IFORS Distinguished Lecture

Addressing Strategic Problems under Uncertainty: Advances in Scenario and Decision Analysis

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Professor Salo has worked extensively on the development of decision analytic methods and their uses in resource allocation, innovation management, risk management, technology foresight, and efficiency analysis. He has published widely in leading international journals (including *Management Science* and *Operations Research*) and received awards for his research from the Decision Analysis Society of the Institute for Operations Research and the Management Sciences (INFORMS). In 2019, he won the MCDM Edgeworth-Pareto Award, the highest distinction of the International Society for Multiple Criteria Decision Making. He serves on the Editorial Boards of several refereed journals.

Professor Salo has directed a broad range of basic and applied research projects funded by leading industrial firms, industrial federations, and funding agencies. He has been visiting professor at the London Business School, Université Paris-Dauphine, and the University of Vienna. He has been the President of the Finnish Operations Research Society (FORS) for two biennial terms. In 2010-11, he was the European and Middle East representative on the International Activities Committee of INFORMS. In 2010-16, he was a jury member of the EDDA Doctoral Dissertation Award of the Association of European Operational Research Societies (EURO) and chaired this jury in 2016. He served on the Board of the Association of Parliament Members and Researchers (Tutkas) in 1999-2019. In spring 2020, he was a member of the Science Panel, appointed by the Prime Minister's Office for obtaining scientific support for the management of the COVID-19 pandemic. In 2020-2023, he is a member of the Government Foresight Group, appointed by the Prime Minister's Office of Finland

ABSTRACT

In crises such as the COVID-19 pandemic, policy and decision makers are under extreme pressure as they must assess major uncertainties before committing themselves to decision alternatives which can have far-reaching consequences for health, environment, economy and society. In order to ensure that relevant uncertainties and their impacts in the evaluation of alternatives are systematically assessed, effective methods of scenario and decision analysis are needed.

In this talk, I first summarize personal experiences from the policy initiatives which the Prime Minister's Office in Finland introduced to strengthen the dialogue between policy makers and researchers. Specifically, the COVID-19 Science Panel had an impactful role in advising the Government during the pandemic while the production of widely disseminated research reviews provided science-based support to a broad range of senior policy makers. The need for collaborative risk management was recognized, reflecting the fact that in many-faceted problems such as the COVID-19 pandemic, there is a need to bring in expertise from a broad range of stakeholders.

Second, I discuss the benefits of using scenario analysis as a tool for exploring the implications of uncertainties for strategic decisions. Even in situations where scenarios are built primarily from qualitative expert judgments, it can be helpful to leverage quantitative techniques to guide the development of scenarios which are both diverse and comprehensive. When dealing with safety-critical systems, there are reasons to deploy theoretically sound probabilistic methods which, unlike qualitative approaches, can be integrated with techniques of statistical analysis and data science.

Third, I present advances in solving multi-stage decision problems which can represented as influence diagrams where interdependencies between decisions, uncertainties and consequences are shown as directed acyclic networks. Conventional approaches to solving influence diagrams (such as using dynamic programming to solve the equivalent decision tree representation) make the 'no-forgetting' assumption in that all earlier decisions must be known when making later ones; yet this assumption may not hold in distributed decision problems. Moreover, earlier approaches have limitations in identifying all non dominated solutions and accommodating relevant logical, resource and risk constraints.

Against this backdrop, Decision Programming is a novel framework (Salo et al., 2022) which accommodates such constraints without making the 'no forgetting' assumption. Technically, the influence diagram is converted into the equivalent mixed-integer linear programming formulation which can be solved with standard commercial solvers. The Decision Programming framework is very flexible and can be extended to optimize information structures in order to determine (i) what optional information should be acquired to guide decisions and (ii) how this information should be exploited. Several numerical examples are presented to illustrate that the optimization of information structures holds considerable promise, for example, in devising testing and screening strategies in the presence of resource and risk constraints.

