

Developments in Pension Design and Investment Modelling 2026

Andros, September 6-9, 2026

BOOK OF ABSTRACTS

(names in alphabetic order)

Michail Anthropolos

On Spatial and Temporary Optimal Risk Sharing

When a risk-averse agent faces a stream of risky payments over time, she may have an incentive not only to share risk across agents but also to transfer risk across time. This paper studies such temporal risk transfer and examines how allowing agents to reallocate risk across periods affects risk sharing and welfare. Besides the Pareto optimal sharing, we study also a non-cooperative framework, in which temporal transfers are chosen strategically.

Under a standard model of preferences, we show that agents have a systematic tendency to front-load risk, transferring exposure toward earlier periods in order to diversify risk over time. When temporal risk transfer is available, this additional dimension of risk sharing increases the welfare gains from cooperation. In contrast, when agents strategically choose their temporal risk transfers, the gains from risk sharing are reduced and are distributed asymmetrically across agents. We further investigate the impact of exogenous reserve-type constraints on temporal risk transfer and characterize how such constraints affect the resulting risk-sharing arrangements. This is joint work with R. Feng (Tsinghua University) and S. Kim (University of Illinois at Urbana-Champaign).

Chris Bakas

The Evolution of the UK DC Pensions Journey: Lessons for Developing Pension Markets

As Defined Contribution pension markets mature around the world, the UK's multi-decade DC journey offers a live case study of what to build toward — and what to avoid. This session traces the evolution of UK Defined Contribution pensions from a traditional accumulation model (targeting only annuity) to a flexible, holistic retirement journey - covering the foundational shifts of auto-enrolment and Pension Freedoms, the evolution of investment approaches from lifestyle strategies to target-date funds, the growing importance of scale and consolidation, and the next frontier of post-retirement solutions including drawdown, annuities, CDC and other hybrid approaches.

The opportunity for developing pension markets is to build this connection from the outset - designing pre-retirement and post-retirement phases as one seamless journey rather than two disconnected systems, and avoiding the costly retrofit the UK is now undertaking.

Carol Bernard

Does Randomization Improve Financial Payoffs?

We study whether external randomization (lottery-linked investment products) can improve optimal financial payoffs in static markets. In an atomless financial market with a continuously distributed state-price density, we first show that, for any law-invariant increasing objective, external randomization does not increase the optimal value. Second, we show that the conclusion changes in finite atomic markets. There, financial payoffs can only select whole atoms, but external randomization then allows atoms to be selected fractionally. In this case, external randomization may improve your objective function strictly. Finally, we propose to test whether empirically people would find lottery-linked pension products more attractive than standard saving products. This talk is based on joint work with Steven Vanduffel (Vrije Universiteit Brussel).

Wing Fung Alfred Chong

Robust Forward Investment and Consumption under Drift and Volatility Uncertainties: A Randomization Approach

This talk studies robust forward investment and consumption preferences and optimal strategies for a risk-averse and ambiguity-averse agent in an incomplete financial market with drift and volatility uncertainties. We focus on nonzero volatility and constant relative risk aversion forward preferences. Given the nonconvexity of the Hamiltonian with respect to uncertain volatilities, we first construct robust randomized forward preferences through endogenous randomization in an auxiliary market. Therein, we derive the corresponding optimal and robust investment and consumption strategies. Furthermore, we show that such forward preferences and strategies, developed in the auxiliary market, remain optimal and robust in the physical market, offering a comprehensive analysis for forward investment and consumption under model uncertainty.

Merce Claramunt

Early Retirement under Survival Uncertainty: A Multi-State Framework

This paper develops an actuarial framework to analyse the optimal timing of voluntary early retirement under survival uncertainty. The retirement decision is modelled through a non-homogeneous multi-state process that distinguishes between active, retired and deceased states, while explicitly retaining the month in which retirement takes place. The valuation criterion is the expected present value of future utility-equivalent income, incorporating wages net of work disutility, retirement-date-dependent pension benefits and a health-related adjustment of pension income after the statutory retirement age. For given behavioural parameters, the model identifies the individually optimal retirement month. The framework is then extended to a collective setting with heterogeneous work disutility and health-related pension valuation, generating a distribution of optimal retirement decisions and effective retirement probabilities. The model is applied to the Spanish pension system, where voluntary early retirement is subject to permanent reduction coefficients depending on both the anticipation period and the contribution history. The results show that longer contribution careers may favour earlier retirement, while higher work disutility shifts the optimal decision towards earlier months. Then, the proposed approach provides a flexible tool for assessing early-retirement incentives and the welfare implications of pension-system design.

