Numerical Methods for Finance and Insurance Workshop (NMFIW) 2026

Sala Lauree, Via del Conservatorio 7
Università degli Studi di Milano

UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI ECONOMIA, MANAGEMENT E METODI QUANTITATIVI

Workshop Schedule and Book of abstracts

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Chair: Lorenzo Mercuri

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12:30-14:30 Lunch break

Abstracts

Optimal carbon emission patterns towards a net zero target

Hansjoerg Albrecher
Université de Lausanne

In this talk the optimal policy for using an allocated carbon emission budget over time is investigated, with the objective to maximize profit under additional considerations of sustainability aspects. Under diffusion assumptions of the underlying budget process, we formulate and solve the associated stochastic control problems, explicitly look into the effects of present-biased preferences of decision-makers, and also consider a constraint on ratcheting-down of consumption. In particular, we use and extend stochastic control techniques developed for optimal dividend strategies in insurance risk theory for the present purpose. The approach enables also to study the efficiency of carbon taxation to steer emission patterns from a governmental perspective towards a certain target.

The gender mortality gap: mathematical perspectives on a cross-cutting issue

Giovanna Apicella
Università degli Studi di Udine

The gender gap in mortality plays an important role in the context of demographic transition and for the construction of a culture of healthy ageing. Both the drivers and the consequences of the gender gap in mortality go beyond the demographic domain, extending, for instance, to the context of social insurance and health public policy. We study a measure of the gender gap in mortality rates, we call "Gender Gap Ratio", and we investigate the age-pattern and the evolution over time of this measure. Specifically, we show the stylized facts that characterize the trend of the Gender Gap Ratio, both in its historical evolution and future projection, and provide evidence of the general shape of the relationship between male and female mortality rates over age, net of the effects of the COVID-19 pandemic disease. We contextualize our quantitative investigation in a broader framework, which highlights both the socio-economic relevance and the educational value of a stochastic analysis of the gender mortality gap. Unlocking the peculiar characteristics of the gender mortality gap allows, for instance, (i) the assessment of the prospective redistribution effects between genders, (ii) the design of proper communication strategies

to increase individuals' levels of demographic literacy which, in turn, impact on retirement readiness and forward-looking decisions highly depending on longevity risk information.

The Calibration Conundrum: Optimizers and (Joint) Objective Functions

Laura Ballotta

Bayes Business School

In this presentation, we investigate the complexities underlying the calibration of option-pricing models, a crucial task for quantitative analysts in financial markets. We emphasize the importance of algorithm selection when navigating the "valleys" of the objective-function landscape, advocating greater scrutiny of optimization routines to ensure consistent, meaningful parameter estimates. We also discuss how to set up adequate objective functions for joint-calibration problems.

Optimal Self-Protection via BSDEs for Risk Models with Jump Clusters

Matteo Brachetta

Università degli Studi di Genova

In this talk we explore some recent advances in optimal control problems in Insurance Theory, with a special focus on self-protection strategies. This framework describes an insurance contract where the policyholder can choose both the level of protection, i.e. the covered losses, and the self-protection effort, which are the preventative actions taken to reduce the frequency of the claim arrivals. These strategies are assessed based on the utility maximization of the terminal wealth, incorporating a final reimbursement that can incentivize the buyer to increase her effort. We show that this problem can be formulated in terms of a suitable BSDE, for which we prove existence and uniqueness of the solution. Then, the optimal strategies are evaluated in terms of the BSDE solution.

Pricing path-dependent options under stochastic volatility models with full error control

Riccardo Brignone
Università degli Studi di Pavia

In this paper, we propose a unified methodology for pricing general path-dependent derivatives (e.g., Asian and Barrier options), whose main benefit over existing literature consists in a simple and effective control of the error. A practitioner simply needs to provide to the pricing algorithm two parameters: *i*) a probability, q; *ii*) an error tolerance, ε. Then, our proposed algorithm provides a price approximation that differs by no more than ε from the true unknown option price with probability at least equal to q. The proposed methodology works for a broad class of stochastic volatility models and it is based on the Monte Carlo-Conditional Fourier-cosine method. We provide an explicit link between the variance of the Monte Carlo simulation estimator of the option price, the error tolerance, and the number of simulations. In this way, the pricing methodology becomes extremely efficient when combined with effective variance reduction techniques that drastically reduce the number of simulations (and, therefore, the computing time) required to obtain an arbitrarily accurate price estimate.

