CLIMATE RISK MANAGEMENT AND ANALYTICS

A workshop in memoriam of Prof. Ken Seng Tan (Nanyang Business School)

July 3, 2023
The Berkeley Hotel, Wilton Place, Knightsbridge, London SW1X 7RLZ

Programme

12:00-13:00 Buffet lunch

13:00-13:10 **Welcome: Franklin Allen** (Imperial)
13:10-14:00 **Keynote: Ray Pierrehumbert** (Oxford)

Session 1 - Transition risks. Chair: **Enrico Biffis** (Imperial)
14:00-14:35 **Peter Tankov** (ENSAE)
14:35-15:10 **Aneesh Raghunandan** (LSE)
15:10-15:45 **Mirabelle Muûls** (Imperial)

15:45-16:15 Coffee Break

Session 2 - Physical climate risks. Chair: **Umut Cetin** (LSE)
16:15-16:50 **Qihe Tang** (UNSW)
16:50-17:25 **Alejandro Del Valle** and **Mathilda Eriksson** (GSU)
17:25-18:00 **Jinggong Zhang** and **Wenju Zhu** (Nanyang)

Organization: Enrico Biffis (e.biffis@imperial.ac.uk), Anna Wilhelme (a.wilhelme@imperial.ac.uk), Megan Irving (m.irving@imperial.ac.uk), Jaswinder Ghil (j.gill@imperial.ac.uk).

Keynote

Raymond T. Pierrehumbert is the Halley Professor of Physics at the University of Oxford, having previously served on the faculties of University of Chicago, Princeton and M.I.T. His work embraces both theoretical fluid dynamics and physics of planetary climate, with the latter including work on global change, deep-time Earth paleoclimate, climate of Solar System planets and climate of exoplanets. He was a lead author of the IPCC Third Assessment report, and has been a co-author of numerous U.S. National Research Council reports, including reports on abrupt climate change, climate stabilization targets, and climate interventions. He is a Fellow of the American Academy of Arts and Sciences, the American Geophysical Union and the Royal Society, was awarded an honorary doctorate in environmental science by Stockholm University, and has been named Chevalier de l'Ordre des Palmes Academiques by the Republic of France for his work on climate physics. He was awarded the 2022 Royal Society Rumford medal. Pierrehumbert is the author of the highly regarded textbook, Principles of Planetary Climate (Cambridge University Press), and recently published Planetary Systems: A Very Short Introduction (Oxford University Press).

"Methane is 80X worse than Carbon Dioxide" — and other methane myths.

Workshop speakers (alphabetical order), titles and abstracts

Alejandro Del Valle is an Assistant Professor at the Maurice R. Greenberg School of Risk Science at Georgia State University (GSU). His research focuses on establishing the economic effects of natural disasters and aims to identify how government policies and markets can help society adapt to climate change. His work has been published in economics, finance, and general interest science journals such as the American Economic Journal: Applied Economics, the American Economic Journal: Economic Policy, the Journal of Financial and Quantitative Analysis, and the Proceedings of the National Academy of Sciences. Before joining GSU, Alejandro was a visiting researcher at the University of California at Berkeley. He holds a Ph.D. in economics from the Paris School of Economics.

Mathilda Eriksson is an environmental economist specializing in the welfare implications of climate change and extreme weather events. One strand of Mathilda's research builds on policy-optimization models that integrate climate change into long-run macroeconomic analysis to evaluate climate change mitigation. Another strand of her research aims to quantify the short-term losses from extreme weather events and assess the potential for policy intervention to reduce these losses. Mathilda received her training at Umeå University, where she completed her Ph.D. in economics, and at UC Berkeley and the Paris School of Economics, where she was a visiting researcher. Outside academia, Mathilda has worked as an economist at the Swedish National Institute of Economic Research and as a consultant at the World Bank. Mathilda is currently a visiting researcher at the M. R. Greenberg School of Risk Science and the Department of Economics at Georgia State University.

