Finance and Technology Programme

Report 2024

Vision

We aim to combine deep expertise in finance — including asset pricing, risk management, financial econometrics, derivatives, fixed income markets, and credit risk modeling — with cutting-edge technology disciplines such as data science, machine learning, artificial intelligence, computational science, cryptography, and information technology.

Team

ACADEMIC DIRECTOR
Prof. Damir Filipovic

POSTDOCS & PhD STUDENTS
Andrea Della Vecchia
Urban Ulrych
Nicolas Camenzind
Paolo Colusso
Joshua Hayes
Quentin le Moal
Andrea Ruglioni

Scientific Highlights

The Finance and Technology Programme team continued to broaden and intensify its research activities at the intersection of finance, financial engineering, and technology. These include:

(i) a technical framework for estimating the yield curve underlying the Swiss Solvency Test for insurance companies, developed in collaboration with a working group from the insurance industry and in coordination with a technical team from FINMA;

(ii) a new method for the joint estimation of yield curves using transfer learning;

(iii) foundational results on linear factor models, including conditions under which an unbalanced asset panel can be spanned by low-dimensional factor portfolios;

(iv) a new nonparametric, kernel-based joint estimator for conditional mean and covariance matrices in large and unbalanced panels;

(v) a rigorous framework for error propagation in stochastic optimal control problems using machine learning;

(vi) a new method for parsimonious online learning with random features;

among other contributions.

Another highlight was the Swissquote "Quant Talk", a knowledge exchange workshop held at Swissquote in May 2024. The event was well attended by Swissquote quants and members of our team. Beyond that, all team members remained active in dissemination, presenting our work at international conferences and seminars.

Research Activities

The research activities have focused on advancing the application of machine learning and statistical modeling in finance, with particular emphasis on developing data-driven models to enhance decision-making and improve risk management strategies in the financial sector.

We finalized and submitted the drafts of two joint projects with Paul Schneider, a researcher at the University of Lugano:

In Fundamental Properties of Linear Factor Models, we provide a comprehensive foundation for the specification and estimation of conditional linear factor models. In particular, we show how the conditional mean-variance efficient portfolio of an unbalanced asset panel can be spanned by low-dimensional factor portfolios.

In Joint Estimation of Conditional Mean and Covariance for Unbalanced Panels, we develop a nonparametric, kernel-based joint estimator for conditional mean and covariance matrices in large and unbalanced panels. In an extensive empirical study of monthly U.S. stock returns from 1962 to 2021, we find that idiosyncratic risk explains, on average, more than 75% of the cross-sectional variance.

Further research has concentrated on the estimation of unobservable discount curves, primarily through a transfer learning approach. *The paper entitled Stripping the Swiss discount curve using kernel ridge regression*, published in the *European Actuarial Journal (EAJ)*, presents a comprehensive empirical analysis of the Swiss government bond market.

This publication received the **2024 EAJ Best Paper Award / GAUSS Prize** from the German Society of Insurance and Financial Mathematics (DGVFM) and the German Actuarial Association (DAV).

https://actu.epfl.ch/news/gauss-prize-for-prof-damir-filipovic-and-nicolas-c/

Findings from this research have informed the work of the Swiss Association of Actuaries (SAV) Working Group on Yield Curves, where the methodology has been extended to encompass various fixed income instruments, including swaps and government bonds across multiple markets. A significant theoretical advancement has been the development of a framework for the joint estimation of multiple discount curves — using transfer learning — both within a single currency and across different currencies. This approach is also being applied in a collaborative project with Markus Pelger and Rose Wang, researchers at Stanford University, focusing on international government bond markets and the construction of a comprehensive dataset of yield curves of the G10 currencies.

Additional work has addressed the extrapolation of yield curves. A forthcoming paper introduces a method based on arbitrage-free interest rate models, offering a parsimonious yet flexible framework capable of adapting to a range of market environments. By construction, the model incorporates stationary economic conditions to ensure long-term stability. The results from these research activities are again shared with Swiss insurance industry practitioners and FINMA, providing the technical input for selecting the new yield curve that will underlie the Swiss Solvency Test from 2027 onwards.

Current work includes a project utilizing deep Gaussian processes to construct a probabilistic linear factor model. This model aims to identify the key factors influencing stock returns, addressing fundamental questions such as: How many factors shape market behavior? What characteristics define these factors? How do these factors evolve over time?