TBA

Corina Constantinescu
University of Liverpool

Advancing Complex Step Approximation

Anna Maria Gambaro
Università degli Studi del Piemonte Orientale

In this work, we introduce an extended complex step approximation (ECSA) for computing derivatives of expectations of discontinuous performance functions, covering derivatives of arbitrary order. The n-th order derivative is represented as an infinite series, for which we establish convergence and provide an upper bound on the truncation error. This formulation extends the classical complex step approximation (CSA) by moving beyond first-term approximations toward a complete infinite-series representation, and by proposing a novel method to evaluate expectations of discontinuous performance functions at complex arguments. We further embed this framework into a Monte Carlo simulation setting, analyzing both the variance properties of the stochastic derivative estimator and its empirical performance.
This is a joint work with I. Kyriakou, G. Fusai and M. Kumar Das.

Exact simulation of stochastic volatility models based on conditional Fourier-cosine method

Gero Junike
Ludwig-Maximilians-Universität (LMU) München

The traditional methodology used for the exact simulation of stochastic volatility models based on the Gil–Pelaez formula presents implementation problems that are observed by many researchers and practitioners. In particular, although conventionally considered exact, such a method presents a difficult control of the error. The bias of the Monte Carlo simulation estimator can only be computed numerically and is controlled by two parameters, typically determined by running time-consuming simulations under different tuning parameter configurations until an optimal setup is found. In this paper, we propose a new exact simulation scheme based on the Fourier-cosine method, which approximates a probability density given the characteristic function as follows: the density is truncated on a finite interval, and approximated by a classical Fourier-cosine series. The method allows full error control via an effective automatic identification of the tuning parameters given a user-supplied error tolerance. The new approach offers the following advantages: improved control of the error, simplified implementation, and reduction in computing time. The error is controlled by only one parameter instead of two. This parameter has a clear interpretation: it is the maximum tolerable bias. This facilitates the implementation, since the maximum bias becomes an input of the simulation algorithm, instead of an output, and can be set a priori, before running simulations. Our analysis shows that the proposed exact simulation scheme is computationally faster than the traditional one, and presents an improved speed-accuracy profile with respect to alternative state-of-the-art fast approximated sampling schemes.

Hybrid Bank Capital: The Economics of Uneconomic AT1 Calls

David Lando

Copenhagen Business School

Additional Tier 1 (AT1) notes are perpetual, callable notes issued by banks to meet their capital requirements. Banks almost always choose to redeem the notes at the first call date, even when issuing new notes is more expensive than keeping the old ones. We argue from a simple model that this reflects a reputational incentive: failing to call raises expected maturities and future financing costs. Our empirical analysis confirms that such a trade-off exists. Calls reduce yields on other AT1 issues from the same bank, consistent with the reputation effect, but leave other classes of subordinated capital unaffected, indicating that they do not signal financial strength.

The distribution of out-of-sample performance of estimated portfolios

Nathan Lassance

Université catholique de Louvain (UCLouvain)

We derive a parsimonious stochastic representation for the joint distribution of the out-of-sample mean and variance of a large class of portfolio rules that combines the sample mean-variance optimal portfolio with the sample global minimum-variance portfolio. Such a representation enables us to obtain the distributions and moments, asymptotically and in finite samples, of various out-of-sample performance measures, e.g., return, utility, and Sharpe ratio. These results offer a comprehensive analytical toolkit that researchers can use to evaluate the out-of-sample performance of existing portfolio rules and to develop new portfolio rules in the future. We illustrate the potential use of these results by constructing and evaluating optimal two-fund rules under different out-of-sample performance criteria.

