Programme

Programme correct as of 28th September 2016. Please check regularly for any updates.

Longevity 12 Conference – Programme

Day 1	**Thursday 29th September 2016**
07:30 - 08:30	Registration and Refreshments
08:30	Welcome **Dale Hall, Society of Actuaries, and David Blake**
	Plenary Session I – The Demographics of Longevity risk
08:40 - 09:00	**Jay Olshansky, University of Illinois at Chicago** *"The Rise and Fall of Human Longevity in the 21st Century"* **Abstract** The rise in human longevity in the last 120 years has been one of humanity's major accomplishments. The good news is that we're living longer because in the absence of fixed genetic programs for aging or death, it has become possible to modify the world around us to foster conditions that favor greater longevity. The bad news is that our increased longevity is accompanied by a Faustian trade -- we now live with regularity into an age window where the biological processes of aging remain immutable, and the fatal and disabling diseases that accompany our longer lives rise in lock step with greater longevity. This makes forecasts of life expectancy based on past trends a tenuous exercise at best since, by definition, the future course of mortality and survival must operate in biological conditions that are fundamentally different from those observed in the past. While optimistic that interventions that modulate biological aging are forthcoming (I am personally supporting these ideas through the Longevity Dividend Initiative), the biological reality is that human bodies were not built to last. In this presentation I will distil this line of reasoning into a brief discussion of why there is excitement in the air about aging science, but this excitement must be tempered by biological reality and observed trends in mortality in long-lived populations suggesting that linear increases in life expectancy are neither biologically nor demographically justifiable -- especially not in the United States.
09:00 - 09:20	**Aubrey de Grey, Chief Science Officer of SENS Research Foundation** "*Longevity Escape Velocity: Incorporating Technological Progress into Extrapolation"* **Abstract** Predictions of future longevity have historically failed, by and large, to prove accurate. I will argue that this is because they are in one or another way based on pure extrapolation of past trends, a method that incorporates the implicit assumption that it does not matter *how* we contrived to achieve longevity improvements. I will explain how a careful examination of the medical and other advances that led to increased longevity could have resulted in much better predictions of their impact. I will then focus on the future, and especially on the initially counterintuitive but ultimately inescapable conclusion that regenerative medicine applied to the health problems of old age will at some point probably within the next few decades, create a sharp discontinuity – which others have termed the "Methuselarity" – in the longevity of successive cohorts. This discontinuity will be so dramatic that period life expectancy will literally cease to be calculable, because mortality rates for all ages so far attained will become so low that survival probabilities will multiply to more than 50%
09:20 - 09:40	**Sam Gutterman, Retired Director and Consulting Actuary, PricewaterhouseCoopers** *"Perspectives on Current and Future Mortality"* **Abstract** Sam will cover recent and possible drivers of future mortality in the United States. Population trends from the 2012-15 period have not been as favorable as the last few decades – are these harbingers of less robust experience or a temporary lull in the long-term trend of improvement? He will explore some of the factors to consider in the assessment of these future trends.

09:40 - 10:00	**Vladimir Canudas-Romo , Max Planck Odense Center on the Biodemography of Aging, at the University of Southern Denmark** "The Past and Future Rise of Human Longevity" **Abstract** Since 1840 life expectancy in the national populations with the highest life expectancy has risen at a steady pace of almost 2.5 years per decade. Since 1950 life expectancy in most high-life-expectancy countries has risen at about this pace. In the last quarter of the 20th century, life expectancy rose more slowly or even stagnated in some countries, notably the United States, the Netherlands and Denmark, but in the 21st century progress has resumed. In the future life expectancy life expectancy in advanced countries could (1) rise more slowly and possibly even fall, (2) rise at about the same pace, or (3) rise at a more rapid pace. I will discuss and try to explain why most actuaries, demographers and other experts predict (1) despite the sorry saga of forecasts of (1) over and over again since the early 1920s when (2) has been generally true in most advanced countries and most time periods. Why have experts been so impervious to empirical reality? I will also discuss why I think that (1), (2) and (3) are roughly equally likely over the next 50 years, with (1) most likely.
10:00-10:30	**Panel on the demographics of longevity risk, chaired by Guy Coughlan, Universities Superannuation Scheme** **Jay Olshansky**, University of Illinois at Chicago **Aubrey de Grey**, Chief Science Officer of SENS Research Foundation **Sam Gutterman,** Retired Director and Consulting Actuary, PricewaterhouseCoopers **Vladimir Canudas-Romo ,** Max Planck Odense Center on the Biodemography of Aging, University of Southern Denmark
10:30-11:00	**Refreshment Break**
11:00-12:30	**Parallel Session I** Mortality Risk in Pensions and Insurance 1 Mortality Modelling 1 Longevity Risk Management 1 Long-Term Care 1 Mortality Forecasting 1 Mortality Data 1
12:30 -13:30	Lunch Break
13:30 -15:00	**Parallel Session II** Product Design 1 Mortality Modelling 2 Basis Risk 1 Micro/Macro Longevity Issues Annuities 1
15:00 - 15:30	**Refreshment Break**
	Plenary Session II – Product innovation
15:30 - 16:00	**Richard L. Sandor, Founder of the Chicago Climate Exchange (CCX)** "Financial Innovation" **Abstract** Financial innovation is often overlooked or underestimated by both the general population and many professional economists. Financial innovations allow markets to exist for transactions where they did not exist before. And yet such financial innovations are often overlooked for at least three reasons. First, because they are intangible and may be difficult to understand by laypeople. Second, they tend to be "wholesale" i.e. they are not part of the retail mass market and third, until recently they were not patentable and their benefits incurred only to first movers. Misunderstanding and suspicion of financial innovation seems to have been enhanced by the Great Recession of 2008. Contrary to popular belief, one could argue that many types of financial innovations have been a positive force. These innovations are transparent, regulated and centrally cleared. Dr. Sandor will cover the process of creating new financial products and the equally important process of building institutions to support and facilitate growth in the financial industry. Using exchanges as

