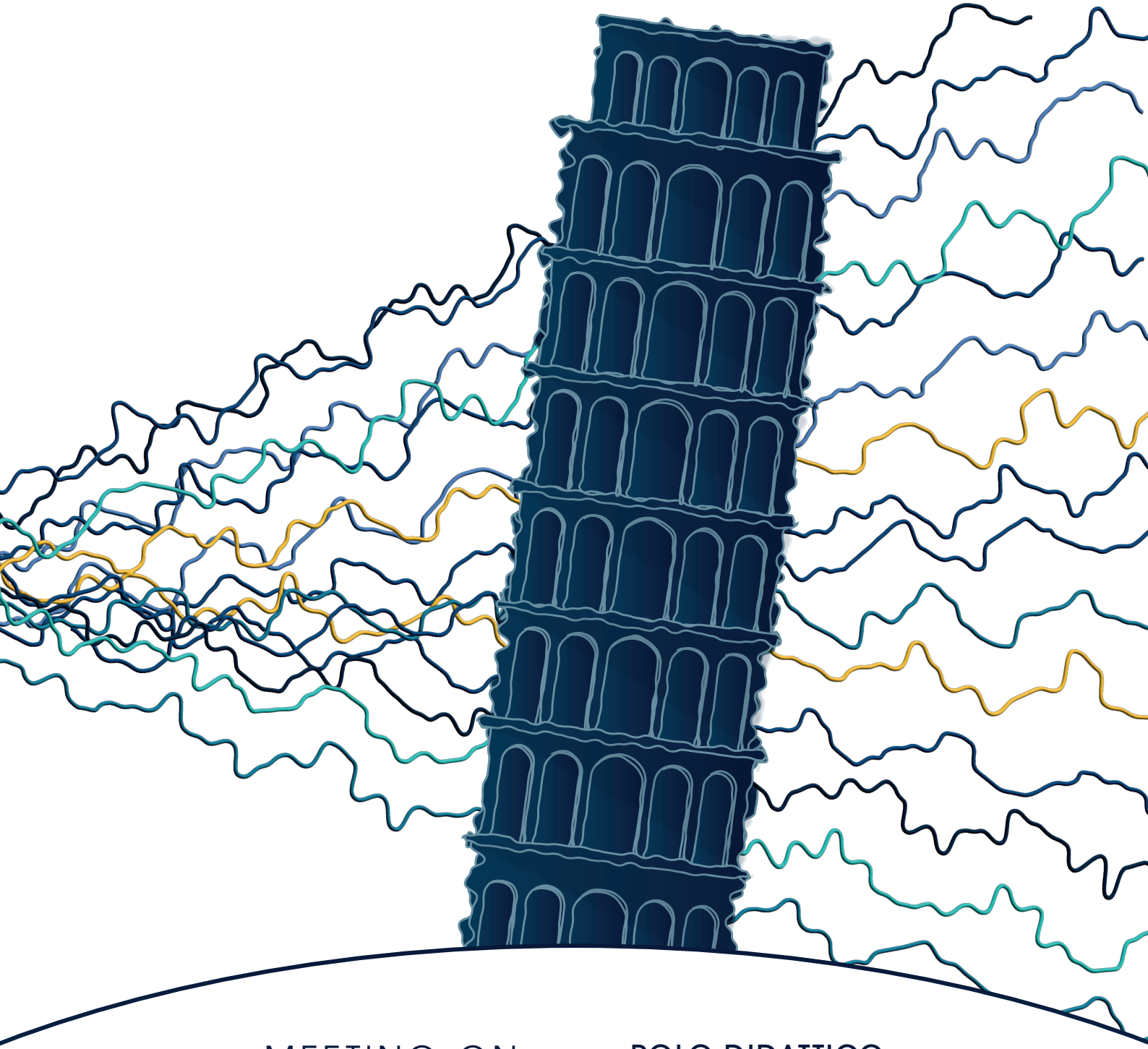
BOOK OF **ABSTRACTS**



MEETING ON
QUANT
FINANCE
2024

POLO DIDATTICO
DELLE PIAGGE
MAY 6~8
PISA, ITALY

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Solving stochastic control problems with reinforcement learning