KEYNOTE SPEAKERS

From the Battlefield to the Gig Economy: How Hybrid Optimization Can Guide Decision Making in Highly Dynamic and Unpredictable Settings

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Karla L. Hoffman is IFORS VP representing the North American region (NORAM). The fourth President of INFORMS and an INFORMS fellow, she is a professor of systems engineering and OR in the Volgenau School of Engineering of George Mason University, USA. Her research has focused on practical applications of operations research and optimization to problems including transportation scheduling, airport landing slot allocation, spectrum auctions, and telecommunications budgeting.

Among her latest distinctions include the 2018 INFORMS Franz Edelman Award for her work with the US Federal Communications Commission on spectrum

allocation. Other awards include the Department of Commerce Silver Medal and the Applied Research Award of the National Institute of Standards and Technology as well as the Kimball and Omega Rho Lecturer Awards. Hoffman graduated from Rutgers University with a BS in Mathematics, earned her MBA from George Washington University, where she completed her doctorate in operations research from the engineering school.

ABSTRACT

This talk describes the use of optimization to assist in real-time decision-making where solutions must be available almost instantaneously. We highlight the success of these methods in two very different settings: (a) the routing and scheduling of deliveries in gig-economy applications; and (b) the problem of sustaining communications in a highly dynamic battlefield environment. In the first of these applications, we present the problem of assigning drivers to service requests and presenting the drivers with an efficient routing of all request locations. The decision framework for these assignment problems often has competing objectives (e.g., minimizing cost to the company, providing assignments that are profitable to the drivers, and assuring that customers receive their orders in a timely fashion). The process may include predicting whether a driver will accept a given assignment and the notification to both the customer and the supplier (e.g., the restaurant providing the food to be delivered). If the drivers are not hired on a schedule, then the driver might refuse an offer and It might, therefore, take multiple "offers' to alternative drivers before the assignment is finalized. The entire process of allocating of assignments to drivers, notifying customers of expected delivery time and alerting suppliers to new demands must be done in under a minute. In our second application, there is the need to reassign wireless channels to a military unit (or units) that lose communication capabilities due to enemy jamming or other interference issues. The need to recover quickly while assuring that reassignments do not harm other units is essential to overall battlefield success. Our approach uses hybrid algorithms designed with problem structure in mind to help satisfy challenging time requirements. In both applications, we work to generate multiple feasible solutions quickly, update prior solutions with new information, and bound the solution space. This hybrid approach obtains near-optimal solutions within the tight timeframe that these applications demand. These fast hybrid algorithms use standard optimization solvers in conjunction with feasibility checkers, constraint programming, and/or decision diagrams. These techniques are likely to be applicable in many other settings.

Reengaging and Reenergizing your Students *and their Instructor* through Active Learning in the Modern Operations Research Classroom!

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James J. Cochran is Professor of Statistics, the Rogers-Spivey Research Fellow, and Associate Dean for Faculty & Research with the University of Alabama's Culverhouse College of Business. He is also a Research Associate with the Alabama Transportation Institute. He has been a Visiting Scholar with Stanford University, the University of South Africa, the Universidad de Talca, Pôle Universitaire Léonard De Vinci, the University of Limpopo, and the University of Namibia. He holds honorary faculty appointments with the University of KwaZulu Natal and the University of Limpopo.

Dr. Cochran's research focuses on problems at the interface of statistics and operations research, and he has taught a wide range of statistics and operations courses from the introductory undergraduate level through PhD seminars. He has published seventeen book chapters, over fifty research articles, and almost 100 other articles. He is coauthor of eight textbooks in statistics, operations research, analytics, and data visualization. He has served on the editorial boards for eighteen journals and as Editor-in-Chief of *INFORMS Transactions on Education* from 2007-2012.

