Functional Analytic tools for Financial Decision Making
Outils d'analyse fonctionnelle pour la prise de décision financière
(Org: **Mario Ghoussoub** and/et **David Saunders** (University of Waterloo))

MATT DAVISON, Western University
Data Science Insights and financial models about the Financial Behaviour of Canadians

I will describe the Financial Wellness Lab of Canada together with three groups of insights we have obtained during the last few years. 1) I will describe a cluster-based quantification of the real and self-perceived financial status of Canadian families, obtained from a comprehensive repeated survey of a large number of Canadians. 2) I will present an analysis of a voluminous database containing the trading behaviour of all of the clients of a financial management firm which allows the comparison of actual risk taken by Canadian investors with their stated risk appetite. 3) The same database also allows an assessment of the relative value of savings behaviour and market decisions in the wealth building process, which is the third example. I close with some outlooks on next steps and projects for our lab. This is is the work of many colleagues most notably Adam Metzler (Laurier) and Chuck Grace (Western) as well as many others to be named in the presentation.

GENEVIÈVE GAUTHIER, HEC Montréal
Joint dynamics for the underlying asset and its implied volatility surface: A new methodology for option risk management

This paper develops a dynamic joint model of the implied volatility (IV) surface and its underlying asset which is tractable and seamless to estimate. It combines an asymptotically well-behaved, parametric IV surface representation with a two-component variance, and non-Gaussian asymmetric GARCH specification for the underlying asset returns. Estimated on S&P500 index return and option data for the 1996-2020 period, the model captures the IV surface movements well and uses them to obtain an improved fit on index returns. It also proves to be an effective risk management tool, producing reliable Value-at-Risk estimates for straddle and strangle positions, and accurate forecasts of the VIX distribution.

JONATHAN LI, Telfer School of Management, University of Ottawa
On Generalization and Regularization via Wasserstein Distributionally Robust Optimization

Wasserstein distributionally robust optimization (DRO) has found success in operations research and machine learning applications as a powerful means to obtain solutions with favourable out-of-sample performances. Two compelling explanations for the success are the generalization bounds derived from Wasserstein DRO and the equivalency between Wasserstein DRO and the regularization scheme commonly applied in machine learning. Existing results on generalization bounds and the equivalency to regularization are largely limited to the setting where the Wasserstein ball is of a certain type and the decision criterion takes certain forms of an expected function. In this paper, we show that by focusing on Wasserstein DRO problems with affine decision rules, it is possible to obtain generalization bounds and the equivalency to regularization in a significantly broader setting where the Wasserstein ball can be of a general type and the decision criterion can be a general measure of risk, i.e., nonlinear in distributions. This allows for accommodating many important classification, regression, and risk minimization applications that have not been addressed to date using Wasserstein DRO. Our results are strong in that the generalization bounds do not suffer from the curse of dimensionality and the equivalency to regularization is exact. As a byproduct, our regularization results broaden considerably the class of Wasserstein DRO models that can be solved efficiently via regularization formulations.

LUKA MILIC, Toronto Metropolitan University
Investment Strategies in the Face of Climate Uncertainty: Balancing Transition and Physical Risks

In this research, we study the influence of climate change on portfolio construction, focusing on the dual impact of transition and physical risks. We develop a dynamic model that integrates a two-factor mean-reverting framework to represent global

temperature variations and transition factors related to climate change. The model is used to examine the optimal stock-bond-cash portfolio selection in a context marked by climate uncertainty. Our approach entails deriving an optimal investment strategy in closed form, initially formulated without considering climate uncertainty. The study also addresses the limitations inherent in a mean-reverting climate assumption and suggests the potential application of Energy Balance Models (EBMs) for a more accurate representation of the climate system. These EBMs open the avenue for leveraging advanced deep-learning techniques for optimal portfolio allocation. The results highlight the critical impact of climate uncertainty on investment strategies, advocating for the integration of climate risk considerations in portfolio management.

MARLON MORESCO, Concordia University
Uncertainty Propagation and Dynamic Robust Risk Measures

We introduce a framework for quantifying propagation of uncertainty arising in a dynamic setting. Specifically, we define dynamic uncertainty sets designed explicitly for discrete stochastic processes over a finite time horizon. These dynamic uncertainty sets capture the uncertainty surrounding stochastic processes and models, accounting for factors such as distributional ambiguity. Examples of uncertainty sets include those induced by the Wasserstein distance and f-divergences. We further define dynamic robust risk measures as the supremum of all candidates' risks within the uncertainty set. In an axiomatic way, we discuss conditions on the uncertainty sets that lead to well-known properties of dynamic robust risk measures, such as convexity and coherence. Furthermore, we discuss the necessary and sufficient properties of dynamic uncertainty sets that lead to time-consistencies of robust dynamic risk measures. We find that uncertainty sets stemming from f-divergences lead to strong time-consistency while the Wasserstein distance results in a new notion of non-normalised time-consistency. Moreover, we show that a dynamic robust risk measure is strong or non-normalised time-consistent if and only if it admits a recursive representation of one-step conditional robust risk measures arising from static uncertainty sets.

SAMUEL SOLGON SANTOS, University of Waterloo
Inducing comonotonic additive risk measures from acceptance sets

We present general conditions on the acceptance sets under which their induced risk and deviation measures are comonotonic additive. We show that an acceptance set generates a comonotonic additive risk measure if and only if the acceptance set and its complement are closed for convex combinations of comonotonic random variables. This result generalizes to risk measures that are additive for random variables with *a priori* specified dependence structures, e.g., perfectly correlated, uncorrelated, or independent random variables.

TONY WARE, University of Calgary
Operator splitting and optimal control of gas storage

We consider a natural gas storage facility where the gas is to be traded on a mixture of spot and forward markets. The problem of determining the optimal operating and marketing strategy for such a facility, and its associated value, is complicated by the range of potential markets for the gas, and by the physical characteristics of the facility which create state-dependent constraints on the allowable injection/withdrawal rates. In [SIAM JFM 4(1) 427-451, 2013] we proposed an operator-splitting approach for time-discretisation of the associated HJB equation in a simple one-factor spot price model, and proved convergence to the viscosity solution. Here we expand that approach to a multi-factor polynomial process setting, where the application of one of the operators corresponds to a set of intrinsic value computations exploiting the structure of the forward curve with injection/withdrawal rates conforming to system constraints.