Paulin Aubert

LaMME Universitè d' Evry

Our work is concerned with the classical problem of dividend optimisation in the case of modelling the cash reserve of an insurance company. This field was inspired by ruin theory and we owe the first results to de Finetti. In the literature, the case where the cash reserve follows a Cramer-Lundberg model has been widely studied and the optimal solutions have been known since the 1970s. Recent advances in the field of Hawkes processes have heightened the interest of insurance companies in these processes because, with their self-excitation property, they more accurately represent the occurrence of claims in insurers' portfolios. This is why we are interested in the problem of optimising dividend payments, in the multi-product case and when the counting process is a Hawkes process. We know that as the size of optimal control problems increases, theoretical solutions become more difficult or even impossible to find, and that conventional approximation methods (finite elements methods, for example) also quickly reach their limits because of the excessive computing power they require. The aim of our work is to characterise the theoretical solution of the insurance problem with a Hawkes process and to propose a numerical method for approximating the optimal control associated with the problem. The numerical method we propose makes use of recent advances in reinforcement learning and we illustrate its effectiveness by first comparing the theoretical results for the classical case (compound Poisson) with those obtained by our numerical method. This is a joint work with Etienne Chevalier and Vathana Ly Vath.

Is (independent) subordination relevant in option pricing?

Michele Azzone
Politecnico Milano

Monroe (1978) demonstrates that any local semimartingale can be represented as a time-changed Brownian Motion (BM). A natural question arises: does this representation theorem hold when the BM and the time-change are independent? We prove that a local semimartingale is not equivalent to a BM with a time-change that is independent from the BM.

Our result is obtained utilizing a class of additive processes: the additive normal tempered stable (ATS). This class of processes exhibits an exceptional ability to accurately calibrate the equity volatility surface. We notice that the sub-class of additive processes that can be obtained with an independent additive subordination is incompatible with market data and shows significantly worse calibration performances than the ATS, especially on short time maturities. These results have been observed every business day in a semester on a dataset of S&P 500 and EURO STOXX 50 options.

Learning conditional distributions on continuous spaces

Cyril Benezet
ENSIIE, Université Paris Saclay

We investigate sample-based learning of conditional distributions on multi-dimensional unit boxes, allowing for different dimensions of the input and output spaces. Our approach involves grouping data near varying query points in the input space to create empirical measures in the output space. We employ two distinct grouping methods: one based on a fixed-radius ball and the other on nearest neighbors. We establish upper bounds for the convergence rates of both methods and, from these bounds, deduce optimal configurations for the radius and the number of neighbors. We propose to incorporate the nearest neighbor method into neural network training, as our empirical analysis indicates an improvement in accuracy. For efficiency, the training process utilizes approximate nearest neighbor search with random binary space partitioning. Additionally, it employs the Sinkhorn algorithm and a sparsity-enforced transport plan. Our empirical findings demonstrate that, with a suitably designed structure, the neural network has the ability to adapt to a suitable level of Lipschitz continuity locally.
This is a joint work with Ziteng Cheng and Sebastian Jaimungal

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Clustering Effects for Derivative Pricing: Application to Interest Rates

Guillaume Bernis

BPCE Vie

This paper includes a marked Hawkes process in the original HJM set-up, and investigates the impact of this assumption on the pricing of the popular vanilla fixed-income derivatives. Our model exhibits a smile that can fit the implied volatility of swaptions for a given key rate (tenor). We harness on the log-normality of the model, conditionally with respect to jumps, and derive formulae to evaluate both caplets/floorlets and swaptions. Our model exhibits negative jumps on the zero-coupon (hence positive on the rates). Therefore, its behaviour is compatible with the situation where globally low interest rates can suddenly show cluster of positive jumps in case of tensions on the market. One of the main difficulties when dealing with the HJM model is to keep a framework that is Markovian. In particular, it is crucial to preserve the important features of the Hull and White version, especially the reconstruction formula that provides the zero-coupon bonds in terms of the underlying model factors. In our case, this formula is based on two factors: a classical Gaussian part and a pure jump martingale part based on a Hawkes process. This is a joint work with Matthieu Garcin, Simone Scotti and Carlo Sgarra.

Unified moment based simulation of multivariate polynomial processes and applications in financial engineering

Riccardo Brignone
University of Freiburg

In this paper, we propose a general simulation scheme for multivariate polynomial processes. The methodology is based on the computation of conditional moments and on performing random sampling given such moments. The general methodology can be adapted to the simulation of many models of practical relevance in financial engineering, namely stochastic volatility (for example, the Jacobi model, among others) and commodity price models (for example, Pilipovic model).

Yet Another Closed Form Approximation of Spread Option Value and Greeks: Sector Formula

Roza Galeeva
The Johns Hopkins University

The goal of the paper is to derive a closed form approximation formulas for the spread option value and Greeks by using a double integration and investigating the exercise boundary. We find that the straight line approximation does not perform well for curved exercise boundaries. We propose a novel approach: to integrate in a sector and find a closed form formula, expressed in terms of the bivariate normal CDF. We call it sector formula. Numerical tests show accuracy and supremacy of our sector formula in comparison with the previous methods.