Dr. Cochran is the founding Editor-in-Chief of the *Wiley Encyclopedia of Operations Research and the Management Sciences*, *Wiley Series in Operations Research and Management Science*, *Oxford Anthology of Statistics in Sports* series, and *INFORMS Analytics Body of Knowledge*. He has served as a consultant to a wide variety of corporations, government agencies, and not-for-profit organizations around the world.

Dr. Cochran established an international teaching effectiveness colloquium series and has organized these events in Uruguay, South Africa, Colombia, India, Tanzania, Argentina, Kenya, Nepal, Cameroon, Croatia, Cuba, Estonia, Fiji, Mongolia, Moldova, Bulgaria, Tunisia, Grenada, and Sri Lanka. He was a founding co-chair of Statistics without Borders and a founding committee member for the INFORMS Pro Bono Analytics initiative. He has delivered keynote addresses to conferences in twenty-seven nations.

Dr. Cochran has received the INFORMS Prize for the Teaching of OR/MS Practice, Mu Sigma Rho Statistical Education Award, Waller Distinguished Teaching Career Award, and Karl E. Peace Award for outstanding statistical contributions for the betterment of society. He is a two-time finalist for the Innovative Applications in Analytics Award. He is also a Fellow of both the American Statistical Association and INFORMS, and he has received both the American Statistical Association's Founders Award and the INFORMS President's Award.

ABSTRACT

We in the operations research community understand that Analytics (and specifically OR and Statistics) are inherently interesting, relevant, important, and enjoyable disciplines - unfortunately many of our students (particularly those in introductory Analytics courses) don't seem to share this understanding with us! So how do Analytics instructors help students appreciate that Analytics is interesting *and* relevant *and* important *and* enjoyable? Professor Cochran discusses several classroom cases and active learning exercises he has developed and regularly uses to accomplish this goal when teaching introductory Analytics courses.

Throughout this session Professor Cochran will emphasize his points with live demonstrations and discussions of several interesting and novel active learning exercises and cases. Card tricks, classroom versions of television game shows, and an exercise that utilizes children's toys will be featured. Because many of these exercises are easily transferable across topics, instructor/classroom styles, cultures, national borders, institutions, faculties, programs, and class sizes, it is very likely you will walk away from this session with ideas on how to improve your own teaching (indeed, Professor Cochran will be very disappointed if you don't!).

Be prepared – audience participation is an integral part of this session, and Professor Cochran may call on *you* during the session!

The Kerkenes Eco-Center Project
OR Meets Archaeology, Architecture and Engineering for Science and the Improvement of Living Conditions in Rural Anatolia

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Gerhard Wilhelm Weber is a Professor at Poznan University of Technology, Poznan, Poland, at Faculty of Engineering Management, Chair of Marketing and Economic Engineering. His research is on OR, financial mathematics, optimization and control, neuro- and bio-sciences, data mining, education and development; he is involved in the organization of scientific life internationally. He received his Diploma and Doctorate in mathematics, and economics / business administration, at RWTH Aachen, and his Habilitation at TU Darmstadt. He held Professorships by proxy at University of Cologne, and TU Chemnitz, Germany. At IAM, METU, Ankara, Turkey, he was a Professor in the programs of Financial Mathematics and Scientific Computing, and Assistant to the Director, and he has been a member of further graduate schools, institutes and departments of METU. Further, he has affiliations at the universities of Siegen, Ballarat, Aveiro, North Sumatra, and Malaysia University of Technology, and he is "Advisor to EURO Conferences".

ABSTRACT

In this paper co-authored with Geoffrey Summers, Francois Summers, and Soofia Tahira Elias-Ozkan from the Middle East Technical University, Ankara, Turkey, I will introduce, through an example, how Operations Research for Development applications are highly interdisciplinary in character, and how OR, together with state-of-the-art tools and devices from engineering, natural and social sciences, could serve projects of architecture, history, water management, agriculture and education, with the goal of improving living conditions.

