CHAIR FINANCIAL RISKS

Partners : Ecole Polytechnique - Ecole des ponts - Sorbonne Université – Société Générale

Scientific director: Nicole El Karoui (Sorbonne Université)

Website: https://www.institutlouisbachelier.org/programme/risques-financiers/

RESEARCH PROGRAM DESCRIPTION

The research topics for 2023 are:

- New modeling challenges: modeling contagion and systemic risk; dependence modeling; valuation, hedging and robustness; credit risk; long term risk and longevity risk.
- Numerical methods and simulations: extreme risks; market imperfections and non-linear equations; efficient simulation techniques.
- High frequency: statistics and optimal management, connection to regulation

RESEARCH TEAM

Permanent members

- ENPC:
  - Aurélien Alfonsi, Professor at ENPC, Part-time Assistant Professor at Ecole Poly- technique
  - Benjamin Jourdain, Professor at ENPC
- Ecole polytechnique:
  - Eduardo Abi Jaber, Assistant Professor at Ecole Polytechnique
  - Charles Bertucci, CNRS Researcher at Ecole Polytechnique
  - Stefano De Marco, Associate Professor at Ecole Polytechnique
  - Fabrice Djete, Assistant Professor at Ecole Polytechnique
  - Emmanuel Gobet, Professor at Ecole Polytechnique
  - Nizar Touzi, Professor at Ecole Polytechnique (on leave from 2023, October 1st to NYU)
- LPSM, Sorbonne University:
  - Lokman Abbas-Turki, Assistant Professor at Sorbonne University
  - Nicole El Karoui, Researcher at Ecole Polytechnique, Emeritus Professor at Sorbonne University
  - Idris Kharroubi, Professor at Sorbonne University

- Daphné Giorgi, research engineer entirely funded by the Chaire Risques financiers, now CNRS research engineer at the LPSM.
- Vincent Lemaire, Assistant Professor at Sorbonne University
- Gilles Pagès, Professor at Sorbonne University

Associate researchers

Ecole Polytechnique

- Sergio PULIDO (Université d'Evry). Fractionnal models for volatility dynamics.
- Claudio FONTANA (Associate Professor, University of Padova). Interest rate modelling.

Ecole des Ponts

- Ahmed KEBAIER (Professor at Université d'Evry) is part-time researcher at CERMICS. He is working on the discretization of rough diffusions and Monte-Carlo methods for Bermudan options with A. Alfonsi.

Post-docs

- Guillaume Szulda (ENPC). Guillaume works on Stochastic Volterra Equations with jumps that extend CBI processes such as the α-CIR process.

Doctoral students

- **Completed PhDs**

1. Mouna BEN DEROUICHE, supervised by A. Kebaier and M. Mnif (ENIT, Tunisia). Title: "Improved multi level Monte Carlo methods for pricing barrier op- tions in finance". Defended on December 15th, 2023.
2. Pierre BRAS (supervised by G. Pagès). Title: "Simulated annealing with multiplicative noise Gibbs measure". Defended on September 14th, 2023.
3. Jérémy CHICHEPORTICHE (co-supervised by R. Elie (Marne-La-Vallée) and I. Kharroubi), CIFRE Bramham Gardens. "Quelques applications d'algorithmes d'apprentissage en finance quantitative". Defended on March 10th, 2023.
4. Roberta FLENGHI (supervised by B. Jourdain) Title: "Central limit theorems for nonlinear functionals of the empirical measure and for stratified resampling". De- fended on december 20th, 2023.
5. Arianna MINGONE (supervised by S. de Marco and C. Martini, CIFRE with Zeliade Systems). Title: "Advanced implied volatility modeling for risk management and central clearing". Defended on November 21st, 2023.
6. Antonio OCELLO (supervised by I. Kharroubi). Title: "Optimisation dynamique des processus de ramification : le point de vue du contrôle stochastique sur les systèmes de particules et leurs limites d'échelle". Defended on november 20th, 2023.
7. Nerea VADILLO FERNANDEZ (supervised by A. Alfonsi, CIFRE AXA Climate), Title: "Risk valuation for weather derivatives related to the energy market". Defended on January 11th, 2024.