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The Continuous Forward Market (CFM) rate model

Bernard Gourion

BPCE

Following the advent of Risk Free Rates replacing the former Inter Bank Offered Rates (IBOR) as the new market reference indexes for interest rates, Lyashenko and Mercurio ((Lyashenko & Mercurio, 2019b) and (Lyashenko & Mercurio, 2019a)) proposed a new market model, the For- ward Market Model (FMM), whose the states variables are the forward Risk Free Rates (RFR) instead of the forward IBOR as the previous market model Brace et al. (1997) did it before. Then, by arbitrage argument, they prove the forward RFR and forward IBOR share the same time dynamic and find a clear identification of the front stub and back stub zero-coupon bond dynamics as soon as the underlying HJM modelling is also provided. In particular, they identify the link between the HJM volatility process and the market volatility process of the forward RFR taken like state variable of the FMM model. The purpose of this paper is to expose a new market model, the Continuous Forward Market (CFM) model, near from the FMM, where the state variable is not directly the forward RFR but its continuously com- pounded equivalent, the continuous forward RFR. Then this choice leads to a much more numerically tractable market model by every aspect: the drifts of the corresponding state variable are no longer depending on all the market rates and are only linearly depending on the volatility pro- cess. Moreover this leads to a direct relationship between the underlying HJM volatility of the instant forward rates and the market volatility of the continuous forward RFR without any interference of the RFR value as it is the case in the FMM. Using a HJM Cheyette modeling analog to the one used in the FMM, this change also leads to a modeling of any zero-coupon - including front and back stub cases - which allows an exact simulation of it as soon as the underlying HJM volatility remains at least deterministic. Last the CFM also is proved to be a market model for the overnight interest rates defining the RFR themselves which means the CFM may also be viewed as a natural multi-curve model of both the OIS and the RFR yield curve.

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Uncovering Market Disorder and Liquidity Trends Detection

Yadh Hafsi

Université Paris Saclay

The primary objective of this paper is to conceive and develop a new methodology to detect notable changes in liquidity within an order-driven market. We study a market liquidity model which allows us to dynamically quantify the level of liquidity of a traded asset using its limit order book data. The proposed metric holds potential for enhancing the aggressiveness of optimal execution algorithms, minimizing market impact and transaction costs, and serving as a reliable indicator of market liquidity for market makers. As part of our approach, we employ Marked Hawkes processes to model trades-through which constitute our liquidity proxy. Subsequently, our focus lies in accurately identifying the moment when a significant increase or decrease in its intensity takes place. We consider the minimax quickest detection problem of unobservable changes in the intensity of a doubly-stochastic Poisson process. The goal is to develop a stopping rule that minimizes the robust Lorden criterion, measured in terms of the number of events until detection, for both worst-case delay and false alarm constraint. We prove our procedure's optimality in the case of a Cox process with simultaneous jumps, while considering a finite time horizon. Finally, this novel approach is empirically validated by means of real market data analyses.

Fly to Quality, Wait and Then Walk Back

Alexis Houssard
BPCE and Université Paris Cité

This paper is concerned by an investment and consumption control problem for a risk averse investor exposed to a self-exciting market. A basic framework is considered where investments may be done in a bank account and a risky asset whose dynamics is driven by a Hawkes process. For technical reasons, strategies including debt or shortselling are not allowed and price jumps will be restricted to negative values in accordance with market disruptions which can be observed in real world, e.g after a bad announcement of the firm. The related value function will be formulated as the unique continuous solution, in the sense of viscosity, of a three-dimensional system of variational inequalities in presence of jumps. After an elementary analysis of the value function, we show that our problem is equivalent to a bi-dimensional singular control problem, simplifying further mathematical developments. We conclude our work with a numerical approximation of the value function performed in order to provide sensitivity tests and understand the evolution of the optimal investment policy in the space.
This is a joint work with Vathana Ly Vath and Simone Scotti.

Hedging Bermudan options with the dual representation

Jêrome Lelong
Grenoble INP - UGA

This paper presents a new algorithm based on the dual approach to calculate the hedging portfolio of a Bermudan options and its initial value. It is a "pure dual" algorithm in the spirit of Rogers [2010] in the sense that it only relies on the dual pricing formula. The hedging strategy is obtained by using a Monte Carlo method, solving backward a sequence of least square problems. We show some convergence results for our algorithm and test it on many different Bermudan options. Beyond giving directly the hedging portfolio, the strength of the algorithm is to assess the relevance of financial instruments and of the rebalancing frequency used for the hedging portfolio.
This is a joint work with Aurélien Alfonsi.

