AFMathConf 2017

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Stochastic Modelling with applications in Financial Markets

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EXHIBITORS

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Advanced Mathematical Methods for Finance

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Lunches and coffee breaks : Marble room

Conference dinner : University foundation (Egmontstraat 11, 1000 Brussel)

Map with important locations : available on

http://www.afmathconf.ugent.be/index.php?page=practicalinfo

Wireless internet

There is wireless internet available in the main building and throne building.

- SSID = academie.
- This is an open network, no password is needed.

Books and software

In the Marble room you can find:

- NAG : a demo stand with numerical software
- Springer
- Cambridge University Press

PROGRAMME - 9 February

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09h45 - 10h15	Contributed talk: Thai Huu Nguyen, Ulm University, Germany *Optimal portfolio for equity-linked life insurance contracts under VaR-Regulation*
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16h00 - 16h15	Closing

- **Lynn Boen**, University of Antwerp, Belgium

  Towards a Δ-Gamma multivariate model

- **Ki Wai Chau**, Centrum Wiskunde & Informatica, the Netherlands

  On the wavelets-based SWIFT method for backward stochastic differential equations

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- **Sina Yansori**, University of Alberta, Canada

  Explicit parametrization for mortality deflators and optimal portfolios

Consistency and fallacies in option pricing

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Joint work with: Martin Herdegen

We provide a unified approach to valuing options in general financial markets. It lies strictly between valuation by absence of arbitrage alone, and valuation by risk-neutral expectation. We illustrate by examples the need for such an approach. Our method always leads to put-call parity for model prices, even in incomplete markets, and yet does not need to distinguish whether we have an equivalent martingale measure or maybe a bubble. We also provide bounds on put and call prices, and show how different types of bubbles naturally lead to different premia in those prices in a natural way.

This is based on joint work with Martin Herdegen (University of Warwick).

A simple algorithm to solve constrained optimal portfolio problems

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Joint work with: Carole Bernard (GEM) and Steven Vanduffel (VUB)

We construct an algorithm that allows to numerically obtain an investor's optimal portfolio
allocation for fairly general objective functions. In particular, the objective function may also reflect state-dependent preferences.
We apply the method to various classic (non) expected utility problems for which explicit solutions are available and show that the numerical solutions are compatible with them. This observation allows to conclude that the algorithm can be trusted as a viable way to deal with portfolio optimization problems for which explicit solutions are not in reach.

Key-words: optimal portfolio, algorithm, law-invariant, distortion, utility, GOP, cost-efficiency, state-dependent preferences.

Smiles Smirks

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Joint work with: Gregory Rayee

In this paper we offer a general setup for modelling the stochastic evolution of stock prices which include risk factors of both diffusive and jump nature, and leverage effects; the proposed framework is based on Time Changed Lévy ;processes and encompasses a large number of the most commonly used stochastic volatility models. Further, it allows for the construction of new potential alternative models, and enables a comparative study of their features in terms of volatility, volatility of volatility and correlation processes. We analyse the performance of these models in terms of calibration and fit of the volatility surface; attention is also paid to the higher order conditional moments. The empirical study also aims at clarifying the performance improvements generated by incorporating stochastic correlation and a diffusion component in the dynamics of the log-return process. This could prove useful in view of constructing parsimonious multivariate extensions.

Dependent Defaults and Losses with Factor Copula Models

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Joint work with: T. Vatter

We introduce a class of flexible and tractable static factor models for the joint term structure of default probabilities, the factor copula models. Those high dimensional models remain parsimonious with pair copula constructions, and nest numerous standard models as special cases. With discrete random individual losses, the loss distributions of credit portfolios and derivatives can be exactly and efficiently computed. Numerical examples on collateral debt obligation (CDO), CDO squared, and credit index swaption illustrate the versatility of our framework. An empirical exercise shows that a simple model specification can fit credit index tranche prices.

