

EWGCFM & MMEI 2024

Book of abstracts

**EURO Working Group for Commodities and Financial Modelling
Mathematical Methods in Economy and Industry**

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Monday

Invited Lecture

S4, 9:30 – 10:10

The Untold Truth Behind Mergers and Acquisitions

Amadeo Gaggion

CFO & Regional Treasury Head at Scotiabank

This presentation unveils the overlooked yet critical facets of M&A that extend beyond mere financial metrics and numerical analysis. Despite the common focus on financials, key elements such as cultural integration, deep market understanding, lessons from past M&A experiences, the impacts of previous mergers on client relations, regulatory constraints, and the profiles of senior management often elude scrutiny but are crucial for the success of mergers. This lecture aims to shift the conventional narrative by integrating these overlooked aspects with the standard financial evaluations, providing a holistic view of M&A dynamics. Finance academics and practitioners will gain insights into a more comprehensive approach to M&A, balancing quantitative analysis with qualitative factors crucial for informed decision-making and strategic success.

Advances in Variational Analysis

S4, 10:25 – 11:45

On a globally convergent SCD semismooth* Newton method in composite convex optimization

Helmut Gfrerer

RICAM Linz

co-author(s): Jiri Outrata

Very recently, a semismooth* Newton method based on SC (subspace containing) derivatives for solving variational inequalities of the second kind has been introduced. In this talk we describe how this approach can be used to efficiently solve nonsmooth composite convex optimization problems.

On the implicit programming approach in a class of mathematical programs with equilibrium constraints

Jiri Outrata

UTIA AV CR

co-author(s): Helmut Gfrerer

We consider a class of mathematical programs with equilibrium constraints (MPECs) which can be converted to minimization of a Lipschitzian objective in the upper-level variable only. It is assumed that the equilibria are governed by generalized equations (GEs), whose solution maps are single-valued and locally Lipschitz and the resulting nonsmooth programs are solved via a bundle method. Since the relevant rules of the generalized differential calculus hold merely as inclusions, we are generally not able to supply the used bundle method with correct subgradients, which makes the application of this, so-called ImP approach, questionable. It turns out, however, that on the basis of some generalizations of the classical semismoothness property one can: (i) suggest a procedure in which the (Clarke) subdifferentials are replaced by some larger sets of the so-called pseudosubgradients. The used bundle method converges then to points satisfying a slightly weaker stationarity condition. (ii) interpret this condition in terms of the C (Clarke) stationarity condition of an equivalent MPEC. (iii) propose a numerically efficient way of computing the pseudosubgradients provided the multi-valued part of the considered GE possesses the so-called SCD (subspace containing derivative) property. The approach is tested via an economic MPEC modelling an oligopolistic market, where one player decides to replace the Cournot-Nash strategy by the Stackelberg one and possible strategy changes of some players are associated with certain costs of change.

Macro and Regulation

S8, 10:25 – 11:45

Stabilizing financial networks via mergers and acquisitions

Markku Kallio

Aalto University School of Business

co-author(s): Aein Khabazian

A bi-level model is proposed to explore efficient policies for supporting negotiations on financial crisis resolution. In a principal-agent framework, this model minimizes a welfare loss function of a central authority (social planner, SP) by simultaneous choice of subsidy levels and potential pairs of banks to merge. The SP's choice of mergers needs to be incentive compatible with autonomous choices of banks and the evaluation of the financial network must obey standard accounting principles. Incentive compatibility is enforced by two options of conditions based on stable matching or competitive bidding. For the evaluation of the financial network, we employ an extended Eisenberg-Noe clearing payment equilibrium by considering bankruptcy costs and seniority levels of liabilities. Additionally, liabilities are not cleared among solvent banks and corporate bonds may be used for clearing payments. The bi-level model states conditions for clearing equilibrium. For demonstration we use major European banks and a scenario which is linked to the adverse economic scenario used in 2016 EU-wide stress testing.

Child - related pension benefits: The case of Slovakia

Igor Melicherčík

Comenius university, Bratislava

co-author(s): Tatiana Jašurková

Population aging and low birth rates are linked to the problem of unsustainability of ongoing pension systems. As demographic predictions follow unfavorable developments, adjusting such pension systems is inevitable. The contribution discusses introducing child-related benefits into pension system models and their advantages and disadvantages. The model with child-related pension benefits dependent on the average wage is examined concerning the effects of the child factor on individual fertility. We estimate the size of the child factor in the current setting of Slovakia's pension system. Finally, the optimal setting of the above pension system model is presented and compared with the presented alternatives. We show that the current setting of the pension system can be brought closer to the optimum by, for example, more generous awarding of personal wage points for raising children.

DSGE Modeling with Python

James Otterson

IMF

co-author(s): Kadir Tanyeri, Alexei Goumilevski, Aquiles Farias

We have developed a flexible, powerful, and user-friendly platform for macroeconomic modeling in Python, including tools for filtering, simulation, estimation, forecasting and model diagnostics for Dynamic Stochastic General Equilibrium (DSGE) models. This platform can be applied for analysis of New Keynesian models, Real Business Cycle models, Gap models, and Overlapping Generations models, to name a few. It applies robust and efficient solution techniques to solve linear and nonlinear perfect foresight models which rely on rational expectations hypothesis. A novel feature of this software is an application of dynamic parameters to analyze models with structural changes which is crucial for policy analysis. For demonstration purposes we apply this Platform to study macroeconomic effects of COVID-19 pandemic on country economy. Our analysis utilizes Eichenbaum-Rebelo-Trabandt and Gali-Smets-Wouters models. ERT model is a non-linear model. It integrates the Neoclassical and the New Keynesian approaches with the theory of infectious diseases. GSW model is a linear model. It incorporates unemployment theory developed by Gali into the new Keynesian model framework of Smets and Wouters. The detrimental effects of epidemic on economy are modeled by an adverse shock to labor supply. This software can help economist to develop and analyze macroeconomic impact of pandemic. We analyze economic impact of COVID-19 for different scenarios. These simulations produce scenarios forecasts, which can inform policy discussions in the context of surveillance and program review work.

Have Asian Central Banks' efforts at transparency fallen short?

Anoop Rai

Hofstra University

co-author(s): Rama Seth

Central banks set monetary policy rates, usually short-term, at the end of each monetary policy meeting and inform the public of the reasons for the changes or lack thereof. Their decisions provide information on their choice of a contractionary or expansionary policy and, thereby, the economy's future course. Investors and analysts worldwide follow these announcements closely to plan future asset allocations. Forecasting central bank actions accurately can benefit investors by rebalancing their portfolios defensively before the announcements. Most central bank announcements follow regularly scheduled meetings and sometimes unscheduled ones. These announcements are major news events and receive significant news coverage. In the past, central bank deliberations were conducted in secrecy. Beginning in the 1990s, central banks worldwide started to emphasize and codify transparency to reduce uncertainty and provide clarity to monetary policy changes and codify transparency. The IMF proposed a new Central Bank Transparency Code in 2019 to facilitate greater transparency of central banks on several dimensions, including policies (IMF, 2020). Several studies have documented the transparency efforts, but few have examined the effectiveness of these efforts. Dincer & Eichengreen (2009) examined the central banks of 100 nations from 1998 to 2006 and found that only 90 increased transparency, with the most dramatic change in the central bank operations. In an updated study covering 112 central banks from 1998 to 2019, the authors found a broad rise in transparency, regardless of the level of economic development and monetary policy framework. Developing countries that joined the bandwagon to establish a modern monetary policy framework, including adopting inflation targeting and having independent and transparent central banks, have found it more important for monetary transmission than financial development (e.g., Brandao-Marques et al., 2020). Sun and Liu (2016) find that central bank communication acts on the market through expectation guidance and has more significant effects on stock prices in the long run than monetary policy actions. The lesson is powerful: central bank communication is a very effective tool for central bank policymaking. We propose to use the central bank monetary policy rate announcements for five of the largest Asian countries, China, Japan, India, South Korea, and Indonesia, to assess the effectiveness of their efforts to improve transparency. Filardo and Guinigundo (2008) report survey results on transparency and communication practices among Asian central banks. They find a 'greater conscious effort within the policymaking circle to clearly communicate policy-relevant information to financial markets, the media and the public at large.' However, we have not found any paper that analyses the effectiveness of these efforts. Increased transparency, if effective, should result in less market disruption and greater predictability for businesses and households. This paper proposes a methodology to examine whether a central bank's transparency efforts are successful. Effective communication should increase the predictability of monetary policy and strengthen the transmission mechanism. This means that markets can better anticipate the central bank's actions, reducing uncertainty and potentially leading to more stable interest rates. We will gauge the efficacy of a central bank's transparency efforts in three ways. First, we will examine whether monetary policy forecasters can anticipate monetary policy changes accurately over time. Second, we will discuss the market responses to monetary policy changes before the announcements to determine if all information is fully reflected in the interest rates. If the announcements succeed in removing uncertainty, market interest rate changes should be negligible after the announcements. Third, we propose to examine the informational content of the Central Banks' announcements. Recent academic literature has decomposed the information content