	an example, he will provide unique insights into financial innovation. The creation of new markets should be of interest to both practitioners and students who want to better understand the creative process in the recent era of financial innovation and how finance can be a force for good in a wide variety of areas. ***Sandor's Seven Stages of Market Evolution*** 1. Structural Change – leading to a demand for capital 2. Development of uniform commodity/security standards 3. Introduction of legal instruments providing evidence of ownership 4. Development of informal spot and forward markets 5. Emergence of formal exchanges 6. Introduction of organised futures and options markets 7. Proliferation of over-the-counter (OTC) markets, deconstruction
16:00-16:30	**Amy Kessler, Prudential Financial** *"New Solutions To An Age-Old Problem: Innovative strategies for managing pension and longevity risk*" **Abstract** Innovation is accelerating the growth of the global pension and longevity risk transfer marketplace. The leaders in the international pension and insurance community are perfecting solutions for pension funds of all sizes and sectors—solutions like reinsurance sidecars and funded reinsurance agreements. In fact, with low interest rates and market volatility continuing unabated—and with pressure on the cost structure of pension funds rapidly increasing—innovation in this space has reached an inevitable inflection point. For example, Solvency II in the U.K. is compelling insurers to manage annuity-block risk using very similar techniques as pension funds. And with more precise mortality tables now in use in the U.S., many American firms are embracing pension de-risking—but choosing a different path than their U.K. brethren. This global trend of de-risking pension funds and insured annuity blocks with innovative solutions is certain to continue in 2016 and beyond, with longevity risk transfer fundamental to the progress.
16:30-17:00	**Laura Hardy, RGA Reinsurance** *"Longevity Risk Transfer: Where Does the Market Turn When All the Cheap Capacity is Gone"* **Abstract** The pensions risk transfer market is dependent on the longevity risk capacity of insurers and reinsurers for its continued existence. Gone are the days where a high investment rate of return could mask the cost of unexpected longevity improvements. But where is the market headed from here? How much will pricing need to increase once the benefit of diversification from mortality heavy life insurers is all used up? Will the market bear this increased cost? Or will alternative solutions evolve to fill the void?
17:00 - 17:30	**Vladimir Nicenko, Willkie Farr & Gallagher** **Nicholas Bugler, Willkie Farr & Gallagher** **Amy Kessler, Prudential Financial** **Chip Gillis, Athene Life Re** *"Sidecars: Alternative Capital or Reinsurance?"* **Abstract** Continued rapid growth in pension de-risking may be constrained by the appetite of the major insurers in the market. The use of reinsurance sidecars in the annuity and longevity space could increase capacity, but this innovation presents challenges and opportunities. For an insurance company seeking sidecar investors, how does it think about limits in the investment horizon and exposure limits that may be imposed by an investor? Will all investors in sidecar arrangements impose these limits? Will these limits determine whether the sidecar is a form of alternative capital or reinsurance?
17:30 - 18:00	**Panel on Innovation, chaired by Guy Coughlan, Universities Superannuation Scheme** Amy Kessler, Prudential Financial James Ciamarro, RGA Reinsurance Vladimir Nicenko, Willkie Farr & Gallagher Nicholas Bugler, Willkie Farr & Gallagher Chip Gillis, Athene Life Re Richard Sandor, Founder of the Chicago Climate Exchange (CCX)
18:30 - 22:30	**Reception followed by Gala Dinner**

Day 2	Friday 30th September 2016
08:00 - 09:00	Registration and coffee
09:00 -10:30	**Parallel Session III** Pricing 1 Mortality Modelling 3 Mortality Modelling 4 Product Design 2 Mortality Forecasting 2
10:30-11:00	**Refreshment Break**
	Plenary Session III – Data Reliability Challenges and Timeliness
11:00-11:20	**Magali Barbieri, Associate Director, Human Mortality Database** *"Data Quality Issues and Adjustments in the Human Mortality Database"* **Abstract** The Human Mortality Database (HMD) is renowned for the high quality of its mortality data. However, the death rate and life table series available in the HMD are only as good as the basic statistical information used for their construction. The systematic checks of official vital statistics (birth and death counts) and census data or population estimates which make the basis of all HMD calculations have highlighted a number of problems which present important challenges for the accurate measurement of mortality level and trends. There are four main types of issues: 1) availability (publication delays; gaps in data series; lack of annual population estimates), 2) level of detail in the data (age groups rather than single year of age; open age interval; diversity of single year data “shapes”); 3) changes in definition (live births; *de jure* versus *de facto* population; territorial changes); and 4) Reliability (under-registration of vital events or population; immortals and phantoms; unknown ages; age misstatement, such as attraction and overstatement in particular). We will present examples of such issues for HMD countries, explain which methods are currently implemented to take them into account, and open a discussion about those remaining unresolved.
11:20 -11:40	**Steve Goss, Social Security Administration** “*The Importance of Consistent Data on Deaths and Exposure over Time, by Age, Sex, and Cause of Death”.* **Abstract** The estimated cost of future U.S. Social Security benefits, and future benefits from any retirement plan, depend critically on projections of death rates for plan participants. For ages under 65, aggregate national death data by age from the NCHS, along with population data by age from the Census Bureau, are the only option. Over age 65, however, data on deaths and exposures for virtually the entire U.S. population have been available for nearly 50 years from a consistent source, Social Security/Medicare records. This consistency removes a major concern over mismatch in deaths and exposures, both in total reporting and age reporting. We will present recent analysis comparing death rates for the population over age 65 from the Social Security/Medicare data versus rates based on the NCHS/Census data. In addition, any projection of future reductions in mortality rates requires the best possible understanding of causes of death in the historical period. For this, the NCHS distribution of deaths by cause of death is useful. Finally, mortality rates and trends may vary depending on the subset of the population considered. While Social Security covers essentially the entire U.S. population, sub-national pensions and annuities cover selective subgroups of the population. Thus, trends in mortality for the population as a whole may not be appropriate for evaluating all plans.
11:40 - 12:00	**Tom Jones, Prudential** *"The Importance of High Quality Data for Underwriting Pension Risk Transfer and Longevity Reinsurance Transactions: An Insurance Company Perspective"* **Abstract** Over the past three to four years there has been an increasing desire of large pension plans to transfer their liability obligations to insurance companies in exchange for a single premium and/or agreed upon plan assets. Many of these plans have a liability in excess of 1 billion dollars, requiring a heavy capital commitment on the part of Insurance companies in order to assume the risk. Insurance companies therefore require robust and accurate data in order to consider such a transaction. A key component of the required data is the plan mortality experience. This data is critical to set an informed base mortality assumption. Another key assumption is the level of future mortality improvements which requires good data from multiple sources. It

	is critical to have an understanding of the credibility, quality and the limitations of these multiple data sources. Misestimating life expectancy by just a few months due to inaccurate data can have a significant impact on cash flow shape and price. Ultimately, lower quality data leads to more uncertainty and risk and a less efficient transaction. We will discuss the key data elements and the impact and ramifications of data quality on transaction pricing
12:00 - 12:30	**Panel on Mortality Data, chaired by Andrew Cairns, Heriot-Watt University** **Magali Barbieri**, Associate Director, Human Mortality Database **Steve Goss**, Social Security Administration **Tom Jones**, Prudential
12:30 - 13:30	**Lunch Break**
	Plenary Session IV – Mortality Forecasting in Practice
13:30 - 13:35	**Steve Goss**, **Social Security Administration** Introductions. Challenge in selecting method and assumptions for projections
13:35 – 13:55	**Karen P. Glenn, Social Security Administration** *"Projecting Mortality by Age and Cause: the Importance of Data Source, Expert Judgment, and Unknown Future Challenges"* **Abstract** The U.S. Social Security Administration's Office of the Chief Actuary has made projections of mortality improvement for more than 80 years. Our method has evolved in recognition of available data and changing conditions, both realized and anticipated. Currently, we project rates of mortality decline by age and cause-of-death group, reflecting historical rates and conditions and expert judgment on how these rates may change in the future. We develop rates of change in consultation with representatives of Social Security and Medicare's Board of Trustees, including staff from the U.S. Department of Health and Human Services. We develop historical rates for ages under 65 based on data from the National Center for Health Statistics and the U.S. Census Bureau. But for ages 65 and over, we develop rates based on data from the Centers for Medicare and Medicaid Services, a single consistent source reflecting all individuals covered under Social Security and Medicare. These data cover nearly the entire aged population. Differences in mortality reductions by age are critical to projecting the cost of Social Security and Medicare. Different reductions by income level are also important, but we reflect those indirectly in our projections.
13:55 – 14:15	**Laurence Pinzur, Aon Hewitt** "The Continuing Evolution of RPEC's Mortality Projection Methodology" **Abstract** The Retirement Plans Experience Committee (RPEC) is one of a number of committees within the Society of Actuaries researching mortality trends in the US. Over the past few years, RPEC has been very active in reviewing US population mortality experience and developing mortality improvement projection methodologies for retirement-related applications. We summarize the evolution of RPEC's projection methodologies and highlight some of the Society of Actuaries' current research efforts.
14:15 – 14:35	**Vladimir Canudas-Romo, Max Planck Odense Center on the Biodemography of Aging, at the University of Southern Denmark** "Mortality Expectations by Cause through 2040: Johns Hopkins Clinicians and Researchers" **Abstract** Johns Hopkins tried a different approach to estimating longevity. We asked senior physicians with expertise in the main causes of morbidity (heart disease, cancer, etc) to consider the clinical advances that will likely occur in the next 30 years and their impact on life expectancy. We then had them project life expectancy by age cohort. The results were remarkably similar to the estimates made by the Social Security Administration and other models.

