These are the abstracts of ADA 2024.

The presenter(s) are underlined, and the other authors are in plain text.

The session IDs are formatted followingly: <Day>.<Session Number>.<Lecture Hall>.
For example, Wed.4.D refers to the 4th session of Wednesday and is arranged in lecture hall D.

The Poster Session Thu.3.X is arranged outside lecture hall B.

Oral Presentations

Wed.2.B: Behavioral Decision Making I

Session Chair: Jack Soll

Generating Policy Alternatives for Decision Making: A Process Model, Behavioural Issues, and an Experiment

Submission ID-036

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The generation of alternative policies is essential in complex decision tasks with multiple interests and stakeholders. A diverse set of policies is typically desirable to cover the range of options and objectives. Decision modelling literature has often assumed that clearly defined decision alternatives are readily available. This is not a realistic assumption in practice. We present a structured process model for the generation of policy alternatives in settings that include non-quantifiable elements and where portfolio optimisation approaches are not applicable. Behavioural issues and path dependence as well as heuristics and biases which can occur during the process are discussed. The behavioural experiment compares policy alternatives obtained by using two different portfolio generation techniques. The results of the experiment demonstrate that path dependence can occur in policy generation. We report thinking patterns of subjects which relate to biases and heuristics.

An approach for modelling interdependent actions in portfolio decision analysis and its application in a regional climate roadmap

Submission ID-034

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We present a structured portfolio decision analysis approach to support the consideration of interdependencies between actions (i.e., interactions). This has been a challenge, for example, in environmental management problems, in which there can be tens of possible actions and consequently,

intensively the interactions would be considered in the modelling. The approach was tested in a case of a climate roadmap of the North Savo region, Finland, for the year 2035. The approach helped to identify an efficient set of actions for preparing and adapting to climate change through better understanding of synergies and trade-offs between the actions.

Inverted Metricks: How Jensen's Inequality Neglect Can Cause Projects to Run Over Time and Over Budget

Submission ID-072

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We examine a judgmental bias that emerges when the metric in which past data are observed or experienced has an inversion-mismatch with the dimension in which the forecast is being made. For example, consider a case in which past data are in terms of *cases* per week that can be handled but the forecast is in terms of how many *weeks* it will take one to handle a certain number of cases. We show, in a series of experiments, that individuals exhibit a predictable behavioral bias in such decision tasks, as a consequence of Jensen's Inequality Neglect. In pre-registered Experiments 1 and 2 we demonstrate how the psychological bias can cause individuals to predictably underestimate how long it will take their organization to complete a given amount of work. In pre-registered Experiments 3, 4, and 5 we examine this phenomenon in a sample of managers, with real world stimuli, and with break-even forecasting, leading to budget overruns. We show how an intuitive misunderstanding of this mathematical principle is sufficient to generate the classic findings of the planning fallacy in predictable situations.

The Inclusion of Anchors When Seeking Advice: Causes and Consequences

Submission ID-096

Jessica Reif , Rick Larrick , Jack Soll

Fuqua School of Business, Duke University

Scholars have devoted considerable research attention to examining how people use advice from others. However, there is much less research exploring the preceding step of how people ask for advice. Sometimes advice seekers include their own thinking in their requests, providing anchors that make it difficult for advisors to access their own independent judgments. Across naturalistic and laboratory samples, we find that advice seekers include anchors when seeking quantitative advice 20-50% of the time. In five pre-registered studies, we investigate the causes and consequences of including anchors when seeking advice. We find that impression management motives increase the tendency to include anchors when seeking advice, while a goal of preserving advisors' independence reduces the tendency to include anchors. We also find that advice seekers who have put more thought into a decision task prior to seeking advice are more likely to include anchors in their requests. Finally, we find that advice seekers who include anchors when seeking advice benefit less from opinion combination strategies such as averaging because they introduce shared sources of error. In sum, this work highlights how the question one asks matters. We discuss implications for research on advice seeking and the wisdom of crowds.

Wed.2.D: Forecasting I

Session Chair: Jay Simon

The Forecasting Proficiency Test: A Practical Forecaster Evaluation Tool

Submission ID-028

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Some people are better at making predictions than others. From forecasting tournaments to surveys of professional forecasters, numerous studies conclude that judgmental forecasting is a measurable and reliable skill. Information about the skill distribution of a pool of forecasters can help information aggregators implement performance weights, or hiring managers select top applicants. But how can the best forecasters be identified in practice? We develop and validate a Forecasting Proficiency Test (FPT), a practical assessment of general forecasting skill that can be administered in one hour. Our research design compares two sources of information as potential diagnostic tools: forecasts about real events that can be adapted for arbitrary time horizons, and objective cognitive assessments established or hypothesized to be associated with forecasting ability. A key emerging insight from our work is that continuous quantile forecasts are more psychometrically reliable indicators of latent ability than probability forecasts, but that probability forecasting also involves unique skills distinct from continuous quantile forecasts. Our results provide both theoretical insight into the nature of forecasting skill, as well as a real world tool that can be used by decision makers looking to build forecasting teams or optimally aggregate groups of forecasters.

Using Prediction Interval Skewness to Improve Forecast Accuracy

Submission ID-024

Yael Grushka-Cockayne [1], Victor Jose [2], Cem Peker [3], Jack Soll [4], Jacob Rittich [5]

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Aggregating individual forecasts improves accuracy through the "wisdom of the crowd" effect. This paper examines how accuracy of the aggregate forecast can be further improved when prediction intervals are also elicited and available. We consider a simple theoretical model where forecasters observe an

underestimates large quantities, and ii) forecasters who have a right(left)-skew in their prediction intervals are more accurate in their most likely estimates for small(large) quantities. Evidence from experimental forecasting tasks supports these observations. Based on these findings, we develop and test an aggregation method that uses the implied skewness in three-point estimates when combining forecasts. Using data from several forecasting tasks, we demonstrate that our method improves forecast accuracy for small and large quantities at the extremes.

Decision-making with Ordinal Ratings

Submission ID-126

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Experts often provide judgments on an ordinal scale, which are easy to generate and intuitive. Ordinal ratings, however, are not trivial to aggregate across multiple experts, as they provide neither the strict preference ordering of a ranking nor the intensity of preference of cardinal scores. In addition, ordinal rating judgments often map to a broad set of outcomes, which are not expressed through the ordinal, discrete set of choices elicited. In this way, ordinal rating also neglects to express the degree of uncertainty that may exist when rankings are interpreted as forecasts. We offer a framework for mapping ordinal ratings to continuous forecasts, allowing for the ratings to be aggregated and for representing the uncertainty that may exist in the submissions. Finally, our framework allows for rendering the aggregate distributional forecasts back to the original ordinal scale, providing again an intuitive set of judgements, to be used by the decision maker. We demonstrate our framework in the context of National Football League (NFL) scout assessments of players' performance. These assessments, treated as forecasts, are utilized by general managers when making player selection decisions in the annual college draft.

Sports Betting Markets as Forecasters: Exploring Real-Time Price Data from Four Major Sports

Submission ID-039

Jay Simon

American University

This work analyzes real-time moneyline data for MLB, NFL, NBA, and NHL games from multiple sportsbooks from opening until closing. The vast majority of prior work on sports betting markets is limited to opening and closing prices only. Generally, the closing prices reflect better forecasts than the opening prices. However, access to each complete sequence of prices allows for more detailed analysis of how these markets behave. Several possible inefficiencies are explored. While some are unique to a particular sport or have diminished over time, two appear to persist broadly. First, price changes tend to exhibit negative autocorrelation. Second, there are classes of games for which forecasts do not improve in the hours leading up to the game. Causes and implications of both types of inefficiencies are discussed.

Source Theory: A Tractable and Positive Ambiguity Theory

Submission ID-048

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This paper introduces source theory, a new theory for decision under ambiguity. It shows how Savage's subjective probabilities, with source-dependent nonlinear weighting functions applied to them, can be used to model Ellsberg's ambiguity (unknown probabilities). It can do so in Savage's framework of state-contingent assets, and does not need complex two-stage gambles, multistage optimization principles, expected utility for risk (descriptively problematic), or any linear algebra. Still the mathematical analysis is simple, with intuitive preference axioms, tractable calculations and prescriptive implementability, empirically realistic fittings and predictions, and convenient graphical representations of ambiguity attitudes. We provide new ways to compare weighting functions, not between persons as is common, but within one person and between sources. So-called p-matchers turn out to capture uncertainty attitudes well, giving Arrow-Pratt-like transformations, however, "within" rather than "outside" functions. Within-person-between-sources comparisons are the main novelty of ambiguity over risk, first demonstrated by Ellsberg's paradox.

Decision Support Model for Incomplete Risk-Seeking Preferences

Submission ID-107

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Risk-seeking behavior has been extensively documented across various research fields such as decision sciences, economics and finance, psychology. In this research, we propose a decision support model based on reverse second-order stochastic dominance (RSD) to accommodate incomplete risk-seeking preferences. Specifically, we establish dominance conditions according to the RSD criterion in discrete state-space. We then develop a stochastic optimization model that enables to identify an optimal decision alternative whose dominance over a pre-specified benchmark is robust for all risk-seeking decision makers. Furthermore, we demonstrate that RSD-based optimization model can be formulated as a mixed-integer linear programming problem to generate decision recommendations. The developed decision support model is well-suited to support data-driven decision analytics problems, including production and operations management, logistics and supply chain management, and healthcare management, particularly in the presence of incomplete preference information.

Why Do People Discount? The Role of Impatience and Future Uncertainty

Submission ID-073

Enrico Diecidue

approximately 43% of the observed time discounting can be explained by an aversion against future uncertainty rather than impatience, even when controlling for utility curvature. Future uncertainty receives disproportional weight because subjects engage in subproportional probability weighting, a behavioral regularity that does not feature in the standard risk framework of most intertemporal choice models. We find that many people do not demand compensation for waiting but rather for an uncertain future.

Spatial Decision Analysis with Location-Dependent Attribute Weights: Axiomatic Foundations and Incomplete Preference Information

Submission ID-051

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Preferences between decision alternatives with geographically varying consequences can be represented by spatial value functions. Such a function first evaluates consequences locally and then aggregates these values across the spatial region under consideration. We present two ways to improve the use of spatial value functions. Firstly, existing spatial value functions evaluate consequences identically at each location. We ease this restriction by evaluating consequences with respect to multiple attributes and allowing the relative importance of these attributes to vary between locations. This multi-attribute model enables the representation of a wider range of preferences without a significant increase in complexity. Secondly, eliciting the spatial weighting that represents the relative importance of locations from a decision maker is challenging. We introduce an approach for generating a spatial weighting based on incomplete information on the decision maker's preferences captured by a limited number of preference statements. This approach is transparent for a decision maker since the resulting weighting can be easily visualized.

Wed.3.B: Behavioral Decision Making II

Session Chair: Gilberto Montibeller

Contextual Thinking in Behavioral Anomalies

Submission ID-014

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People's choices often depend on choice sets they face. In binary choices, people tend to choose the relatively “moderate” option (called the compromise effect) or to choose the dominant option after adding an "asymmetrically dominated" option (called the attraction effect). Such behavior anomalies are

dimensions' importance. Meanwhile, it remains the forms of dimensions' value functions unchanged. The unique feature of our theory is extending the bedrock of the classical range-based model by further incorporating the influences of relative position of options. We exploit the applausive features like elasticity vanishing, proportional thinking, diminishing sensitivity, and loss aversion, which enhance the theory's capacity of explaining behavior anomalies. Our model particularly explains the attraction and compromise effects in a united way.

Predicting The Present Equivalent Of Cash Streams

Submission ID-058

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We explore the implicit discount rates individuals use to discount not one, but multiple future payouts. Our focus is to incorporate both decreasing impatience and the often neglected magnitude effect. Employing a ceteris paribus design, the study investigates whether the magnitude effect is driven by the sum of cash flows, the highest cash flow, the first, last, or the lowest. The best predictive model suggests that the discount rate decreases with the sum of payoffs and the highest cash flow. We also observe decreasing impatience, using either a beta-delta model or the Ebert-Prelec model. We do not find a strong support for a model with cash-flow specific discount rates. We also use different model specifications to design a retention bonus whose goal is to keep employees as highly motivated as possible during an extended period of time. All models that account for magnitude effect do a good out-of-sample job, whereas the models that only account for decreasing impatience do not. Thus, our research provides better predictions that can aid in designing the financial aspects of products.

„Silly“ mistakes and our willingness to rely on people and machines for decision support

Submission ID-104

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We report a series of experiments that assess people’s reliance on AI and other algorithmic decision support systems in a judgment and a reasoning task. Our results suggest that people willingly rely on AI/DSS when they expect that doing so should improve their performance on the task. In contrast with prior findings, we do not find evidence for a generalized aversion to using AI/DSS or evidence for people avoiding AI/DSS (more so than decision support coming from another person) after observing the AI/DSS make mistakes. Our findings indicate that people’s reliance on AI and other algorithmic decision support systems may be both simpler in theory and more diverse in practice than suggested by previous research.

Behavioral Decision Analysis: Past, Present, and Future

Submission ID-155

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Traditional research in the domain of Decision Analysis has focused on the design and application of logically consistent tools to support decision-makers during the process of structuring problem complexity, modeling uncertainty, generating predictions, eliciting preferences, and, ultimately, making better decisions. Two commonly held assumptions are that the decision maker's cognitive belief system is fully accessible and that this system can be understood and formalized by trained analysts. However, in past years, an active line of research has emerged studying instances in which such assumptions may not hold. We aim to unite this community under the common theme of Behavioral Decision Analysis. This presentation traces the historic evolution of this sub-field of Decision Analysis and lays out a foundation and taxonomy for Behavioral Decision Analysis, which can unify this work across various domains. The taxonomy we suggest categorizes research based on task focus (prediction or decision) and behavioral level (individual or group). Two theoretical lenses that lie at the interface between (1) normative and descriptive research, and (2) normative and prescriptive research are introduced. We then proceed to highlight representative works across the two lenses focused on individual and group-level decision-making.