8. Wanqing WANG* (supervised by E. Gobet, funded by Chinese Research Council and Chaire Financial Risks), Title: "Approximation et simulation des équations dif- férentielles stochastiques rétrogrades réfléchies, applications en finance". Defended on November 11th, 2023.

- Ongoing PhDs

1. Hervé ANDRES (supervised by B. Jourdain), CIFRE Milliman, 3rd year PhD student. Topic: Dependence modelling in economic scenario generation for insurance, started in June 2021.
2. Leila BASSOU (supervised by N. Touzi), 4th year PhD student. Topic: Systemic risk modelling by stochastic differential games and mean field games, started in Jan. 2020.
3. Guillaume BOUTOILLE (supervised by G. Pagès), 4th year PhD student. Topic:"Unsupervised learning applied to the detection and classification of features in images ", started in Oct. 2020.
4. Sharu CHARDUL (supervised by E. Gobet and A. Richou), 4th year PhD student. Title: "Mean-field infinite horizon stochastic control and numerical approximation of infinite horizon backward stochastic differential equations", started in October 2020.
5. Jules DELEMOTTE (supervised by S. de Marco and M. Rosenbaum, CIFRE with 80 Technologies), 2nd year PhD student. Dynamique du smile et modèles à volatilité rough, started in October 2022.
6. Aurélien GRENARD (supervied by S. Crépey, L. Abbas-Turki and G. Pagès), 3rd year PhD student. Machine Learning et modèles génératifs pour le pricing et la couverture d'instruments financiers, started in October 2021.
7. Edoardo LOMBARDO (supervised by A. Alfonsi and L. Caramellino (U. Tor Vergata Roma)), 4th year PhD student. Topic:"High order numerical approximation for some singular stochastic processes and related PDEs", started in November 2020.
8. Alexandre PREVOT (supervised by N.El Karoui, G.Pagès) (Disabled Student) 4th year PhD student. Topic: "Population dynamics in random environment". Alexandre investigates the impact of uncertainty environment on the population dynamics. Starting with Poisson and Birth processes filtering equations are established and analyzed. The consequences in terms of heteregeneous populations are interpreted and simulated. The general study is still in progress, with delay due to serious health problems during this year.
9. Djibril SARR (supervied by A. Kebaier and M. Ben Alaya), 4th year PhD CIFRE student with FBH Associés. Interest rate and credit spread modeling and calibration using deep learning, started in February 2021.
10. Nathan SAULDUBOIS (supervied by N. Touzi), 2nd year PhD student. Hedging under Market place, started in October 2022.
11. Kexin SHAO (supervised by B. Jourdain and A. Sulem), 3rd year PhD student. Topic: Martingale optimal transport and financial applications, started in October 2021
12. Songbo WANG (supervied by Z. Ren and N. Touzi), 3nd year PhD student. Mean field Langevin equation and neural networks, started in October 2021.
13. Christian YEO (supervised by V. Lemaire & G. Pagès), 3rd year PhD student. Valorisation et couverture d'options de type swing, started in October 2021.

- New PhDs

1. Marius CHEVALLIER (supervised by S. De Marco and P.E. Levy-dit-Véhel,

CIFRE with Société Générale), 1st year PhD student. Arbitrabilité et cohérence des déformations dans les métriques de risque de marché et de contrepartie, started in October 2023.

2. Mathieu TRUC (supervised by V. Lemaire & G. Pagès), 1st year PhD student. Méthode multilevel pour valcul de capital économique, started in October 2023.

PUBLICATIONS OF THE YEAR DIRECTLY RELATED TO THE RESEARCH PROGRAM

Published papers

[1] L. Abbas-Turki, S. Crépey, and B. Saadeddine, *Pathwise CVA regressions with oversimulated defaults*, Math- ematical Finance **33** (2023), no. 2, 274–307.