14:35 – 14:55	**Jay Olshansky**, **University of Illinois at Chicago** “Understanding Biology: Going Beyond Simple Statistical Extrapolation” **Abstract** Is there a biologically based limit to life expectancy that evolved under the direct force of natural selection? Are there aging or death clocks ticking within us that preclude lifespans of 150+ years and life expectancies of 120 years or more? Of course not! Natural selection could not have given rise to such genetically driven programs. However, contrary to the popular views of some, this does not mean biologically based limits to life do not exist. The best way to understand this distinction is to consider the consequences of simple statistical extrapolation as a way to project the future of life expectancy. While linear extrapolation of age-specific death rates yields diminishing gains in life expectancy, linear extrapolation of life expectancy at birth or at older ages requires the underlying assumption that declines in death rates accelerate in the future. Since most deaths now occur past age 65 in developed nations, this assumption means that accelerating reductions in death rates in the future would have to occur in an age range where the currently immutable process of biological aging has become the most important risk factor for disease and death. Our biology has caught up with us! The time has arrived to move on from simple statistical extrapolation to forecasting methods that take into account the fundamental biological processes of aging.
14:55 – 15:15	**Steve Goss, Social Security Administration** “Projecting Mortality, Different Models for Different Purposes and Views About the Future” **Abstract** Over time, future mortality has been projected in a variety ways, from static life tables and age set back, to extrapolating historical decline in death rates by age, by cohort, or by cause of death. There has always been a tension between pure statistical extrapolation of past trends versus making assumptions based on expected future conditions. For retirement plans in general, and national plans financed on a current funding basis in particular, differences in mortality improvement by age are crucial for both future cost and future funding capacity. For longer term projections, the degree to which mortality improvement may decelerate from the dramatic gains in the 20th century is just as important. The method selected for projecting mortality largely reflects the beliefs and expectations of the modeller, and determines the outcome. The future is uncertain and is unlikely to be a simple extension of past trends. Therefore, judgement in model selection, which data to use and for what time period, and what changes in underlying conditions should be reflected and anticipated, are the determinants of what each model produces.
15:15 – 15:30	**Discussion, questions, and wrap-up moderated by Steve Goss, Social Security Administration**
15:30	**Closing Ceremony – handover to the L13 team**

Parallel Sessions	Thursday 29th September 2016
11:00 – 12:30	**Parallel Session I**
	Mortality Risk in Pensions and Insurance 1
Ling-Ni Boon	**Longevity Risk Mitigation in Pension Design: to Share or to Transfer** **Abstract** We investigate the attractiveness of two longevity risk mitigation contracts in retirement: a collective arrangement that shares the risk between plan participants, and a market-provided annuity contract. We evaluate the contracts' appeal with respect to the beneficiaries' welfare, and the viability of the market solution through the financial return to shareholders, whose capital provision is necessary due to the annuity provider's solvency requirements. In our framework, the annuity contract can only exist if it is priced within the upper limit implied by the maximum cost that individuals are willing to bear to offload longevity risk, and the lower limit imposed by the remuneration of the contract provider's shareholders. Our model suggests that the collective scheme yields marginally higher individual welfare than the annuity contract that is priced at its best estimate. The outcome is generally insensitive to a range of risk aversion levels, age, and the elimination of the provider's default risk. Due to the lack of distinct individual preference for the annuity contract, there is no margin for a positive loading to adequately compensate shareholders for bearing longevity risk. Our results suggest that when annuity providers are to fully hedge financial market risks, and in the absence of comparative advantages such as natural hedge between different types of contracts on the provider's balance sheet, market-provided annuity contracts would not coexist with collective schemes.
Andrew Hunt	**Modelling Mortality for Pension Schemes** **Abstract** For many pension schemes, a shortage of data limits their ability to use sophisticated stochastic mortality models to assess and manage their exposure to longevity risk. In this study, we develop a mortality model designed for such pension schemes, which compares the evolution of mortality rates in a sub-population with that observed in a larger reference population. We apply this approach to data from the CMI Self-Administered Pension Scheme study, using UK population data as a reference. We then use the approach to investigate the potential differences in the evolution of mortality rates between these two populations and find that, in many practical situations, basis risk is much less of a problem than is commonly believed.
	Mortality Modelling 1
Liang Chen	**Impact of Sampling Variation on the Calibration of Stochastic Mortality Models** **Abstract** This talk considers the impact of sampling variation on the calibration of stochastic mortality models. Random variation deaths counts results in parameter uncertainty in estimates of age, period and cohort effect in the model. In turn, this has an impact on time series parameter estimates. With small populations, sampling variation causes an upwards bias in the estimated volatility of period effects using standard maximum likelihood methods. We seek to counteract this problem of bias, using Bayesian Inference. We use England and Wales (EW) males as a benchmark and then scale this down to stimulate small populations. We will discuss to what extent Bayesian methods reduce bias in the model volatility, using full EW population as a benchmark
Petar Jevtic	**The Joint Mortality of Couples** **Abstract** This paper introduces a probabilistic framework for the joint survivorship of couples, in the context of dynamic stochastic mortality models. In contrast to previous literature, where the dependence between male and female times of death was achieved using a copula approach, this framework gives an intuitive and flexible pairwise cohort-based probabilistic mechanism that can accommodate both deterministic and stochastic effects which the death of one member of couple causes on the other. It is sufficiently flexible to allow modeling of effects that are short term (broken heart) or long term in their durations. In addition, it can account for the state of health of both the surviving and dying spouse and thus can allow for dynamic and asymmetric reactions of varying complexity. Finally, it can accommodate the dependence of lives before the first death. Analytical expressions for bivariate survivorship in representative models are given, and their