The Kerkenes Eco-Center Project was initiated in 2002 with the following objectives:

- To advocate the use of renewable sources of energy;
- To act as a stimulus and a catalyst for environment-friendly building with appropriate materials and energy efficient designs;
- To act as a dynamic experimental base for testing designs, materials and activities suitable for viable and sustainable village life;
- To encourage village development and income generating activities that might halt and even reverse migration from rural areas to the cities.

I will discuss a very successful program for the promotion of solar energy, a drip irrigation scheme for organic gardens, solid waste separation for composting and recycling, reuse of grey-water and promotion of appropriate materials and design for energy efficient buildings.

Şahmuratlı Village possesses a world class cultural heritage site, ancient Pteria, an Iron Age mountain-top city founded on the Kerkenes Dağ. The Kerkenes Eco-Centre piloted schemes for renewable energy and appropriate technologies against a background of climate change, socio-economic inequality and rapid depopulation of rural areas in favour of urban growth. The Kerkenes Eco-Centre experiments with

appropriate building materials and energy efficient designs, drip irrigation for organic gardens, solar energy, solar drying and cooking, recycling, stimulating and creating income generating activities for both men and women.

International agencies assist in raising political commitment to a low carbon high growth economy in Turkey. This small project makes use of an existing Eco-centre in Turkey to promote energy efficient and renewable energy designs. It brings together local officials, businessmen, MPs and villagers to stimulate more formal work at the Municipality level, greater replication of ideas in other regional areas, and an increased media awareness of how local projects fit into the bigger strategic goals on energy and climate change.

Other activities involve the production of stabilized mud bricks with the Parry Brick Press. This press was also used to compress wastepaper into briquettes to be burnt as fuel in the traditional stove during winter months. Garden activities in the Kerkenes Eco-Center continued to yield vegetables. Meetings with housewives in the village helped to understand their needs and aspirations. Discussed were solar energy use for cooking and domestic water heaters as well as for income generating activities.

In Kerkenes, Ankara and various places in Europe and all over the world, modern OR offers a platform and methodology for scientifically discussing and supporting local development and the improvement of living conditions.

XAI: Confounding disease states and the Determinants of Sovereign SDG Healthcare Accessibility

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Nina Kajiji is a Principal of The NKD Group, Inc. She is also an adjunct associate professor in the Computer Science and Statistics Department at the University of Rhode Island. She has been conferred the title Accredited Professional Statistician™ from the American Statistical Association.

Her principal research interests are in applied optimization, volatility modeling, and artificial intelligence (AI). Application fields include: socially responsible investing, modeling risk, neuroscience-based modeling for the development of smart cities, 'big data' analysis of intra-day municipal bond yield curves, and obtaining complex educational assessment elasticity metrics. Her research continues to expand to include 'big data' analytics featuring visualization, high-performance computing, and explainable AI (XAI) to assist in complex data mining. Dr. Kajiji's academic research has been published in several operational research journals, finance journals, and, most recently, in the journal *Neuroscience*. Besides contributing several book chapters, Nina is currently co-authoring two e-Books titled *"Applied Risk Management: Valuation of Derivatives under AI and Data Science Technologies" (www.ARMDAT.com)* and *"AI and Data Science in Applied Security and Investment Management" (www.aisimbook.online).*

Nina is the co-architect of the cloud-based computing platform, $WinORS_{e\text{-}AI}$ 2021. The computing platform is geared towards solving problems using techniques commonly used in financial engineering, statistics, operations research, and economics. Research models using $WinORS_{e\text{-}AI}$ have been presented to capital market professionals in Italy, India, Thailand, South Africa, Lithuania, Turkey, and the UK. Some specialized techniques incorporated in $WinORS_{e\text{-}AI}$ 2021 are combinatorial non-linear goal programming, Bayesian enhanced regularized univariate and multivariate radial basis neural network, Explainable AI (XAI) using SHAP, and more.

Nina has taught courses in Statistics, Time Series Analysis, Operations Research, and Finance at various Universities in the U.S. and internationally. She is a member of the Greek-based RiskGroupAuth, an interdisciplinary research group (think-tank) specializing in developing risk assessment and management tools for modern energy systems.