[2] E. Abi Jaber and Shaun Xiaoyuan Camille and Li, *The quintic Ornstein-Uhlenbeck volatility model that jointly calibrates SPX & VIX smiles*, Risk Magazine (2023).

[3] A. Alfonsi and V. Bally, *Construction of Boltzmann and McKean Vlasov type flows (the sewing lemma approach)*, Annals of Applied Probability **33** (2023), no. 5, 3351–3386.

[4] A. Alfonsi, B. Lapeyre, and J. Lelong, *How many inner simulations to compute conditional expectations with least-square Monte Carlo?*, Methodology and Computing in Applied Probability **25** (2023), no. 3.

[5] A. Alfonsi and E. Lombardo, *High order approximations of the Cox-Ingersoll-Ross process semigroup using random grids*, IMA Journal of Numerical Analysis (2023).

[6] C. Alasseur, M. Basei, C. Bertucci, and A. Cecchin, *A mean field model for the development of renewable capacities*, Math. Finan. Econ. **17** (2023), 695–719.

[7] M. Allouche, S. Girard, and E. Gobet, *Estimation of extreme quantiles from heavy-tailed distributions with neural networks*, Statistics and Computing **34** (2023), no. 12, 1–35.

[8] M. Allouche, E. Gobet, C. Lage, and E. Mangin, *Structured Dictionary Learning of Rating Migration Matrices for Credit Risk Modeling*, Computational Statistics, posted on 2023, DOI s00180-023-01449-y.

[9] M. Beiglböck, B. Jourdain, W. Margheriti, and G. Pammer, *Stability of the weak martingale optimal transport problem*, Ann. Appl. Probab. **33** (2023), no. 6B, 5382–5412.

[10] M. Ben Alaya, K. Hajji, and A. Kebaier, *Adaptive importance sampling for multilevel Monte Carlo Euler method*, Stochastics **95** (2023), no. 2, 303–327. MR4557682

[11] C. Bénézet, E. Gobet, and R. Targino, *Transform MCMC schemes for sampling intractable factor copula models*, Methodology and Computing in Applied Probability **25** (2023), no. 1, 13.

[12] C. Bertucci, *Monotone solutions for mean field games master equations : continuous state space and common noise*, Communications in Partial Differential Equations (2023), 1-41.

[13] F. Bourgey, S. de Marco, P. Friz, and P. Pigato, *Local volatility under rough volatility*, Mathematical Finance **33** (2023), no. 4, 1119-1145, DOI 10.1111/mafi.12392.

[14] F. Bourgey, S. De Marco, and E. Gobet, *Weak approximations and VIX option price expansions in forward variance curve models*, Quantitative Finance **23** (2023), no. 9, 1259-1283.

[15] P. Bras and G. Pagès, *Convergence of Langevin-simulated annealing algorithms with multiplicative noise*, Math. Comp. **93** (2024), no. 348, 1761–1803.

[16] _____, *Convergence of Langevin-simulated annealing algorithms with multiplicative noise II: Total variation*, Monte Carlo Methods Appl. **29** (2023), no. 3, 203–219.

[17] J. Chichportich and I. Kharroubi, *Discrete-Time Mean-Field Stochastic Control with Partial Observations*, Applied Mathematics & Optimization **80** (2023), no. 90.

[18] F. Djete, *Large population games with interactions through controls and common noise: convergence results and equivalence between open-loop and closed-loop controls*, ESAIM: Control, Optimisation and Calculus of Variations **29** (2023), 39.

[19] M. Echenim, E. Gobet, and A.-C. Maurice, *Unbiasing and robustifying implied volatility calibration in a cryptocurrency market with large bid-ask spreads and missing quotes*, Quantitative Finance **23** (2023), no. 9, 1285-1304.

[20] O.P. Faugeras and G. Pagès, *Risk quantization by magnitude and propensity*, Insurance Math. Econom. **116** (2024), 134–147.