Hydropower and public health in a changing climate: Assessing the impact of droughts on air quality in Latin America and the Caribbean. The transition to a green economy requires the power sector to rely on non-carbon-based energy generation, such as hydropower. However, the stability of hydropower, a key source of clean energy in Latin America and the Caribbean, is at risk due to the increased probability of severe drought events caused by climate change. When hydropower generation capacity declines, the region relies on fossil fuels like natural gas, oil, and coal for electricity, contributing to climate change and local pollution. Taking advantage of recent advances in measuring PM 2.5 concentrations and hydrological variability at a high spatial and temporal frequency, we provide some of the first causal estimates of the impact of droughts on local pollution via the change in the composition of electricity generation. We use fixed-effect regression methods to estimate the effect of droughts on PM 2.5 concentrations. Our estimates indicate that droughts have increased PM 2.5 concentrations by at least 1.5 percent over the last two decades through this mechanism. Furthermore, counterfactual simulations based on our estimates demonstrate that the excess pollution generated by droughts leads to a considerable increase in premature deaths in the region. Our findings demonstrate the potential health benefits of reducing reliance on fossil fuels as a marginal source of electricity generation in the region and highlight the public health benefits of prioritizing investments in renewable energy sources and increasing the degree of interconnection between electricity markets.

Mirabelle Muûls is an Associate Professor in Economics at Imperial College Business School and the co-director of the Hitachi-Imperial Centre for Decarbonisation and Natural Climate Solutions. She is also a Research Associate at the Grantham Institute, CEPR, the National Bank of Belgium and the Centre for Economic Performance at the London School of Economics. Her current research focuses on the economics of climate change, seeking in particular to understand the impact of carbon markets on firms' emissions, energy efficiency, innovation, competitiveness and performance, as well as the interactions with financial markets. Her research interests also cover energy demand and behaviour.

The production network impacts of carbon pricing: Innovation, productivity and greenhouse gas emissions. Carbon markets are growing in number and scope around the globe as a response to the need to decarbonise economies and avoid dangerous climate change. In the EU, for instance, carbon pricing has so far focused on electricity generation as well greenhouse gas (GHG)- intensive industries. Typically, only a subset of firms is regulated. However, one might expect that the carbon price that regulated firms face affects not only their own operations and investments, but also those of other firms in their production network even when suppliers or clients are not directly subject to a carbon price themselves. This could be directly through a price effect, but also through changes in the production process or market structure. This project uses a unique dataset for Belgium to explore how the EU's carbon price and its recent surge affects low- carbon innovation, productivity and GHG emissions intensity across the entire production network in the industrial sector by using typical shock propagation approaches. We will also include other shocks to the Belgian economy to understand potential combined effects. Such an analysis will not only inform the economic dynamics of decarbonisation, it will also be important evidence in the design of policies to cute hard-to-abate emissions in industrial sectors such as cement, limestone or steel who still produce substantial quantities of combustion and process emissions, and whose ability to mitigate these might depend on the firms upstream and downstream. With carbon markets being considered as the key policy tool in many countries, leveraging insights from production networks is key for designing future climate policy on the way towards climate neutrality. The talk is based on joint works with Ralf Martin and Thomas Stoerk.

Aneesh Raghunandan is Assistant Professor in the accounting department at the London School of Economics. His research focuses on environmental, social, and governance ("ESG") issues, with an emphasis on measurement issues and the extent to which stated private- and public-sector efforts to measure and improve ESG performance result in actual change. His work has been published in top journals and cited extensively in leading media outlets such as the Financial Times, Wall Street Journal, Bloomberg, and The Economist. He has also served as an expert witness before the UK Parliament on ESG reporting issues. He received his PhD from Stanford University and BSc from Yale University.