	estimation, done in two stages, is seen to be straightforward. First marginal survivorship functions are calibrated based on UK mortality data for males and females of chosen cohorts. Second, the maximum likelihood approach is used to estimate the remaining parameters from simulated joint survival data. We show that the calibration methodology is simple, robust and fast and can be readily used in practice.
Severine Arnold	**On the Heterogeneity of Human Population as reflected by the Mortality Dynamics** **Abstract** The heterogeneity of human population is a common consideration in describing and validating its various age-related features. Particularly the heterogeneity, amongst other factors, is used to explain the variability of mortality rates across the lifespan and their deviations from an exponential growth at young and very old ages. A mathematical model that combines the population heterogeneity with the assumption that the mortality of each constituent subpopulation increases exponentially with age, has recently been shown to successfully reproduce the entire mortality pattern across the lifespan as well as its evolution over time. Furthermore, the analysis of time-evolution of the mortality patterns, performed by fitting the model to actual data of consecutive periods, confirms the applicability of the compensation law of mortality to each subpopulation and concludes on the evolution of the population towards its homogenization. In this work we aim to show that the heterogeneity of human population is not only a convenient consideration for fitting mortality data but is indeed the actual structure of the population as reflected by the dynamics of its mortality over age and time. Particularly we demonstrate that the model of heterogeneous population fits mortality data better than most of the other models if the data are taken for the entire lifespan and better than all other models if we consider only old ages. Also, we show that the model can reproduce seemingly contradicting observations in late-life mortality dynamics namely the deceleration, the leveling-off and the mortality decline. Furthermore, assuming that the heterogeneity is reflected by genetic variations in the population and using Swedish mortality data for 20th century we confirm that the evolution of mortality dynamics and homogenization of the population can be explained by natural selection and a spread of favored gene variant. This has important implications for potential future mortality improvements.
	Longevity Risk Management 1
Stuart Silverman, FSA, MAAA, CERA **Milliman** **Silver Sponsor**	**Diversification of Longevity and Mortality Risk** **Abstract** There is real value for an insurer in performing stochastic modeling with volatile mortality assumptions when pricing, setting deterministic margins, determining economic capital, and determining its optimal mix of business. This presentation will explore relevant questions related to margins using a simple combination of life insurance and payout annuity products by applying stochastic projections of future mortality rates. Percentile values from the stochastic projections will be compared to results using deterministic projections and margins. In addition, we will demonstrate the relative diversification benefit of the longevity exposure from the annuity product along with the mortality exposure of the life insurance product.
Yijia Lin	**Longevity Risk Transfer and Dynamic Hedging Strategies** **Abstract** Pension plans around the world are increasingly facing funding challenges that arise from market downturns, low interest rate environments, increasing life expectancies and new pension accounting standards (Cox et al., 2013; Lin et al., 2014, 2015). Pension funding deficits and related costs can diminish a firms ability to maintain its existing operations and invest in positive net present value (NPV) projects (Lin et al., 2016). As a result, defined benefit (DB) pension sponsors are keenly interested in de-risking their DB plans through, for example, pension buy-ins and buy-outs in recent years. Notably, the buy-in and buy-out volumes in the UK reached £ 13.2 billion in 2014, breaking all previous annual records. 2015 also saw over £ 10 billion of buy-in and buy-out business written in the UK (Lane Clark & Peacock LLP, 2015).
Carsten Rosenskjold	**Hedge Effectiveness of Index Based Transactions Across Socio-Economic Groups** **Abstract** A particular worry of pension funds and life insurance companies is the risk that their insured members deviate from the average forecasted life expectancies for the general population. This uncertainty naturally leads to a desire to share or sell off the risk associated with longevity. Since 2000, a number of risk sharing transactions have occurred typically with insurers or reinsurers on the buying side using indemnity hedges. However, for the capital markets to take on a greater amount of longevity risk focus has to be on alternative products such as index based solutions. This would give a higher visibility in the transaction and thus eliminate the current adverse selection issues. The index based solution has the advantage of being standardized which give a more efficient and cheaper product solution but at the cost of containing a mismatch between the pension payments and the index, reflecting the basis risk. The use of index based transactions also implies accepting a certain shortfall probability which depends on a number of factors, one of which is the hedge effectiveness of the transaction. The evaluation of the hedge effectiveness is naturally complicated by the heterogeneity of populations in different pension funds and life insurance companies compared to the total population as well as lack of available data. This paper addresses both of these issues by using ten socio-economic subgroups for the time period 1985-2012 based on Danish register data as of Cairns et al., 2016. We analyse the hedge effectiveness of various financial instruments, by proxying

	individual pension funds with the socio-economic subgroups and analyse the following: Firstly, how large is the hedge effectiveness for each of the socio-economic groups and how does it differ between groups. This will enable pension funds with significantly different characteristics from the total population to assess whether index hedges or indemnity should be used. Secondly, how different financial products influence the hedge effectiveness enabling an assessment of the relation between security type and hedge effectiveness. Thirdly, the gains in hedge effectiveness from lumping subgroups is evaluated and thus allows for assessing the importance of the role.
	Long Term Care and Health 1
Les Mayhew	**Paying for Long Term Care Insurance: The Pros and Cons of Different Payment Methods** **Abstract** With the number of UK citizens aged 75+ expected to double to 10million by 2040, and with 1.3 million people already receiving social care services in England alone, social care funding is a key public policy challenge. The Government has launched a set of reforms designed to get social care funding onto a sustainable footing, by establishing a new system which clarifies the respective contributions that individuals and the state are expected to make towards the cost of care. How to pay for long term care is a hot topic in the insurance world and among policy makers. Local authority social care budgets continue to be squeezed and the thresholds for state support have been tightened so that fewer people will be eligible unless their needs are assessed as being substantial or critical. This will mean that more people will be forced to pay for their own care and so should consider options for how to do this. This paper will investigate different ways in which individuals can purchase insurance products specifically to help them to pay for their care costs in later life. The main objective of our research is to try and indentify mechanisms which do not unduly reduce the individual's standard of living due to high premium payments, and which could include making use of assets other than savings such as property.
Jack Yue	**Using Taiwan National Health Care Database to Design Long term Care Insurance** **Abstract** Prolonging life is a common trend of the 21st century and preparing the needs for the elderly becomes important. This is why the arrangement of retirement life is popular, in addition to the economic and medical needs for the elderly. Long-term care insurance is one of the key issues of life arrangement since the elderly have higher probability of being disable. However, pricing the long-term care insurance is not easy. Lacking the experience rates is one of the main reasons, as well as long-tail liability risk and asset management to the insurers. In fact, high premium and high managing risk make the sales of lon-term care insurance slow in the U.S. In this study, we use the Taiwan NHI (National Health Insurance) database to price the long-term care insurance products. Taiwan started the national healthcare insurance in 1995 and about 99% of Taiwan population are covered. Catastrophic diseases (CD) are one of the key features of NHI and those who are judged with the CD can waive their deductibles for medical cost related to the CD. The judgment of CD is based on the medical diagnosis and professional opinions from a group of physicians from different medical institutions. The CD accounts for about 30% NHI total cost, despite that only 4% of population are with the CD. Since the NHI has almost the whole Taiwan population data, it would be more reliable to evaluate the need of long-term care using the NHI database, if the needs of long-term care are CD related.
Derek Yach	**Transforming Life Insurance to Promote Longevity** **Abstract** Two macro trends will increasingly impact on financial services and human health: advances in technology and increased longevity. To date, the response by the life insurance industry to these trends has been modest and slow. This presentation will highlight how longevity is receiving unprecedented political interest exemplified by the G7 meeting in Kobe (September 2016); and the relationship between longevity and technology is leading to new insurance business models that actively enhance longevity and healthy living. These build on work that started 100 years ago. The core ideas behind transforming "death" to true "life" insurance will be illustrated using examples being rolled out globally.