of central bank announcements into two types of news: monetary policy news and macroeconomic news (Jarociński & Karadi, 2018). Monetary policy news reveals the central bank's choice of action to manage new macroeconomic information. Embedded in the announcements is information on the future state of the economy based on the central bank's superior harnessing ability to gather data on global and domestic macroeconomic conditions. We will examine the market responses to the release of several macroeconomic variables in each country before and after central bank announcements to determine whether new information is revealed in the announcements. If central bank transparency efforts are successful, the macroeconomic news released during the announcement should also be minimal. Using event study methodology to capture market responses before and after the announcements and a combination of univariate and multivariate tests, we develop and test three hypotheses: Hypothesis 1: As Asian central banks implemented a policy of increased transparency, the accuracy of forecasts by market analysts increased over time.

Hypothesis 2: In these countries, investors anticipate monetary policy actions and appropriately adjust interest rates before monetary policy announcements.

Hypothesis 3: Investors adjust or reverse interest rates after the monetary policy announcement if they receive new macroeconomic information from the release of MPR announcements. We will construct a data set for our analysis by collecting and then splicing together data from multiple sources. We will manually collect forecasts from Bloomberg by economists of major financial institutions and think tanks in the selected Asian countries. Data for the monetary policy rates and all the macroeconomic variables for the countries will be obtained from national bank websites, except the stock market indices taken from Yahoo Finance. Our results will indicate whether transparency efforts have improved the predictability of monetary policy announcements and the transmission mechanism over the years. We will also look for evidence that transparency efforts have reduced investor uncertainty and whether there have been improvements over time, as markets may take some time to develop the skills to interpret central bank communications. Putting the results of the tests together, we can conclude whether central bank transparency efforts have been as effective as planned or whether more must be done to reduce uncertainty in the market.

Financial Markets

S10, 10:25 – 11:45

Differential Effects of Investor Sentiment on Large and Small Companies: Insights from the Russell 1000 and Russell 2000

Bahate Maidiya

VSB - Technical University of Ostrava

co-author(s): Aleš Kresta

This study investigates the influence of investor sentiment on stock market characteristics, utilizing daily data from 841 large-cap companies in the Russell 1000 Index and 1,235 small-cap companies in the Russell 2000 Index, covering the period from January 1, 2000, to December 31, 2023. We conduct a comparative analysis of returns, Fama-French five-factor model components, volatility, and trading volumes between large and small firms. The results indicate that sentiment exerts differential effects on large and small companies. While sentiment has limited explanatory power for returns and premiums, it significantly influences market factors (e.g., SMB, HML, CMA) in small firms. Meanwhile, sentiment has a higher negative impact on

volatility in small firms. Besides, the impact of sentiment on trading volume is more significant for big companies. These findings show that investor sentiment has varying effects on market behavior with respect to the size of the firm, bringing attention the significance of managing sentiment in investment strategies.

Short Selling and Audit Reporting Lags

Robinson Reyes Pena

Florida International University

co-author(s): Krishnan Dandapani, Suchismita Mishra, Kannan Raghunandan

We examine the relation between audit report lags and short selling activity. Our results show that the timing of audit reports decreases monotonically with the intensity of short selling around the end of the fiscal year. This association is significant after controlling for the conventional client and auditor characteristics in a multivariate framework including year fixed effects. These findings are indicative of management exerting pressure on audit firms to release their reports sooner, when firms are targeted by short sellers, as a means to curb price declines. A faster audit turnaround time amid increased short selling is also consistent with the previously documented positive relationship between short selling and audit fees.

Effect of Pre-IPO Litigation on the Choice of Issue Method and Underpricing

Edward Lawrence

Florida International University, Miami, USA

co-author(s): Supriya Katti and Mehul raithatha

We investigate the effect of pre-IPO litigation on firm's choice of opting book building or fixed pricing method for their IPO. We find the firms that face pre-IPO litigations have higher probability of choosing book building method irrespective of the type of litigation. Our results show that the IPOs of litigated firms issued through book building method are significantly more underpriced as compared to all other IPOs. Firms with pre-IPO litigations that opt book building method experience full subscription for their IPOs. These firms have significantly higher legal costs, and their market valuation remains static in the post IPO period.

Returns-to-scale in data envelopment analysis: slacks-based vs. path-based models

Mária Trnovská

Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava

co-author(s): Margaréta Halická

Data envelopment analysis (DEA) is a field in Operations Research that studies non-parametric methods for assessing the performance of decision-making units. Each DEA model is formulated as a mathematical programming problem. Based on the structure and objective of these problems, we can distinguish two main classes of DEA models: the slacks-based and the path-based. DEA models appear in two forms: the envelopment and the multiplier form, which are in a primal-dual relationship.

In this contribution, we introduce the general envelopment and multiplier form for both classes. We utilize Lagrangian duality theory to establish the relationship between the supporting hyperplanes of the technology set generated by the decision-making units and the optimal solutions of the multiplier model.

Returns-to-scale (RTS) measurement in DEA can serve as a tool in risk management, helping organizations assess and optimize the scale at which they operate their processes, and make informed decisions. Some of the RTS techniques are closely related to supporting hyperplanes of the technology set. We propose and compare RTS methods for both classes of models in a unified framework. We also discuss the main advantages and disadvantages of the proposed methods and demonstrate them with numerical examples.

Generalizing Nash equilibria for games with random payoffs

Lukáš Račko

Charles university, Department of Probability and Mathematical statistics

co-author(s): Miloš Kopa, Petr Lachout

The paper deals with non-cooperative games in which the payoff function of its players is influenced by exogenous randomness. The main goal is to provide a general concept of stability in those games because the standard notion of Nash equilibrium is no longer satisfactory. This is because the best response strategy must be the best response for each different payoff scenario and if the corresponding payoff matrices are too different this results in an empty set of best responses. Therefore, different solution concepts are required. One could find a deterministic equivalent to the game with a random payoff by considering a collection of risk measures and defining a new game with a payoff function adjusted by applying specific risk measures to each player's payoff. This, however, causes several problems as with the added payoff non-linearity in mixed strategies the Nash's Theorem no longer holds for most of such equivalents, and the existence of equilibria in those games must be proven on an ad hoc basis. With an increasing number of parameters such as player-specific risk measures, this problem becomes increasingly difficult. In our article, we propose to loosen the standard concept of the best response to an α -best response which requires the strategy to be the best response only with a certain high probability. Based on this idea we define the α -Nash equilibria and we prove that for every finite game with random payoff non-trivial α -Nash equilibria exist. Moreover, we show that those

equilibria characterize equilibria in a broad class of deterministic equivalent games. Finally, we extend the idea of a static game with a random payoff to a game with multiple stages and we show that every finite stochastic game may be represented as a sequential game with a random payoff. In the numerical study, this theory is applied to a management problem of competition of hospitals for vaccines during a pandemic.