Wed.3.D: Forecasting II

Session Chair: Pavel Atanasov

Enhancing Flood Prediction Through The Application Of Large Language Models - Case Studies In The UK, Scotland, And Japan

Submission ID-108

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Floods, intricate in causation and profound in local impact, necessitate early and intelligent responses. This paper introduces an advanced early flood warning system leveraging the capabilities of Llama 2 and Mistral large language models (LLMs). The system extracts insights from textual information, encompassing factors like property damage and human casualties. Using a case study approach, the paper explores flash floods in the UK and Scotland and floods in Japan, all of which occurred in 2023, by drawing data from social media platform X (formerly Twitter) and digital news stories. The integration of retrieval augmented generation augments LLM knowledge with supplementary text data from the sources.
The paper outlines a framework for data analysis, emphasizing context-aware reasoning capabilities of the LLMs along with data pre-processing and model validation accuracy for the intelligent early flood warning system. Preliminary findings suggest that LLM-based warning systems may serve as a foundation for enhanced flood predictions. Furthermore, it is suggested that human expert verification remains crucial due to the inherent uncertainty in the utilized data sources.

Submission ID-080

Ville Satopaa [1], Marat Salikhov [2]

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[2] *New Economic School, School of Management SKOLKOVO*

The BIN (Bias-Information-Noise) model decomposes differences in predictive performance between two groups of forecasters in terms of bias (systematic deviations from the base rate), information (use of relevant cues), and noise (use of irrelevant cues). In this work, we generalize the BIN model by allowing bias, information, and noise to depend on the characteristics of the target event (e.g., the topic, geographical region, etc.) and the forecaster (e.g., intelligence test scores, open-mindedness, gender, etc.). This allows us to understand what kind of forecasters' predictions tend to have low noise, low bias, or high information, and whether certain types of events can exacerbate the negative effects of bias, (lack of) information, or noise. Akin to item-response theory models used in psychometrics, our model controls for event difficulty and hence explains forecaster skill in terms of bias, information, and noise. In our application, we consider a large dataset of probabilistic predictions of geopolitical events. We find that there is considerable heterogeneity in terms of bias, information, and noise parameters both across experts and events; and that several forecaster- and event-specific covariates appear to have a strong and statistically significant link with the bias, information, and noise parameters.

Machine-Moderated Judgmental Forecasting to Improve Prediction Accuracy and Decision Making

Submission ID-063

Ville Satopaa [1], Asa Palley [2], Yael Grushka-Cockayne [3], Charles Persinger [4]

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[4] *Eli Lilly and Company*

Obtaining accurate forecasts is critical to making good decisions in many managerial problems. Forecasts may be generated by a statistical model (machine) or through human judgment. Machines are well-suited to detect patterns and regularities in existing data while humans can apply their domain-specific knowledge and reasoning to the problem at hand. An integrated method that uses both sources might rely on a machine to make an initial forecast and then allow humans to update this forecast. Human judgments, however, may suffer from systematic behavioral patterns that reduce their accuracy. Based on a model of humans as imperfect Bayesian updaters, we propose a three-stage hybrid approach which adds a second machine to search for and reduce biases in the human adjustment. We illustrate our approach by applying it to more than 20 years of forecasts at a major pharmaceutical company and to judgments gathered from participants in two laboratory experiments.

Human Forest and Wisdom-of-Crowds Solutions to the Reference Class Problem

Submission ID-068

Pavel Atanasov [1, 2], Regina Joseph [2, 3]

Decision scholars have promoted the benefits of base rates in judgmental forecasting for five decades. But picking a suitable reference class is an even older challenge, dating back to the 1800s. We propose a two-step wisdom-of-crowds solution to the reference class problem. First, elicitation uses the Human Forest process, whereas forecasters define ‘predictively useful’ reference classes and query a database. For example, a clinical trials forecaster may select a class consisting of all Phase II, large-molecule, COVID-19 trials. The resulting custom base rates (e.g., 20%) and forecaster adjustments (e.g., 20% to 25%) are scored for accuracy. Second, the Most Popular Selections (MPS) algorithm aggregates the class selections of many forecasters, selecting the most popular variables (e.g., Trial Phase) and values (e.g., Phase II). Stopping rules guard against overly narrow classes. We test MPS performance using data from two forecasting tournaments, featuring over 1700 reference-class selections across 60 probabilistic questions, focused on clinical trial progression. MPS-derived base rates outperform 75% of individual forecasters’ base rates in terms of Brier scores ($p < .01$ vs. 50%). MPS-aggregation does not involve forecast averaging, so the wisdom-of-crowds effect is not driven by error cancellation but by collective selection of relevant features and algorithmic restraint.

Wed.3.E: Incomplete Information

Session Chair: Eeva Vilkkumaa

Optimization Models for Cumulative Prospect Theory under Incomplete Preference Information

Submission ID-049

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Prospect stochastic dominance conditions can be used to compare pairs of uncertain decision alternatives when the decision makers' choice behavior is characterized by cumulative prospect theory, but their preferences are not precisely specified. This paper extends the use of prospect stochastic dominance conditions to decision settings in which the use of pairwise comparisons is not possible due to the high or possibly infinite number of decision alternatives. In particular, we first establish equivalence results between these conditions and the existence of solutions to a specific system of linear inequalities. We then utilize these results to develop stochastic optimization models whose feasible solutions are guaranteed to dominate a specified benchmark distribution. These models can be used to identify if there exists a decision alternative within a set that is preferred to a given benchmark by all decision makers with an S-shaped value function and a pair of inverse S-shaped probability weighting functions. As such the models offer a flexible tool to conduct behavioral analyses in decision settings such as portfolio selection, procurement optimization or inventory management. We demonstrate the application of these models using real data.

Exploring representational power and decision-making performance in imprecise Bayesian methods

Submission ID-141

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When faced with uncertain situations where relevant physical probabilities are unknown, determining how to make decisions becomes challenging. The Bayesian approach suggests creating a probability distribution by blending subjective intuition and objective constraints. However, imprecise Bayesians argue that this method falls short in capturing ambiguity and propose an alternative using credal sets to represent doxastic states. The degree of uncertainty regarding the physical probability of an event corresponds to the level of divergence in the credal set according to their view. This approach effectively represents and accounts for ambiguities by measuring the extent of the divergence.
While imprecise Bayesianism has primarily been hailed for its epistemological features, this abstract examines its properties in decision-making scenarios. To evaluate the effectiveness of standard Bayesianism versus imprecise Bayesianism, we develop a model and conduct tests using a binomial probability problem. Our findings reveal that the representational tools employed by imprecise Bayesianism can lead to underperformance in decision-making. This observation has been overlooked as previous research on imprecise Bayesianism has not utilized agent-based modeling to provide insights into its short-term performance. Therefore, we raise the question of how much value should be attributed to representational power versus decision-making performance in imprecise Bayesian methods.

Identifying Cost-Efficient Actions Portfolios to Improve the Reliability of Distribution Grids

Submission ID-078

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In distribution grids, the cost-effectiveness of a given reinforcement action in mitigating the risks due to external hazards depends on what other actions are implemented. Thus, to maximize the effectiveness of selected actions, all alternative action portfolios have to be considered. For this problem, we develop a framework to help Distribution System Operators (DSOs) protect multiple grids by selecting reinforcement actions in response to several hazards, based on information provided by reliability indices and subject to investment constraints. The problem is structured as an influence diagram in which scenarios, defined as combinations of realizations for three types of hazards, are represented by a chance node. The proposed framework accommodates partial information about the scenario probabilities, the perceived importance of the grids, and the relevance of reliability indices. Building on this information, a mixed-integer linear programming problem is solved to identify all non-dominated portfolios at different levels of investment costs. The decision model is illustrated with a case study in which the DSO seeks to mitigate risks associated with three hazards in three distribution grids. The novelty of the proposed approach lies in combining reliability indices and scenario analysis with the use of partial information in Portfolio Decision Analysis.

Supporting the Development of a Robust, Market-Shaping Strategy with Scenario-Based Portfolio Decision Analysis: Case Study with Nordea

Submission ID-047

Eeva Vilkkumaa [1], Petri Rikkinen [2], Juuso Liesiö [1]

Strategic decision-making is challenging due to multiple strategic objectives and long planning horizons that make it difficult to assess the future impacts of proposed strategic actions with respect to these objectives. Moreover, strategy work often requires a balance between preparing for alternative scenarios for the future (i.e., developing a robust strategy), and trying to steer the course of change towards a desirable direction (i.e., developing a market-shaping strategy). We present a model-based framework for supporting the development of a robust, market-shaping strategy. For the purposes of this framework, we develop a new portfolio decision analytic model and algorithms to help generate decision recommendations for selecting strategic actions, when (i) the actions' scenario- and objective-specific impacts, the baseline values for these impacts, as well as preferences between strategic objectives are incompletely specified, and (ii) information regarding scenario likelihoods is incomplete and may depend on the selected actions. This framework is applied in a high-impact case on supporting the strategy process at the payments unit of Nordea Bank Abp, the largest retail bank in the Nordic countries.

Wed.4.B: Eliciting and Modelling Probabilities

Session Chair: David Gonzalez Jimenez

The Metalog+: A Feasible and Universal Probability Distribution Family

Submission ID-086

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There has been a longstanding interest among statisticians and analysts for parametric probability distributions flexible enough to match arbitrarily shaped, non-normal data sets (e.g., the traditional Pearson family proposed in 1895, or the Johnson family introduced in 1949). The metalog family emerged in 2016 as a new alternative and has been widely adopted for use in practice for its simplicity and flexibility. The properties and limitations of the metalog, however, remain poorly understood; resulting in users not knowing what they are doing. The goal of this paper is to uncover a variety of properties and offer prescription on how to handle the metalog family. Properties include the maximal number of modes, how to diagnose feasibility, how to repair lack of feasibility, and ensure universality of convergence. In all cases, we consider both the theoretical aspects, as well as the numerical implementation. The result is the so called metalog+, a flexible parametric family with the potential of approximating any distribution.

Utilization of Advice from Human-in-the-loop Systems

Submission ID-038

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The availability of effective artificial intelligence tools is pushing organizations to pay attention to and possibly adopt algorithms as a source of advice. Whether decision makers trust algorithmic advice is not unequivocal and depends on aspects such as the nature of the task, decision-maker expertise, and the level of control decision makers have on algorithms. In this work, we investigate whether advice from human-in-the-loop systems is appreciated, and we compare advice utilization from such systems to direct algorithmic advice and advice from other people.
In five experiments, where we use the judge advisor system paradigm for prediction tasks, we change the type of information provided to the participants, the task's subjectivity, the forecast's type, and the decision makers' expertise. We find that the appreciation of advice from human-in-the-loop systems is on par with that of direct algorithmic advice and is higher than the appreciation of advice from other people, except for experts who discount advice regardless of its source. Our results contribute to the discussion on algorithm aversion and appreciation by extending it to the domain of human-in-the-loop systems and they have implications on how managers can utilize different advice sources.

Incentive-Compatible and Strongly Fair Cake Cutting

Submission ID-129

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The classical cake cutting setting is concerned with dividing a resource, modeled by the [0,1] interval, and allocating subintervals to different agents. Preferences of agents are represented by a function over the [0,1] interval with the agent's utility corresponding to the area under the curve for those subintervals they get allocated. A recent result shows that there does not exist a deterministic cake cutting mechanism that is both incentive compatible and even only one of envy-free or proportional. In this work, leveraging proper scoring rules, we design a randomized cake cutting mechanism that is ex ante incentive compatible, ex post strongly proportional, and ex post strongly envy-free. (Ex ante means the property needs to hold in expectation, ex post means it needs to hold in all instantiations, and strongly means that, roughly speaking, every agent does strictly better than they would in the naive solution that simply allocates the entire cake uniformly at random.) Observe that this result is tight in the sense that additionally achieving ex post incentive compatibility is impossible as it would violate the aforementioned impossibility result.

Learning gap: Noisy signals as Experienced or Described information.

Submission ID-060

David Gonzalez Jimenez

Erasmus School of Economics, Erasmus University Rotterdam

The study of how individuals update after receiving information about noisy signals is one of the most studied areas of updating in decision-making. Typically, on these studies individuals are given the signal distribution and the correlation between signal and state space. However, this might be quite an artificial setting, in most situations individuals learn about the correlation between signal and state space with their own experience. For example, there might be diseases that share symptoms, but doctors learn from their own experience which might be more common in the population they are treating. In this project I investigate how information processing differs in described signals vs experienced signals. I do this by adapting a typical Decision from experience-decision from description methodology to noisy signals and using the hedging method of Baillon et al. (2018) to derive ucertainty attitudes and beliefs. I compare the individuals updating and uncertainty attitudes in the experience information case vs the described

Wed.4.D: Value of Information

Session Chair: Emanuele Borgonovo

Reassurance in information acquisition

Submission ID-040

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Marketers traditionally encourage consumers to seek information about their offerings by emphasizing the usefulness (or instrumental value) of acquiring such information. This paper presents a new approach that taps into consumers' psychological need for reassurance as a motivation for information acquisition. Our main finding is that when consumers face a large but unlikely potential loss, they are drawn to seek information, not to adapt their decision but to experience reassurance. We explore this phenomenon theoretically using a disappointment model and then validate our findings and their marketing implications across seven studies (N=3,430) involving diverse situations such as the timing of exam result disclosures, the choice between compound lotteries, the decision to undertake COVID-19 testing, the decision to engage in virtual product trials, and the post-purchase monitoring of technology updates and promotional discounts. For firms, this research offers two pivotal insights. First, there exists a segment of consumers who will demand non-instrumental information (or tests)–those who perceive a looming but improbable loss. Second, encouraging reassurance-based information-seeking behavior may require counterintuitive tactics, such as bolstering consumers' confidence in their initial choices or projecting irreversibility by making returns less convenient.

Constructing Ensemble Estimates for the Risk Averse Decision Maker

Submission ID-095

Andrea Hupman

University of Missouri-St. Louis

A common technique to improve machine learning predictions is to create an ensemble estimate from the combination of multiple models. This work examines methods to construct ensemble estimates with the goal of increasing the value of information to a risk-averse decision maker who faces a two-action decision. We use simulation and sensitivity analysis to examine how properties of the data such as varying levels of multicollinearity among predictor variables, in concert with properties of the decision situation such as the relative value of the alternatives and the risk aversion, affect the construction of ensembles that will improve the decision maker's situation. Insights from the analysis are illustrated in the context of real-world examples derived from sample datasets available through the Kaggle and the UCI Machine Learning Repository.