[21] E. Gobet and C. Lage, *Optimal ecological transition path of a credit portfolio distribution, based on multidate Monge–Kantorovich formulation*, Annals of Operations Research (2023), 1–35.
[22] K. Hu, Z. Ren, and N. Touzi, *On path-dependent multidimensional forward-backward SDEs*, Numerical Al- gebra, Control and Optimization **13** (2023), no. 3&4, 413–430.
[23] B. Jourdain, W. Margheriti, and G. Pammer, *Lipschitz continuity of the Wasserstein projections in the convex order on the line*, Electronic Communications in Probability **28** (2023), 1–13.
[24] S. Kaakai and N. El Karoui, *Birth Death Swap population in random environment and aggregation with two timescales*, Stochastic Processes and their Applications **162** (2023), 218–248.
[25] M. Laurière and G. Pagès and O. Pironneau, *Performance of a Markovian neural network versus dynamic programming on a fishing control problem*, Probab. Uncertain. Quant. Risk **8** (2023), no. 1, 121–140.
[26] G. Pagès and F. Panloup, *Unadjusted Langevin algorithm with multiplicative noise: Total variation and Wasserstein bounds*, The Annals of Applied Probability **33** (2023), no. 1, 726–779.
[27] G. Pagès and C. Rey, *Discretization of the Ergodic Functional Central Limit Theorem*, Journal of Theoretical Probability (2023), 1–44.
[28] Y. Liu and G. Pagès, *Functional convex order for the scaled McKean-Vlasov processes*, Ann. Appl. Probab. **33** (2023), no. 6A, 4491–4527.
[29] M. Talbi, N. Touzi, and J. Zhang, *Viscosity solutions for obstacle problems on Wasserstein space*, SIAM Journal on Control and Optimization **61** (2023), no. 3, 1712-1736.

Accepted papers

[30] A. Alfonsi and A. Kebaier, *Approximation of Stochastic Volterra Equations with kernels of completely mono- tone type*, Mathematics of Computation **93** (2024), no. 346, 643–677.
[31] A. Alfonsi and N. Vadillo, *A stochastic volatility model for the valuation of temperature derivatives*, IMA Journal of Management Mathematics (2024).
[32] H. Andrès, A. Boumezoued, and B. Jourdain, *Signature-based validation of real-world economic scenarios*, ASTIN Bulletin.
[33] R. Flenghi and B. Jourdain, *Central limit theorem over non-linear functionals of empirical measures: beyond the iid setting*, Annales de l'Institut Henri Poincaré (B) Probabilités et Statistiques.
[34] B. Jourdain and S. Menozzi, *Convergence rate of the Euler–Maruyama scheme applied to diffusion processes with L^q-L^ρ drift coefficient and additive noise*, The Annals of Applied Probability **34** (2024), no. 1B, 1663– 1697.
[35] B. Jourdain and G. Pagès, *Convex ordering for stochastic Volterra equations and their Euler schemes*, Finance and Stochastics.
[36] B. Jourdain and G. Pammer, *An extension of martingale transport and stability in robust finance*, Electron. J. Probab. **29** (2024).
[37] J. Keppo, N. Touzi, and R. Zuo, *Dynamic Contracting in Asset Management under Investor-Partner-Manager Relationship*, Operations Research (2024)
[38] I. Kharroubi and A. Ocello, *A Stochastic Target Problem for Branching Diffusions*, Stochastic Processes and their Applications (2024).
[39] V. Lemaire and G. Pagès and C. Yeo, *Swing contract pricing: With and without neural networks*, Frontiers of Mathematical Finance, posted on 2024, DOI 10.3934/fmf.2024007.