Data-mining : new paradigm for risk management

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Quantitive finance within financial institutions has undergone an important change. The heydays of financial innovation where exotic financial instruments were engineered and sold to investors seem to be over. In the aftermath of the financial crisis of 2008, risk managers and compliance officers got involved at all the hierarchical levels within banks and insurance companies. At the same time, IT departments got to deal with the implementation of the new regulations such as Basel III, CRDIV, Dodd-Frank, Mifid II, etc... Even before Basel III was fully rolled out, Basel IV came luring around the corner in the summer of 2016. Because financial institutions were very occupied, new entrepreneurial companies jumped on the band-wagon. This was the advent of FinTech and RegTech companies. Hedge-funds but also traditional asset managers, who unlike banks had a much lighter legacy, focused their quantitative research in the direction of algorithmic trading, robo advisors, machine learning and all kinds of implementations of data mining tools. Data scientists became the new quants on the trading floor. This lecture illustrates the new opportunities both from a research and business perspective.

Optimality and robustness of 'rule-based' trigger strategies under transaction costs

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Joint work with: Antje Mahayni

We consider a HARA investor who maximizes her expected utility of terminal wealth under transaction costs. In contrast to the existing literature, we restrict the investor to tractable trigger strategies defined by a proportionality factor, and a lower and upper trigger level. The expected utility of such strategies is, for infinite and finite investment horizons, derived in quasi-closed form. We compare the optimal certainty equivalent growth rate of the proportional trigger strategies (TCPPI) with the ones without transaction costs. Rather low loss rates justify the effectiveness of the optimized trigger strategies, i.e. the strategies are close to optimal if compared to the overall optimal strategies under transaction costs. However, the tractability of the strategies provides further insights into the effectiveness of optimized strategies under transaction costs (and model mis-specification). Although a main focus is on (leveraged) constant proportional portfolio insurance strategies, we include a differentiation between convex and concave strategies such that our results reach beyond the application to portfolio insurance strategies.

A switching self-exciting jump diffusion process for stock prices

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Joint work with: Guillaume Bagnarosa

There is considerable empirical evidence suggesting that the random walk model for changes in stock prices is not appropriate due to extreme movements. In this context, jump diffusion processes are very useful to accommodate the skewness and the excess kurtosis of financial security returns. However the absence of time dependency in their dynamics prevent them to model extremes and quiet periods, clustered in time. This jump clustering phenomenon questions the traditional understanding of equity market dynamics. By the way, a recent strand of the literature makes significant efforts to understand the cause of the clustering of jumps and to investigate implications of it for asset pricing, option pricing and risk management. The reason why we observe jumps in equity prices has been especially investigated with high-frequency data and there is a broad consensus in this literature that news releases impact a lot at both the individual and market levels.

A recent endogenous way to include clustering of jumps in the daily price dynamics is provided by self-exciting point processes. In this category of processes, the jump arrival intensity at a given point in time (that is also the instantaneous probability to observe a jump) depends on the number and sometimes the size of jumps that the price of the asset experiments before. This approach is linked to the Hawkes self-exciting processes. In the most common and simplest specification, the jump arrival intensity process is persistent and it suddenly increases as soon as a jump occurs in the asset price.

However, contrary to switching regime processes, self-excited jump processes are partly unsatisfactory because they fail to duplicate economic cycles. Switching regime processes have already received a lot of attention in investment management practice and the society of actuaries (SOA) since 2004, recommend switching processes to model long term stocks return, in actuarial applications.

These observations motivate the new Markov switching process with jump clustering effects that is studied in this paper. In our model, a self-excited jump process is combined with a geometric Brownian motion. And their parameters are modulated by a a hidden Markov chain with a finite number of states. Each regime corresponds to a particular economic cycle. The specification of this model captures several dynamic features of assets return, like the random volatility and the clustering of extreme movements during periods of economic turmoil. The proposed framework remains analytically tractable and is used to evaluate options. To motivate empirically the dynamics, we calibrate the model to the SP 500 with a Particle Monte Carlo Markov (PMCMC) chain algorithm.