On Some Definitions And Clarifications For The Value Of Information

University of Southern California

Abstract:

The value of information (Howard 1967) is an important concept in decision analysis. It identifies the maximum amount of money that a decision maker is willing to pay to receive perfect information about an uncertainty of interest. An abundance of literature provides alternate definitions and approximations for the value of information. Examples include (i) the difference in expected utility of the decision with and without the information, and (ii) the difference in valuation (certain equivalent) of the decision with and without the information. We derive propositions to show that these definitions are not equivalent and also identify the particular instances for which they are. We also comment on some recently proposed simplifications for the value of information calculation using constructed scales. Several examples illustrate the issues encountered with alternate formulations.

The Shapley Value of Information

Submission ID-102

Emanuele Borgonovo [1], Francesca Beccacece [1], Margherita Cigola [1], Giovanni Rabitti [2]

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We consider how the total value expected value of perfect information (total VoI, henceforth) in a decision problem can be apportioned to one ore more of the given uncertainties. We start with Howard's 1988 decomposition which shows that the information value can be decomposed in a series of conditional terms. However, the decomposition is not unique and depends on the order with which uncertainties are included. We prove that one regains uniqueness defining a notion of Shapley value for information value. With this notion, the partial VoI of each uncertainty becomes unique and the sum of the partial VoIs equals the total VoI. We discuss the meaning and interpretation of the new quantity and we show that its application improves the interpretation of a VoI analysis.

Wed.4.E: Multicriteria Decision Analysis

Session Chair: Evangelos Triantaphyllou

An Innovative and Effective Approach for Determining the Most Critical Criteria When Additive MCDM Models Are Used

Submission ID-030

Evangelos Triantaphyllou [1, 2], Juri Yanase [3]

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when ranking alternatives. Traditional sensitivity analysis approaches determine how the ranking of alternatives is impacted under various scenarios or what is the minimum change of current criteria weights that can cause ranking changes. Our study reveals that traditional sensitivity analysis approaches can be dramatically misleading and may fail to identify the most critical criteria. An innovative approach to sensitivity analysis is proposed that can effectively capture the notion of the most critical criteria. This is accomplished when only a single weight changes or when multiple weights can change simultaneously. Determining the most critical criteria successfully can guide the weight determination process towards a more accurate elicitation of the criteria weights and thus it can achieve better final decisions. Therefore, any application area that uses additive MCDM methods can directly benefit from the results of this study.

Interactive multi-objective optimization for supporting climate smart forestry

Submission ID-121

Juho Roponen

University of Jyväskylä

Increasing the amount of carbon sequestered by forests has been proposed as a solution for reducing the net CO2 emissions in the EU. However, the increased carbon storage usually comes at the cost of reduced short-term income, and thus, implementing new forestry management strategies that facilitate these changes can be challenging, especially in the Nordic countries where forest ownership is highly fragmented among many private forest owners. This presentation discusses how interactive multi-objective optimization can be used to explore and quantify the trade-offs faced by the forest owners, focusing on profitability, land value, weather risks, and carbon capture. We showcase the DESDEO open-source software framework, as well as the new interactive methods for supporting forest owners. The goal of our research is to create tools to aid the forest owners to make informed impactful climate-smart decisions. We aim to impact the carbon stored in larger landscapes involving many forest owners and bring them together in workshops to also collect information their willingness to give up profits in favour of higher CO2 capture. In the future, we hope to use this information and the developed tools to research potential compensation schemes that could incentivize higher carbon retention in the forest lands.

Compensation within the Outranking Approach PROMETHEE

Submission ID-071

Sebastian Schär , Jutta Geldermann

University of Duisburg-Essen, Chair of Business Administration and Production Management

Compensation in multiple criteria decision aggregation procedures is commonly understood as allowing a gain in one criterion to offset a loss in another. Generally, the compensatory behaviour is determined by the selected multicriteria approach. Depending on the approach chosen, the possibility for compensation can also be further influenced by the design and parametrization of the preference model. For example, in multi-attribute value theory approaches, it is well established in the literature that the design of the aggregation model affects the possibility for compensation. If necessary, the compensatory behaviour can be limited by the aggregation function to match the stakeholders' preferences. However, different statements exist in the literature regarding the compensatory properties of the PROMETHEE methods, which belong to the set of outranking approaches. We analyse the compensatory behaviour of the PROMETHEE family of methods. Specifically, we identify instances where compensation can occur within the PROMETHEE methods and quantify the degree of compensation as far as possible. We also highlight how to prevent compensation for specific criteria. By

Should Data Derived from Pairwise Comparisons be Trusted? Perhaps not Much

Submission ID-050

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Pairwise comparisons offer an intuitive and practical approach for eliciting qualitative / subjective data from decision makers for many MCDM applications. Their use is based on various phycological studies. Their proliferation was achieved after Saaty used them as an integral part of his AHP approach, including its numerous variants. Given two entities, say A1 and A2, to be compared, a decision maker has to use a discrete ratio scale of choices to approximate the value of their ratio, denoted as value(A1/A2). A problem may occur when the value(A1/A2) is assigned to some value, say V1, from the discrete ratio scale, while the value(A2/A1) is assigned to a value V2 which it is not the reciprocal of V1. We state that in such cases a violation of the reciprocity condition occurs. Our study reveals that such violations may occur frequently when considering simulated (synthetic) or real-world data. Such violations can occur frequently under a deliberately optimistic assumption according to which the decision maker is ultra-accurate when he/she considers one pairwise comparison at a time. The impact of such violations can be dramatic. Understanding the nature and magnitude of this problem is crucial before trying to remedy it.

Thu.2.B: Environmental Applications

Session Chair: Kyle Eyvindson

How to manage forests to meet climate and biodiversity goals? -reflections on the use of systems analysis in forestry

Submission ID-106

Anna Repo [1], Katharina Albrich [1], Juha Honkaniemi [1], Kyle Eyvindson [1, 2]

[1] *Natural Resources Institute Finland LUKE*
[2] *Norwegian University of Life Sciences NMBU*

The stewardship of forests offers solutions to mitigate climate change, halt biodiversity loss, and secure the provision of vital ecosystem services. To achieve international climate and biodiversity goals, it is necessary to adopt more integrated approaches to land-use planning that cover both natural and managed forests, in order to conserve biodiversity, mitigate climate change, and ensure that societal needs for fiber, timber, and energy are met. From a decision-making and policy development perspective, this is a complex problem involving dynamic interactions and multiple decision-makers. The issue is further complicated by uncertainty related to climate change and forest disturbances. This presentation reflects on the challenges and lessons learned from our research on forest planning using a

systems analysis methods for supporting decision-making on biodiversity conservation and climate change mitigation efforts that aim to maximize multiple benefits and enhance forest resilience under a changing climate.

The Consequences Of Connectivity: Using Structured Decision Making To Inform Fish Passage Decisions

Submission ID-032

Shane Flinn [1], Kelly Robinson [2]

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[2] *U.S. Geological Survey, Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry and Natural Resources, University of Georgia*

Dams have dramatically altered riverine systems and are a major contributor to native fish population declines. However, many dams serve important ecological, social, and economic functions, such as flood control, invasive species control, and provision of recreational opportunities. Therefore, dam removal is often contentious among stakeholders and involves making tradeoffs among multiple competing objectives. This research uses Structured Decision Making to evaluate the ecological, social, and economic consequences and tradeoffs of enhancing connectivity for migratory fishes in the Laurentian Great Lakes (North America). We describe our efforts to engage a diverse group of stakeholders to elicit their objectives under various fish passage alternatives. We developed predictive models to help stakeholders weigh the costs and benefits of enhancing connectivity for several fish species with varying life history traits and distributions. We evaluated four scenarios of stakeholder weights to understand how stakeholder values affect the decision. We found that the optimal management alternative was passage of native fishes only; however, the optimal alternative varied based on the weight stakeholders place on each objective. The results of this research will help inform decision-makers on fish passage alternatives that are preferred by stakeholders and that are likely to achieve their objectives.

Decision analysis for building resilience, capacity, and understanding in riverine systems facing climate change

Submission ID-055

Kaili Gregory [1], Kelly Robinson [2], Dana Infante [3], Randall Claramunt [4], Justin Miller [3], Jared Ross [3]

[1] *Warnell School of Forestry and Natural Resources, University of Georgia*

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[3] *Department of Fisheries and Wildlife, Michigan State University*

[4] *Michigan Department of Natural Resources*

Cold-water rivers and streams are at the forefront of climate change impacts, with shifting precipitation patterns and air temperatures posing a significant threat to the resilience of these ecologically, socially, and economically valuable systems. The Au Sable River, Michigan, USA, known for its scenic waterways and rich angling history, is experiencing diverse stressors including habitat degradation and invasive species, the effects of which are only expected to worsen with climate change. There are multiple interest groups in the system with capacity for on the ground implementation of habitat management projects, data collection, and outreach efforts each year. Coordination of these efforts is difficult, and disagreements exist regarding management decision making among these active, involved groups. In a highly participatory decision process, we co-developed an adaptive management framework to identify key uncertainties, strategically acquire new knowledge, and facilitate more effective decision making for

undergoing significant change.

Exploring optimal forest management strategies – adapting optimization approaches to enable use of process-based landscape simulators

Submission ID-099

Kyle Eyvindson [1, 2], Juha Honkaniemi [2], Katharina Albrich [2], Anna Repo [2]

[1] *Norwegian University of Life Sciences, Faculty of Environmental Sciences and Natural Resource Management*
[2] *Natural Resource Institute Finland (LUKE)*

Traditional forest management planning tools utilize deterministic, empirically based models to forecast the development of the forest across a wide range of management alternatives. These models provide guidance on how to best manage the forest stand, often focused on economic objectives. However, this approach can fail to accurately mimic real forest ecosystem landscapes, due to the interaction between forest stands and external forces on the landscape. However, it is well-suited for mathematical optimization, as decisions are related to the forest stand. Innovative ecological approaches to model forest landscapes have been developed to assess predefined management strategies. These models are process based, operating at the tree level, and spatially explicitly integrating neighborhood impacts to the landscape-scale dynamics. To appropriately reflect the forested landscape, these models integrate a variety of disturbances (biotic and abiotic), utilizing a stochastic approach to estimate the ecological impacts on the landscape. These stochastic elements increase the complexity of the decision system. To address this, we propose a stochastic programming approach to incorporate such simulations of a case study area in Finland in an optimization framework. We identify the key challenges and highlight adaptions required to enable the use of spatially explicit process-based models for optimization scenario analyses.

Thu.2.D: Game Theory and Dynamics

Session Chair: Topi Miettinen

Game Theory, Data Analytics, and Homeland Security

Submission ID-064

Jun Zhuang

University at Buffalo

Society is faced with a growing amount of property damage and casualties from man-made and natural disasters. Developing societal resilience to those disasters is critical but challenging. In particular, societal resilience is jointly determined by multiple stakeholders such as federal and local governments, private and non-profit sectors, private citizens, and adversaries. The tradeoffs between protecting against man-made and natural disasters, between preparedness and relief, between efficiency and equity, and between private and public investment, will be studied using a game-theoretical framework.

Designing Payment Models for the Poor

Submission ID-122

Sasa Zorc [1], Bhavani Shanker Uppari [2]

[1] *University of Virginia, Darden School of Business*
[2] *Singapore Management University*

Several basic services, such as energy, clean water, and cooking gas, are out of reach for millions of people living in poverty. There has been an emergence of firms that offer these services by, for example, selling solar home systems. These firms deploy a pay-as-you-go (PAYGo) model in which consumers can manage the amount and frequency of their payments based on their own erratic cash flows. However, because a firm under this model cannot observe how much money the consumers have, they can pay less to the firm and turn their income to other needs.

We employ a dynamic mechanism design approach, which allows us to reduce the problem of finding the best possible contract with the consumers to a dynamic program.

The optimal contract summarizes a consumer's payment history with a single score (the v-score). The contract allows the consumer to chose any amount to pay, and adjusts the v-score dynamically. The v-score also determines the level of technology access granted to the consumer and whether the contract is terminated or continued. We discuss how the optimal contract can be implemented in the field and how it can solve some of the practical problems currently.

Coordination of Heterogeneous Resources in Inspection Games

Submission ID-134

Bobak McCann , Mathieu Dahan

Georgia Institute of Technology

We consider an inspection game, in which a security agency positions heterogeneous detectors according to a probability distribution in order to detect multiple illegal commodities hidden by a strategic adversary within a critical system. We assume the defender has access to multiple types of detectors that can potentially differ in their accuracy and cost, and that the adversary has multiple types of illegal commodities that can potentially differ in their value. The objective of the security agency (resp. adversary) is to maximize (resp. minimize) the expected value of detected commodities. We provide a polynomial algorithm to compute Nash Equilibria for this inspection game. We then leverage our equilibrium analysis to determine the optimal detector investment for the security agency given the partial information regarding the adversary's illegal commodities.

Commitment and conflict in multilateral bargaining

Submission ID-088

Topi Miettinen [1], Christoph Vanberg [2]

[1] *Hanken School of Economics*
[2] *University of Heidelberg*

majority rules. Under unanimity rule, an ine-cient equilibrium always exists, and e-cient equilibria exist only if the probability that commitments bind is su-ciently large and the number of players is su-ciently small. Under any (super)majority rule, every equilibrium is effi-cient.

Thu.2.E: PhD Incubator I

Session Chair: Sasa Zorc

Can Reinforcement Learning Be Used for the Valuation of American Option?

Submission ID-022

Peyman Kor , Reidar Brumer Bratvold , Aojie Hong

Energy Resources Department, University of Stavanger, Stavanger, Norway

Discussant: Spyros Zoumpoulis

American Option Valuation is essentially a sequential decision-making problem with two binary actions (Stop or Continue) at each decision point in time and thereby can be transformed into an optimal stopping time problem. Various methods can be utilized to solve for the (near-)optimal policy and, hence, the fair value of the American Put Option.

This research aims to investigate, compare, and discuss the performances of the approximate dynamic programming method – Least-Squares Monte Carlo (LSM) – and Reinforcement Learning (RL) based methods for identifying the optimal policy for pricing American options. In addition, two price models – the classical Geometric Brownian Motion and a calibrated Stochastic Volatility model (GARCH) are implemented to represent the underlying uncertain assets.