Runhuan Feng

Rethinking the Aaron Condition: How Population Ageing Re-opens the PAYG vs. Capitalization System Debate

Is a pay-as-you-go (PAYG) pension system superior to a funded system in an ageing society? The classical Aaron condition provides a simple comparison: PAYG is preferable when population growth plus wage growth exceeds the market interest rate. However, this condition assumes a stable demographic structure—an assumption increasingly untenable in modern societies. This paper extends the Aaron condition to allow for time-varying dependency ratios, deriving cohort-specific internal rates of return that systematically deviate from the classical benchmark. We identify an “ageing penalty” that reduces PAYG returns for cohorts born during demographic transitions. We also analyze intergenerational risk-sharing rules, showing that how demographic pressure is distributed between workers and retirees matters precisely because of population ageing. The results have direct implications for pension reform: during periods of demographic transition, PAYG systems impose implicit losses on transitional cohorts, making funded systems relatively more attractive. However, risk-sharing mechanisms can smooth these losses across generations, potentially preserving the social value of PAYG arrangements even in ageing populations.

Peter Hieber

Notional Defined Contribution Systems with a Surplus Redistribution

In a notional defined contribution (NDC) system, employees contribute to their individual fictitious account, based on contribution rate and assumptions on salary growth. At the time of retirement, the account balance is transformed into a lifelong pension. Sweden adopted a system where benefits are adapted depending on the system’s solvency (=asset-liability ratio). The aim of this talk is to link this stream of literature on PAYG and automatic balancing mechanisms of NDC schemes to target benefit schemes in Germany, group self-annuitization schemes in Australia and modern tontine designs. If, as in the Swedish system, an NDC system distributes surplus to its members, one needs to discuss the fairness of the system, also from the viewpoint of different socioeconomic groups (for example, Arnold et al. (2025)). Additionally, it might be interesting to complement the NDC scheme by additional riders, for example for long-term care (LTC), see for example Levantesi et al. (2024).

Jean Hindriks

Pension design for unequal longevity and arduous jobs: A proposal with application to Belgium

If we want to maintain our pensions system, we will have to work longer. How can we do this without affecting those who started their careers earlier (low skilled) and who are exposed to arduous jobs? In this article, we propose to integrate the age at which people start their careers and the arduous nature of their jobs explicitly into the pension system. The normal retirement age would be indexed to the career starting age. An envelope of arduous occupations is set by income quintile, the intra-group allocation is organised by the social partners within each sector. Compensation for arduous work takes the form of years of retirement anticipation. Fitting our proposal to Belgium, we calculate the budgetary cost of compensation, and the corresponding adjustment of the highest pensions to break even. Our results suggest that granting 3 years of early retirement to 30% of workers in the first salary quintile, 2 years to 15% of workers in the second quintile and 1 year to 7% of workers in the third quintile would entail a loss of 1% of the

average pension in the 4th quintile and 4,69% of the average pension in the 5th quintile. This is a joint work with Laurent Collot (CERPE-UNamur).

George Lagarias

Throw Markowitz off the train: Portfolio Management for Pension Funds in the Age of Debt

The risk and return framework Markowitz invented is three-quarters of a century old, and becoming increasingly irrelevant as the debt cycle matures. Modern portfolio theory rests on two assumptions: a stable covariance matrix and a genuinely risk-free asset. In the mature part of the debt cycle, both of these come under immense pressure. For liability-driven investors, with fixed obligations and fixed income instincts, the problem is far from academic. Sovereign long ends have become one of the most unpredictable segments of global markets. Thirty-year yields in the US, UK, Japan and Germany sit at levels unseen since before the financial crisis, term premia have been restored after a decade of suppression, and issuers are visibly unable to control either end of the curve.

The resulting risk framework is not merely imprecise but outright misleading. Whatever the mathematical method, diversification calculated on the correlations of the past three decades offers comfort but little protection. A matched nominal portfolio can meet its obligations and still fail in real or currency terms. Markowitz optimised variance but pension funds are paid to stay solvent.

Will you?

Anne Lavigne

Why is it so Difficult to Reform the French Pension System, and could Points-based Schemes Offer a Possible Solution?

France has reformed its pension system almost continuously since 1993, yet each reform is contested and, as the 2025 suspension of the 2023 law shows, readily reversed. This intervention argues that the difficulty stems from two structural obstacles. First, public debate collapses onto a single, highly visible lever – the statutory retirement age – while the system's genuinely inequitable and opaque features (the 25-best-years rule, the fragmentation into some thirty schemes) escape scrutiny because they are too complex to mobilise opposition. Second, France suffers a governance deficit: an adversarial, top-down reform process, a fragmented architecture split between basic and complementary tiers, and the persistent inability to install an automatic stabiliser, leaving adjustment hostage to the electoral cycle. Against this backdrop, points-based schemes are often presented as a remedy. They can embed actuarial logic transparently, unify the system, and support automatic balancing. Yet the 2019-2020 failure of the universal points reform shows that points do not abolish the governance problem; they displace it from “what age?” to “who governs the point's value?” Points are therefore a possible solution only if coupled with a credible monitoring mechanism.