While Paolo Colusso completed his PhD on *Function Learning with Financial Applications* and left EPFL in October 2024, the Finance and Technology Programme welcomed three new members: one postdoctoral researcher (Andrea Della Vecchia), bringing expertise in kernel-based machine learning from the University of Genova, and two new PhD students (Joshua Hayes and Andrea Ruglioni), who are working on the aforementioned projects on yield curve extrapolation and machine learning and statistical modeling in finance.

Events

KNOWLEDGE EXCHANGE WORKSHOPS

Swissquote "Quant talk"
(D. Filipovic, U. Ulrych), May, 2024
- "Smart Kernel Factors" joint project of U. Ulrych, P. Collin-Dufresne and D. Filipovic
- "Large Language Models" a brief introduction to LLMs and their usage at Swissquote from Oksana Bashchenko (Swissquote)

Dissemination

Publications

- **Dynamic Currency Hedging with Non-Gaussianity and Ambiguity**
  (P. Polak and U. Ulrych) *Quantitative Finance*, 24(2): 305-327, 2024 (SSRN)

- **Portfolio Construction with Hierarchical Momentum**
  (A. Cirulli, M. Kobak and U. Ulrych) *The Journal of Portfolio Management*, 50(4): 136-159, 2024.
  (SSRN)

- **Stripping the Swiss discount curve using kernel ridge regression**
  (N. Camenzind and D. Filipovic) *European Actuarial Journal*, Vol.14: 371-410, 2024
  (EAJ) (SharedIt) (SSRN)
  GAUSS-Prize/Best Paper Award of the European Actuarial Journal 2024

- **StockTwits Classified Sentiment and Stock Returns**
  (M. Divernois and D. Filipovic), Digital Finance, 6, 249-281, 2024 (*Digit Finance*) (SSRN)

PhD Theses

- **Function Learning with Financial Applications.**
  P. Colusso, D. Filipovic (dir.), EPFL Lausanne. 2024. (Infoscience)

Working Papers

- **Fundamental properties of linear factor models**
  (D. Filipovic and P. Schneider), Revise & Resubmit for *Review of Financial Studies*, 2024 (SSRN) (arXiv)

- **Global Currency Hedging with Ambiguity**
  (U. Ulrych and N. Vasiljević), 2024 (SSRN)

- **Kernel Conditional Factor Models**
  (P. Collin-Dufresne, D. Filipović and U. Ulrych), 2024

- **Joint Estimation of Conditional Mean and Covariance for Unbalanced Panels**
  (D. Filipovic and P. Schneider), 2024 (SSRN) (arXiv)

- **Neural Control Systems**
  (P. Colusso and D. Filipovic), 2024 (arXiv)

- **Regularized Multi-Currency Expected Shortfall Portfolios**
  (P. Lucescu and U. Ulrych), 2024

- **Shrinking Expected Shortfall Portfolios**
  (A. Cirulli and U. Ulrych), 2024

- **Sparse Portfolio Selection via Topological Data Analysis based Clustering**
  (D. Filipovic, A. Goel and P. Pasricha), Revise & Resubmit for Quantitative Finance, 2024 (SSRN) (arXiv)

Selected Conference Presentations

- **"Kernel Methods with Applications in Finance and Statistics,** CMS Colloquium, Stockholm Mathematics Centre, 20 March 2024, (D. Filipovic)

- **Smart Kernel Factors, International Conference on Computational Finance ICCF24,** CWI, Amsterdam, 2-5 April 2024, (U. Ulrych)

- **Learning the Moment Kernel: Nonparametric Conditional Mean and Covariance Estimation for Unbalanced Panels,** The OMI Machine Learning in Quantitative Finance Conference, Oxford, 6 June 2024, (D. Filipovic)

- **Smart Kernel Factors, 12th Bachelier World Congress of the Bachelier Finance Society,** FGV EMAp, Rio de Janeiro, 8-12 July 2024, (U. Ulrych)

- **Kernel Conditional Factor Models, 39th meeting of the European Economic Association and the 75th European meeting of the Econometric Society EEA-ESEM,** Erasmus University Rotterdam, 26-30 August 2024, (U. Ulrych)

- **Kernel Conditional Factor Models, Probability Day,** University of Ljubljana, 23 December 2024, (U. Ulrych)

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