The novelty of this work lies in two aspects: (1) applying LSM and RL to determine option prices with a specific focus on analyzing the dynamics of decisions and identifying any differences in the proposed policies resulting from the two methods, and (2) studying and shedding light on how “learning” in RL contributes to updating/optimizing decisions at each batch, revealing the evolution of the decisions, during the learning process, leading to the optimal policies.

Predicting Tail Quantiles Through Aggregation of Medians: Model and Analysis

Submission ID-056

Long Zhao [1], Zhi Chen [1], Junnan Wang [2]

[1] *NUS Business School, National University of Singapore*
[2] *INSEAD*

Discussant: Blitz

Quantile forecasts are essential inputs for decision-making under uncertainty. The most useful quantiles are from the tails since tails provide rich information about the underlying uncertainty. However, directly

median forecasts by the true difference between median and tail quantiles. However, this task is challenging because the underlying randomness is unknown, and the median forecasts are subject to biases and noises. Our method involves aggregation of median forecasts to achieve a substantial reduction of noises, and leveraging past data to correct the biases and to estimate the shift. We evaluate our proposed method using the M5 uncertainty competition submissions and find that our method outperforms established benchmarks in the literature. We also offer a theoretical understanding of why our method performs well empirically.

Identifying Experts with Small Contributions in Forecast Aggregation

Submission ID-057

Xinyu Hou [1], Zhi Chen [2], Long Zhao [2]

[1] *National University of Singapore, Institute of Operations Research and Analytics*
[2] *National University of Singapore, NUS Business School*

Discussant: Ilia Tsetlin

Forecast aggregation, particularly through the linear opinion pool method, is widely adopted in practice, showcasing superior accuracy over individual forecasts—the wisdom of crowds phenomenon. In many business contexts (i.e., demand forecasts), experts providing forecasts are internal employees of a firm, involving even senior executives. For a resource-constrained firm, how can it identify experts whose contributions to the consensus forecast accuracy are minimal? This not only leads to cost savings but also improves the operational efficiency of resource-constrained firms.

We begin by examining the scenario where one expert's contribution to the consensus forecast accuracy is zero. We prove that this occurs if and only if the forecast error of this expert can be expressed as an affine combination of other experts' forecast errors, along with an independent noise. This affine combination can be conceptualized as a hypothetical expert who dominates the focal expert. In a broader context, we demonstrate that the expert who contributes the least may not necessarily have the lowest optimal weight in the linear opinion pool. Instead, the minimal contributing expert performs the worst in the part that cannot be replicated by combination of others. Empirically, we validate our insights in a case study.

Regularized Aggregation of Point Predictions From Experts With Different Amounts of Past Performance Data

Submission ID-067

Junnan Wang , Ville Satopaa

INSEAD

Discussant: Yael Grushka-Cockayne

Aggregating multiple experts’ point forecasts is a critical challenge, especially in the common context where experts have made different numbers of predictions in the past. For instance, suppose one expert has made only two predictions in the past but with 100% accuracy, while another has made 100 predictions but with lower accuracy. One is more accurate but riskier than the other. In this work, we introduce a new aggregator that makes such considerations precise and balances risk with statistical evidence of skill. Specifically, our aggregator uses Bayesian regularization, estimates each expert’s expected level of bias and noise, takes into account their individual-specific prediction histories, and appropriately shrinks each expert's weight toward equal weight, depending on the expert’s skill and how

Thu.3.B: Judgment and Dec. Making I

Session Chair: Konstantinos Katsikopoulos

Role of gender on start-up investors' perception of uncertainty and risk

Submission ID-046

Onesun Yoo [1], Chia-Jung Tsay [2]

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There has been a surge of interest in the role of gender in entrepreneurship, including work that documents how female-led ventures are perceived by investment communities. Such findings suggest that female-led ventures tend to be considered riskier and thus are discounted relative to male-led ventures. However, there is a relative lack of studies considering behavior of female investors and their impact on investment teams.

Given existing literature from management to psychology suggesting that women may be more risk averse than men, female-led investment teams may be less willing to invest in female-led startups, due to their perception such companies pose more risk, compared to those led by men. Yet, other factors (e.g., homophily, familiarity) suggest that female-led teams could be more willing to do so.

We examine a novel, comprehensive dataset covering investment transactions of SaaS start-ups in the UK between 2015 to 2023. Using the gender information of both the startup's founding team and the lead investors, our analyses disentangle the contradicting hypotheses and present insights regarding the role of gender in the start-up ecosystem. We complement these analyses with a series of experiments to the causal relationship between the gender of evaluators and perceptions of uncertainty and risk.

Learning to Suppress: Decision Makers Can Learn to Treat Irrelevant Information as Suppressor Variables Using the MCPL Paradigm

Submission ID-012

Hagai Rabinovitch [1, 2], David V. Budescu [3], Yoella Bereby-Meyer [2]

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[2] *Ben-Gurion University*
[3] *Fordham University*

When selecting candidates for a position, the selection process may be affected by irrelevant factors, unrelated to job performance, such as age, appearance, etc. This can give unjustified advantage to candidates who are high on these factors. To correct this bias, the decision-maker (DM) needs to recognize these factors and weigh them negatively, namely, treating them as suppressor variables.

regression equations (separately for each DM) showed they learned to consider the irrelevant attribute as a suppressor (assigned it a negative coefficient), albeit to a lesser extent than the normative model. This effect was found when we provided (Exp. 1-2) or didn't provide (Exp. 3) information about the correlations between the variables but almost disappeared when we presented two irrelevant attributes simultaneously (Exp. 4). The results demonstrate that DMs can learn to consider irrelevant information as suppressors and illustrate their adaptive ability.

Preferences for Wealth Distributions in the Presence of Group Structure

Submission ID-093

Stefano Balietti [1], Rupert Freeman [2]

[1] *University of Mannheim*
[2] *University of Virginia Darden School of Business*

We examine individual preferences for wealth inequality in a population that is endowed with group structure. We conduct an online experiment in which we assume that each individual in the population is associated with a single group identity. Using a custom Distribution Builder tool, participants are asked to build their preferred distribution of wealth for various group structures, including the case of separated and well-mixed groups. In the former case, all members of one group are disadvantaged relative to the other, and in the latter, the distribution of wealth is roughly equal across each group. Preliminary results based on n=243 participants indicate that preferences for inequality differ significantly when group structures are present relative to a baseline case with no group fairness considerations. Our work is relevant to any setting where group fairness considerations are relevant (e.g., hiring, civic participation, public policy, college admissions), and stands in contrast to existing literature on preferences for inequality that does not simultaneously consider inequality at both the individual and group levels.

A simple model for mixing intuition and analysis

Submission ID-043

Konstantinos Katsikopoulos [1], Luis Fuentes Garcia [2], Martin Egozcue [3]

[1] *University of Southampton*
[2] *University of Coruña*
[3] *University of Montevideo*

Firefighters, emergency paramedics, and airplane pilots can make correct judgments and decisions in challenging situations. Experts often attribute such successes to intuition and report that they avoid analysis. Decision analysis should ideally respect human intuition while supporting and improving it with analytical modelling. We utilize psychological theories of intuition to build a model of mixing intuition and analysis over a set of interrelated 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. We make 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., using intuition 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 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%, and the accuracy benefit of using the optimal mix over analysis alone is estimated between 3% and 27%.

Thu.3.E: PhD Incubator II

Session Chair: Sasa Zorc

Optimizing Investment Period Length and Strategies for Later Stage Venture Capital Staged Financing Portfolio

Submission ID-082

Guanrou Deng , Maurizio Fiaschetti

Institute of Finance and Technology, University College London, London, WC1E 6BT, UK

Discussant: Juuso Liesiö

This paper proposes the Sequential Investment Allocation Model (SIAM) to address the gap in existing literature regarding the modelling of the Venture Capital (VC) later-stage financing investment period. SIAM aims to minimize investment period length while considering constraints on fund payoff and investment strategies. It incorporates distribution and stochastic process models to explain parameters such as investment timing, amount, and company performance. Validation is conducted using Pitchbook data covering a broad range of VC later stage (after rounds C) rounds of financing deals. Analyzing investment period length under different strategies reveals an "S"-shaped relationship between payoff and period, emphasizing timely termination for higher payoffs. The optimal investment period aligns with market averages, approximately 4-6 years, supported by Pitchbook data. Exit conditions based on exit multiples for each portfolio company lead to more stable payoffs than predefined exit times. Investing in higher-performing companies yields enhanced payoffs for portfolio managers. However, excessive selectivity results in limited exits, thereby impeding both the desired payoff and investment period length. These insights contribute to understanding VC fund portfolio dynamics, offering guidance for informed decision-making on optimal investment strategies in the private sector.

Optimal Experimentation for Learning Personalized Policies Across Locations

Submission ID-087

Georgina Hall , Stefanos Poulidis , Spyros Zoumpoulis

INSEAD

Discussant: Blitz

Firms wish to learn personalized policies for customers in heterogeneous yet related locations to maximize their monetary gains. To do this, they conduct experiments at each location to estimate the parameters of a customer response function. A crucial decision is which action to assign to each participant in the experiment, especially when a participant can only be assigned one action or there are budget constraints. The existing experimentation methodology considers locations and experiments individually. In this work, we leverage the relationship between locations in the experimentation problem to learn more profitable policies by proposing novel estimators and a semidefinite programming approach.

Neutral Pivoting: Strong Bias Correction for Shared Information

Temple University

Discussant: Asa Palley

In the absence of historical data for use as forecasting inputs, decision makers often ask a panel of judges to predict the outcome of interest, leveraging the wisdom of the crowd (Surowiecki, 2005). Even if the crowd is large and skilled, shared information can bias the simple mean of judges' estimates. Addressing the issue of bias, Palley and Soll (2019) introduces a novel approach called pivoting. Pivoting can take several forms, most notably the powerful and reliable minimal pivot. We build on the intuition of the minimal pivot and propose a more aggressive bias correction known as the neutral pivot. The neutral pivot achieves the largest bias correction of its class that both avoids the need to directly estimate crowd composition or skill and maintains a smaller expected squared error than the simple mean for all considered settings. Empirical assessments on real datasets confirm the effectiveness of the neutral pivot when compared to alternative methods.

A decision analysis model for colorectal cancer screening

Submission ID-103

Daniel Corrales , David Ríos Insua

Institute of Mathematical Sciences, ICMAT-CSIC

Discussant: Jun Zhuang

Colorectal cancer (CRC) is the third most common type of cancer worldwide, making up for about 10% of all cases and being accountable for around 12% of all deaths due to cancer. Despite this, as an example, only about 14% of susceptible European Union citizens participate in screening programmes. Hence, there is an urgent need for accurate, non-invasive, cost-effective screening tests based on novel technologies and raise further awareness on the disease and its detection. Moreover, personalized screening approaches are required to consider socioeconomic variables as well as environmental stressors that can lead to different onsets of the disease.

This presentation outlines one such approach within the ONCOSCREEN Horizon Europe project. First, we develop a Bayesian network model to facilitate CRC predictions drawing on expert judgement and a large database from an observational study. This network is used to map CRC risks depending on numerous factors. We then embed such network in an influence diagram model aimed at advising about personalised screening strategies depending on patient information and cost-effectiveness of the methods. We also discuss incentives in relation to promoting the uptake of screening in the population.

Thu.4.B: Applications in Business

Session Chair: Sanjith Gopalakrishnan

Machine Learning Methods Are Not Always Better: Predicting Bankruptcy In US Public Companies

Submission ID-135

Several bankruptcy models exist in literature. However, few have been tested outside of the context of the paper in which they are introduced. In this paper, we test five existing bankruptcy models including three of the most cited bankruptcy models (Altman, Ohlson and Godfrey) with three new data sets. In addition, we create three new models using the three most accepted methods, logistic regression, linear discriminant anlaysis and machine learning. We test these models as well. Based on our analysis we find that an updated model using linear discriminant analysis outperforms all historical models along with models using more "modern" approaches like machine learning. Particularly, we test the models using three data sets, a matched sample of United States Department of Defense suppliers, a non-matched sample of United States Deparment of Defense suppliers and a large sample of publically held companies of US origin. This work demonstrates the importance of "traditional" methods in bankruptcy predition. Sometimes the simple model is the best model.

On designing patient-centric distribution channels in pharmaceutical supply chains with multi-attribute value analysis and network optimization

Submission ID-125

Milena Janjevic [1], Gilberto Montibeller [2, 3], Jarrod Goentzel [1]

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Abstract: Recent developments in pharmaceutical technologies have opened up new avenues for personalized medicine. Two important developments were brought about by this technological innovation. First, pharmaceutical companies are experiencing a change of scope in their supply chains, with a requirement to move from a distributor model toward a direct-to-consumer model. Second, patient-centric distribution services may create sources of competitive advantage by further increasing customer satisfaction and by promoting high-quality healthcare. In this paper, we argue that the designing of patient-centric distribution channels requires a novel perspective. Specifically, the designing process must take into account patients' preferences, consider the competing objectives of relevant stakeholders, engage these stakeholders in the co-design of such systems, and facilitate learning and a shared understanding that promotes agreement on a suitable supply chain solution. We suggest an emerging framework that can guide the design of patient-centric distribution channels in pharma supply chains and discuss possible choices that supply chain designers may contemplate. We tested the use of this designing framework in two in-depth interventions, in which interactive decision support systems were developed to support stakeholders in co-designing patient-centric distribution channels in supply chains for a large pharmaceutical manufacturer. We describe the main outcomes of these interventions.

Modeling Misinformation Spread for Policy Evaluation: A Parsimonious Framework

Submission ID-029

Yiting Deng [1], Richard Staelin [2]

[1] *UCL School of Management, University College London*

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We develop a parsimonious framework for evaluating the efficacy of different approaches for limiting the spread of misinformation. We use this framework and simulation studies to determine the evolution of truthful and fake messages on social media platforms and then investigate the following policy interventions: 1) our suggested approach of having the platform require senders of messages to also

under our suggested approach. If this is not the case, we find the other approaches are effective in reducing the spread of misinformation.