Roberta Melis

Optimal Replacement Rate in a Mixed PAYG-Fully Funded DC Pension Scheme

This paper investigates the optimal design of a mixed pension system combining pay-as-you-go (PAYG) and fully funded (FF) components within a pure Defined Contribution (DC) framework under conditions of population ageing. The analysis is managed from the perspective of a

representative agent facing uncertain demographic, wage, and financial environments. A fixed global contribution rate is allocated between PAYG and FF schemes, with the allocation share to PAYG denoted by a policy parameter, while the funded component is invested in a portfolio composed of a risk-free asset and a risky asset with constant rebalancing. The central objective is to determine separately and jointly the optimal mix between PAYG and funding, as well as the optimal exposure to financial risk, by analysing their joint impact on retirement outcomes.

The model incorporates stochastic diffusion dynamics for wages, asset returns, and demographic dependency ratios, allowing for potential correlations between these risk factors. In the PAYG component, pensions are determined by contemporaneous contributions and demographic structure, yielding pension benefits that are lognormally distributed and whose expected replacement rates decline over time as population ageing intensifies. In contrast, the FF component accumulates individual pension wealth through capitalized contributions and converts this wealth into annuities at retirement, resulting in pension benefits that depend on financial returns, annuity pricing, and post-retirement indexation rules.

The paper derives explicit expressions for pension benefits and replacement rates in both components and aggregates them to define a global replacement rate, which serves as the primary performance metric. First, a deterministic benchmark model is examined to highlight the fundamental trade-offs between PAYG and funding, in accordance with the well-known Aaron-Samuelson principle. In this setting, the optimal allocation rule is shown to be corner-based: depending on the relative magnitude of demographic returns and the financial return–wage growth spread, the optimal system is either fully PAYG or fully funded. This result underscores the sensitivity of optimal pension design to demographic evolution and capital market conditions, as well as the potential for intergenerational conflicts arising from time-varying optimal policies. The study then extends to a stochastic framework and conducts a mean–variance analysis of the global replacement rate for a representative agent.

Overall, the paper contributes to the literature on pension economics by offering a unified analytical framework to study the interaction between demographic risk, market risk, wage risks and pension system design in an ageing DC environment. It highlights the conditions under which mixing PAYG and funding can improve retirement outcomes and sets the stage for further extensions based on utility maximization and lifetime welfare criteria. This is a joint work with Pierre Devolder (Université Catholique de Louvain).

Frank Riedel

Knightian Uncertainty under Identifiability: Uncertainty Sharing, Insurance, and Portfolio Choice

Knightian uncertainty arises when the decision maker lacks precise probabilistic information about the relevant model. This talk focuses on the important case in which the uncertainty is identifiable: although the correct probabilistic model is unknown *ex ante*, it can be perfectly learned from sufficiently rich observations *ex post*. This setting is relevant, for example, to uncertainty about volatility in financial markets.

Using smooth ambiguity preferences, the talk explores the implications of identifiability for the sharing and management of model uncertainty. First, it characterizes efficient uncertainty sharing and shows that, because contracts can be made contingent on the model that is eventually revealed, efficiency separates across models and coincides with conditional efficiency under each model. Second, it studies optimal insurance when the true model can be identified *ex post*. Remarkably, Arrow's classical result is restored: optimal insurance consists of a straight deductible in each model, although the optimal deductible varies with the model. The talk concludes with portfolio choice under identifiable uncertainty, including an application to uncertain volatility in the Variance-Gamma model.

Jochen Russ

The Future of Human Life Expectancy – Do we Know how Little we Know and what Does it Mean for Mortality Modelling?

The uncertainty of the future development of human life expectancy is probably larger than most people think. On the one hand climate change, pandemics, micro plastic, particulate matter in the air and many other trends imply a slowdown of the increase (or even a reduction) of human life expectancy. On the other hand, most medical experts agree that the mechanisms of aging are essentially understood and slowing down (or even reversing) aging is within reach. The talk gives a short overview over these aspects and concludes that mortality models (in particular stochastic models that are used to model risk / quantify uncertainty should be based on interdisciplinary research that particularly takes into account insight from medical experts. The author presents the results of two recent interdisciplinary papers (one published one currently under review) that were co-authored between actuaries and bio-gerontologists. The first paper presents a methodology how insights from other disciplines can be used (additionally to using data) in the calibration of mortality models. The second paper shows that the structural relation between the “speed of medical progress” and the “speed of increase of life expectancy” will be completely different if the future will bring a different “type of medical progress” (i.e. a modification of the biology of aging rather than improving cures for individual diseases).

Thaleia Zariphopoulou

Pension Fund Management under Forward Performance Criteria: A New Approach and Open Problems

The talk will present new ideas for pension fund management by building an optimal stochastic control approach with progressively measurable risk preferences (forward utilities). Such utilities allow for dynamic adaptation of market conditions, varying population dynamics and stochastic level of contributions in a general incomplete market setting. Managing the fund gives rise to interlinked sequential forward indifference valuation problems whose solution yields, among others, the optimal investment policies of the fund. Several open problems will be discussed related to solvability, long-term feasibility, correlation effects and others. This is a joint work with M. Anthropelos (University of Piraeus).