	Mortality Forecasting 1
Jimmy Risk	**Gaussian Process Models for Mortality Improvement Factors** **Abstract** We investigate modeling the mortality rate surface and mortality improvement factors in the Gaussian process (GP) regression framework. We use a nonparametric response surface approach which quantifies the uncertainty regarding the underlying mortality experience and allows to generate full stochastic trajectories for out-of-sample forecasts. GP regression takes a data-driven approach to determining the spatial dependence in mortality rates, coherently handling the smoothing of existing data across both calendar years and ages. Our framework is also well suited for updating projections when newly available data arrives, and for dealing with \edge" issues where credibility is lower. We present a detailed analysis of Gaussian process model performance for US mortality experience based on both CDC an SSA datasets. Some of the specific questions we investigate are the interaction between trend and residual modeling, Bayesian and non-Bayesian GP methodologies, accuracy of in-sample and out-of-sample forecasting, stability of model parameters, and the effect of chosen covariance structures. We also document the general decline, along with strong age-dependency, in mortality improvement factors in the past few years, contrasting our findings with the RP-2014 and -2015 models that continue to project constant improvement factors into the future. Joint work with Jimmy Risk and Howard Zail.
Andrew Cairns and Vasil Enchev	**Multi-population Mortality Models Fitting Forecasting, Comparisons and Applications** **Abstract** We review a number of multi-population mortality models: variations of the Li and Lee (2005) model, and the common-age-effect (CAE) model of Kleinow (2015). Model parameters are estimated using maximum likelihood. We propose to solve the challenging identifiability problems by applying two dimensional constraints over the parameters. Using data from six countries, we compare and rank, both visually and numerically, the models' fitting qualities and develop forecasting models that produce non-diverging, joint mortality rate scenarios. It is found that the CAE model fits best. But we also find that the Li and Lee model potentially suffers from robustness problems when calibrated using maximum likelihood. Finally we consider possible applications for those models involving multipopulation longevity risk decisions.
Torsten Kleinow	**Parameter Risk in Time-series Mortality Forecasts** **Abstract** The projection of mortality rates is an essential part of valuing liabilities in life-insurance portfolios and pension schemes. An important tool for risk-management and solvency purposes is a stochastic projection model for mortality. We show that ARIMA models can be better representations of mortality time-series than simple random-walk models. We also consider the sometimes-overlooked issue of parameter risk in time-series models | formulae are given for decomposing overall risk into undiversifiable trend risk (parameter uncertainty) and diversifiable volatility. Using the bootstrap approach from Pascual et al. (2004) we find that, while certain kinds of parameter risk are negligible, others are too material to ignore. In our specific mortality examples, a modification to the procedure from Pascual et al. (2004) reduced bias when bootstrapping the variance of the volatility, σ_ϵ^2 The conclusions have relevance to projection models used by insurers in the European Union under Solvency II.
	Mortality Data 1
Alexandre Boumezoued	**A Reliability Challenge for the Human Mortality Database** **Abstract** Following the work of Cairns et al. (2016), we aim at correcting mortality estimates based on fertility data. As already conjectured by Richards (2008), the computation of exposure to risk can suffer from errors for cohorts born in years in which births are fluctuating. In this context, we first point our attention to the Human Mortality Database (HMD), the reference mortality data provider. While comparing period and cohort mortality tables, we highlight the presence of anomalies in period ones in the form of isolated cohort effects. Our investigation of the HMD methodology exhibits a strong assumption of uniform distribution of births that is specific to period tables, therefore likely to be at the core of the asymmetry between both. Based on the idea of Cairns et al. (2016) regarding the construction of a fertility-based data quality indicator, we make a new and intensive exploitation of the Human Fertility Database (HFD), which is from our point of view a crucial source as it represents the perfect counterpart of the HMD in terms of fertility. This indicator is then used to construct corrected period mortality tables for several countries, which we analyze on both an historical and prospective point of view. Our main conclusions relate to the reduction of volatility of mortality improvement rates, the impact in the use of cohort parameters in stochastic mortality models, as well as a better fit of corrected tables by classical mortality models.

H C Kevin Wang	**Using the Select Table to Model Mortality Rates of Domestic Immigrants** **Abstract** Migration and aging are expected to be two major population issues in the 21st Century. The low fertility rates and low mortality rates cause the rapid population aging, in addition to causing population reduction. Migration would slow down the speed of population aging and population reduction, and this is one of the reasons why the issue of immigration becomes popular in many developed countries. However, there are not many studies regarding mortality rates of domestic immigrants, while the longevity of international immigrants have been studied in quite a lot of countries. In this study, based on the data from Taiwan's population registration, we want to explore the mortality rates of domestic immigrants and examine if they can live longer. The study region of interest is Kinman, an island county, about 200 miles from Taiwan. Kinman county has many immigrants (mostly domestic immigrants) in last 20 years, almost tripling the population size. The size of immigrants in Kinman creates a good opportunity to study the longevity of domestic immigrants. Because the sizes of county-level population are usually small, their (mortality rates and life expectancy) estimates are likely to fluctuate a lot. We use graduation methods to smooth the estimates (e.g., the age-specific death rates), and the smoothing methods considered in this study include Whittaker method, Partial SMR method, Lee-Carter model. We found that the mortality rates of domestic immigrants are related to the time when they moved in. This is similar to the idea of select and ultimate tables. Thus, we propose a stochastic model to describe the mortality rates of immigrants. The empirical study of Kinman immigrants shows that the select period is about 10 years. Our study results can serve as a reference to government for population projections and policy planning. In addition, the proposed approach can be used to construct select and ultimate tables in insurance industry, to avoid adverse selection and to reduce the impact of longevity risk.
13:30 -15:00	**Parallel Session II**
	Product Design 1
Ming-hua Hsieh	**The Product Design of the Long-Term Care Annuity** **Abstract** Long-term Care Annuity (LTCA), a combination of Long-term Care (LTC) insurance and an annuity, provides a complete solution for retirement. Individuals with relatively high risk in the annuities market are relatively low risk in the LTC insurance market. Therefore, due to the effect of natural hedge, LTCA has the potential of lowering the adverse selection cost of annuity and LTC insurance. This paper investigates the benefits of adverse selection and natural hedge under different payout patterns of annuity and Long-term Care and propose a better product design strategy for LTCA. Our results show that a good design strategy of LTCA can provide a cheaper retirement product with higher coverage and create a win-win situation for consumers and life insurers.
Patrick L. Brockett	**The Impact of Financial Literacy on Long-term Care Insurance and Annuity Decision-making: Product Innovation Implications** **Abstract** With increased longevity worldwide, long-term care insurance is an increasingly important decision component in individuals' retirement planning. In stark contrast, however, long-term care expenditures also represent one of the largest uninsured financial risks facing the elderly, with only 4% of the expenditure paid for by private insurance (Brown and Finkelstein 2007). Like other financial decisions such as savings, investments, annuities or retirement planning, long-term care insurance decision making is complex because of the long-horizon and the high uncertainty (Banks 2010, Brown and Finkelstein 2009, 2011), and likely to be influenced by many behavioral biases of consumers. Drawing upon the growing literature on understanding financial literacy and its effects on economic decision making (cf., Lusardi and Mitchell 2013), we study the effects of financial literacy on long-term care insurance purchase decisions. We use the HRS data (Health and Retirement Study, University of Michigan) to empirically examine how cognitive skills and financial literacy affect the demand for long-term care insurance, both the decision to purchase and more specific insurance choices. In so doing, we control for other important factors that have been shown to affect the demand. Following Cole et al. (2011) and van Rooij et al. (2012), we measure financial literacy by using a series of questions from the HRS intended to query respondents' knowledge and perceptions of current financial expert opinions/behaviors and basic financial computations. These include: compound interest, self-perceived investment skills, bond prices vs interest rate changes, risk vs diversification, market strategy perceptions and risk perceptions for alternative investment alternatives. Any respondent with a degree in accounting or finance was assigned to a separate category. The questions used are well documented by the module in Health and Retirement Survey 2008 core data. Motivated by the existing studies (Brown and Finkelstein 2007, Davidoff 2010, van Rooij et al. 2012), we control for four sets of contributing factors for long-term care insurance demand: health status and expectations; demographic characteristics (age, gender,