Optimal Pricing Across Markets with Deal Seekers

Submission ID-042

Sanjith Gopalakrishnan , Rim Hariss

McGill University, Desautels Faculty of Management

Deal seeking is a prevalent consumer behavior entailing a deliberate effort by customers to hunt for cost-saving opportunities across markets. Global tourism, for example, presents ample deal-seeking opportunities, particularly in the luxury retail market, and accounts for a significant portion of revenue for brands. While deal-seeking behavior can be explained as a rational utility-maximizing response, it is observed in practice that it is also influenced by cognitive biases, especially an anchoring effect where consumers fixate on the anchor price in their home market, and perceive a greater value in discounts. This can lead to irrational purchasing decisions based on perceived value. It is therefore useful to distinguish two types of deal-seekers: optimal deal seekers whose decisions are explainable via rational utility maximization and anchored deal seekers who derive value due to the extent of discounts on the price in their home market. The presence of cross-market deal-seeking customers necessitates a pricing strategy that explicitly accounts for such behaviour. That is, from the brands' perspectives, deal seekers introduce opportunities for cross-market price optimization. This work contributes to an emerging stream of literature that argues for a careful consideration of the implications of behavioral biases on firm pricing strategies.

Thu.4.D: Computational Approaches

Session Chair: Topias Terho

A CEO-BASED BEHAVIORAL FRAMEWORK PREDICTING ESG RISK: A MACHINE LEARNING APPROACH.

Submission ID-083

Martial Ndtoungou Pfouga

Manchester Metropolitan University

The ESG rating of firms is increasingly taken into consideration when making decisions such as purchasing stock or offering green bonds. As such, stakeholders of a firm have a common interest in avoiding a downgrade of their focal firm's ESG ratings to maintain its attractiveness.
This study uses a machine learning approach to develop a decision tree, which provides rules describing how CEOs' personality traits interacts to predict a downgrade in the future ESG rating of their firms. Based on CEOs' rhetoric during earnings calls, the author computed numerical measures of CEOs' personality traits that were subsequently used as features in the decision tree model. Furthermore, the author used the change in the ESG rating of firms between the current and the following year as the outcome of the decision tree model.
The result of the study reveals one primary decision path from the decision tree, which is that if CEOs

Data-driven Sequential Search

Submission ID-138

David Brown , Cagin Uru

Duke University, Fuqua School of Business

In this paper, we study a sequential search problem with an unknown distribution of alternative values. The goal is to find a stopping rule that maximizes the worst-case ratio of reward compared with an oracle with full knowledge of the value distribution. We consider simple policies that select the highest valued alternative if and only if its value is below a threshold. In each period, the decision maker elevates the threshold, provided that the search continues. We show that by randomizing over these threshold rules, we can design policies that perform well. Furthermore, we develop an upper bound on the performance of feasible policies. Our approach is based on formulating and solving a linear program to optimize the first period decision to select the first explored alternative while approximating the continuation value with the oracle performance. The resulting upper bound suggests that our randomized threshold policies perform close to the optimal.

Decision Trees: Fitting Continuous Features without Preprocessing

Submission ID-143

Flávio Araújo Lim-Apo [1], Leonardo Bastos [1, 2], Fabricio Oliveira [3], Silvio Hamacher [1, 2]

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[3] *Systems Analysis Laboratory, Department of Mathematics and Systems Analysis, School of Science, Aalto University, Finland*

In data mining, decision trees are an off-the-shelf procedure that creates interpretable splits for classification or prediction problems. They may quickly construct and produce models with numerical and categorical variables. On the other hand, a dataset with continuous variables requires an exhausting search to achieve the best split, resulting in a time-consuming activity. Discretization or bucketization reduces the number of values used as splits and sacrifices optimality accuracy since it excludes a portion of the values that could be used as a split. This study provides a new heuristic for training the decision tree. The proposed method focuses on predicting continuous features without pre-processing, such as discretization, and minimizing misclassification to improve accuracy. We tested on 53 UCI Machine Learning Repository datasets. The heuristic demonstrated superior performance compared to CART by 1.4% in-sample data and 2.8% out-of-sample data. Therefore, the model performs better than CART with a slight increase in model training time, which may be a trade-off for a better solution, and its training time for shallow depth trees is similar to CART.

Risk-averse decision strategies for influence diagrams using rooted junction trees

Submission ID-075

Olli Herrala , Topias Terho , Fabricio Oliveira

Aalto University

utility distribution of the consequences and thus allowing CVaR and other risk metrics to be used in the model. The drawback of decision programming is that the complexity of the resulting MILP grows exponentially with the size of the influence diagram. Alternative MINLP formulation for influence diagram (Parmentier et al., Informs Journal on Optimization, 2/3, 2020) based on an intermediate step of transforming the diagram into a rooted junction tree offers superior computational performance. However, the flexibility of the MINLP formulation is limited since risk cannot be straightforwardly represented in the model. We present a formulation combining the modeling flexibility of decision programming and the superior computational performance of the rooted junction tree approach. We illustrate the effectiveness and flexibility of the formulation with numerical examples.

Thu.4.E: PhD Incubator III

Session Chair: Sasa Zorc

Trusting the Algorithm: A Decision Under Ambiguity

Submission ID-031

Qiong Xia , Ahmed Guecioueur , Enrico Diecidue

INSEAD

Discussant: Aurelien Baillon

We show that ambiguity attitudes influence decision-makers' (DMs) choices to trust the forecasts of both human and machine learning (ML) financial analysts. Using a lab experiment to measure DMs' ambiguity attitudes and beliefs, we show that DMs exhibit similar patterns of ambiguity-seeking and ambiguity-generated insensitivity (a-insensitivity) toward changes in the likelihood of prediction accuracy, regardless of the analyst type. DMs hold more optimistic beliefs in the accuracy of ML analysts over human analysts, which significantly predicts higher trust in ML analysts. DMs with greater a-insensitivity regarding the prediction accuracy of either type of analyst are less likely to incorporate their own beliefs into their trust decisions. A-insensitivity tends to increase with greater financial literacy, suggesting that more financially literate DMs perceive greater ambiguity in prediction accuracy rates.

Computing Stochastically Non-Dominated Solutions for Risk-Informed Maintenance Decisions in the Management of Transport Infrastructure Assets

Submission ID-120

Leevi Olander , Ahti Salo

Aalto University

Discussant: Blitz

Stochastic dominance helps screen decision alternatives when the decision maker's risk preferences are not completely known. In this talk, we employ stochastic dominance to guide risk-informed maintenance decisions in transport infrastructure asset management. More generally, we present an exact algorithm to identify all first-order stochastically non-dominated solutions in discrete multi-criteria decision

Confirmation trees – creating hybrid intelligence when humans and algorithms disagree

Submission ID-123

Julian Berger [1, 2], Frederik Andersen [4], Diana Verdes [4], Kristian P. Lorenzen [3], Pantelis P. Analytis [4], Ralf H.J.M. Kurvers [1, 5]

[1] *Max Planck Institute for Human Development*
[2] *Department of Psychology, Humboldt University*
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[4] *Department of Business and Management, University of Southern Denmark*
[5] *Science of Intelligence, Research Cluster of Excellence*

Discussant: Ville Satopaa

We study hybrid confirmation trees, a simple heuristic for creating hybrid intelligence, in high-stakes decisions within criminal justice, deepfake identification and cancer detection. Hybrid confirmation trees work by leveraging independent decisions of humans and algorithms. Whenever a human and an algorithm agree on an option, said option is chosen as the final answer. In case of disagreement, a second human breaks the tie. Our approach proves to be a powerful alternative to human-only decision making strategies as it performs similar, if not better, at reduced costs. Compared to humans on their own, hybrid confirmation trees also allow to more flexible trade-off true and false positives. We find that hybrid confirmation trees benefit from uncorrelated errors between the humans and the algorithms, which allows to further boost performance by pairing algorithms and high-performing humans. We posit hybrid confirmation trees as a complement to the well studied algorithm-as-advisor setting and discuss future improvements as well as critical considerations to bring hybrid systems into the real world.

Advice Taking under Time Pressure

Submission ID-026

Erik Kommol , Christopher Lettl

Vienna University of Economics and Business

Discussant: Jack Soll

Many decisions are not made alone, but decision-makers seek advice from others. In increasingly hypercompetitive markets, management teams are often under pressure to make strategic decisions fast. Therefore, decision-making and advice taking often takes place in environments that are associated with time pressure. We study the influence of time manipulations on advice taking in two pre-registered experiments (n = 593). In experiment one, we employ a judge-advisor system, where advice is presented unsolicited and not associated with costs, to study the effect of time pressure on advice utilization. Results indicate that confidence mediates the influence of time manipulations on advice utilization leading to a positive indirect effect. To provide a more nuanced understanding of the effect of time pressure on advice taking, we then investigate how time pressure influences advice seeking in environments where advice is optional and associated with costs. Results indicate that confidence moderates the effect of time pressure on advice seeking: less confident individuals spent proportionally more time seeking advice compared to highly confident individuals when under time pressure. Our study emphasizes the importance of considering the environments individuals are embedded in when taking advice while distinguishing between different advice taking scenarios prevalent in the organizational context.

Fri.1.B: (previously Thu.5.B) Judgment and Dec. Making II

Session Chair: Tong Deng

Utilizing ludic pedagogy to introduce decision analysis concepts

Submission ID-045

Trent Tucker

Thompson Rivers University

The Decision Analysis course I teach has a reputation among the MBA students who take it of being a conceptually difficult course. In order to address this issue and ease the students into learning new quant concepts, I've adopted a "ludic" approach to my teaching of the course material. The Ludic Pedagogy model — as described by Lauricella and Edmunds (2022) — "builds upon four elements: fun, play, playfulness, and positivity." They conclude that "in this model, students can boast increased retention of course information, a reduced cognitive load, and deeper learning (p.11)" — outcomes that any educator would be pleased with!

Pendegraft's famous 1997 exercise — "LEGO of my Simplex" — is an example of this. Through naïve play with LEGO bricks, students are introduced to linear programming concepts and the formal mathematics comes later. This past year I challenged myself to incorporate a ludic approach into nearly all of my lectures. The purpose of this talk is to share novel ludic approaches to data analysis, linear programming, and Monte Carlo simulation from my classroom. If you're looking for a way to make management science concepts more engaging and less threatening for students — this session is for you!

Understanding the Mental Simulation in Risk Decisions with Operational Data Based on Causal Discovery

Submission ID-139

Tong Deng , Chen Wang

Industrial Engineering Department, Tsinghua University

The key point of risk decision is the uncertainties of the potential outcomes, which will evolve over time in dynamic processes. Prior studies have indicated that individuals engage in mental simulations of event development during the risk decision process. Due to the cognitive effort required for mental simulation, it is only triggered under certain conditions. Most previous research has been conducted through experiments or surveys. Our goal is to use data-driven approach and vast contextual data to explore the existence of mental simulation in risk decision and its triggering conditions. We adopt a nonlinear causal discovery method to find the factors influencing risk decision and mental simulation at root. Inspired by risk perception studies, we categorize these contextual factors according to its controllability. In case of air traffic management decision-making, we conduct several numerical studies assuming that decision-makers' mental simulation is consistent with the admitted air traffic evolution process. We have designed an air traffic simulator following the air traffic rule. This simulator enables us to explore the considered time length of mental simulation and uncover the mental simulation abilities of these air traffic controllers. Our research can provide valuable insights for risk decision in complex network systems.

Fri.1.D: (previously Thu.5.D) Forecasting III

Session Chair: Majid Karimi

Constructing Quantiles via Forecast Errors: A Bias-Variance Framework

Submission ID-101

Zhi Chen [1], Long Zhao [2]

[1] *National University of Singapore*
[2] *National University of Singapore*

Probabilistic forecasts such as quantiles are essential inputs to decision-making under uncertainty. The most common type of forecasts often comes in the form of point forecasts, and it is, therefore, necessary for the decision maker to construct uncertainty measures around the obtained point forecasts. One simple approach suggests leveraging historical forecast errors to create quantiles around the given point forecast (the E2Q method). While these E2Q estimators may take different forms, we develop a theoretical framework to understand how the bias and variance of a quantile estimator affect the overall performance, as measured by the pinball loss. We find that unbiasedness is not optimal for a given variance, and the bias towards the center of the distribution is more costly. Besides, higher estimator variance leads to worse performance. These bias-variance insights allow for comparisons among different estimators. For example, with limited samples, we find that sample quantile (SQ) is inferior to normal approximation (N) for tail quantiles in both bias and variance. In the same setting, an estimator based on a more general parametric fit, such as the generalized normal (GN), could perform worse than N. Empirically, we validate our theory using the M5 competition submissions.

Comparison Between Linear Opinion Pool and Stacking

Submission ID-077

Xiaochuan Pang [1], Zhi Chen [2], Guowei Zhang [3], Long Zhao [2]

[1] *Sun Yat-sen University*
[2] *National University of Singapore*
[3] *Tianjin University*

Forecast aggregation via linear opinion pool tries to obtain the optimal weights that minimize the variance of the aggregated forecast. We prove that this is equivalent to a linear regression where the realization is regressed on the predictions from experts subject to the constraint that the summation of the coefficients is one. Meanwhile, in the machine learning community, stacking, which is a popular ensemble learning method, also adopts a similar linear regression but without such a constraint. In this paper, we seek to understand the role of the constraint theoretically and identify conditions when one should use a linear opinion pool.

Leveraging i.i.d. training samples of realizations and predictions, our analysis reveals nuanced insights. Under identical distribution between training and test sets, a surprising absence of bias-variance tradeoff emerges, with the constraint-free linear regression potentially outperforming its constrained counterpart regarding both bias and variance. If the test set deviates from the training, adding such a constraint

Wisdom of Sequential Crowds: Quantile Forecast Aggregation With Learning and Updating

Submission ID-059

Majid Karimi [1], Arthur Carvalho [2]

[1] *Department of Operations and Supply Chain Management, College of Business Administration, California State University San Marcos*
[2] *Department of Information Systems and Analytics, Farmer School of Business, Miami University*

From forecasting the yield of corn in agribusiness problems to winning the Nenana Ice Classic by correctly estimating the exact date and time the ice breaks on the Tanana River, point forecasts are often made sequentially, allowing for *learning* and *updating*. This study investigates quantile forecast aggregation in the presence of learning from previous forecasts and updating whenever new information becomes available. In the absence of learning or updating, simple averaging of quantiles is often a common and robust solution, canceling out the individual biases. In sequential settings, however, point forecasters (humans, machines, or both) can engage in *social learning* — learning from others' actions — and update their forecasts in light of new information. Furthermore, optimal forecast combinations in sequential settings, in particular, can be hard to come by due to the significance, relevance, or efficacy of the forecasters' historical performance.
Using synthetic and real data, we explore different aggregation methods, including our proposed Bayesian approach, and compare different techniques. We find that incorporating learning and updating results in sharper and more calibrated forecasts in sequential settings, particularly for the proposed Bayesian approach and even when considering simple learning heuristics such as quantile matching estimation.