XVA modelling with (non)linear PDEs and its numerical solution

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Joint work with: Iñigo Arregui and Beatriz Salvador

Since the last financial crisis, a relevant effort in quantitative finance research concerns to the consideration of counterparty risk in financial contracts, specially in the pricing of derivatives. As a consequence of this new ingredient, new models, mathematical tools and numerical methods are required.

In this presentation, we mainly consider the problem formulation in terms of linear and nonlinear partial differential equations (PDEs) models to price the total credit value adjustment (XVA) to be added to the price of the derivative without counterparty risk. Different sources of XVA, contract specifications and sets of stochastic factors will be considered. Therefore, in the case of vanilla options and forward contracts different linear and nonlinear PDEs arise. In the present work we propose original suitable boundary conditions to be applied and numerical methods to solve the resulting PDEs problems. These methods are based on semilagrangian discretizations of the first order derivatives in time and space, jointly with finite elements for the spatial discretization combined with fixed point iteration and other adequate algorithms for the nonlinear parts.

Expected utility maximizers invest in three funds not in two

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Joint work with: Steven Vanduffel

Markowitz' mean-variance optimization framework is known to be consistent with expected utility maximization under the assumption that returns are multivariate elliptically distributed or when a quadratic utility function is employed. Both assumptions are questionable. By contrast, the multivariate generalized hyperbolic distribution is known to provide an excellent fit to returns. By extending Stein's seminal lemma to this context we are able to completely describe the optimal portfolio of an expected utility maximizer. In particular, he invests in three funds instead of two (as in mean-variance optimization).

VaR bounds for joint portfolios with dependence constraints

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Joint work with: L. Rüschendorf et al.

We derive lower and upper bounds for the Value-at-Risk of a portfolio of losses when the marginal distributions are known and an additional (in)dependence structure is assumed. We provide several actuarial examples showing that the newly proposed bounds strongly improve those available in the literature that are based on the sole knowledge of the marginal distributions.

Optimal portfolio for equity-linked life insurance contracts under VaR-Regulation

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Joint work with: A. Chen and M. Stadje

We study, under the VaR regulation, the optimal portfolio problem of the equity holder of an equity-linked life insurance contract having some participation surplus in the profit sharing policy. In such a problem, the Basak-Shapiro well-known result can not be directly applied because the derived utility function is neither not concave nor strictly increasing. Using the the pointwise Lagrangian maximization technique we show that the VaR constrant does not completely prevent the equity holder form making use of gambling strategies on good market scenarios and an additional minimum insurance payment can be used to fix this "shifting risk to the tail" effect. This analysis is particularly relevant for an insurance company operating under the Solvency II regulation which aims to maximize the expected utility of its shareholders, while at the same time being required to provide its policyholders a minimum guaranteed amount. Our theoretical and numerical results also show that contrary to a pure Value-at-Risk regulation, combining a VaR constraint with a portfolio insurance gives a comprehensive protection in very bad market scenarios, while significantly reducing the regulatory costs of a pure portfolio insurance strategy. Some connections with concavification technique are also pointed out.

On risk models with recovery and dividends

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Joint work with: Adva Keren, Onno Boxma

In risk models ruin is defined as the first time that the surplus of the company is negative. Lately, practitioners and researchers introduced the concept of Parisian ruin, where ruin occurs the first time that the reserve is below 0 for more than some predetermined time. We study risk models where the company operates even when the surplus is negative and bankruptcy occurs in one of the following cases:

(1) The first time that the time spent below 0 is longer than some given threshold.

(2) The first time that the reserve is below a threshold.

(3) The minimum between the stopping times in (1) and (2).