Preprints

[40] E. Abi Jaber and Nathan de Carvalho, *Reconciling rough volatility with jumps*, HAL preprint hal-04295416 (2023).
[41] E. Abi Jaber and Eyal and Voss Neuman Moritz, *Equilibrium in Functional Stochastic Games with Mean- Field Interaction*, HAL preprint hal-04119787 (2023).
[42] A. Alfonsi, *Nonnegativity preserving convolution kernels. Application to Stochastic Volterra Equations in closed convex domains and their approximation*, arXiv preprint arXiv:2302.07758 (2023).

[43] A. Alfonsi and N. Vadillo, *Risk valuation of quanto derivatives on temperature and electricity*, arXiv preprint arXiv:2310.07692 (2023).
[44] M. Allouche, M. Echenim, E. Gobet, and A.C. Maurice, *Statistical error bounds for weighted mean and median, with application to robust aggregation of cryptocurrency data*, HAL preprint hal-04017151 (2023).
[45] H. Andrès, A. Boumezoued, and B. Jourdain, *Path-dependent implied volatility surfaces*, arXiv preprint arXiv:2312.15950 (2023).
[46] M. Ben Alaya, A. Kebaier, and D. Sarr, *Deep Calibration of Interest Rates Model*, arXiv preprint arXiv:2110.15133 (2024).
[47] M. Ben Derouich and A. Kebaier, *The interpolated drift implicit Euler scheme Multilevel Monte Carlo method for pricing Barrier options and applications to the CIR and CEV models*, arXiv preprint arXiv:2210.00779 (2023).
[48] C. Bertucci and Mérouane and Lasry Debbah Jean-Michel and Lions, *A Spectral Dominance Approach to Large Random Matrices*, HAL preprint hal-04239316 (2023).
[49] C. Bertucci, *Mean field games with incomplete information*, HAL preprint hal-03666652 (2023).
[50] C. Bertucci, J.M. Lasry, and P.L. Lions, *On Lipschitz solutions of mean field games master equations*, HAL preprint hal-03980892 (2023).
[51] _____, *A singular infinite dimensional Hamilton-Jacobi-Bellman equation arising from a storage problem*, HAL preprint hal-03799871 (2023).
[52] C. Bertucci, *Stochastic optimal transport and Hamilton-Jacobi-Bellman equations on the set of probability measures*, HAL preprint hal-04118729 (2023).
[53] O. Bonesini and G. Callegaro and M. Grasselli and G. Pagès, *From elephant to goldfish (and back): memory in stochastic Volterra processes*, arXiv preprint arXiv:2306.02708 (2023).
[54] P. Bras and G. Pagès, *Policy Gradient Optimal Correlation Search for Variance Reduction in Monte Carlo simulation and Maximum Optimal Transport*, arXiv preprint arXiv:2307.12703 (2023).
[55] S. Crépey and N. Frikha and A. Louzi and G. Pagès, *Asymptotic Error Analysis of Multilevel Stochastic Approximations for the Value-at-Risk and Expected Shortfall*, arXiv preprint 2311.15333 (2023).
[56] F. Djete, G. Guo, and N. Touzi, *Mean field game of mutual holding with defaultable agents, and systemic risk*, HAL preprint hal-04565544 (2023).
[57] M. Echenim, E. Gobet, and A.C. Maurice, *Thorough mathematical modelling and analysis of Uniswap v3*, HAL preprint hal-04214315 (2023).
[58] R. Flenghi and B. Jourdain, *Central limit theorem for the stratified resampling mechanism*, arXiv preprint arXiv:2308.02186 (2023).
[59] _____, *Convergence to the uniform distribution of vectors of partial sums modulo one with a common factor*, arXiv preprint arXiv:2308.01874 (2023).
[60] E. Gobet and W. Wang, *Improved convergence rate for Reflected BSDEs by penalization method*, HAL preprint hal-04020304 (2023).
[61] B. Jourdain and G. Pagès, *Convex ordering of solutions to one-dimensional SDEs*, arXiv preprint arXiv:2312.09779 (2023).
[62] B. Jourdain and K. Shao, *Non-decreasing martingale couplings*, arXiv preprint arXiv:2305.00565 (2023).
[63] __, *Maximal martingale Wasserstein inequality*, arXiv preprint arXiv:2310.08492 (2023).
[64] I. Kharroubi and A. Ocello, *Optimal Stopping of Branching Diffusion Processes*, arXiv preprint arXiv:2401.12811 (2023).
[65] G. Pagès, *Volterra equations with affine drift: looking for stationarity*, arXiv preprint 2401.15021 (2024).