	ethnicity, etc.); wealth and economic factors (such as income, assets, and other insurance); and preferences (risk attitude, patience, bequest motive, etc.). To the best of our knowledge, this study is one of the first to examine whether and how financial literacy affects long-term care insurance purchase decisions. In addition, we speculate that annuities might be a competing or complementary product with long-term care insurance (cf., Murtaugh, Spillman and Warshawsky, 2001, Brown and Finkelstein, 2011). Thus, as a secondary contribution we discuss implications for the relationship of financial literacy and annuity purchase behavior suggesting product innovation blends around long-term care insurance (insurance product bundling). Our study makes four contributions to the longevity and retirement planning literature. First, our results can help explain the small demand for long-term care insurance by adding behavioral evidence toward an explanation of decision-making. Second, our results can inform product innovations and public policy making to encourage the proper use of long-term care insurance. Third, our study contributes to the limited but growing understanding on how financial literacy and related cognitive skills affect individuals' financial decision making by adding new evidence found for long-term care insurance. Finally, the empirical results of our model and analyses will have implications for further insurance product development contributing to the already growing literature on the relationship between the demand for long-term care insurance and annuities. Both markets need demand stimulation for societal and public policy reasons. The demand on societal resources is anticipated to be increasingly large as the population lives longer with, possibly, a larger percentage of the longevity increase spent in poor health (morbidity expansion) which increases the need to address longevity risk both individually and societally. With annuities being attractive when morbidity compression occurs and, conversely, long-term care insurance being attractive with morbidity expansion, product innovations that successfully combine the market demand for both products might make annuity and long-term care insurance offerings moreattractive purchases, benefiting all. The purchasers cannot predict the future so these innovations become a consumer market hedging product. Currently, both annuities and long-term care insurance have depressed demand relative to rational expectations and their economically projected need for individuals and society.
	Mortality Modelling 2
Yahia Salhi	**A Random Field Approach for Modeling Mortality Improvements Surface** **Abstract** In this paper we consider the projection of mortality tables at the national level. We propose to project mortality improvement rates taking into account correlations across generations. Therefore, we propose to model the whole mortality surface as a random field with a specific causal structure instead of a univariate modeling framework using a generalization of the classical linear ARCH model. Such an approach has the advantage of accounting for a local dependence among adjacent cohorts. We investigate the indentifiability of the model as well as the estimation of the parameters. Applications to real-world datasets are explored especially to those with a pronounced cohort effect. This is a joint work with P. Doukhan and D. Pommeret
Chengwei Qin	**Multi-population Mortality Modelling with Levy Processes** **Abstract** This paper constructs a theoretical framework for multi-population mortality modelling by introducing generalized linear models and Levy stochastic perturbations driven by a common and an idiosyncratic factor. To accommodate the evolution of factor loadings across age and calender time, we specify the loadings on common factors to be deterministic non-linear functions of age and calender time. Different model formulations are explored by using Levy processes such as Gamma process and Variance Gamma process, and their in-sample fitting and out-of-sample forecasting performances are evaluated. In addition, we systematically investigate the dependence structure of both the inter-population and cross-population kind. In our empirical investigations, the mortality experiences of male and female lives in UK over the period 1964-2013 are used.
Hong Li	**Co-integrated Mortality Rates: A Spatial-Temporal Approach** **Abstract** In the past decade, longevity risk has become one of the primary risks for life insurers and annuity providers. However, although there have been great advances in the modelling of mortality rates, there remains some critical issues to the solved. First, an appropriate model should guarantee the non-divergence of mortality forecasts at different ages, for a same population. Second, the model should be able to take into account the mortality correlation between different populations in a multiple population study. Although there is a growing interest in developing new stochastic mortality models satisfying the second criteria, most of them do not satisfy the rst one. This paper contributes to the literature by proposing a model that ensures coherence both between different ages within a population, and between different populations, in a unified framework. In traditional mortality models, such as the Lee and Carter (1992) model, the mortality improvement in each age is captured by a common factor, as well as an age-specific sensitivity coefficient with respect to the

	common trend. One inconvenience of this approach is that the mortality forecast at different ages would diverge in the long run, due to the different sensitivity coefficients [see also Li et al. (2013) for a discussion]. As an alternative, these authors suggest to gradually rotate the sensitivity coefficients so that these exposures would be equal for the majority of age at some point in the future. Nevertheless, this approach is rather ad hoc, and is not data driven. Moreover, it is not clear how to generalize this approach to multi-population mortality models, and/or to take into account the cohort effect. Another important criteria of an appropriate mortality model is the possibility of extension to multiple population mortality modelling, by taking into account between-population correlation and coherence. Indeed, the valuation of the life-contingent products and liabilities typically depends on assumptions of future mortalities at multiple ages, and of multiple populations (such as males and females). Therefore, the accurate joint mortality forecast of the mortality development of different ages and populations is crucial for the product design and risk management of an insurer. The aim of this paper is to propose a model that satisfies these two criteria in a natural, unified manner, using the so-called spatial-temporal autoregressive (SAR) model. In this model, the mortality improvement at each age is driven by a combination of two effects: a period effect and a cohort effect. The period effect captures the serial dependence of mortality rates in time for the same age; whereas the \cohort" effect captures the persistence of mortality shocks within the same cohort. The interplay of these effects induces contemporaneous dependence between different ages. This dependence has a spatial pattern in the sense that the closer the two ages are, the stronger the dependence is between them. A direct consequence of the contemporaneous dependence is that the mortality rates in any two ages are co-integrated, i.e., the series of mortality difference between any two ages is stationary, and with an age-specific equilibrium mean. This co-integration property ensures that the forecasted mortality rates in different ages would not diverge in the long run. On the other hand, the model allows the speed of the error-correction between mortality rates of different ages to be depend on the age gap. This largely improves the flexibility of our model compared to Lee-Carter model. The SAR model is then naturally generalized to the two population case, in which the (log-) mortality differences between any two ages in any two populations would follow a stationary process with an age- and population-specific equilibrium mean. Moreover, in the multi-population context, we do not need to specify the dominant population, which is required by the gravity model studied by Cairns et al. (2011). As noted by Zhou et al. (2014), it is not always straightforward to specify a dominant population in practice. In a numerical illustration, we apply the SAR model in the case where the insurer wishes to hold standardized longevity-linked derivatives to reduce the longevity risk exposure of its annuity business. We show that the SAR model can be naturally used by insurers and annuity providers for their risk management.
	Basis Risk 1
Yanxin Liu	**Disentangling Mortality Trend Risk and Population Basis Risk: A Functional Time Series Approach** **Abstract** In most existing multi-population stochastic mortality models, the distinction between trend risk and population basis risk is vague. In particular, the cross- and auto-correlations between the innovations of the latent factors representing the common trend and the population specific trends are often assumed to be non-existent, although they are possibly statistically significant. While it is theoretically possible to capture such correlations by treating the latent factors as a vector time-series, the resulting model would contain a large number of parameters, which may in turn lead to robustness problems. In this paper, we consider an alternative modeling approach, in which the latent factors are, by construction, independent. This approach permits us to disentangle trend risk and population basis risk, thereby sparing us from the need of using a heavily parameterized vector time-series process. Compared to the augmented common factor model of Li and Lee (2005), the approach we consider yields term-structures of correlations and hedging performances that are more robust with respect to how cross- and auto-correlations between the latent factors are treated.
Andrew Cairns and Ghali El Boukfaoui	**Basis Risk in Index Based Longevity Hedges: A Guide for Longevity Hedgers** **Abstract** We will consider the economic capital calculations for longevity risk under Solvency II, and discuss how to calculate the capital relief for an index based longevity hedge while quantifying basis risk. Using a Dutch case study, we consider the issues involved in calculating regulatory capital and the basis risk arising from liability valuation. How is this assessed? How to account for company/portfolio specific features? How to account for it in the capital charge assuming an index hedge? How to use consistent models for valuation and basis risk assessment? How to simulate the payoffs of different hedging instruments? How to assess the impact of index hedges on economic capital? Our talk will present a step by step guide building on Cairns et al. (2014) to ensure clarity and precision in the calculation of economic capital with and without a hedge in place. We will also highlight which elements of the process are generic, and which are likely to be country specific.