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A Sparsity test for Multivariate Hawkes Processes

Antoine Lotz

EDF Labs and Université Paris Dauphine

Multivariate Hawkes processes (MHP) are a class of point processes in which events at different coordinates interact through mutual excitation. The weighted adjacency matrix of the MHP encodes the strength of the relations and shares its support with the causal graph of interactions of the process. We consider the problem of testing for causal relationships across the dimensions of a marked MHP. The null hypothesis is that a joint group of adjacency coefficients are null, corresponding to the absence of interactions. The alternative is that they are positive, and the associated interactions do exist. To this end, we introduce a novel estimation procedure in the context of a large sample of independent event sequences. We construct the associated likelihood ratio test and derive the asymptotic distribution of the test statistic as a mixture of χ^2 laws. The performance of our method is illustrated on two sets of financial data. In the first, we consider bid arrivals in online auctions. We provide evidence of a deviation from a static equilibrium in bidder's strategies. We then turn our attention to power trading on the German intraday market, in which we uncover some factors at play in the dynamics of hourly futures' prices.

Semi-static variance-optimal hedging with self-exciting jumps

Beatrice Ongarato
Università di Padova

The aim of this work is to study a hedging problem in an incomplete market model where the underlying log-asset price is driven by a diffusion process with self-exciting jumps of Hawkes type. We aim at hedging a variance swap (target claim) at time $T > 0$, using a basket of European options (contingent claims). We investigate a semi-static variance-optimal hedging strategy, combining dynamic (i.e., continuously rebalanced) and static (i.e., buy-and-hold) positions to minimize residual error variance at T. The semi-static strategy has already been computed in literature for different models. The purpose of our work is to solve the hedging problem for an unexplored model featuring self-exciting jumps of Hawkes type. The key aspect of our work is the generality of our framework, both from the perspective of the hedging and the model investigated. Moreover research into models with self-exciting jumps is significant as it has been observed that prices in the financial market (e.g. commodity markets) exhibit spikes having clustered behavior. In our work, we establish and analyze our model, studying its properties as an affine semimartingale. We characterize its Laplace transform to rewrite contingent claims using a Fourier transform representation. We finally obtain a semi-explicit expression for the hedging strategy. A possible further development might regard the problem of optimal selection of static hedging assets.
This is a joint work with Giorgia Callegaro, Paolo Di Tella and Carlo Sgarra.

Existence and regularity of law density of a pair diffusion-running maximum

Monique Pontier
Institut Mathématique de Toulouse

Let X be a continuous d-dimensional diffusion process and M the running supremum of the first component. We show that, $\forall t > 0$, the law of the $(d+1)$ random vector (M_t, X_t) admits a density with respect to the Lebesgue measure using Malliavin's calculus. In case $d = 1$ we prove the regularity of this density.
This is a joint work with Laure Coutin.

Opinion dynamics in communities with major influencers and implicit social influence via mean-field approximation

Huyen Pham
Université Paris Cité

We study binary opinion formation in a large population where individuals are influenced by the opinions of other individuals. The population is characterised by the existence of (i) communities where individuals share some similar features, (ii) opinion leaders that may trigger unpredictable opinion shifts in the short term (iii) some degree of incomplete information in the observation of the individual or public opinion processes. In this setting, we study three different approximate mechanisms: common sampling approximation, independent sampling approximation, and, what will be our main focus in this paper, McKean-Vlasov (or mean-field) approximation. We show that all three approximations perform well in terms of different metrics that we introduce for measuring population level and individual level errors. In the presence of a common noise represented by the major influencers opinions processes, and despite the absence of idiosyncratic noises, we derive a propagation of chaos type result. For the particular case of a linear model and particular specifications of the major influencers opinion dynamics, we provide additional analysis, including long term behavior and fluctuations of the public opinion. The theoretical results are complemented by some concrete examples and numerical analysis, illustrating the formation of echo-chambers, the propagation of chaos, and phenomena such as snowball effect and social inertia.
This is a joint work with Délia Coculescu, Médéric Motte.