MAJOR COMMUNICATIONS RELATED TO THE RESEARCH PROGRAM

Conferences and Summer Schools

- MCM 2023, 26–23 June 2023, Paris. Web site : https://mcm2023.sciencesconf.org/
- A Random Walk in the Land of Stochastic Analysis and Numerical Probability, 4–8

September 2023. Web site : https://conferences.cirm-math.fr/2390.html

Seminars and working groups

- A. Alfonsi and A. Kebaier are co-organizers of a weekly seminar on *numerical methods and finance* that takes place at Ecole des Ponts, see https://cermics.enpc.fr/~alfonsi/ GTMSF.html.
- I. Kharroubi and G. Pagès are co-organizers of the weekly seminar on *Financial math- ematics, Actuarial Sciences and Numerical Probability*, see https://www.lpsm.paris/ mathfipronum/gt.
- A. Alfonsi, N. El Karoui, G. Pagès and N. Touzi are co-organizers of the weekly seminar *Séminaire Bachelier*, see https://sites.google.com/site/seminairebachelierparis/

OTHER HIGHLIGHTS

Short-term visitors

Ecole Polytechnique:

- 10th to 24th May 2023: Skander Esseghaier (Université de Manouba)
- 30 March to 11th July 2023: Peter Friz (TU Berlin)

Editorial responsabilities

- E. Gobet, Associate Editor of *Annals of Applied Probability*, *Applied Mathematics and Optimization*, *Bernoulli*, *SIAM Financial Mathematics*, *ESAIM Proceedings and Surveys*
- B. Jourdain, Associate Editor of *Stochastic Processes and their Applications*, *Stochastics and Partial Differential Equations: Analysis and Computations* and *ESAIM Proceedings and Surveys*
- I. Kharroubi, Associate Editor of *Stochastics An International Journal of Probability and Stochastic Processes*
- G. Pagès, Associate Editor of *ESAIM P&S* (former Editor-in-Chief 2012-17). Associate Editor of *Market Microstructure and Liquidity*. Associate Editor of *Frontiers in Mathe- matical Finance*.
- N. Touzi, Co-Editor of *Finance and Stochastics*, *Paris-Princeton Lectures in Mathematical Finance* and *SIAM Book Series in Financial Mathematics*. Associate Editor of *Annals of Applied Probability*, *Mathematical Finance*, *Journal of Op- timization Theory and Application*, *Mathematical Control and Related Fields*, *Stochastic Processes and their Applications*, *Stochastics*, and *Advances in Calculus of Variations*.

Master-level courses

Master programs:

- *Probability and Finance* of Sorbonne Université-X: http://www.masterfinance.proba. jussieu.fr. Co-headed by N. El Karoui, E. Gobet, G. Pagès and M. Rosenbaum.

- *Financial Engineering Executive degree – Modeling, Simulation and Data Analytics* of Sorbonne Université-X: https://fc.sorbonne-universite.fr/nos-offres/financial-engineering-mode Co-headed by E. Gobet & G. Pagès.
- *Mathematiques and applications, finance track* of UPEM: http://www.u-pem.fr/formations/loffre-de-formations/les-masters/domaine-sciences-technologies-sante/mention-mathematiqu master-ingenierie-mathematiques-informatique-et-statistique/.
  IFMA of SU: http://www.proba.jussieu.fr/IFMA/. Headed by V. Lemaire.
- *MSC International Finance* of HEC-X, Paris: http://www.hec.edu/Masters-programs/Master-s-Programs/One-Year-MSc-MS-Programs/MSc-International-Finance/Program-Details