We study both the classical risk model and the dual risk model.
In the dual risk model expenses outflow are at fixed rate, and income arrives occasionally according to a Poisson process.
While ruin occurs when the surplus become negative, dividends are given when the surplus is big enough. We consider the dual risk model where dividends from each income are given when the surplus is above a given threshold.

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Joint work with: P. Cirillo, C. W. Oosterlee

In this work we introduce a novel approach to risk management, based on the study of concentration measures of the loss distribution.

In particular we show that indices like the Gini one, especially when restricted to the tails by conditioning and truncation, represent a good way of assessing the variability of the larger losses–the most relevant ones–and the precision of common risk management measures like the Expected Shortfall.

We then introduce what we call the *Concentration Profile*, that is a sequence of truncated Gini indices that, we show, is able to characterize the loss distribution, providing interesting information about tail risks.

Combining concentration profiles and standard results from utility theory, we then develop a *Concentration Map*, which can be used to assess the risk attached to potential losses on the basis of the risk profile of the user.

Finally, we use the sequence of truncated Gini indices as weights for the expected shortfall defining the so-called *Concentration Adjusted Expected Shortfall*, a measure able to capture interesting additional features of tail risk.

All tools are applied to empirical data and the codes for their computation and visualization are provided.

Risk in a large claims insurance market with bipartite graph structure

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Joint work with: O. Kley and G. Reinert

We model the influence of sharing large exogeneous losses to the reinsurance market by a bipartite graph. Using Pareto-tailed claims and multivariate regular variation we obtain asymptotic results for the Value-at-Risk and the Conditional Tail Expectation. We address the following problems in our setting of networks of agents.

(1) We explain the influence of the network structure on diversification effects in different network scenarios. As is well-known in a non-network setting, if the Pareto exponent is larger than 1, then for the individual agent (reinsurance company) diversification is beneficial, whereas when it is less than 1, concentration on a few objects is the better strategy.

(2) An additional aspect is the amount of uninsured losses which have to be covered by society. In our setting, diversification is never detrimental concerning the amount of uninsured losses. If the Pareto-tailed claims have finite mean, diversification turns out to be never detrimental, both for society and for individual agents. In contrast, if the Pareto-tailed claims have infinite mean, a conflicting situation may arise between the incentives of individual agents and the interest of some regulator to keep the risk for society small.

(3) We also obtain asymptotic results for conditional risk measures based on the Value-at-Risk and the Conditional Tail Expectation. These results allow us to assess the influence of an individual institution on the systemic or market risk and vice versa through a collection of conditional risk measures.

(4) For large markets Poisson approximations of the relevant constants are provided. Differences of the conditional risk measures for an underlying homogeneous and inhomogeneous random graph are illustrated by simulations.

Risk Management with Weighted VaR

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This article studies optimal portfolio selection of expected utility maximizing investors who must also manage their market-risk exposures. The risk is measured by a so-called weighted Value-at-Risk (WVaR) risk measure, which is a generalization of both Value-at-Risk (VaR) and Expected Shortfall (ES). Feasibility, well-posedness, and existence of the optimal solution are examined. We obtain the optimal solution when it exists, and show how risk measures change asset allocation patterns. In particular, we characterize three classes of risk measures: the first class will lead to models that admit no optimal solution; the second can necessitate portfolio insurance endogenously; the third will allow economic agents to engage in "regulatory capital arbitrage", incurring larger losses when losses occur, which includes VaR and ES, two popular regulatory risk measures.

Risk Sharing under Pareto Efficiency and Financial Fairness

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Joint work with: Hailong Bao, Jaroslav Pazdera, Eduard Ponds, Bas Werker

Risk sharing is a classical topic in actuarial science. Borch (1962) gave a characterization of Pareto efficient single-period risk sharing agreements between von Neumann-Morgenstern agents (expected utility). In recent years, extensive research has been carried out on efficient risk sharing between agents whose preferences are described by monetary acceptability measures.