Exploring the translog production function: theoretical insights and applications for generating artificial data

Bernadett Bertóková

Comenius University Bratislava, Faculty of Mathematics, Physics and Informatics, Department of Applied Mathematics and Statistics

co-author(s): Mária Trnovská, Zuzana Chladná

The translog (transcendental logarithmic) production function is a flexible functional form used in economics to model various production processes. It allows for variable elasticity of substitution of inputs and variable returns to scale, often providing better empirical accuracy than the commonly used Cobb-Douglas production function. In this contribution, we examine the properties of the translog production function and utilize it to design a procedure for generating artificial production data. Such data can be beneficial in risk management for simulating different economic scenarios. It can also be used in Data envelopment analysis (DEA) for measuring the accuracy of DEA models, and for numerical analysis of algorithms for large-scale DEA.

Higher Order Stochastic Dominance: Advancements and Numerical Exposition

Rajmadan Lakshmanan

Technical University of Chemnitz

co-author(s): Alois Pichler

This contribution extends our previous work on optimization problems with stochastic dominance constraints by integrating both theoretical advancements and extensive numerical results. Building on the relaxation of traditional constraints, we provide a comprehensive analysis that demonstrates the robustness and versatility of our approach. Through rigorous theoretical exploration and detailed computational experiments, we show how these methods can be effectively applied across various domains. In particular, we offer a comparative analysis with existing stochastic dominance frameworks, such as those used in portfolio optimization, demonstrating significant improvements in performance and broader applicability. The results not only validate the theoretical underpinnings of our approach but also highlight its practical impact in solving real-world optimization problems.

Do pension funds outperform inflation?

David Neděla

VSB-Technical University of Ostrava

co-author(s): Audrius Kabašinskas

In this paper, we address the question of whether investors and managers of pension funds are losing the value of their investments over time. We aim to propose a new methodology of pension funds risk and performance evaluation based on the trend-risk measurement concept. In the long term, inflation and consumer price changes significantly affect an investor's wealth. For this reason, we consider these macroeconomic indicators to represent a time-dependent trend, which pension funds should outperform. In the empirical part, we study our new methodology across various pension funds in Lithuania while reflecting on various market conditions and regimes detected by Hidden Markov Models.

A Model of Firms' Delisting Based on the Access to Capital Perspective

Lucia Ludovici

Sapienza University of Rome

co-author(s): Gianluca Vagnani, Rita Laura D'Ecclesia

Voluntary delisting, the decision to remove a company's securities from a public exchange, has gained attention due to its significant impact on firms' operations, market presence, and shareholder wealth. Research highlights that firms delist due to declining net benefits from being listed, as well as difficulties in securing capital. This study introduces a delisting model based on firms' pledgeable income, which depends on corporate governance quality and stock liquidity. Good governance and high liquidity reduce private benefits for managers, making it more advantageous for firms to stay listed, whereas poor governance and low liquidity increase delisting incentives.

Leveraging the theoretical models of Tirole and Holmstrom, we propose an integrative model of delisting at the firm level. Our model links a firm's decision to delist to its pledgeable income, assessing that it is easier for a listed firm to enhance its borrowing capacity due to the board of directors and financial market monitoring. We also introduced two variables, corporate governance quality, and stock liquidity, that we argue are predictors of a firm's effective monitoring in reducing private benefits. The latter variable determines a firm's capacity to raise capital in financial markets, thereby contributing to a firm's decision to delist from its stock market.

Through our integrative model, we develop three key propositions. The first proposition compares the utility of remaining publicly listed with that of delisting, determining the relative advantages of each decision. The second and third propositions suggest that the quality of corporate governance and stock market liquidity can influence this utility, thereby reducing the net benefits for the manager. Consequently, when corporate governance is of high quality and the market is sufficiently liquid, it is more advantageous for a firm to remain listed.

Our study contributes to the literature on voluntary delisting by presenting a model that explains how internal and external governance issues can hinder a firm's ability to raise capital,

leading to delisting. We provide firm-level empirical evidence showing that poor corporate governance worsens market signaling and hampers capital acquisition. Additionally, we highlight how low stock liquidity increases agency costs and reduces borrowing capacity, driving firms to exit public markets. Our findings offer insights for investors, regulators, and decision-makers regarding the factors influencing a firm's decision to delist from stock exchanges.

Echoes of the past: The long-lasting effects of entrepreneurs' generational imprints on value-creation models

Karen Watkins Fassler

UNIR

co-author(s): Ileana Maldonado-Bautista, Paul Sanchez-Ruiz, Annaleena Parhankangas

We draw from theories of generations and imprinting to introduce an alternative conceptualization of the effects of age on entrepreneurship—namely, entrepreneurs' generational imprints. We conducted two studies in the historical sociological context of Mexico. We theorize how imprinted characteristics of entrepreneurs from a conservative generation (vs. a progressive generation) are positively (negatively) associated with higher levels of financial returns and negatively (positively) associated with higher engagement in corporate social responsibility. We found that entrepreneurs from a conservative generation create more financial value than social value in their businesses, while entrepreneurs from a progressive generation create more social value than financial value in their businesses. We also explored the intervening mechanisms and found that entrepreneurs who are more embedded in the church and their families and have more family obligations are more likely to experience generational imprinting. We also found that women tend to experience generational imprinting differently than men, leading to important heterogeneity in our results. Further, we found that older entrepreneurs experience generational imprints more acutely than their counterparts. Overall, this study provides new insights into entrepreneurs' generational imprints and demonstrates how and why generational imprinting matters in entrepreneurial research.

Corporate resiliency and the choice between financial and operational hedging

Yakov Amihud

New York University - Stern School of Business

co-author(s): Viral Acharya, Heitor Almeida, Ping Liu

We study how firms manage two potential defaults: Financial default on their debt obligations, and operational default, i.e., failing to deliver on obligations to customers. Since operational hedging requires upfront costs, firms with limited ability to raise capital substitute between hoarding cash (financial hedging) to mitigate financial default risk and spending on inventories and supply-chain diversification (operational hedging) to mitigate operational default risk. Thus higher credit risk lowers marginal production costs and all else being equal, raises markup, a relationship that is stronger for financially constrained firms. Empirically, operational hedging measured by inventory and supply-chain diversification lowers markup and raises cost of goods sold. As predicted, markup increases and cost of goods sold decreases with the firm's credit risk, especially in episodes where capital markets impose financial constraints.

