percent. So animals and plants will extinct with extremely high speed and earth will be a lifeless planet with current trend. So if Global Warming continues it only take a decade to reach an irreversible point. If human race improve 30% in Public Awareness about Global Warming effects and Policies, Laws, Guidelines effectiveness on deforestation and forest growth Global Warming will decrease to 41% in 2050 and 37% in 2100. So a global effort needed to save the earth and humankind.

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