Fri.1.E: (previously Thu.5.E) Strategic Decision Making

Session Chair: Mathieu Dahan

Under what conditions? A scenario technique for exploring the prerequisites of future events

Submission ID-114

Tommi Ekholm , Theresa Schaber

Finnish Meteorological Institute

In an increasingly complex world, strategic decisions require in-depth understanding of the conditions that define future events’ realization. We present a novel, scenario-based approach to explore under what conditions a chosen future event would occur. Our approach can be seen as fusion of exploratory scenarios with the backward-looking perspective of backcasting, while resembling cross-impact methods in how future events’ realization is seen to arise from several interacting, uncertain assumptions. It focuses on mapping the assumptions and causal mechanisms that lead to the realization of the investigated event. This results in identifying the subset of assumption combinations that lead to the event being realized or not realized, and scenario sets where the event is either realized or not. This analysis provides insights beyond ‘Is the event likely to occur?’, revealing the various circumstances under which it can occur. We also provide ways for considering probabilities and deliberate decisions

The Wisdom of Strategically Diverse Crowds

Submission ID-011

Yanwei Jia [1], Jussi Keppo [2], Ville Satopää [3]

[1] *Chinese University of Hong Kong*
[2] *National University of Singapore*
[3] *INSEAD*

We investigate the impact of strategic diversity on predictions made by a group of interacting agents. The agents receive public and private information and have varying external motivations, from conformity to contrarianism. We find that the agents' strategic tendencies become more pronounced, i.e., conformists (contrarians) aligning closer to (deviating further from) the shared public information as the average level of conformity in the population increases. Both a typical agent's and the group's consensus perform worse as the level of strategic diversity in the group rises. Consequently, strategic diversity in crowd forecasting does not yield the same benefits as the information diversity. Nevertheless, in the presence of strategic diversity, a mild contrarian crowd induces the best performance for both typical agents and the group consensus. We illustrate the distinct implication of strategic diversity on aggregating agents' predictions by studying a new weighted-by-deviation scheme that assigns greater weight to contrarian viewpoints to preserve more independent private information. We show that, under mild conditions and with a large crowd, the accuracy of the aggregation is improved and demonstrate its effectiveness with a finite crowd by a simulation study.

Dynamic Operational Planning in Warfare: A Stochastic Game Approach to Military Campaigns

Submission ID-136

Joseph McCarthy , Mathieu Dahan , Chelsea White

Georgia Institute of Technology

We study a two-player discounted zero-sum stochastic game model for operational planning in military campaigns. At each stage, the players manage multiple commanders who order military actions on objectives that have an open line of control. When a battle occurs to determine control of an objective, its stochastic outcome depends on the actions and the enabling support provided by the control of other objectives. Each player aims to maximize the cumulative number of objectives they control, weighted by their criticality. To solve this large-scale stochastic game, we derive properties of its Markov perfect equilibria, significantly reduce state and action spaces, and accelerate Shapley's value iteration algorithm by eliminating dominated actions. We demonstrate the computational value of our equilibrium results on a case study that reflects representative operational-level military campaigns with geopolitical implications. Our analysis reveals a complex interplay between the game's parameters and dynamics in equilibrium, resulting in new military insights for strategic leadership.

Fri.2.B: Judgment and Dec. Making III

Session Chair: Zeev Shtudiner

Robin Dillon-Merrill [1], Richard John [2], Nicholas Scurich [3]

[1] *Georgetown University*
[2] *University of Southern California*
[3] *University of California, Irvine*

Normalcy bias occurs when individuals underestimate or ignore the possibility that a disaster or crisis is occurring, even when warnings or evidence suggests otherwise. People may downplay the significance of a threat and assume that things will continue to function as they always have (normally). Fundamentally people fail to recognize the current risks and warnings. Many cognitive factors may contribute to this including an optimism bias, normalization of deviance, a near-miss bias, habituation, or the cry wolf effect. Motivational factors would could include motivated reasoning to avoid the inconvenience or discomfort associated with making significant changes or social proof if others around them behave as if everything is normal. This presentation will explore the normalcy bias and its many causes in the context of the challenges faced by decision makers in the US Coast Guard.

Beliefs About Quality Under Impending Regime Shifts.

Submission ID-092

Sreyaa Guha [1], Matthias Seifert [2], Canan Ulu [3]

[1] *Nova School of Business and Economics*
[2] *IE Business School*
[3] *McDonough School of Business*

Previous research has shown that individuals exhibit optimism or pessimism when predicting price movements of financial assets, depending on whether the asset is owned by the decision-maker. In fact, asset ownership is likely to influence the formation of probabilistic beliefs when observing distorted signals regarding the underlying quality of the asset. We study the role of ownership in belief updating under impending regime shifts which are characterized by the stability of the decision-making environment and signal precision. Using a sequential task design, we elicit beliefs in response to observing price movements, when the underlying quality of the (owned/non-owned) asset can change with the shift in the regime. We show that ownership generally reinforces beliefs regarding asset quality when signals are generated in stable environments with noisy signals. However, in unstable environments with precise signals, perceptions between owned and non-owned assets are indistinguishable. An analysis of the belief errors reveals that individuals overextrapolate in their predictions for owned assets in stable environments with noisy signals, and overextrapolate for non-owned assets in unstable environments with precise signals. We show that this behavioral pattern can be explained as a combination of the system neglect hypothesis and ownership-driven attention.

From Point Predictions to Probabilistic Aggregate: A Novel Variational Bayes Approach to Harnessing the Wisdom of the Crowd

Submission ID-066

Yanwei Jia [1], Jussi Keppo [2], Ville Satopaa [3]

[1] *The Chinese University of Hong Kong*
[2] *National University of Singapore*

finds that using peer predictions, i.e., predictions about others' judgments, can greatly enhance the accuracy of aggregated judgment. However, the methods proposed so far either request individuals provide probabilistic predictions or are restricted to output only an aggregated single-point prediction. The former is difficult to elicit, and the latter is insufficient to inform the decision-making. Using variational Bayes inference techniques, we propose an aggregation method that takes the individual judgments and their peer predictions, both single-point values, as inputs to construct a probability distribution that can be expressed analytically. Under the Normal-Gamma information structure, we prove the efficiency of the proposed method. Using simulated data and experimental data collected in previous studies, we demonstrate the proposed method outperforms conventional practices and achieves comparable accuracy to state-of-the-art methods in single-point prediction.

Exploring Ethnicity and Gender Discrimination in Judging Resume Fraud and Counterproductive Workplace Behavior

Submission ID-147

Zeev Shtudiner [1], Arthur Fishman [2]

[1] *Ariel University, Department of Economics and Business Administration*
[2] *Bar-Ilan University, Department of Economics*

The impact of ethnicity and gender on employment and income disparities in the labor market has been extensively studied, revealing patterns of discrimination. We focus on these specific attributes as potential influencers of perceptions regarding resume fraud and counterproductive behavior in the workplace. In our research, 1,002 participants reviewed CVs of prospective job candidates and were subsequently informed about various instances of resume fraud and counterproductive behavior exhibited by the candidates. The names of the candidates were selected to reflect distinct ethnic origins and genders. Our findings indicate the presence of ethnic discrimination. Specifically, individuals within each ethnic group tended to evaluate candidates from their own group with less severity compared to candidates from the opposite group. We did not uncover any indications of gender bias; both male and female candidates were assessed in a similar manner. Our findings uncover ethnicity-based discrimination in the evaluation of negative behavior within the workplace.

Fri.2.D: Applications in Military and Security

Session Chair: Laura Albert

Strategic Management of Data Access

Submission ID-116

Marat Salikhov [1, 2], Ruslan Momot [3], Oleh Stupak [4], George Charlson [5]

[1] *New Economic School, Moscow, Russia*
[2] *Moscow School of Management SKOLKOVO, Moscow, Russia*
[3] *Ross School of Business, University of Michigan, United States*

A standard data access guideline is to limit employee access to only the essential data for their roles, raising the question of how to define these roles and their corresponding data needs. We aim to address this question by considering a game-theoretic model of joint cybersecurity and operational decision-making. The firm chooses the level of data access for its employees and the level of overall protection they enjoy. Providing more data access to employees makes the firm more economically efficient but also more vulnerable to attacks by an adversary who steals the data that employees possess, inflicting damage that increases with the amount of data stolen. Adversaries may vary in their attack strength and sophistication rate (the ability to pinpoint the most lucrative targets). We find that in our model, the firm may counter-intuitively decrease its overall protection level when adversarial attacks become stronger and increase its overall access level when the adversaries become more sophisticated.

Decision Analytics: Using Decision Analysis in Analytics Projects

Submission ID-052

Gregory Parnell [1], Eric Specking [1], Randy Buchanan [2]

[1] *University of Arkansas*

[2] *U.S. Army Engineer Research and Development Center*

Abstract

Analytics/Data Analytics/Data Science is a growing field that uses recent and real-time data, statistics, and AI/machine learning to find meaningful patterns and information to make data driven decisions to meet organizational objectives. Analytics involves sifting through large data sets to discover, interpret, and share new insights and knowledge. Analytics uses descriptive, predictive, and prescriptive methods. Our research uses data analytics to provide data driven insights to Army installation management decisions in three areas: severe weather alerts, avoiding heat related injuries in training, and evaluating the financial return on investment of installation resilience options to reduce the impact of severe weather influenced by climate change. Our research team involves the U.S. Army's Engineer Research and Development Center project managers and researchers, Army installation managers, contractors, and university researchers. We describe the decision analysis techniques we have used to structure decision analytics problems, identify the data sources, identify system design objectives, capture the system requirements, develop prescriptive models, evaluate the system solutions, verify the system solutions, and validate the solutions.

Protection Decisions for Node-to-Route Relationships in Multi-layer Networks

Submission ID-133

Nazanin Tajik [1], Kash Barker [2], Andres Gonzalez [2], Sridhar Radhakrishnan [2]

[1] *Mississippi State University*

[2] *University of Oklahoma*

Interdependent relationships can exist across multiple layers of a multi-layer network. For example, the failure of a node in one layer can disrupt one or more nodes and links in an interdependent layer. In particular, we formulate an optimization model to explore protection-interdiction problems across layers when the interdiction of a node in one layer impacts a route in another layer. We illustrate this problem with an example of interdependent information and physical network layers, where the diffusion of disinformation infects and disrupts a node in the information layer, and this results in the disruption of a

Voting by mail: on managing the security risks of election systems

Submission ID-154

Carmen Haseltine , Laura Albert

University of Wisconsin-Madison

The scrutiny surrounding vote-by-mail (VBM) has increased in recent years in the United States, raising concerns regarding the integrity and security of absentee voting. We address these issues by introducing a dynamic modeling framework for performing a risk assessment of VBM processes. We introduce a discrete-time Markov chain (DTMC) to model the VBM process and assess election performance and risk with a novel layered network approach that considers the interplay between VBM processes, threats (both malicious and non-malicious), and security mitigations. Unlike previous research efforts that are static, the proposed framework captures dynamic risks and performance over time. The DTMC model is evaluated by a case study based on real-world data from Milwaukee County, Wisconsin. The analysis provides critical insights and a quantitative foundation for developing robust security strategies to ensure secure and reliable elections.

Fri.2.E: AI and Inference

Session Chair: Jussi Leppinen

Risk, Uncertainty and AI: Non-probabilistic Methods for Anticipating and Preventing AI Risks

Submission ID-098

Alexander Gutfraind [2], Vicki Bier [1]

[1] *University of Wisconsin-Madison*
[2] *Loyola University Chicago*

The rapid advancement of artificial intelligence (AI) created a situation where risks may be difficult to foresee. Some researchers have begun applying probabilistic methods to AI risks, but this seems unlikely to be useful for AI safety in practical applications.

We argue that many AI problems could be addressed using a toolkit of non-probabilistic risk-management methods (drawn from fields such as safety engineering, product management, and medicine). Methods for anticipating AI risks range from fault trees and event trees, to hazard and operability studies or failure mode and effects analysis, to scenario analysis and robustness analysis. Simpler but potentially effective solutions include checklists, what-if thinking, and pre-deployment testing, some of which are well-suited for use by non-expert users.

With regard to mitigating AI risks, we distinguish between strategies for safe design and strategies that enable rapid reaction to undesired behaviors. The former include fail-safe design, prototype-driven development, and staggered rollout. Reactive solutions include contingency planning, monitoring and anomaly detection, and dedicated response units. Such strategies can be used in parallel, creating “defense in depth” that can reduce the risk of undesired behaviors. Such non-probabilistic methods should make it possible to develop safer AI applications while allowing the field to advance.

Submission ID-035

Ya-Lun Lee [1], Hung-Jui Wang [2], Ruby Lin [2], Ling-Jing Kao [1], Chih-Chou Chiu [1]

[1] *National Taipei University of Technology*
[2] *Digital Transformation Research Institute, Institute for Information Industry*

In the retail industry, understanding consumer shopping behavior is pivotal for retailers aiming to predict shopping locations accurately, thereby improving personalized services, optimizing marketing strategies, and fostering customer loyalty. While traditional statistical models like regression and time series analysis were prevalent, their limitations in capturing complex dependencies and nonlinear relationships prompted a shift to deep learning technology. Deep learning algorithms, renowned for their adaptability to nonlinear patterns, have gained traction across various fields to enhance prediction accuracy. This study addresses research gaps by focusing on electronic invoice data and integrating Markov chain methods with Long Short-Term Memory (LSTM), a deep learning algorithm tailored for time series data. The Markov chain model, relying on state transition probabilities, describes time series probability models and predicts a consumer's next shopping location likelihood. The integrated approach, evaluated using five machine learning methods, including CART, logistic regression, MARS, random forest, and gradient boosting, reveals that the Markov chain and LSTM model surpasses other methods in predicting consumer shopping locations. Crucial factors such as product quantity, prices, consumption time, and location highlight the need for businesses to adjust marketing strategies and product layout based on consumer geography and time factors for enhanced revenue and profitability.