Geopolitical risk and uncertainty in energy markets

Ivan De Crescenzo

Dept. of Social and Economical Sciences, Sapienza University of Rome

co-author(s): loret

In these recent years, geopolitical studies have gained an increasing interest across mainstream arenas as well as among researchers. The pandemic outbreak in 2020 and warfare tensions in many hot spots across the globe are the prime drivers of the attraction of geopolitical studies speculating the “post-globalized” world. Geopolitical (dis)equilibria and energy market have demonstrated a solid linkage due to the interconnected global economy alongside with uncertainty over both climate and global policy. This presentation covers a study on the relationship between the above-mentioned risks and the energy market, indulging on natural gas, coal and oil as the fundamental dimensions of the latter. The underlying study consists of an application of wavelet entropy-based measures to assess how much uncertainty indices can predict the dynamics of these three commodities and vice-versa. Generally speaking, the uncertainty indexes appear to exert a predictability for all the commodities; the reverse happens to a much smaller extent. The phenomenon is quite outstanding for coal, as this commodity appears to be more susceptible to climate uncertainty than the others. The reverse doesn’t happen quite as much. With regard of gas, it is clear how climate uncertainty influences the predictability of the European-based gas index rather than it does with respect of the US-based one. This is consistent with the observation that gas plays a crucial role in the energy transition in Europe but, at the same time, Europe keeps a stigma conceiving the commodity basically as a fossil fuel. On the flip-side, climate uncertainty poorly impacts oil as this can be deemed as the result of the observation that this commodity has been progressively drifting away from its role of direct fuel for energy production, or at least, is less and less conceived as directly connected to climate change. The mainstream narrative is perhaps more inclined to relate oil to general pollution instead. As far as geopolitical risk is concerned, we found that the related index does not happen to be very responsible for the dynamics of both coal and EU based gas indexes compared to the other indexes. We believe this result reflects the long era in which gas used to flow abundantly through the pipelines connecting Russian Federation and Europe. Ground-steady facilities might have contributed to a solid security of the physical commodity as well as acting as a “price stabilizer” despite geopolitical disorders. Less intuitive is the scarce predictability of geopolitical risk against coal if compared to the other commodities. The reason of this result might be found in the circumstance that coal has a long history of supply in areas that are quite preserved by possible geopolitical turmoil. To some extent, we can state that whilst uncertainty over climate policy can help predict the array of commodities of this analysis, the same does not happen when the geopolitical risk is under scope. In an overall perspective, climate and policy uncertainty appear to have a greater impact on coal than geopolitical risk does. In our opinion this speaks loud about the de-carbonization narrative that revolves around this commodity and that has a stronger impact than geopolitical instability. If we assume that climate policy and global policy uncertainty better reflect regulations, laws and macroeconomic scenarios whereas geopolitical risk resembles the instability of geographical/physical areas, we can argue that coal is more dependent on the first set of risks rather than suffer a physical disruption of the commodity in its fundamental components. The rest of the findings will be furthermore explained in due course and supported with a comprehensive

Analysing the impact of CfD contracts for wind producers using a stochastic bilevel approach

Ruth Domínguez

University of Brescia (Italy)

co-author(s): Carlos Ruiz Mora, Giorgia Oggioni, Rossana Riccardi

The increasing renewable generation in power systems is leading to very low electricity prices. New market mechanisms must be offered to motivate new investments in generating technologies while ensuring cost recovery. In this work, we focus on the Contracts for Differences (CfD) and propose a stochastic bilevel programming problem in which regulators auction off CfD to wind power producers. The market regulator seeks to minimize the costs of CfD while finance capacity expansion projects up to a certain capacity level. In this context, wind power producers have to decide how much capacity to trade through CfD contracts and how much in the spot markets. Thus, producers participate in the CfD auction offering to install a certain amount of new capacity at a specific price regarding its risk level perspective, which is modeled through the CVaR. Then, the regulator clears the bids and assigns the wind capacity accepted to be covered by the CfD. In addition, we model the case in which the wind producer owns an energy storage to counteract the variability of the wind power. A realistic case study based on the Spanish electricity market is carried out and different sensitivity analyses on (i) the risk level of the wind power producer, (ii) the total capacity in the CfD auction, (iii) the size of the battery, and (iv) the difference between the reference price and the spot market price are analyzed.

Electricity Markets with Elastic Demand and Bounded Production: Bilevel Optimization and Sensitivity Analysis

Martin Branda

Faculty of Mathematics and Physics, Charles University Prague

co-author(s): E. Allevi, J. V. Outrata, M. Pištěk, R. Riccardi

This paper presents a novel multi-leader common-follower equilibrium model for day-ahead electricity markets. In this model, each profit-maximizing producer's problem is structured as a bilevel program based on specific assumptions. The Independent System Operator (ISO) manages market clearing using a pay-as-clear mechanism, while producers are constrained by production limits and demand is determined endogenously. Utilizing the unique structure of these bilevel programs, we apply generalized differentiation techniques to establish first-order optimality conditions. To numerically solve these complex programs, we implement an efficient bundle method tailored for nonsmooth optimization. Our methodology is illustrated using a real-world dataset from the Italian energy market, which includes renewable energy sources.

Highlighting the key challenges in Power-to-X Cogeneration: A Data-Driven Approach Using IoT and Advanced Analytics

Mehar Ullah

Lappeenranta-Lahti University of Technology, Lappeenranta, Finland

This study provides a systematic analysis of selected research articles on the Power-to-X (P2X) sector, emphasizing its importance in addressing the global reliance on fossil fuels, which has led to substantial greenhouse gas emissions and contributed to climate change. One of the most promising solutions to this issue is the use of renewable energy sources, such as solar and wind. However, these sources are intermittent, creating the need for large-scale, long-term energy storage. The P2X process chain offers a potential solution by converting renewable energy into storable forms like hydrogen, chemicals, and fuels through electrolysis and CO₂ synthesis. This study highlights the challenges companies face when using advanced data-driven technologies such as the Internet of Things (IoT), big data analytics, and machine learning to optimize P2X cogeneration plants. Key challenges include the need to upgrade legacy architectures, address security concerns, and select the most suitable IoT platform from the vast array of options available. In this paper, we propose a theoretical framework to help companies overcome these obstacles and enhance the efficiency of P2X cogeneration operations. Key words: Power-to-X; IoT; big data; machine learning; Renewable energy, Cogeneration plants

Recent Advances in Mathematical Optimization

S4, 14:20 – 15:40

Duality in Conic Reformulations of Standard Convex Programming Problems

Jakub Hrdina

Comenius University in Bratislava, Faculty of Mathematics, Physics and Informatics, Department of Applied Mathematics and Statistics

Convex conic linear programming problems are problems of minimizing a linear function over the intersection of an affine subspace with a convex cone. Since every convex set can be embedded into a convex cone, standard convex programming problems can be equivalently reformulated as convex conic linear programming problems. We focus on examining duality and its aspects in such reformulations. In addition, we concentrate on the relationship between the conic version of the Slater condition and the weak version of the Slater condition for standard convex programming problems.

Bilevel models with moving window analysis

Monika Kařatová

Department of Probability and Mathematical Statistics, Faculty of Mathematics and Physics,
Charles University

co-author(s): Miloř Kopa

In investment decision-making, it is common to consider both in-sample efficiency and out-of-sample performance. To combine these two objectives, one can employ a bilevel stochastic optimization problem. In our paper, the lower level of the problem consists of the mean-risk optimization model, where Conditional Value-at-Risk as the risk measure is applied. The upper level searches for in-sample efficient (lower level) portfolios which maximize the out-of-sample performance (out-of-sample return).

Moreover, except the assumption of discrete probability distribution, additional assumption can be made about variables in the upper level. In a moving window analysis, these variables can vary or remain the same for all windows. Therefore, two bilevel optimization problems with multiple followers are considered. One of them can be split in time, the other one not. The results for these two cases will be presented.

Risk-Sensitive Average Optimality in Semi-Markov Decision Processes

Karel Sladký

ÚTIA

In this note we consider semi-Markov reward processes evolving on finite state spaces. We focus attention on so-called risk-sensitive models, i.e. we establish explicit formulas for the growth rate of expectation of the exponential utility function. Using Taylor expansion of the utility function we present explicit formulas for the expected reward generated by the considered semi-Markov decision processes along with its asymptotic behavior of moments and central moments of the considered exponential utility function. Recall that the result for risk-sensitive optimality criteria for the classical Markov decision chains in discrete- and continuous-time setting turn out to be a very specific case of the considered model.