The notion of Pareto efficiency by itself is usually not strong enough to single out unique solutions. If a pricing measure is brought in, it becomes possible to compare the financial values of agents' claims before and after a risk sharing contract is agreed. Financial fairness (i.e. absence of cross-subsidies) can then be used as an additional criterion. In the talk, several situations will be discussed in which uniqueness of solutions is obtained in this way. Attention will be paid to numerical methods as well.

Towards a Δ-Gamma multivariate model

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Joint work with: Florence Guillaume

In this paper, we propose a multivariate Lévy model as an extension of the univariate Difference of Gammas model introduced by Finlay and Seneta. The construction is based on the work of Mathai and Moschopoulos, where we model the log price gains and losses by separate Gamma processes, each containing a common and idiosyncratic components. Furthermore, we extend this multivariate model to the Sato setting, allowing for a better replication of the univariate option prices in both the strike and time-to-maturity dimensions. A numerical study reveals the advantages of these new types of multivariate models, compared to a multivariate VG model.

On the wavelets-based SWIFT method for backward stochastic differential equations

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Joint work with: C.W. Oosterlee

We propose a numerical algorithm for backward stochastic differential equations based on time discretization and trigonometric wavelets. This method combines the effectiveness of Fourier-based methods and the simplicity of a wavelet-based formula, resulting in an algorithm that is both accurate and easy to implement. Furthermore, we mitigate the problem of errors near the computation boundaries by means of an antireflective boundary technique, giving an improved approximation. We test our algorithm with different numerical experiments.

Modelling losses via stable distribution

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Joint work with: Tonu Kollo

Keywords: bootstrap, empirical cumulant function, Danish Fire insurance losses, severity distribution.

General stable distribution as single law model for describing non-life insurance losses in the whole domain are proposed. The single distribution models based on Pareto, Burr or log-normal laws usually focus on fitting the small, moderate or extreme claims sizes while for the entire range the composite or mixture models are proposed. However, the four parameter stable law can serve as a flexible model for fitting the whole domain of a set of losses data. Alas, the deficiency of closed form for the density of stable law complicates the estimation procedure. In the study a simple technique based on the cumulant function of stable law is introduced. An application to the data set of Danish Fire insurance losses and a comparison with other models is presented.

A linear continuous time affine term structure model for a certain premium leg

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Joint work with: Farzaneh Niknejad and Zahra Sokoot

There are many studies on developing models suitable for analyzing some derivatives such as Credit Default Swap (CDS). As with any swap, valuing CDS involves calculating the present value of the two legs of the transaction, premium leg and default leg.
A continuous time autoregressive moving average (CARMA) driven by Levy process is utilized for modeling the CDS spread since such series exhibit both long memory and heavy tail. We show that this model is a class of affine term structure (ATS) model which has remarkably flexible structure.
ATS models start from the assumption that there are no arbitrage opportunities in financial markets and implies the existence of a positive stochastic process that prices the assets.
Recovery rates play a critical role in the estimation and pricing of the credit risk. Because of different risks in a company and determining the default leg we change the rate from constant to stochastic recovery rate and compare the results. So ew provide the new model under term structure time series model. The fair default payment which is applied in risky companies contract are also considered.
Finally we illustrate the effectiveness of the new time-varying model by simulating the Levy driven CARMA(2,1) process. By comparing models fitted by maximum likelihood to the same data and also smaller BIC we get to a better fitting model.