Is there a hype bias? The perception of AI in demand planning

Submission ID-142

Anna Sroginis [1], Nikolaos Kourentzes [2], Tove Helldin [2]

[1] *Lancaster University, UK*
[2] *University of Skövde, Sweden*

Many of the forecasting methods available to companies have a proven track record of high accuracy. Nonetheless, they are frequently adjusted by human experts to incorporate additional information. This information is often unstructured and difficult to systematically add to statistical models. Although there are cases where they add value to predictions (for example, incorporating special events), on average adjustments, tend to harm accuracy. At the same time, we observe the rapid rise of artificial intelligence (AI) in predictive tasks, often touted as working out of the box, and being able to handle unstructured rich contextual information. AI methods are typically black box and mathematically intractable. Explainable AI (XAI) methodologies attempt to increase the transparency of the models, however, there is limited evidence of the success of XAI tools in business environments. We hypothesise that users can exhibit a “hype bias” where they will be less averse to AI implementations, compared to conventional modelling (primarily statistical) approaches, even though they are complex and opaque, due to hype. We investigate this hypothesis with a laboratory experiment by providing both statistical and AI forecasts with or without model details, exploring cognitive biases towards more complex methods simply due to their hyped performance.

A Stage-Gate Decision Process for Guiding the Development of AI Solutions for Preventive Maintenance

Submission ID-115

[2] *Aramix s.r.l.*

The development of Artificial Intelligence (AI) solutions for preventive maintenance is a risky and resource-demanding process, as there can be several candidate solutions whose performance in transforming data into useful prognostic information is uncertain. These uncertainties can be managed by structuring the development process into multiple stages in which these uncertainties are iteratively reduced before choosing and implementing the final solution.

We apply Robust Portfolio Modelling to screen increasingly specific candidate solutions through a structured stage-gate process that consists of four development stages and three decision gates. The development stages produce evidence on how the candidate solutions contribute to six development objectives represented by both financial and non-financial criteria. At the decision gates, decisions about the continuation/termination of candidate solutions are taken by identifying portfolios of candidate solutions that are non-dominated in view of time and budget constraints. Uncertainties are captured with incompletely specified criteria weights and scores for the candidate solutions.

We illustrate the process by considering the development of an AI solution for a train's toilet door system. The process brings consistency to the development process and helps mitigate the risk of not reaching the development objectives due to premature fixation on a single candidate solution.

Fri.3.B: Behavioural Economics

Session Chair: Jeeva Somasundaram

Altruism and the Endowment Effect

Submission ID-015

Matthew Nagler [1], Ben Ho [2]

[1] *The City College of New York*
[2] *Vassar College*

Using random assignment in an online laboratory setting to different orderings of a sequence of charitable donation solicitations and a tangible item auction, we conduct a preregistered study of whether altruistic behavior plays a causal role in eliminating the endowment effect. We use a social norming treatment to exogenously stimulate giving, observing the effects on the WTA-WTP disparity in the subsequent auction. We also toggle asking participants to describe vividly the experience of giving before participating in the auction and employ several construal level manipulation checks. A negative association, consistent with prior work, would provide a possible explanation for the survival of altruism in market contexts, while a causal link could also offer valuable insights for devising new policy solutions to address public goods problems.

Random Preference Model

Submission ID-023

[2] *Columbia University*
[3] *Poznan University of Technology*

Modeling preferences from observed choices is a pivotal theme in mainstream economics and decision theory with expansive applications in policymaking, marketing, and transportation. The standard approach in modeling preferences is to attach utility scores to choice options consistent with the order defined by the preferences. Nevertheless, the utility scores are merely artifacts or mediums to represent preferences, whereas preferences are the underlying construct generating choices. We aim to develop a framework faithful exactly to this view.
Our model takes preferences as the central primitive. Preferences generate choice data and are represented by analytically convenient mediums called utility functions. We argue that, contrary to our approach, defining preferences in terms of utilities and choices can pose severe challenges for nonparametrically inferring the underlying choice process. To address this shortcoming, we model preferences directly by a probability distribution over the set of strict linear orderings of alternatives instead of an underlying utility. We build on the theoretical ground of the random preference literature and use the distributionally robust nonparametric approach to minimize the specification and distributional assumptions required to derive robust conclusions. We address the computational challenges and demonstrate the applicability of our model through an empirical application to a conjoint setting.

Reminder policy effectiveness with heterogeneous agents and scarce resources: the case of mobile data.

Submission ID-076

Nicolò Bertani [1], Joren Gijsbrechts [2], Miguel Godinho de Matos [1], Laura Wagner [3]

[1] *Católica Lisbon*
[2] *ESADE*
[3] *IESE*

It is empirically well-established that individual behavior is reactive to reminders. However, interventions in reminder policy (whether and when to remind) have often been unsuccessful. We speculate this is because interventions fail to account for individual heterogeneity, ending up being detrimental to many, and for the interplay between the timing of the reminder and behavior. To confirm this, we study how mobile data consumption changes in reaction to a near-end reminder. We show that aggregate analysis not only does not reflect individual heterogeneity, but it is straight-up misleading because of Simpson's paradox. We build formal dynamic models that use limited attention and overconfidence to explain observed individual behavior, while reproducing the aggregate pattern. Every model implies a different optimal reminder policy. To assess the feasibility of a uniform policy, we explore the prevalence of each model in the population: we classify each individual by drawing testable implications and embedding them in a Bayesian mixture model. To understand the interplay of the timing of the reminder and behavior, we run a field experiment at a telecommunications company. We analyze whether the prevalence of the models changes with the timing of the reminder. For the company, reminder policy does not affect revenues.

Make it Stick: The Role of Alternative Activities in Reducing Habitual Smartphone Usage

Submission ID-089

Pham Quang DUC [1], Jeeva Somasundaram [2], Laura Zimmermann [3]

Monetary interventions have been utilized across a variety of domains to change consumers' habitual behavior. However, frequently the inculcated behavior change does not stick and the old habit recurs. We address this relapse problem across two longitudinal field studies (involving 153 subjects and 5,686 observations). Our research delves into the effectiveness of encouraging individuals to reduce undesired habitual behaviors, such as excessive social media or smartphone usage, using positive alternatives like learning a language or engaging in regular walks. Specifically, we study whether consumers who receive incentives for adopting both the beneficial activity (learning a new language or walking) and curbing the undesired habit demonstrate greater success in the post-treatment compared to those solely incentivized to reduce the undesired habit. We find that subjects who achieved both targets (instead of only one target) tended to have lower social media and smartphone usage during the post-treatment relative to their baseline. Our evidence shows that consumers who successfully engage in an alternative activity are less addicted to their smartphone and therefore tend to use it less during post-treatment.

Fri.3.D: Applications in Healthcare

Session Chair: Md Rifayat Islam

Push or Pull? Motivating investment for rare disease drugs

Submission ID-110

Chenxi Xu , David Ridley , Peng Sun

Duke University

Clinical trials for drug development is time consuming and costly. For rare diseases, the commercial market may not generate sufficient profit to attract pharmaceutical companies to develop drugs. In these cases, funding agencies may step in to help. However, asymmetric information is prevalent in this setting. In this paper, we study how to manage both adverse selection and moral hazard in order to motivate investments into rare disease drugs efficiently. For example, given different preferences between the funding agency and the firm, should the funding agency pay the firm up front, or after the clinical test? Our model reveals perhaps a counter-intuitive result that under certain conditions, it is optimal for the funding agency to provide financial support after the drug fails the clinical trial.

DIVERSIFIED LEARNING: BAYESIAN CONTROL WITH MULTIPLE BIASED INFORMATION SOURCES

Submission ID-010

Michael Kim [1], Xinyuan Zhang [1], Jussi Keppo [2]

[1] *University of British Columbia*
[2] *National University of Singapore*

We consider a decision-maker (DM) who can acquire signals from multiple biased information sources to learn about a hidden state prior to making an earning decision. Unbiased signals are also available, but the acquisition cost is high. The DM jointly optimizes his learning (acquisition) and earning decisions to

unconstrained) versions of these problems. In the budget case, we explicitly characterize the optimal acquisition policy, which always seeks to diversify over the biased sources to reduce the risk of being manipulated by misinformation. In the penalty case, we show that such diversification property still holds, but the optimal policy is implicitly characterized and problem-specific. Thus, we obtain the optimal solution for the estimation and testing problems, which motivate good approximations and heuristics for the general setting

Value-driven Welfare Analysis: a multidimensional dominance approach and application to comparisons of European populations

Submission ID-069

Nikolaos Argyris [1], Lars Peter Østerdal [2], M. Azhar Hussain [3, 4]

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[3] *University of Sharjah*
[4] *Roskilde University*

Recent decades have seen an increased acceptance globally that the measurement of social welfare must encompass more than material economic standards, and should include dimensions such as health, education, social relationships etc. At the heart of this problem is the question to compare population distributions over a multi-dimensional space. Here we introduce the theoretical framework for such multi-dimensional comparisons and apply this to a specific dataset. The basis of our framework is multivariate first- and second-order stochastic dominance. We introduce theoretical results that enable practical comparisons of multidimensional distributions using these concepts. Additionally, we consider how value judgements can be integrated in the evaluation framework to refine the determinable comparisons. We illustrate our approach with the results of an application to compare welfare across European countries.

Exploring XAI-driven Personalised Health Risk Communication and its Effect on Healthy Behaviour Intention

Submission ID-130

Md Rifayat Islam [1], K.Nadia Papamichail [1, 2], Marzena Nieroda [3], Kenneth Muir [4], Artitaya Lophatananon [4]

[1] *Alliance Manchester Business School, The University of Manchester*
[2] *The Alan Turing Institute*
[3] *UCL Global Business School for Health, University College London*
[4] *Division of Population Health, Health Services Research and Primary Care, School of Health Sciences, Faculty of Biology, Medicine and Health, The University of Manchester*

This work explores the communication of health risks in different settings (human vs AI vs human with AI) and its effect on healthy behaviour intentions. Indeed, consumers are reluctant to follow health advice from algorithms compared to human providers due to a lack of personalisation, transparency and understanding. A subdomain of AI, named as explainable artificial intelligence (XAI), integrates individual data (e.g., genetic information, medical record) to predict personalised future health risks and explain complex medical AI risk assessments for patients. Drawing on the theory of processing fluency, this study aims to test whether consumers are more fluent in processing health risks communicated through

risk communication. The current study will employ a mixed-method approach and conduct several experimental studies to empirically test these propositions. This work will provide insights for healthcare service providers and AI developers in medical settings.

Fri.3.E: Applications in Energy

Session Chair: Ulla Ahonen-Jonnarth

Unit Commitment without Commitment: A Dynamic Framework for Managing an Integrated Energy System Under Uncertainty

Submission ID-044

David Brown [2], James Smith [1]

[1] *Tuck School of Business, Dartmouth College*
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Though variability and uncertainty have always posed challenges for power systems, the increasing use of renewable energy sources has exacerbated these issues. At a vertically integrated utility, the system operator manages many generation units – renewable and otherwise – and storage units to ensure that the total energy production matches contemporaneous demand. Current industry practice at these utilities involves solving “unit commitment” and “economic dispatch” optimization problems to choose production plans: these models, while complex, do not explicitly incorporate uncertainty. In this paper, we develop a dynamic framework to help system operators manage production under uncertainty and illustrate it using data from the Duke Energy Carolinas and Progress systems. Our numerical experiments demonstrate that this dynamic approach is computationally feasible at an industrial scale and can improve on current practice. Specifically, our results suggest that this dynamic approach can reduce operational costs by about 2% on average in the present Duke Energy system and, in a “future” system with increased solar and storage capacity, can reduce operational costs by 4-5% on average. Perhaps more strikingly, this dynamic approach, on average, performs within 0.2-0.3% of production plans based on perfect foresight about future net demands.

Technocracy in transition: enhancing stakeholder inclusion in Denmark's energy planning

Submission ID-131

Antti Silvast [1], Per Dannemand Andersen [2]

[1] *LUT University*
[2] *Technical University of Denmark*

The objective of this paper is to examine citizen and stakeholder inclusion in long-term energy planning. It focuses on extended planning horizons up to 2050 in Denmark. Based on in-depth interviews with expert stakeholders and analysis of policy processes surrounding long-term energy decarbonization scenarios, it examines how diverse stakeholders are included in the development of the Danish Energy Agency's technology catalogues, which forecast detailed techno-economic data across various energy

stakeholders in long-term energy planning and what are the key limitations of these approaches?
2) What methodological strategies can be used to expand the definition and inclusion of stakeholders in long-term energy planning?
3) How can the impacts of citizen and stakeholder inclusion in long-term energy planning be assessed and improved?

The research generates new empirical and conceptual knowledge on the study of technocratic policymaking, the concept of a stakeholder, the configuration of new knowledge infrastructures and platforms that are scaled up to share forecasted energy data, and the inclusion of citizens in complex forecasting of sustainability transitions during several next decades.

A model for global cooperation on climate change: Dynamic Lindahl equilibrium under uncertainty

Submission ID-149

Markku Kallio [1], Iivo Vehviläinen [1], Hanna Virta [2]

[1] *Aalto University School of Business*
[2] *National Audit Office of Finland*

We study the value of a cooperative solution to the global climate externality problem in a world that is uncertain and dynamic. Our analysis incorporates negative emissions technologies that seem critical to resolve the crisis, especially if the climate future proves catastrophic. We generalize earlier theoretical results for Lindahl's equilibrium, and integrate with an up-to-date version of Nordhaus's pioneering RICE-model to quantify regional economic impacts. Low-income regions end up with the highest relative value of cooperation through three distinct channels: lower damages, equilibrium compensations, and burden sharing of abatement actions.

Condition-Based and Value-Difference Based Aggregation in Wind Power Permit Application Assessment

Submission ID-113

Ulla Ahonen-Jonnarth , Åsa Elmqvist , Magnus Hjelmblom

Department of Computer and Geospatial Sciences, Faculty of Engineering and Sustainable Development, University of Gävle, Sweden

Assessment of an application for wind power establishment is a multi-criteria decision problem including the core problem: whether to grant permission or not. In Sweden, County Administrative Boards decide the outcomes of these kinds of applications. Five permit officers were interviewed to investigate the difficulties they meet and the type of value aggregation(s) they use when assessing permit applications, and to test a seven-step model as a possible decision support tool. The commonly used type of aggregation was condition-based aggregation. Aggregation based on value differences was considered difficult to apply. Most of the respondents agreed that some of the aspects that speak against granting permission could be aggregated but that aggregation of all aspects would be hard due to differences between aspects. In addition, the value of the main aspect that speaks for permission, climate friendly energy supply, is very difficult to estimate. Thus, aggregation based on value differences was found to be difficult to apply in practical wind power permit application assessment. If policymakers wish to apply value-difference aggregation to make it possible to take both pros and cons into consideration and to discuss the trade-offs transparently, the seven-step model could be a way forward.