	Micro/Macro Longevity Issues
Anna Rappaport, F.S.A., M.A.A.A.	**Public knowledge and perceptions about retirement risk, risk management and longevity** **Abstract** The Society of Actuaries has conducted public attitude studies about post-retirement risk knowledge and management, and knowledge about longevity. Eight surveys (conducted every two years) provide some consistent questions and special issues in each report. The research offers a great deal of insight into planning, asset spend down rationale, risk management, risk concerns, and spending decisions. The research also includes focus groups with retirees retired 15 years or more and conducted in 2015, and with more recent retirees in 2013. The SOA surveys cover US retirees, and the 2015 focus groups include both US and Canadian retirees. This information is very important for people who are designing public and private systems for old age-security. Many of the expectations of experts about consumer behavior are incorrect. The research shows a lot of consistency about how consumers think about these issues.
Pawel Rokita	**Measures of Risk in Life-long Financial Planning for Households – What Should They Be Like** **Abstract** One of the most important differences between risk of household financial plans, as compared with risk in financial institutions or enterprises, is in definition of a success and failure. A life-long financial plan for a household must, first of all, guarantee that accomplishment of all life objectives which are set by the household members will be possible. In financial terms, the life objectives translate to the ability of making expenses for a descent level of consumption, securing desired dwelling conditions for one's family, education for children, etc., as well as satisfying higher-order needs. This cannot be reduced to management of the value of a portfolio, net profit, free cash flow, etc. The financial situation of a household, taking accomplishment of all life objectives into account, is well described by the term structure of cumulated net cash flow throughout the whole life span. The behaviour of the shapes of this term structure under different scenarios shows also threats to household's life objectives. At the same time, it includes, in a synthetic way, the information about the influence exerted by all risk factors that are included in a given cumulated net cash flow model. In this research it is postulated that an integrated risk measure for a household financial plan should be a mapping from the space of cumulated net cash flow generating models to the real number set. The measure must take the information about possible shapes of the whole cumulated net cashflow term structure, not just cumulated net cash flow values at a given moment. This article discusses postulates on the properties of such a measure.
Justyna Majewska	**The Impact of Longevity on Long-term Investments Returns: Scenarios for Europe** **Abstract** The consequences of populations ageing for long-run economic growth perspectives have gained attention in academic research as well as in the public debate for the past few years. The magnitude of the longevity trend and its impact on growth varies by country. From individuals' perspective, longevity fuels the need for long-term investments. Individuals would need to save more for retirement, retire later, or reduce consumption during retirement and cover some additional cost of health care, which could be a further drag on the economy. Globally (according to MGI researches) the rate of global GDP growth would fall by 40 percent over the next 50 years (even if productivity were to grow) given the decline in employment growth. The global economy expanded sixfold in the 50 years after 1964 but would grow only threefold between 2014 and 2064. Therefore, the following question arises: how global economic and demographic trends will impact on returns on some long-term investments in selected European countries over the next decades? To answer this question we focus on different scenarios for future investment returns.
	Annuities 1
Karin Fröhling **Hannover Re** **Silver Sponsor**	**Deferred annuities at retirement** **Abstract** An annuity sold at retirement which starts at e.g. age 85 is a product that might more easily be sold than a standard annuity. In principle it comes with the same protection but with a substantially lower single premium and gives the policyholder flexibility / investment management for the remaining pot.

Min Ji	**Evaluating Hedge Effectiveness for Longevity Annuities** **Abstract** Recently, longevity annuities were made accessible to the 401(k) and IRA markets in the United States. These annuities start benefit payments at an advanced age and provide a cost-effective way to protect retirees against outliving their retirement assets. However, concerns have been raised about the longevity risk embedded in these annuities and the lack of effective hedging instrument against the risk. In this paper, we consider hedging longevity annuities with newly developed capital market solutions, including deferred longevity bond, s-forward, and q-forward, and examine hedge effectiveness of different derivative structures. We further incorporate sampling risk, parameter risk, model risk, and population basis risk in the hedge and study their impact on hedge effectiveness. We aim to provide guidance to practitioners on effective hedging strategies for longevity annuity portfolios.
Ralph Rogalla	**Optimal Portfolio Choice in Retirement with Participating Life Annuities** **Abstract** This paper derives optimal consumption, investment, and annuitization patterns for retired households that have access to German-style participating payout life annuities (PLAs), allowing for capital market risks as well as idiosyncratic and systematic longevity risks. PLAs provide guaranteed minimum benefits in combination with participation in insurers' surpluses. Minimum benefits are calculated based on conservative assumptions regarding capital market and mortality developments, while surpluses distributed to annuitants bridge the gap between the insurers' actual investment and mortality experiences and the projections used in pricing. Through the participation scheme, systematic longevity risk is shared between insurers and annuitants, as unanticipated longevity shocks result in benefit adjustments via the surplus mechanism. We show that the retiree draws substantial utility from access to PLAs, equivalent to 20% of initial wealth in the presence of systematic longevity risk. We also find that stochasticity in mortality rates only has minor impact on the appeal of PLAs to the retiree. Even if the interest rate guarantee is reduced to zero in adverse capital market environments, PLAs prove to provide substantial utility for retirees. Overall, the participating life annuity design produces substantial welfare gains over a no-annuity world, while being an efficient setup that helps providers to hedge long-term risks that are difficult to hedge otherwise, such as systematic longevity risks.
Parallel Sessions	**Friday 30th September 2016**
09:00 -10:30	**Parallel Session III**
	Pricing 1
Melvern Leung	**Comparison of Pricing Approaches for Longevity Markets** **Abstracts** Longevity risk has been an ongoing issue for many insurance companies and pension funds. The deviation of the realized mortality from the anticipated on has provided an incentive for financial institutions to issue new financial instruments designed for managing longevity risk. This adds strain to those companies that payout based on how long people are anticipated to live, one such example is pension funds. This uncertainty has led to the development of longevity derivatives that help hedge away the risk of longevity to a third party that is willing to take it. However a major difficulty in pricing longevity linked instruments is the determination of longevity risk premium. The problem arises from the fact that the longevity market is illiquid and hence incomplete. In this paper we aim to provide a comprehensive review of the most recent approaches for pricing longevity derivatives proposed in the literature. We then analyze and compare the methods based on the pricing of a range of longevity instruments. A state-space representation of the CBD mortality model is developed and applied for the analysis. We comment on the advantages and disadvantages, of these pricing approaches.
I-Chien Liu	**Pricing Survivor Index Swaps under CBD Models with Multivariate Affine non-Gaussian Processes.** **Abstract** The purpose of this paper aims to price survivor index swaps under the Cairns-Blake-Dowd (CBD) models (also known as Model M5) with multivariate affine non-Gaussian processes. Generally, the CBD mortality indices are modelled by a bivariate random walk with drift. To capture the heavy-tailed phenomena of the CBD mortality indices, we consider not only the original Gaussian assumption but also the multivariate affine