Stochastic Optimization Problems with Nonlinear Dependence on a Probability Measure and an Application to Special Type Problems with Endogenous Uncertainty

Vlasta Kaňková

ÚTIA

Nonlinear dependence on a probability measure has recently been encountered with increasing intensity in stochastic optimization. This type of dependence corresponds to many practical demands. The corresponding problems are rather complicated, from the mathematical point of view. However, these problems can be employed to analyze other situations; e. g. ambiguity investigation.

Originally, the above mentioned problems have been constructed under the assumptions of exogenous uncertainty only. But this type of problems can be considered simultaneously with both type of uncertainty as exogenous as endogenous. To this end introduce a special type of “Two stage stochastic optimization problems“. Moreover, we focus on the situation in which a solution has to be found on the basis of the data. A relationship between the original and empirical versions will be investigated with help of the Wasserstein metric and \mathcal{L}_1 norm.

Comparison of Market Attention-Driven and Traditional Portfolio Strategies

Jialei Xiong

Technical university of Ostrava

The objective of this study is to investigate whether incorporating market attention factors into portfolio optimisation can enhance investment performance. To achieve this, the study analyses the difference in results by comparing traditional portfolio strategies with those influenced by market attention. In addition, the study adopts a rolling-window approach to consider the impact of portfolio rebalancing on the optimisation results. The results show that market attention has a positive impact on portfolio optimisation and outperforms traditional portfolio strategies.

Relaxing stochastic dominance constraints in portfolio optimization

Jana Junová

Charles University

co-author(s): Miloš Kopa, Sebastiano Vitali

In portfolio optimization problems with stochastic dominance constraints, the return of a feasible portfolio must dominate the return of the benchmark with respect to a chosen order of stochastic dominance. However, this requirement might be too strict for many investors. Therefore, we introduce measures of stochastic non-dominance and use them to relax the traditional stochastic dominance constraints.

The measures of stochastic non-dominance between a given random variable and a benchmark are found by solving an optimization problem that seeks an optimal random variable, which is as close as possible to the original one but dominates the benchmark. The measure of stochastic non-dominance is then defined as the Wasserstein distance between this optimal random variable and the original one. In portfolio optimization problems, we constrain this value by a certain constant. Additionally, we explore the relationship of these problems to those with almost stochastic dominance constraints.

Using data regarding monthly returns of 12 industry representative portfolios, we find the optimal portfolios by maximizing their expected return subject to the first-order and the second-order stochastic dominance and non-dominance constraints. We evaluate the out-of-sample performance of these different types of portfolios using moving window analysis. It demonstrates that allowing certain non-zero measures of stochastic non-dominance results in higher out-of-sample mean returns.

Portfolio selection based on implied volatility and state price density

Sebastiano Vitali

University of Bergamo

co-author(s): Milos Kopa, Ruth Dominguez, Alessandro Giancesin, Marco Garofalo

Portfolio selection models aim to choose the best securities available in the asset universe according to a given source of information. Such information could be extracted from an analysis of the history or a forecast of the future. In fact, the financial markets are driven mainly by the expectations of market investors and by exogenous sources. An explicit way for market investors to make clear their expectations about a certain asset is to define the implied volatility of the options that are written on that asset. Moreover, a recently developed tool generates the state price density of the given asset observing the implied volatility of the options. The combination of the implied volatilities and the state price density can give deep insight into investors' expectations and, thus, can represent a reliable source of information based on which to select a portfolio. This approach constitutes a completely new technique to establish a ranking among the available assets, and we apply it to an extensive set of data regarding financial indexes. In the empirical analysis, we consider both the time-picking problem for a single index and the portfolio selection problem when multiple indexes are available.

A Portfolio Optimization Method Using Ensemble Learning Forecasting

Qian Gao

VSB - Technical University of Ostrava

This study proposes a hybrid portfolio optimization method that integrates time series prediction and asset classification to improve the portfolio's risk-adjusted return. First, we use ensemble learning technology to predict the time series of portfolio components to improve the accuracy and stability of the prediction. The prediction results are used to classify assets into positive and negative categories: when the prediction error is positive, the asset has a higher potential return; when the prediction error is negative, it indicates that the asset may face higher risks. For positive assets, we use the maximum Sharpe ratio model for optimization to maximize returns; for negative assets, we use the minimum risk model for optimization, focusing on reducing the portfolio's overall volatility. Through the analysis of empirical data, the results show that this method can effectively improve the risk-adjusted return of the portfolio under different market conditions and show significant advantages in controlling risks. This proves the effectiveness and application potential of our method in portfolio optimization.

Invited Lecture
S4, 15:45 – 16:25

Electricity procurement for industrial consumers considering self-generation and flexible consumption

Miguel Carrion
University of Castilla-La Mancha

Given the volatility of both the economic and energy landscapes, it is imperative for large electricity consumers to carefully evaluate strategies for their future energy procurement. These strategies should explore the feasibility of integrating non-polluting, economically viable self-generation options, particularly those based on solar photovoltaic technology. This study aims to identify optimal electricity procurement strategies for cement producers, considering participation in the electricity market, power purchase agreements, and the integration of photovoltaic self-generation and battery storage systems. To achieve this, we examine the case of a real cement producer. We model the flexibility of electricity consumption across all production processes involved in cement and clinker manufacturing. This modeling leads to the formulation of a mid-term decision-making problem under uncertainty, tackled through a two-stage, risk-averse stochastic programming framework. To improve computational efficiency, the planning horizon is defined by a set of representative periods generated via a clustering technique. To demonstrate the practicality of the proposed approach, a case study is conducted using data from a real-world cement producer, actual electricity market prices, and renewable energy production values. Future work will explore the participation of industrial consumers in existing demand-side flexibility programs.

Applications of Machine Learning
S4, 16:40 – 18:00

A Machine Learning perspective to explore cryptocurrencies' dynamics and derive buy/sell trading signals.

Rosella Castellano
UnitelmaSapienza University of Roma
co-author(s): Federico Cini; Annalisa Ferrari

In this paper, we adopt a Machine Learning approach to analyze the cryptocurrencies' dynamics. The aim is to ascertain whether they align with established traditional asset classes or warrant recognition as a distinctive asset class. To unravel their authentic nature, we construct a daily dataset from 2019 to 2023. This dataset forms the basis for training and testing Random Forest Regression models, facilitating a comprehensive analysis of cryptocurrency dynamics. The selected significant features pertain to commodity, stock, and currency markets, along with leveraging Google Trends to gauge the level of interest in cryptocurrencies. Furthermore, based on the highlighted dynamics, we generate buy/sell signals using a binary classification Support Vector Machine model and compare it with the buy-and-hold strategy, considering the years 2022 and 2023 separately. The results in terms of return on investment show that the model can replicate the benchmark in a rising market and, more importantly, outperform it during highly volatile market phases, making it an essential tool for strategic investment decisions.

Impact of ESG measures on the energy sector stock prices

Patrycja Chodnicka-Jaworska

University of Warsaw

In this paper, a specific sector is considered for analysis; specifically, the energy sector. The reason for testing the impacts of the ESG measures in this sector is strictly connected with the changes in regulations for particular regions and countries. An analysis of the previous studies focused on the relationship between ESG measures and their impact on the financial condition of companies and their rates on returns on stock prices gives varied results. As a result, the aim of this paper is to analyze the impact of ESG measures on rates of return in the energy sector. The main hypothesis is as follows: The ESG measures have a significant impact on rate of return in the energy sector, especially in the context of the ESG initiatives and regulations. An analysis was conducted by using the rates of return on stock prices of companies listed on stock exchanges all over the world. In the analysis, more than 2800 companies from all countries were analyzed, where the data were collected from Refinitiv database. To verify the abovementioned hypothesis, it was collected quarterly data from financial statements (profitability, earning power, liquidity, leverage, operating, size of company factors), macroeconomic data, and ESG measures (e.g. CO2 Emission, ESG Score, Environmental Pillar Score, Social Pillar Score, Corporate Governance Pillar Score, ESG Controversies Score) for all companies listed on stock exchanges worldwide for the period 2010–2024. The energy sector was divided into sub-sectors according to the type of sector (renewable energy, uranium, coal, and oil and gas), considering the regulations period, ESG scores. Machine learning models—LASSO, IV LASSO, 2LASSO—were used. The mentioned models are used because the large number of variables. It was used also a treatment and control groups.