Thu.3.X: Poster Session

Support a Capital-Constrained Supplier with Purchase Order Financing and Refundable/Non-refundable Cash in Advances

Submission ID-007

Andy Wu

Department of Marketing, National Chung Hsing University

This study considers a supply chain in which a credit-worthy buyer purchases goods from a capital-constrained supplier to satisfy her deterministic demand. The buyer implements *cash in advance* (CIA) and *purchase order financing* (POF) simultaneously to fund the supplier's operation. This research contributes toward proposing guidelines for coordinating the two main pre-shipment financing plans with purchasing decisions, which will facilitate the buyer on supplier development. We reveal that whether or not a CIA agreement includes so-called refundability strongly affects buyer preferences for CIA and POF. Specifically, we summarize our findings as follows: (1) Pure CIA financing strategy is optimal when CIA is refundable, which implies refundable CIA dominates POF. (2) When CIA is non-refundable, POF is preferred over CIA because POF allows a buyer to share the financing risk with a bank, whereas non-refundable CIA involves high risk. (3) When CIA is non-refundable, we recommend the buyer implementing mixed financing strategy, with POF and CIA as primary and backup financing options, respectively.

Instantaneous and limiting behavior of an n-node blockchain with random resetting times under cyber attacks

Submission ID-008

Liang Hong , Xiufeng Xu

Department of Mathematical Sciences University of Texas at Dallas

We investigate the instantaneous and limiting behavior of an n-node blockchain which is under continuous monitoring of the IT department of a company but faces non-stop cyber attacks from a single hacker. The blockchain is functional as far as no data stored on it has been changed, deleted, or locked. Once the IT department detects the attack from the hacker, it will re-set the blockchain using a random amount of time, rendering all previous efforts of the hacker in vain. The hacker will not stop until the blockchain is dysfunctional. When the hacking times, resetting times, and detecting times all follow arbitrary distributions, we derive the limiting functional probability, instantaneous functional probability, and mean functional time of the blockchain. We also show that all these quantities are increasing functions of the number of nodes, substantiating the intuition that the more nodes a blockchain has, the harder it is for a hacker to succeed in a cyber attack.

Utilizing Deep Learning Models for Analyzing Consumer Store Preferences

[1] *National Taipei University of Technology*
[2] *Digital Transformation Research Institute, Institute for Information Industry*

Unlike mobile GPS and single-channel sales records, Taiwan's electronic invoices offer unique value by providing extensive cross-channel information, geographic details, and specific shopping item data. This study aims to leverage geographical information to understand consumer channel choice behavior, analyze channel competition, and assess whether integrating feature selection and geographic data can improve the predictive accuracy of deep learning models—specifically, recurrent neural networks (RNN), long short-term memory networks (LSTM), and gated recurrent units (GRU). The empirical findings demonstrate that incorporating geographic information into LSTM can enhance prediction accuracy. This research promises nuanced insights into cross-channel consumer behavior, facilitating data-driven decisions in marketing technology (MarTech) for enterprises and fostering the creation of more personalized consumer experiences.

OPTIMIZING HEALTHCARE BUSINESS PROCESSES WITH PROCESS MINING SOFTWARE: A COMPARATIVE AHP-GRA-TOPSIS ANALYSIS

Submission ID-054

Michael Maiko Matonya [1], László Pusztai [2], István Budai [2]

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This study addresses the challenge of selecting process-mining software for healthcare business processes, employing the Analytic Hierarchy Process (AHP) and Grey Relational Analysis with Technique for Order of Preference by Similarity to the Ideal Solution (GRA-TOPSIS) for decision-making enhancement. Criteria like functionality, user-friendliness, technical support, cost, scalability, and security are evaluated, emphasizing the reduction of cycle time, waiting time, and operational costs for patients and hospitals.

In the AHP analysis, Disco is prioritized at 12.9%, followed by ProM and Celonis at 11.6% each, indicating Disco as the top choice. GRA-TOPSIS ranks ProM and Celonis as the closest alternatives to the ideal solution, with ProM leading. Combining AHP and GRA-TOPSIS yields consolidated scores, ranking ProM as the top choice (8.03), followed by Celonis (5.51) and Aprome (5.45). Sensitivity analysis highlights the disco/celonis ratio as the most critical variable (72.5%).

Integrating AHP and GRA-TOPSIS offers a robust healthcare software selection framework, with ProM, Celonis, and Aprome prioritized by AHP, and ProM leading according to GRA-TOPSIS. Combining both methods refines rankings for informed decisions. Future research should explore real-world applicability and dynamic adaptation in evolving healthcare contexts.

Comparative approaches for economic modeling in healthcare markets , relevance of random price generators

Submission ID-061

Christine Huttin

Aix Marseille university and Endepusresearch

logit models, cumulative logit models, latent model of choices , shrinkable estimators with Hierarchical Bayesian approach, multinomial logit choice models with random price generators; an application of the BLP model on genomic medicine is also presented.
RESULTS: random generators are useful but do not fit any kind of structural conditions to adjust supply and demand of health care markets, especially in more regulated health and economic systems. An approach by sets of alternatives for choice models allows to adjust for heterogeneity of demand but lack of price data in some markets makes it useful to rely on shrinkable estimators with HB approaches. In duopoly cases, the BLP model may help investigation of antitrust policies.
CONCLUSIONS: complexity of health care markets lead to consider various combinations of models and even participatory modeling to reach growing consensus between decision makers on the payer side and economic actors, with more use of data driven models for drug and vaccines.

Context-based Complex System Risk Identification and Inspection Decision Auto-generation

Submission ID-062

Nan Li , Chen Wang

Tsinghua University

Complex machinery in production and service systems is valuable and has a long-life cycle. The strict risk requirements and complex maintenance procedures impose high costs due to labor, material, and idle time. Most of them are equipped with intensive sensors for condition-based maintenance (CBM). Most CBM strategies are based on thresholds that neglect the dynamic context. Deep learning methods achieve high prediction accuracy while the application is not credible because of the black-box property. We propose a flexible data-driven CBM framework that can infer the hidden machine conditions under dynamic contexts and provide sensor baselines. This framework integrates sensor data and domain knowledge, such as the principles of machine mechanisms, into the Conditional Variational Autoencoder (CVAE). CVAE can learn a probabilistic latent space indicating the machine's health. To enhance the usability of learning results, we propose the concept of fault influence to capture the interaction of physical structures. We improve the multi-type anomaly recognition capability by incorporating a Gaussian mixture model. We prove that the loss function can distinguish between different anomalies. Furthermore, it outputs the probability of each fault type and a joint probability about the health condition of multiple components which helps the maintenance decision making.

Selective Bayesian Expert Debiasing Model: Application with Portfolio Decisions guided by Regularized Expert Predictions

Submission ID-081

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Expert predictions are one source of information for educated decision-making. Many models for the mathematical aggregation of expert predictions assume unbiased predictions, but in reality, human predictions tend to include biases, and experts' competence may vary. We propose a Bayesian aggregation model that consists of a regularization process to eliminate the influence of experts who have not yet shown competence. The model also includes a debiasing process for systematic biases and considers correlations between experts.

We applied the proposed model to a stock portfolio decision problem with real experts' return predictions in different industries. We assumed that the decision-maker allocates capital between the industry index

capital growth was only slightly higher, but the difference increased when applied only to industries estimated to have multiple competent experts.

Geo-agnostic, Open-sourced data pipeline to study spatiotemporal effects of climate variables on operational generation of renewable plants

Submission ID-090

Vijay Chiluveru , Renee Obringer

Energy and Mineral Engineering, Pennsylvania State University

Renewable energy systems have the best potential to reconcile our collective energy needs with worsening climate change. The key piece of understanding is that these systems are very much dependent on suitable ambient surroundings. Although much of the work has been by looking from either a supply-demand or a systems-modeling lens, there is a rising trend of using a climate data-driven decision making approach. The aim here is to build sound empirical models of renewable systems. For this, we need robust datasets that are large, multidimensional and standardized enough to give the trained models significant predictive power. We propose an open-source and geo-agnostic data access framework that is built using the USA's Energy Information Agency (EIA) power plant portfolio combined with North American Regional Reanalysis (NARR) climate variables. Currently, the dataset is pan USA with a size of 306,576 rows X 30 climate features and work is in progress to extend the same framework to include Germany too. This rich data is already used in developing tree-based regression models (R2 = 0.94) capturing non-linear influence of hyperlocal climate on renewable plant generation. The proposed pipeline is modular, scalable and transparent to encourage active collaboration.

Automated Design of Indoor Positioning Systems using Floor Plan Images

Submission ID-112

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Designing base station locations for indoor positioning systems (IPSs) based on customer floor plans is a time-consuming task reliant on human expertise. This paper addresses this issue by introducing a data analysis pipeline for the automated deployment of base stations on floor plans. The proposed methodology involves processing the initial customer floor plan image through a Convolutional Neural Network (CNN)-based algorithm, specifically *CubiCasa5k*. The algorithm's output is transformed into a binary image, and the number of required stations is estimated using techniques of rectangular area detection.

Preliminary results are presented and compared with manually crafted expert plans. The findings demonstrate promising accuracy suggesting that a notable reduction in both time and costs associated with IPS design could be achieved. Particularly, this is the case when dealing with complex floorplans with numerous small rooms such as healthcare facilities and nursing homes.

Jonathan Roberts , Lily Popova Zhuhadar

Western Kentucky University

In the age of uncertainty, the intersection of human cognition and the rapidly advancing realm of Artificial Intelligence (AI) presents novel opportunities and challenges in organizational decision-making. As the principles of bounded rationality elucidate constraints related to cognition, time, and information during decision processes, contemporary developments in AI are paving the way to attenuate these very constraints.

Particularly, Automated Machine Learning (AutoML) heralds a transformative shift in healthcare, emphasizing its application in the diagnosis of chronic diseases such as diabetes. By adeptly combining human expertise with AI capabilities, AutoML's approach in predictive modeling not only underscores the significance of key variables but also prioritizes efficiency and sustainability. Such AI-augmented processes promise a reduction in decision-making times, and potentially transcend human cognitive limits, particularly in data-intensive fields.

However, the core question remains: **In this AI era, does bounded rationality become a historical relic or continue to play a pivotal role in behavioral approaches to organizational dynamics and human judgment?**

The overarching aim of this research is to architect a model that melds the precision of AI with the depth of human insight, ultimately enhancing both efficiency and sustainability in organizational decision-making processes.

Optimal Decision Strategies for Bioenergy: Circular Economy-Driven Supply Chain Design for Agricultural Waste

Submission ID-150

Maryam Roudneshin , Amanda Sosa

University College Dublin

In alignment with the United Nations' Sustainable Development Goals, particularly the objective to secure clean, affordable, and sustainable energy" for all, this study embarks on a crucial exploration of alternative energy solutions amidst the global push for energy diversification and climate change mitigation. The utilization of agricultural waste as a bioenergy source stands out as a strategic opportunity to enhance environmental sustainability and foster renewable energy production within the framework of a circular bioeconomy. The core of this initiative's success hinges on informed decision-making in designing supply chains that are robust, efficient, and sustainable. This research introduces an innovative decision-making framework aimed at optimizing the supply chain network for agricultural waste-to-bioenergy conversion, with a particular focus on the decision analysis for selecting biorefinery locations. Employing an integrated approach that combines Geographic Information System (GIS) with Multi-Criteria Decision Making (MCDM), the study delineates optimal sites for biorefineries. This decision-making process meticulously considers both economic and environmental factors to propose a model that aligns with the principles of sustainability. Through this approach, the study seeks to influence stakeholders and investors by demonstrating the feasibility and attractiveness of bioenergy projects.

Forecasting the success of International Joint Ventures

Submission ID-151

[2] *emlyon*

A joint venture is a business partnership where two or more companies work together on a specific project, sharing resources and risks. Each company keeps its own identity while collaborating to achieve a common goal. Partner selection can be defined as the process of seeking, evaluating, and finally choosing the right partner to achieve the firm's strategic growth objectives in a specific host country. Country Governance is defined as the traditions and institutions by which authority in a country is exercised. There are six dimensions of governance are constructed based on this definition; Voice and Accountability (VA), Political Stability (PV), Government Effectiveness (GE), Regulatory Quality (RQ), Rule of Law (RL) and Control of Corruption (CC).
In an increasingly globalized world, firms aiming to stay competitive in international business must explore foreign markets and many multinational enterprises (MNEs) from developed countries use Ventures (IJVs) with local partners rather than wholly-owned subsidiaries (WOSs) to enhance the success of their international endeavours and reduce the risk of failure. This study focuses on analysing how weak country governance influences the criteria MNEs use to select local partners and develops a forecasting model for Forecasting the success of International Joint Ventures.

R&D innovation and decision-making strategy to advance science and technology

Submission ID-152

Donghun Yoon

Kyonggi University

In this study, we analyze decision-making strategies to advance science and technology and discuss the direction of R&D innovation. We present a science and technology roadmap, the optimization of R&D portfolio, and securing the financial soundness of R&D as decision-making strategies. We discuss the contribution of three decision-making strategies to advance science and technology. It is very important to establish an optimal decision-making strategy for R&D innovation. R&D innovation play an important role in the economic growth, strengthening the global competitiveness, and the technology innovation. In this study, we present and discuss optimal decision-making strategies for R&D innovation and advance in science and technology.

Developing a Resilient Humanitarian Supply Chain Framework for Managing Pandemics, with an Emphasis on Supporting the Elderly Community

Submission ID-153

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As a detrimental phenomenon, the pandemic can significantly impact supply chains, particularly the supply of medical relief. Additionally, the recent pandemic severely affected the elderly population. To mitigate these disruptions, this study proposes a multi-objective mathematical model for a humanitarian supply chain network focusing on the elderly population. The model not only manages the direct flow of relief supplies and the reverse flow of waste but also aligns with sustainable development goals. To deal with the computational complexity of the model, metaheuristic optimizers are used to obtain effective