Emissions measurement issues in empirical asset pricing. Academic and practical evidence is mixed on whether a carbon risk premium exists in financial markets. I discuss one reason for this mixed evidence: measurement issues related to firm-level carbon emissions data. Within this context, I focus on three main issues. First, what are some issues and areas for discretion underlying how firms measure their own emissions, and how might this lead to difficulties in comparing firms? Second, many users of emissions databases are unaware of the fact that much of the data is estimated by the vendor rather than actually provided by firms – and that using estimated data in this context lead a user to draw different conclusions. Third, even assuming one can resolve the first two issues, what specific metric(s) should be used to assess a firm's emissions performance within the context of both its peers and society more generally?

Qihe Tang is Professor of Actuarial Science at UNSW Business School, Sydney. After earning his PhD in statistics from the University of Science and Technology of China in 2001, he has worked at different places around the world including the University of Hong Kong (2001), the University of Amsterdam (2002-2004), Concordia University (2004-2005), and the University of Iowa (2006-2019). At the University of Iowa, he was promoted to Full Professor in 2012 and conferred an Endowed Chair in 2014. He joined UNSW Business School under the SHARP (Strategic Hires and Retention Pathways) scheme in July 2017. His expertise centres on extreme value theory for insurance, finance, and risk management. Recently, he has been working on various topics at the intersection of insurance, finance, applied probability, and operations research.
He has been the Principal Investigator/Lead Chief Investigator of various major grants from the Australian Research Council, U.S. National Science Foundation, NSERC of Canada, National Natural Science Foundation of China and Society of Actuaries. He is an Editor of the journal *Insurance: Mathematics and Economics*, and an Associate Editor of several other major journals. He is an Elected Member of the International Statistical Institute.

Understanding compound weather and climate events through the lens of systemic financial crises. Climate change has emerged as one of the greatest global challenges of our time. One of the most concerning risks of climate change is the potential for compound events (CEs) to increase, where multiple climate drivers and/or hazards interact with each other in a complex manner, leading to amplified impacts on the physical environment, human systems, and ecosystems. To achieve a quantitative understanding of CEs, we develop a modeling framework that comprises climate drivers, hazard events, and damages and addresses the stochastic nature of CEs. Motivated by recent studies on complex financial networks and the long-standing concept of systemic risk, we liken CEs to systemic crises in complex financial networks. Despite apparent differences between the two concepts, CEs and financial crises share strong similarities. CEs are influenced by climate change, which, in turn, is caused by carbon emissions. Similarly, financial crises are driven by factors like excessive risk-taking, macroeconomic imbalances, and regulatory failures, all of which can be traced back to human greed. Therefore, some of their similarities may be attributed to their common anthropogenic nature. The fully stochastic and dynamic nature of our modeling framework makes it feasible to accommodate some important features of CEs, such as spatio-temporal dependencies, causal chains, feedback loops, tipping points, nonlinearity, and deep uncertainty.

Peter Tankov is Professor of Quantitative finance at ENSAE, the French national school for statistics and economic administration, having previously worked at Paris-Cite university and Ecole Polytechnique. He is a mathematician, specialist in applied probability and stochastic processes. His current research interests include quantitative finance, energy finance, and green and sustainable finance. Peter is the author of over 50 research articles on these and other topics and of the widely read book, Financial Modelling with Jump Processes. He is the recepient of the 2016 Best Young Researcher in Finance award of the Europlace Institute of Finance and the principal investigator of several national grants. Peter is the scientific director of the Green and Sustainable Finance Research Program at Louis Bachelier Institute and member of editorial boards of the quantitative finance journals Mathematical Finance and Finance and Stochastics.

Asset pricing under transition scenario uncertainty. Risks and opportunities related to environmental transition are usually evaluated through the use of scenarios, produced and maintained by international bodies such as the International Energy Agency or the Network for Greening the Financial System (NGFS). This approach assumes perfect knowledge of the scenario by the agent, but in reality, scenario uncertainty is an important obstacle for making optimal investment or divestment decisions. In this talk we present two studies of the impact of transition scenario uncertainty on the optimal financial decision-making and asset pricing.