The supremacy of ML in ESG ratings estimation

Annalisa Ferrari

UnitelmaSapienza

co-author(s): Federico Cini

The objective of this paper is to contribute to the scientific debate on predictability of ESG ratings. Through a ML approach we develop a RF classification model able to provide investors with indications on ESG rating class at time $t+1$ starting from a small and simple set of variables at time t . Two elements of innovation are introduced in this work: (i) A classification approach instead of a regression approach. (ii) The introduction of Conditional Beta in a small, selected basket of directly or indirectly public variables. With unprecedented accuracy, the model is able to predict whether, one year later, a company will remain in the same ESG rating class or migrate to another one using a very simple and small set of variables: balance sheet data, financial information, and a dynamic measure of systemic risk (Conditional Beta). An analysis of the importance of each variable in the model constructed in this way demonstrates the soundness of this choice, as this model strongly considers the main balance sheet variables and Conditional Beta itself. The parsimonious and agile model thus obtained allows for effective evaluations to be obtained starting from a significantly reduced set of variables compared to that usually involved in the formulation of ESG ratings. Assuming that the sustainable investor uses the ESG rating to define investment strategies, our model becomes an important source of information to enable informed decision-making. The downward trend shown in accuracy as the ESG rating sub-class changes seems to suggest a hierarchical distribution of information and values of the independent variables with respect to the sub-classes themselves. In other

words, for higher ratings (macro-class A) more precise indications are obtained regardless of the model. This observation seems to confirm that the intrinsic value of the ESG rating is a function of its own level. The results obtained are particularly significant as our models can pave the way for the formulation of estimates for unlisted companies and/or SMEs as well, helping to provide further models to support the sustainable investor's investment strategies.

Dynamic Multistage Portfolio Optimization Using Reinforcement Learning for Scenario Tree Generation

Karel Kozmík
MFF UK, KPMS

co-author(s): Lukáš Janásek, Jakub Vondráček, Miloš Kopa

This paper introduces a novel multistage portfolio optimization approach using a mean-CVaR framework with scenario trees generated by reinforcement learning. We train a neural network to dynamically construct the scenario tree by predicting the number of children at each node, allowing for an adaptive representation of uncertainty. The scenario trees model the evolution of asset returns over multiple stages, with each stage representing one year. Unlike traditional methods, our approach generates scenarios by sampling various time windows from historical data, creating dynamic and robust trees. The optimization is formulated as a multistage stochastic program, where decisions are adjusted based on observed returns. We explore the performance and characteristics of the scenario trees, demonstrating the advantages of using reinforcement learning in scenario generation for improved portfolio optimization outcomes.

When mathematical correctness is not enough – experience from COVID modeling

Martin Šmíd
Charles University

We present a discrete-time stochastic epidemic model that addresses uncertainty and partial observability. This model has been used for policy recommendations during the COVID pandemic and has therefore sparked controversy. While much of the criticism has been unjustified, several weaknesses can still be identified, both in this model and in the general process of mathematical modeling in this context. Though the model is interpretable and statistically sound, some issues remain. First, the accuracy and validity of input data may be questioned. Second, confounding factors could distort predictions. Third, computational errors, such as local minima, could prevent proper estimation. More broadly, models that describe human behavior are not merely descriptive but also normative, complicating their verification. Additionally, the prevention paradox and ethical concerns further challenge their application. Finally, questions remain about the appropriate degree of development at which such models should be applied in policy decisions.

Distributionally Robust Fixed-Interval Scheduling Problem with Heterogeneous Machines and Stochastic Delays

Monika Matoušková
Faculty of Mathematics and Physics, Charles University Prague
co-author(s): Martin Branda

We address an operational fixed-interval scheduling problem where start times are predetermined, and actual finishing times may be impacted by random delays. We further consider the heterogeneous case, involving multiple job and machine types. We assume that the multivariate distribution of delays follows an Archimedean copula. Our objective is to maximize the worst-case probability that the schedule remains feasible, given that a certain proportion of the marginal delay distributions are stressed. The problem has an interesting reformulation incorporating a commonly used risk measure. We implement a decomposition algorithm to solve it. A potential application is the gate assignment problem, where incoming flights need to be allocated to available airport gates. In this context, heterogeneity arises from the fact that different aircraft types may require different gates. Additionally, a certain proportion of flights may experience more severe delays.

Machine Learning for football performance evaluation: a comprehensive player analysis

Giuseppina Dello Ioio

University of Naples Parthenope

co-author(s): Stefania Corsaro, Zelda Marino

The sports industry has a significant global reach, with a value of \$480 billion in 2023, which is expected to increase to \$629.81 billion by 2028. These data reveal various profit potentials, particularly for bookmakers and investors. In this framework, it is crucial to identify the value of the players, which is associated with several factors, including age, contractual duration, performance, popularity, sponsorships, and other aspects. Therefore, the player can be considered as a financial asset, for which not only the sporting performance is significant but also the economic value and potential future financial impact. The aim of our research activity is to understand how a football player can be valued as a financial asset. For this purpose, we began by focusing on performance measures, which can be disparate. In this work, we focus on the analysis of one of the most relevant performance measures in today's sporting landscape: Expected Goal (xG). The accuracy of predicting xG plays a crucial role in the financial and strategic decisions of football teams, as well as for investors and bookmakers, as it allows for a more accurate assessment of a team's performance and the identification of value bets. Moreover, the xG metric can significantly influence a player's market value and influence transfer decisions. The aim of this study is twofold. Firstly, we want to address the lack of clarity in the definition of xG. It is evident that each data provider has developed its own xG estimation model, which has produced disparate evaluations of the player's performance. Therefore, the aim is to investigate Machine Learning techniques in order to understand and clarify the model used by one of the leading football data providers, Understat, to produce xG values. Moreover, we want to contribute to the existing literature by proposing a Neural Network approach with the aim of improving xG estimates.

Tuesday

Environment and Sustainability

R, 8:30 – 9:50

Managing the Transition Risk

Kevyn Stefanelli

Sapienza University of Rome

co-author(s): Roy Cerqueti

Climate change is increasingly shaping investment strategies in the energy market, forcing funds worldwide to balance their holdings between fossil fuel-based and clean energy assets. The hidden risks of natural disasters compound the growing demand for power, the rise of environmentally responsible investments, and the scarcity of raw materials. The ongoing energy transition introduces significant risks, as a complete shift to a net-zero emissions system remains unfeasible in the near term. Recent advancements in nuclear fusion technology have positioned it as a potential frontrunner among renewable energy sources for the future. However, public skepticism towards atomic energy continues to fuel debate over the profitability and timing of investments in this sector. In this paper, we propose a climate factor-mimicking portfolio to hedge against transition risk in the energy market, building on the methodology proposed by De Nard et al. (2024). This strategy enables investors to protect their portfolios and capitalize on opportunities during heightened uncertainty, as the market struggles to identify the dominant energy source for the forthcoming decades.