Optimal stopping and divestment timing under scenario ambiguity and learning

Andrea Mazzon
Università degli Studi di Verona

Aiming to analyze the impact of environmental transition on asset values and potential asset stranding, we study optimal stopping and divestment timing decisions for an economic agent whose future revenues depend on the realization of one scenario among a set of possible futures. Since the future scenario is unknown and the probabilities of prospective scenarios are themselves ambiguous, we adopt the smooth model of decision making under ambiguity aversion of Klibanoff et al. (2005), framing the optimal divestment decision as an optimal stopping problem with learning under ambiguity. We establish a minimax result reducing this setting to a sequence of standard optimal stopping problems with learning, which makes the problem amenable to computation. The theoretical contribution is complemented by two numerical illustrations: the problem of optimally selling a stock with ambiguous drift, and the problem of optimal divestment from a coal-fired power plant under transition scenario ambiguity, where we show how different specifications of ambiguity aversion translate into concrete differences in optimal exit times.

American multi-asset option pricing under vine Lévy copulae and the Ballotta-Bonfiglioli model

Alice Pignatelli di Cerchiara
Università Cattolica del Sacro Cuore

In this work, multivariate Lévy processes are discussed focusing on two different characterizations of dependence: the Ballotta-Bonfiglioli method and Lévy copulae (with also their vine extension). The first of the two provides a flexible way of modelling dependence, while the second extends the classic idea of copulae into the world of Lévy processes, with the consequence of a potentially wider and more precise capture of dependence, but at the cost of a reduced analytical tractability. The final aim of our work was to price several multi-asset options while highlighting the effect of dependence between the underlying assets introduced by the two different models. For both the approaches, the analysis focused on the selection of the best marginal stochastic processes and on the construction of a specific dependence structure. These two steps paved the way to the effective identification of robust models which were then used to retrieve the prices of the options by applying the specific payoff conditions. Then, a sensitivity analysis was performed for each method, with the objective of showing how the results could change in terms of pricing if different dependence structures were exploited. Finally, a comparison between the two methods is provided, clearly explaining the fact that different assumptions about marginal stochastic processes and dependence modelling were used.

Effective binomial discretizations of bivariate diffusion processes

Francesco Rotondi
Università Bocconi

In this paper, we investigate the general conditions under which a bivariate continuous-time stochastic process can be approximated by a computationally feasible discrete-time bivariate binomial process. The key requirement is that two associated partial differential equations must be explicitly solvable. As a prominent application of this result, we construct a simple recombining bivariate binomial tree for the stochastic volatility model introduced by Heston (1993). We then use this discretized model to compute no-arbitrage prices for European call and put options, obtaining results consistent with those produced by other well-known numerical methods. Finally, we conduct an in-depth analysis of the two-dimensional free boundaries of American call and put options as functions of the spot price and spot volatility.

A new model for the perceived time to transition to a low carbon economy

Ilaria Stefani
Università degli Studi di Parma

In the context of the transition to a low or zero carbon economy, we expect the difference in greenium between pairs of twin bonds with different maturities to disappear or, at least, to reduce in both level and volatility. Consequently, we need a model that imposes a terminal condition on the dynamics of the process representing the difference in nodes within the greenium term structure. An important feature of this difference, observed in empirical data, is its mean-reverting behavior. This characteristic motivates the introduction of ad-hoc models that consider the possibility of a transition occurring at a specific time. We discuss two models: the first is an extension of the classical Vasicek model, where the volatility term remains constant until a future time instant, after which it decreases linearly. This model is integrated into a regime-switching framework, where the perceived deadline for transitioning to a low or zero carbon economy defines the regime. Both models are calibrated using market data extracted from twin German government bonds.

Pricing of synthetic CDOs with infectious defaults and market based measures of systemic risk

Gabriele Torri

Università degli Studi di Bergamo

A vast literature that studied the pricing of synthetic CDOs flourished in the first decade of the 00s due to the expansion of the market of CDOs and other complex credit derivatives. The relevance of CDO-type contracts and the correct estimation of the probability of joint defaults is still relevant today. Indeed, the market perception of joint default correlations implied by such contracts is valuable to regulators and practitioners interested in assessing systemic risk and financial contagion. We introduce a model for the loss distribution of a credit portfolio considering a contagion mechanism for the default of names which is the result of two independent components: an infection attempt generated by defaulting entities and a failed defence from healthy ones. We then propose an efficient recursive algorithm for the loss distribution. Then we extend the framework with a more flexible mixture distribution to better fit real-world data. In the empirical analysis, we calibrate the model on the CDO tranches of the iTraxx index, and we use the information embedded in the market prices of CDOs as market based measures of systemic risk.