Market-Consistent Actuarial Valuations with Application to EIOPA Risk-margin and Time-consistent Pricing

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Joint work with: Antoon Pelsser

Most life insurance and pension contracts are very long-dated liabilities that are not traded in the market. The supervisor requirement for a "Market-Consistent" valuation emphasizes the importance of pricing and risk management for such liabilities. To obtain a market-consistent price, we combine hedgeable financial risk with an (partially) unhedgeable actuarial risk and price the hybrid payoff using a "two-step market evaluation." In a general setting, the valuation process comprises the no-arbitrage price of pure financial risk, the value of partially hedged actuarial risk attributable to its correlation with financial risk (if available), and finally the value of pure actuarial risk through well-known actuarial premium principles. We implement a two-step valuation using a backward iteration method and obtain a time-consistent market-consistent (TCMC) price during the valuation period. We also provide a continuous-time limit of the TCMC price for the Variance and Standard-Deviation actuarial prices.
We also provide a market-consistent version of alternative pricing methods: the Best-Estimate pricing method typically used for pension liabilities and the EIOPA's Risk-Margin method used under Solvency II to value life insurance liabilities. By comparing these prices with the TCMC price for a unit-linked contract, we show that the EIOPA Risk-Margin method acts in the correct direction to reflect part of the uncertainty attributable to the future dynamics of non-hedgeable risks, whereas Best-Estimate pricing completely ignores that uncertainty. Because the Risk-Margin method still ignores certain uncertainties, it is not fully time consistent and its gap with TCMC should not be ignored for long-dated contracts. We also numerically show that the two-step actuarial valuation captures partial (or perfect) hedging because all three prices converge to one adjusted Best-Estimate price when the correlation between financial and actuarial risks increases.

Explicit parametrization for mortality deflators and optimal portfolios

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Joint work with: T. Choulli, J. Deng

We consider a market where there are two groups of agents. One group receives through time the public flow of information denoted by $\mathbb{F}$, while the second group receives additional information concerning the occurrence of a random time and then receives a bigger flow $\mathbb{G}$ through time ($\mathbb{F} \subset \mathbb{G}$). This random time can model different situations in various contexts. In fact, in credit risk theory this random time represents a default time, while in insurance market its represents the death time of insured. In (mathematical) finance this random time might represent a random horizon, or the occurrence time of an event that can impact the market somehow. In this setting of two levels of information, our main objective lies in quantifying and evaluating -as explicit as possible– the impact of the death time on three types of optimal portfolio. Namely, we focus on the (local martingale) numéraire portfolio, and the optimal portfolios for the log and exponential utilities. These portfolio problems are investigated when the logarithm of the underlying asset price follows a jump-diffusion model driven by Brownian motion and Poisson shocks. The key idea behind the analysis of these portfolios lies in elaborating an explicit parametrisation for the mortality deflators (i.e. deflators under the flow $\mathbb{G}$, called $\mathbb{G}$-deflators hereafter). We prove that any $\mathbb{G}$-deflator, stopped at the death time, can be "uniquely" associated to a triplet which includes an $\mathbb{F}$-deflator. Besides the fact that our parametrisation is essentially based on the risk's decomposition of Choulli et al. (2015), it can also be viewed as the dual decomposition to Choulli's risk decomposition. In this latter paper, the authors decompose any $\mathbb{G}$-risk up to the death time into the sum of different risks that are mutually orthogonal. These risks are pure financial risk, two different mortality risks, and the risk induced by the correlation between mortality and the financial market. Our parametrisation for mortality deflators is achieved in the most general framework. This makes our results applicable to the numerous contexts cited above, and for complex financial/economic systems as well. Both decompositions (the current mortality deflators' decomposition/parametrisation and Choulli's risk decomposition of [1]) allow us to single out deeply various risks and their corresponding dual parts in a deflator. We believe that these achievements are highly important in addressing the longevity and mortality risks, and hence contribute to the analysis of the securitisation of these risks.
This talk is based on joint work with Choulli, T. (University of Alberta) and Jun Deng (Beijing).

References:

1. Choulli/daveloose/Vanmaele (2015): Mortality Risk Minimisation and Optional Martingale Representation. Preprint with an available version on Arxiv

2. Choulli/Deng/Yansori(2016): Explicit parametrisation for Mortality Deflators and Optimal Portfolios. Work in Progress.

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