For her volunteer work, Nina has been awarded the President's Volunteer Service Award (Gold Level) from the President's Council on Service and Civic Participation. She was named Woman of the Year by the National Association of Professional Women. She currently serves as the co-Chair of the European Working Group on Operational Research for Development (EWG-ORD).

ABSTRACT

This talk discusses the importance of modeling global healthcare accessibility. For any nation, healthcare accessibility is a complex measure rooted in individuals of all ages' ability to receive healthcare, especially for those with demonstrated anxiolytic effects. Driven by sovereign socioeconomic interests and the United Nations sustainable development goals (SDGs), there has been a steep rise in the use of analytics to investigate healthcare accessibility. Of the seventeen SDGs, the third goal seeks *to "achieve universal health coverage" to promote access to essential healthcare services and access to safe, effective, quality, affordable essential medicine and vaccines for all*. Over the past decade or so, nations have been observed to be committed to the advancement of healthcare equity. But then, to the world's surprise and dismay, the dawning of the COVID-19 pandemic slowed and then disparaged advances in health outcomes – a condition characterized by restricted access to medical facilities and services. With a flattening of the COVID-19 curve, sovereign decision-makers now seek to slow the re-emergence of healthcare inequities.

In the contemporary analytics era, shaping a national healthcare policy requires a combination of forward-thinking administrative management and the ability to design new products and services. The rebuild partly rests on extracting updated insights from evolving 'big data' databases. The challenge – no two countries are alike in organizing the shift from the data science-driven pre-COVID period to a new era of disruptive AI and cognitive technologies that utilize digital health solutions to transform care for an entire population. Take the Southeast Asian region as an example. Across region neighbors (i.e., Cambodia, Vietnam, Thailand, and Indonesia), we can observe different healthcare management systems in alternate stages of development.

This talk discusses our current study, which aims to promote the global development of national healthcare accessibility through the implementation of explainable artificial intelligence (XAI). XAI represents a set of processes and methods applied to machine learning algorithms to promote human trust and comprehension of the AI-produced results. To exemplify the potential for the universal appeal of XAI in healthcare administration, we propose an empirical analysis of the top seven chronic health-impacting conditions. The data is obtained from the U.S. Center for Medicare and Medicaid Services (CMS). Medicare is the U.S. national health plan for people 65+, certain younger people with disabilities, and a class of people with end-stage renal disease.

According to CMS, most beneficiaries have multiple chronic disease states. Understanding the confounding nature of disease states requires integrating various measures into one framework. Empirically, the nonlinear interactions among the multiple and binary disease state response variables make the modeling exercise complex. Accordingly, we invoke a multivariate Bayesian enhanced radial basis function neural network with regularization enhancements to estimate error-minimizing classification weights and effectively model the complex response function. Model explainability and trustworthiness are approached by adopting XAI encapsulated in SHAP values. Enumerated SHAP values permit us to evaluate the contribution made by each predictor-feature variable to all model prediction points. Preliminary studies indicate that our solutions show a classification accuracy (overall correct classification) of 98.73% and 87.33% for hypertension and depression. Focusing on patients with heart disease, we report that over the COVID-19 era, patients express their ability to pay rent has decreased, feel less financially secure, and overall experience greater anxiety.

Blockbuster Shrinkage of Multiobjective ESG Portfolios Using Explainable AI for Asset Return Prediction

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Dr. Gordon H. Dash joined the faculty of the College of Business (COB) in 1974. As a Full Professor, he holds appointments in Finance & Decision Sciences and the Interdisciplinary Neuroscience Program. He completed his undergraduate degree in business administration at Coe College (1968). He earned a master's and two-field Doctorate in Finance and Operational Research from the University of Colorado at Boulder (1978).