In the first study, we develop a real-options approach to evaluate assets and potential investment projects under dynamic climate transition scenario uncertainty. We use off-the-shelf Integrated Assessment Model (IAM) scenarios and assume that the economic agent acquires the information about the scenario progressively by observing a signal, such as the carbon price or the greenhouse gas emissions. The problem of valuing an investment is formulated as an American option pricing problem, where the optimal exercise time corresponds to the time of entering a potential investment project or the time of selling a potentially stranded asset. To illustrate our approach, we employ representative scenarios from the NGFS scenario database in two energy-related examples: the divestment decision from a coal-fired power plant without Carbon Capture and Storage (CCS) technology and the potential investment into a green coal-fired power plant with CCS.

In the second study, we develop a structural model for pricing a defaultable bond issued by a company subject to climate transition risk. We assume that the magnitude of the transition risk impacts depends on a transition scenario, which is initially unknown but is progressively revealed through the observation of the carbon price trajectory. The bond price, credit spread and optimal default/restructuring thresholds are then expressed as function of the firm's revenue level and the carbon price. Numerical implementation of the resulting formulas is discussed and illustrated using real data. Our results show that under transition scenario uncertainty, carbon price adjustments are more likely to trigger a default than when the true scenario is known because after each adjustment the more environmentally stringent scenario becomes more likely. We also find that faster discovery of scenario information leads to higher credit spreads since better information allows the shareholders to optimize the timing of default, increasing the value of default option and decreasing the bond price.

This talk is based on the following papers: Green Investment and Asset Stranding Under Transition Scenario Uncertainty (joint with Maria Flora) https://ssrn.com/abstract=4084302 and Corporate Debt Value under Transition Scenario Uncertainty (joint work with Théo Le Guenedal) https://ssrn.com/abstract=4152325.

Jinggong Zhang is an assistant professor in Nanyang Business School at Nanyang Technological University, Singapore. He obtained his PhD in actuarial science at the University of Waterloo. He is a Fellow of the Society of Actuaries and he was a Society of Actuaries James C. Hickman Scholar during 2015-2018. His research interests include actuarial science, risk management and predictive analytics. He has published in top academic journals including Management Science, Insurance: Mathematics and Economics, European Journal of Operational Research, ASTIN Bulletin, North American Actuarial Journal.

Wenjun Zhu (PhD, FSA, CERA) is an assistant professor in Nanyang Business School at Nanyang Technological University, Singapore. She received her Ph.D. in the Department of Statistics and Actuarial Science, University of Waterloo in 2015. As the first student admitted to the PhD program without a Master's degree in the department, Dr. Zhu holds double Bachelor's degree in Economics as well as Mathematics. She is a Fellow of the Society of Actuaries (FSA) and a Chartered Enterprise Risk Analyst (CERA). She is also a winner of the Society of Actuaries James C. Hickman Scholar (2013-15). Wenjun has been publishing in leading academic journals such as the Management Science, Journal of Risk and Insurance, North American Actuarial Journal, Insurance: Mathematics and Economics, ASTIN Bulletin, Journal of Banking & Finance. Her research interests include climate change, weather risks and agricultural insurance, predictive analytics with machine learning, and longevity risk management.

Integrated Design for Index Insurance. Weather index insurance (WII) is a promising tool for agricultural risk mitigation, but its popularity is often hindered by challenges of product design, such as basis risk, weather index selection and product complexity issues. In this paper we develop machine learning methodologies to design the statistically optimal WII to address those critical concerns in the literature and practice. The idea from tree-based models is exploited to simultaneously achieve weather variable selection and payout function determination, leading to effective basis risk reduction. The proposed framework is applied to an empirical study where high-dimensional weather variables are adopted to hedge soybean production losses in Iowa. Our numerical results show that the designed insurance policies are potentially viable with much lower government subsidy, and therefore can enhance social welfare.