Country policy drives companies' sustainability

Sergio Hoffmann

Sapienza University of Rome

co-author(s): Rita Laura D'Ecclesia

Sustainability became one of the criteria determining investors' preference worldwide, attracting the attention of agents, researchers, and regulators. Albeit the market pushes corporates to meet the UN sustainable development goals (SDGs), local policies diverge affecting the way each agent perceive its goals. Several recent studies focus on determining the most relevant features that influence the outcome of the sustainability performance of corporations, countries and financial institutions. Main findings highlight that discrepancies mostly arise from the way corporates disclose their sustainability performance. In this paper, we measure the effect of local policies on determining corporate sustainability and to what extent firms align with country-specific features. Computing the national average corporate Environmental, Social, and Governance (ESG) score, exploiting LSEG Refinitiv data between 2013 and 2022,

we proxy the local commitment to sustainability and find that country-specific features strongly affect corporate ESG performance. Results emerge from the implementation of machine learning algorithms, which are able to capture the non-necessarily linear stickiness of corporate ESG performance to the national one.

Impact of ESG regulations on the energy sector stock prices

Piotr Jaworski

University of Warsaw

co-author(s): Patrycja Chodnicka-Jaworska, Marcin Kot

The aim of this paper is to analyze the current impact of the implementation of the European Union regulations and meetings like COP on the abnormal rates of return on the stock prices of companies from the energy sector listed on the stock exchanges. It was hypothesized that the implementation of the European Union ESG regulations is causing the varied abnormal rates of return on the stock prices of companies from the energy sector that are listed on the stock exchanges, taking into consideration the type of subsector, the geographical location, and the level of economic development. The analysis used panel data event studies prepared using the daily rates of return on the stock prices. Data were collected from the Refinitiv Eikon database.

Rewarding Green Revenues

Rita D'Ecclesia

Sapienza University of Rome

co-author(s): Kevyn Stefanelli, Giacomo Morelli

The integration of non-financial criteria, such as social and environmental sustainability, in portfolio construction is now a widespread practice and, importantly, is being increasingly demanded by both the market and regulators (Abate et al. (2023), Amon et al. (2021), Dyck et al. (2019), Lahtinen et al. (2017), Liagkouras et al. (2020), Pedersen et al. (2021), Serafeim and Yoon (2023)). However, the currently available sustainability metrics are still considered unreliable leaving open the debate on what is truly ESG (Berg et al. (2022), Gibson Brandon et al. (2021), Parise and Rubin (2023)). Particularly in the environmental context, the quest for the ideal, universal, and scientifically replicable metric could be described as the new green gold rush of our times (Bender et al. (2019), Popescu et al. (2021)). Among the various proposed metrics, FTSE Russell offers the Green Revenues Data Model (GRDM), which quantifies balance sheet exposure to environmental impact. Using this new metric, we can differentiate between companies that generate a significant portion of their profits through eco-friendly projects, initiatives, and activities from those that do not or only partially participate in the global economy's ecological transition. In this paper, we build a "green" portfolio by selecting assets according to the GRDM data. Then, we compare its financial performance with a standard portfolio to assess whether the market rewards the most ecological firms. Results point out differences between the performance of the two portfolios which depend on the time frame analyzed.

Invited Lecture
R, 10:05 – 10:45

Numeraire-invariant quadratic hedging and portfolio selection

Aleš Černý

Bayes Business School, Faculty of Finance

co-author(s): Christoph Czichowsky, Jan Kallsen

The talk investigates quadratic hedging in a semimartingale market that does not necessarily contain a risk-free asset. An equivalence result for hedging with and without numeraire change is established. This permits direct computation of the optimal strategy without choosing a reference asset and/or performing a numeraire change. New explicit expressions for optimal strategies are obtained, featuring the use of oblique projections that provide unified treatment of the case with and without a risk-free asset. The analysis yields a streamlined computation of the efficient frontier for the pure investment problem in terms of three easily interpreted processes. The main result advances our understanding of the efficient frontier formation in the most general case in which a risk-free asset may not be present. Several illustrations of the numeraire-invariant approach are given.

Risk Management
R, 10:50 – 12:10

Making intuitionistic risk management more intuitive – on the role and use of intuitionistic fuzzy sets in the representation of risk

Jan Stoklasa

LUT Business School, LUT University, Lappeenranta-53850, Finland

co-author(s): Shahid Ahmad Bhat

Intuitionistic fuzzy sets allow for the reflection of degree of membership and degree of non-membership, while leaving room for a specific degree of hesitancy. In other words they can be used as a model for those uncertain concepts, where there is evidence that supports the existence (or realization) of the connected event, there is evidence that supports the opposite, but there is also some missing or ambiguous information that needs to be acknowledged as well. As such the intuitionistic fuzzy set provides appealing and quite general structure for the representation of quantities or events in risk management, as it allows for the expression of support of, evidence against and lack of knowledge concerning a specific phenomenon or its outcome. This paper recalls several applications or intuitionistic fuzzy sets and the main approaches that are used to treat these mathematical objects in risk analysis. Subsequently, it points out the connection of intuitionistic fuzzy sets with type-2 fuzzy sets and draws several implications and recommendations for the development of methods for intuitionistic risk management.

Stress testing of conservative pension funds

prof. Audrius Kabasinskas

Kaunas University of Technology

co-author(s): Milos Kopa, Kristina Sutiene

Stress testing of financial funds presents a complex challenge. Recently, we published a study detailing a methodology for conducting stress tests on pension funds in general. In this presentation, we will report the findings of a counterfactual analysis on fund management strategies during the onset of a financial crisis, specifically focusing on the actions fund managers should take in response. The analysis will emphasize conservative funds within the second pillar of the Lithuanian pension system.

Market Risk and ESG Rating: a Markov-Switching Approach

Francesco Morelli

Link Campus University

co-author(s): Marco Nicolosi

This paper investigates the relationship between ESG ratings and the systematic risk of companies listed on the U.S. market. Using a Markov-switching Capital Asset Pricing Model (CAPM), we explore whether changes in ESG ratings influence market risk over time. ESG ratings, which evaluate a company's performance across environmental, social, and governance dimensions, are incorporated as time-varying factors affecting transition probabilities between different risk regimes. The dataset comprises 2,500 U.S.-listed companies from 2004 to 2024, with monthly company returns and annually updated ESG ratings. Our analysis finds that ESG ratings significantly impact market risk, particularly in facilitating transitions from high-risk to low-risk states. Specifically, over 90% of the companies studied show a significant relationship between ESG ratings and at least one of the two risk-state transition probabilities. While only 50% of firms demonstrate that higher ESG ratings increase the likelihood of remaining in a low-risk state, more than 80% exhibit a higher probability of moving from a high-risk regime to a low-risk one as their ESG scores improve. These findings highlight that, while ESG ratings may not prevent an initial increase in systematic risk, they play a key role in shortening the duration of high-risk periods, supporting a quicker recovery to low-risk levels. This underscores the growing importance of ESG considerations in risk management and portfolio strategy for investors and policymakers.

Interest Rate Risk on Real Estate Exchange Traded Funds

Tzu-Man Huang

California State University Stanislaus

co-author(s): Andrew Wagner

This study examines how interest rate changes affect the real estate Exchange Traded Funds (ETFs) performance in the U.S. Interest rate is one of the most important macroeconomic factors, and often serves as the leading tool that governments utilize to implement monetary policy. Higher interest rates indicate higher costs for housing market, making mortgage loans and real estate less appealing. However, at the same time, rising interest rates might indicate a strong economy, which booms real estate market. The twofold of interest rate risk on real estate investment is examined with the U.S. real estate ETFs as target in this study. The first real estate ETF was introduced in 2000 in the U.S. As ETFs get popular in recent decades, there are currently 62 real estate ETFs traded in the U.S. We collect the historical prices and generate monthly returns for the real estate ETFs. We investigate how interest rates, including short-term and long-term rates, affect real estate ETFs performance. Our control variables include stock market return and fund characteristics, such as market capitalization, expense ratio, and market-to-book ratio. Our preliminary results suggest that long-term interest rate has a positive impact on real estate ETFs returns, while the impact from short-term interest rate is not significant. Stock market performance also has a positive impact on real estate ETFs returns. In addition, funds with smaller market capitalization and lower expense ratio tend to offer higher returns. We only have preliminary results at this point. We plan to conduct more analysis to explore other effects. As the literature about interest rate risk on real estate investment is inclusive and the study about interest rate sensitivity on real estate ETFs is scarce, we hope to have shed some light in the area and encourage more study on interest rate risk in real estate markets.