Dr. Dash has ongoing research projects that link traditional optimization algorithms to neural network algorithms for classification and prediction. His research emphasizes the development of algorithmic extensions in combinatorial optimization and radial basis function neural networks. Using newly developed algorithms, Dr. Dash has produced a current research strain that spans topics such as the neuroeconomics of SMART cities, ethical AI and the determinants of chronic disease states (neuroethics), and sustainability in multiobjective behavioral portfolio optimization. Dr. Dash's research is published in journals that target portfolio optimization and management, multiobjective optimization, complex decision analytics, energy management, and more. Research service includes serving as an associate editor for the International Journal of Applied Optimization Studies and co-chair of the European Working Group for Operational Research on Development (EWG-ORD). Since 2018 the annual EWG-ORD international meeting format has promoted the dissemination of recent research findings on the integration of operational research and the United Nation's seventeen sustainable development goals. Dr. Dash's research has been presented globally in over thirty countries spanning the continents of Europe, Africa, and Asia.

Besides contributing several book chapters to books in financial engineering, Professor Dash is the co-author of two e-books. His book on derivatives market valuation is titled *"Applied Risk Management: Valuation of Derivatives under AI and Data Science Technologies" (www.ARMDAT.com).* The twenty-two-chapter text features valuation applications that draw upon his state-of-the-art algorithmic tools. His investment and portfolio management textbook is titled *"AI and Data Science in Applied Security and Investment Management" (www.aisimbook.online).* The textbook includes new valuation analytics to

incorporate the latest in portfolio optimization and the use of neural networks to model key prediction targets such as corporate earnings.

Dr. Dash is a member RiskGroupAuth (Greece), an interdisciplinary research group (think-tank) specializing in developing risk assessment and management tools for modern energy systems. He remains a member in good standing of several honorary societies, including Beta Gamma Sigma, Phi Kappa Phi, and Delta Sigma Pi.

ABSTRACT

This talk focuses on the environmental, social, and governance (ESG) framework necessitated by the United Nation's sustainable development goals (SDGs) to create investment value. The ESG movement has grown from a simple social responsibility initiative launched by the UN in 2015 to a global phenomenon representing almost US$30 trillion in asset management. We are now in what is called the fifth industrial revolution (5IR), which is brought about new digitalization geared toward building a better society by delivering service to humanity.

Universally, portfolio managers and individual investors are now in quest of explainable AI (XAI) to improve the trust in the predictive performance of time-varying asset returns. The search for performance-enhanced specifications of asset returns is driven by asset managers seeking efficient portfolios defined by multiple and hierarchical goals (i.e., ESG prioritization). Fund managers who ex-ante seek to construct a market-neutral portfolio under the complexities of layered behavioral constraints may identify ex-post that the portfolio still possesses a significant exposure to the market, ESG, and other systematic risk factors. We summarize extant literature that finds established asset return estimation techniques fail to produce asset return estimates that contribute to delineating ESG market-neutral portfolios. More generally, the paper presents a novel approach to optimizing the behavioral portfolio management model in the presence of investor biases for ESG sustainability, loss aversion, and cognitive dissonance.

We extend the factor pricing literature by implementing a factor extraction protocol to identify three unique and pervasive ESG factors. After examining the factors' interconnectedness, machine learning methods are applied to a production-theoretic six-factor Fama and French model to predict individual asset returns. Enumeration of efficient asset allocations modified by a Blockbuster shrinkage estimator. The optimal allocations are obtained by solving a hierarchical multiobjective portfolio optimization model. Simulation results from solving alternate specifications of the layered goal ESG-driven model corroborate and extend emergent research on portfolio sustainability, network theory, and the interconnectedness of financial returns. Additionally, we provide results to amplify the existence of a hump-shaped ESG efficiency frontier. The results provide new information about the trade-offs for resolving cognitive dissonance when investors are conflicted between holding 'green' versus 'brown' asset diversification plans.

The research was jointly conducted with Nina Kajiji from the University of Rhode Island and The NKD Group, Inc. USA.