Polynomial Volterra processes

Sergio Pulido
ENSIIE / LaMME Evry

Recent studies have extended the theory of affine processes to the stochastic Volterra equations framework. In this talk, I will describe how the theory of polynomial processes extends to the Volterra setting. In particular, I will explain the moment formula and an interesting stochastic invariance result in this context.
This is a joint work with Eduardo Abi Jaber, Christa Cuchiero, Luca Pelizzari and Sara Svaluto Ferro

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Pricing Climate Change Risks: CAPM with Self-excited jumps

Davide Radi
Universitá Cattolica di Milano "Sacro Cuore"

We develop a dynamic asset pricing framework with brown and green assets. Green assets are affected by rare natural disasters related to climate change by rare macroeconomic events. Brown assets are also affected by transition risk which we assume to be correlated to physical risk. The novelty of this paper is to assume that natural disasters are generated by a self-excited jump. Using theory and simulations we show how these natural disasters impact on the portfolio composition.

Optimal dividends with a SNLP subject to a level-dependent intensity of ruin

Jean-Francois Renaud
Université du Québec à Montréal

We consider de Finetti's stochastic control problem when the (controlled) process is allowed to spend time under the critical level. More precisely, we study an adaptation of this classical dividend optimization problem when the intensity of ruin is level-dependent. In a Lévy risk model, we show that, under a mild assumption on the jump measure, an optimal strategy is formed by a barrier strategy. This is a joint work with Dante Mata López.

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Dichotomy for Lévy-type dividends and capital problems

Alexandre Roch

Université du Québec à Montréal

I will present solutions to optimal dividends and capital injection problems in which the cash flows of the firm is driven by a Lévy process. I consider both the general (singular) case and the case in which dividends are constrained to be absolutely continuous with a upper bound as a function of the current firm process. In both situations, the capital injection process is general and shown to be only optimal when capital is injected at 0. Using viscosity techniques, I show that there exists a threshold above which the firm pays dividends at the maximal rate. In the Brownian case, I present a dichotomy result in which it is either optimal to inject capital at 0, or not at all. This is determined by the boundary condition of the HJB variational inequality. In the general Lévy case, the boundary condition depends on whether the Lévy process has unbounded variation or not. In all cases, there exists a lower threshold at which it is no longer optimal to inject capital.

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(Rough) continuous states branching processes and their applications in volatility modelling

Simone Scotti

Università di Pisa

This presentation is based on three different papers sharing the idea to joint calibrate SPX and VIX implied volatilities and many empirical facts in a parsimonious way. The three models are exponential affine and then the Fourier-Laplace transform of the log returns and the square of the volatility index can be computed explicitly in terms of solutions of deterministic pseudo-Riccati (Volterra) equation. The first model is driven by a branching alpha-stable and then also reproduce the empirical results on jump infinite activity by Todorov and Tauchen. The two other models are based on extension of Hawkes processes since the intensity of the jumps coincides with the volatility process itself. In the last case, the volatility is rough. We show that our parsimonious setup is able to simultaneously capture, with a high precision, the behavior of the implied volatility smile for both S&P 500 and VIX options. Besides the applications in mathematical finance many open questions arises that can resumed by which properties of CSBPI are preserved when a kernel is added?
This presentation is based on joint works with Ying Jiao, Chunhua Ma, Chao Zhou; Guillaume Bernis, Riccardo Brignone, Carlo Sgarra; Alessandro Bondi and Sergio Pulido.

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Guaranteed Minimum Maturity Benefits in a Self-Exciting Stochastic Mortality Model: Pricing, Estimation and Calibration

Carlo Sgarra

Università degli Studi di Bari 'Aldo Moro"

The guaranteed minimum maturity benefit (GMMB) is quite a popular feature embedded in several unit-linked policies offered by insurance companies. The value of this benefit depends on several processes assumed to describe both the mortality and the financial dynamics, typically represented by interest rates and by the fund associated to the unit-linked policy. A large literature is devoted to the valuation of GMMB for different mortality models, in particular when the mortality dynamics is described by affine models of diffusion type. In the present article we assume a self-exciting behavior for the mortality dynamics, described by a Hawkes-type process with exponential kernel. This allows us to keep both the Markov and affine features but introduces jumps with a stochastic intensity. These types of dynamics, exhibiting a jump clustering property, are quite convenient for describing mortality in some critical situations, like epidemics, where contagion phenomena make the probability of jump arrivals higher whenever a jump occurs. By assuming diffusion-type dynamics for both the fund and the interest rate and introducing all of the possible correlations among the diffusion processes necessary to obtain realistic dynamics, we take advantage of the affine features of the model proposed and compute in a semi-explicit form the value of a GMMB. Lastly, we calibrate our model and perform an empirical analysis to determine the effects of excess mortality on GMMB prices as well as a death benefit portfolio.
This is a joint work with David Banos and Aasmund Hausken Sande.

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