Round Table Discussion

R, 12:25 – 13:30

Wednesday

Applications of AI
R, 9:00 – 10:20

Enhancing the performance and efficiency of explainable artificial intelligence in healthcare under uncertainty based on a novel multi-criteria group decision-making algorithm using interval valued q-rung orthopair fuzzy information

Shahid Ahmad Bhat

LUT Business School, LUT University, P.O. Box 20, FIN-53851 Lappeenranta, Finland

In recent years, artificial intelligence (AI) has significantly impacted the healthcare sector by enhancing diagnostic accuracy, personalizing treatment plans, and predicting patient outcomes. However, despite these advancements, AI adoption in healthcare faces significant challenges, especially due to the "black box" nature of many AI models. These models, which often rely on complex machine learning algorithms, make decisions without revealing their internal processes, leading to user mistrust. This lack of transparency raises ethical and legal concerns in critical healthcare areas, where decisions significantly impact individuals' lives, leading to uncertainties in accurate decision-making. To overcome these challenges and enhance the performance and efficiency of explainable artificial intelligence (XAI) in healthcare under high uncertainty. The q-rung orthopair fuzzy set (q-ROFS) theory has been gradually becoming more advantageous to deal with information under complex uncertainty more accurately and reasonably. Therefore, this study designs a novel multi-criteria group decision-making (MCGDM) framework under Interval-Valued q-ROF information, i.e., (q-ROFMCGDM), by introducing a new Interval-Valued q-rung orthopair fuzzy weighted averaging aggregation operator (q-ROFWAAO) and entropy measure. Utilizing the designed q-ROFMCGDM framework for prioritizing the most critical influencing factors of XAI systems in the healthcare sector. Further, a sensitivity and comparative analysis have been conducted to determine the validity and effectiveness of the proposed q-ROF-MCGDM framework. Finally, the findings of this study can assist future AI developers and researchers in developing decision-making policies to enhance the performance and efficiency of XAI in healthcare under uncertainty.

Multiple Yield Curve Modeling and Forecasting using Deep Learning

Salvatore Scognamiglio
University of Naples Parthenope
co-author(s): Ronald Richman

This manuscript introduces deep learning models that simultaneously describe the dynamics of several yield curves. We aim to learn the dependence structure among the different yield curves induced by the globalization of financial markets and exploit it to produce more accurate forecasts. By combining the self-attention mechanism and nonparametric quantile regression, our model generates both point and interval forecasts of future yields. The architecture is designed to avoid quantile crossing issues affecting multiple quantile regression models. Numerical experiments conducted on two different datasets confirm the effectiveness of our approach. Finally, we explore potential extensions and enhancements by incorporating deep ensemble methods and transfer learning mechanisms.

Deep Learning for evaluating temperature based weather options

Zelda Marino
University of Naples Parthenope
co-author(s): Maria Carannante, Vincenzo Di Sauro, Salvatore Scognamiglio

This work explores the pricing dynamics of European heating degree day (HDD) options for Italy, focusing on using a Ornstein–Uhlenbeck process to model temperature fluctuations. What sets this study apart from traditional methodologies is its innovative approach in integrating multivariate analysis, wherein diverse geographical regions are considered by leveraging NASA satellite data instead of relying solely on conventional weather station data. Various models have been proposed to capture the complex dynamics of temperature variations and their impact on financial contracts. One notable contribution is the model proposed by Alaton et al in 2002, which considered a specification for the variance in their analysis of temperature data, using a time-dependent variance model smoothed to a constant variance over each month. However, this model may not fully capture the nuances of temperature fluctuations over time. Additionally, several works improve the modeling and pricing of weather derivatives using different stochastic processes. For instance, Brody et al. in 2002 introduce a fractional model with fractional Brownian motion, which captures long-term memory in temperature data. Similarly, Benth et al in 2005 present a mean-reverting stochastic framework incorporating Levy processes, offering a robust approach to modeling temperature variations. While these models provide more intricate representations of temperature dynamics, their derivations can become excessively complex, leading to challenges in practical implementation and interpretation. Instead, the model proposed by Alaton strikes a suitable trade-off, providing sufficient flexibility to capture temperature fluctuations over time without introducing excessive complexity that may hinder implementation and interpretation. The aim is to improve upon the Alaton model by integrating neural networks, which generalize and enhance the estimation of parameters, moving beyond pixel-based evaluations. This allows for calculating risk exposure at any given point, offering a more precise and practical tool for understanding and modeling temperature-driven financial contracts in the weather derivatives market.

Ranking- and Market Sentiment-aware Deep Reinforcement Learning Portfolio Management Method

Eshagh Jahangiri

Ca' Foscari University of Venice

co-author(s): Maximilian Goebel

Portfolio management has always been a difficult task because of the volatile and unpredictable characteristics of financial markets. Machine learning has opened up new potential to improve decision-making by harnessing enormous volumes of data and sophisticated algorithms. In this research , we provide a novel framework for portfolio management that combines Deep Reinforcement Learning (DRL), a learning-to-rank (LTR) algorithm, and market sentiment monitoring to improve asset allocation decision-making. Our proposed framework utilizes the Twin Delayed Deep Deterministic Policy Gradient (TD3) deep reinforcement learning algorithm in conjunction with LambdaRank LTR algorithm to dynamically predict stock rankings and incorporate market sentiment as a crucial decision-making factor. Our suggested methodology was backtested on 28 stocks from the S&P 500 index in the U.S. market. Our findings demonstrate considerable increases in portfolio returns while efficiently reducing risk. The proposed TD3-based approach outperforms traditional portfolio management strategies and also four benchmark DRL methods, such as Proximal Policy Optimization (PPO) and Soft Actor-Critical (SAC). Furthermore, the suggested framework outperformed the S&P 500 index in various performance criteria such as, annualized return and Sharpe ratio. Having stock ranking scores as features, the model detects subtle market signals that standard techniques often miss, resulting in more informed portfolio allocation decisions. ”

Semi-plenary Lecture

R, 10:35 – 11:05

Remarks to the history of conferences MMEI

Karel Zimmermann

MFF UK KAM, Prof. emer.

Short survey of the history of conferences MMEI with emphasis on the role of Prof. František Nožička, who founded the series of these conferences in the 70-ties of the last century. The conferences were oriented from the beginning on the applications of mathematical methods to economics both in deterministic and in stochastic environment. The conferences were successfully organized in Czech republic, Slovak republic, GDR and after 1990 also in BRD. They became an opportunity for meeting of students and doctorands with leading scientists both from the organizing countries and from further countries (e.g. Switzerland, Austria, U.S.S.R., Hungary, Poland and others). It will be given a survey of main research areas, to which the contributions at the conferences were devoted. In the concluding part, some author's personal experience with the collaboration with Prof. Nožička will be shortly presented.

Invited Lecture
R, 11:15 – 11:55

Portfolio selection using stochastic dominance principles

Miloš Kopa

Faculty of Mathematics and Physics, Charles University Prague

Stochastic dominance is a statistical tool developed for comparing the random variables among each other. In financial applications, these random variables usually represent random returns of the considered assets or portfolios. The paper focuses on portfolio selection problems with stochastic dominance constraints for various orders of stochastic dominance relations. Firstly, the tractable necessary and sufficient conditions for particular probability distributions are discussed. Secondly, these conditions are employed in the static and dynamic portfolio selection problems. Finally, the theoretical results are accompanied by empirical examples.

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