	non-Gaussian processes, for example, multivariate affine variance gamma (MAVG) process and multivariate affine normal inverse Gaussian (MANIG) process. In order to pricing survivor index swaps, we introduce the Esscher transformation of MAVG and MANIG in our models and also build a valuation framework. Finally, we numerically investigate the fair swap rates of the survivor swap and show the misestimate of the swap rates and loss reserves.
Kenneth Q. Zhou	**Longevity Greeks: What Insurers and Capital Market Investors Should Know About?** **Abstract** Recently, it has been argued that capital markets may share some of the overwhelming longevity risk exposures borne by the pension and life insurance industries. The transfer of risk can be accomplished by trading standardized derivatives such as q-forwards that are linked to published mortality indexes. To strategize such trades, one may utilize `longevity Greeks', which are analogous to equity Greeks that have been used extensively in managing stock price risk. In this paper, we first derive three important longevity Greeks - delta, gamma and vega - on the basis of an extended version of the Lee-Carter model that incorporates stochastic volatility. We then study the properties of each longevity Greek, and estimate the levels of effectiveness that different longevity Greek hedges can possibly achieve. The results reveal several interesting facts; for example, in a delta-vega hedge formed by q-forwards, the choice of reference ages does not materially affect hedge effectiveness, but the choice of times-to-maturity does. These facts may aid insurers to better formulate their hedge portfolios, and issuers of mortality-linked securities to determine what security structures are more likely to attract liquidity.
	Mortality Modelling 3
Hong Li	**Modeling and Forecasting Mortality with Economic Growth: A Multi-Population Approach** **Abstract** Existing literature on mortality modeling of multiple populations focuses mainly on extrapolating the past mortality trends and summarizing these trends by one or more common latent factors. This paper proposes a multi-population stochastic mortality model which utilizes the explanatory power of economic growth. In particular, we extend the Li and Lee model (Li and Lee, 2005, Coherent mortality forecasts for a group of populations: An extension of the Lee-Carter method. Demography 42 (3), 575-594) by including economic growth, represented by the real gross domestic product (GDP) per capita, to capture the common mortality trend for a group of populations with similar socioeconomic conditions. We find that our proposed model provides a better in-sample fit and an out-of-sample forecast performance. Moreover, it generates lower (higher) forecasted period life expectancy for countries with high (low) GDP than the Li and Lee (2005) model.
Rui Zhou	**Changes of Long-term Relation in Multi-Population Mortality Modeling** **Abstract** Standardized longevity risk transfers often involve modeling mortality rates of multiple populations. Some researchers have found that mortality indexes of selected countries are cointegrated; i.e. there exists a linear relationship between the indexes. Vector error correction model was used to incorporate this relation, thereby forcing the mortality rates of multiple populations to revert to the relation over the long run. However, empirical observations show that this relation may be subject to change. In fact, our statistical test for U.K. and Canadian mortality data reveals that structural change occurred in their cointegration relation. To capture this change, we adopt the threshold vector error correction model. We further apply this model to pricing a longevity bond using multivariate Wang transform, and study the impact of changes in the long-term relation on longevity bond price.
Malene Kallestrup-Lamb	**Explaining the Female Longevity Puzzle: Using Register Data to Analyse Mortality Behaviour of Socio-economic Groups and Exploiting Coherent Relations to Improve Mortality Forecasting.** **Abstract** The observed increase in life expectancy for developed countries does not follow a general pattern, as periods with gender-specific divergence between countries have emerged. In particular in the Scandinavian countries we have observed a decrease in the mortality rates for Norwegian and Swedish females, but a stable or in some cases even increasing mortality rate for Danish females in the time period 1980-1995. The idea of this paper is to understand the complexity of female longevity improvements in Scandinavia by using detailed register data for Denmark and Norway and explain why this puzzle has emerged. We partition every individual in the population at each age and year into ten socio-economic groups based on an affluence measure derived from the individual's income and wealth. The aim of this paper is two-fold; first we analyze the female longevity puzzle and identify which specific socio-economic groups have been driving the "stagnation" in life expectancy and second we investigate the forecasting implications of using disaggregation into subgroups. From the analysis of the subgroups improvements we find that the decline in life expectancy for Danish women is present for all subgroups, however with particular large decreases for the middle income groups 3-5, whereas the subgroups for Norwegian women all exhibit positive improvements over the period. Interestingly, we see that the two groups with lowest affluence measure for Danish women actually see large

	improvements in life expectancy for the oldest ages, i.e. 80-95 year olds. This corresponds well with the findings in Brønnum-Hansen and Juel (2004) that the decline in longevity for Danish women cannot solely be explained by higher smoking prevalence for the lower socio-economic groups.
	Mortality Modelling 4
Pasquale Cirillo	**Modeling Joint Mortality and its Impact on Annuity Contracts** **Abstract** In this paper I propose a new modeling approach to joint (or dependent) mortality, that is to say the mortality risk in couples of individuals, whose lives and survivorships are likely to be interconnected (e.g. husband and wife, after many years of marriage), as often proven by empirical studies, so that assuming independence may represent the wrong choice for the reliability of results. Differently from the other (few) works in the literature about joint mortality, I do not make use of copulas and I do not develop bivariate extensions of the commonly used univariate models of survivorship (Frees et al., 1996; Luciano et al., 2008). Rather, I propose a constructive approach based on a special class of combinatorial stochastic processes, i.e. reinforced urn processes, or RUP in acronym (Muliere et al., 2000). Exploiting the Bayesian update mechanism embedded in RUP, the new model has the ability of continuously learning from data, even when new observations become available at a later stage. Thanks to this, the model is able to improve its predictive power over time. If prior beliefs about the dependence structure and/or the marginal survivorships are present, these can be easily embedded in the model, by acting on the urn compositions. If no meaningful a priori can be elicited, then an empirical Bayes approach is also available.
Qiheng Guo	**Mortality Trends Implied by Term Insurance Prices** **Abstract** To infer forward-looking, market-based mortality trends, we estimate a flexible affine mortality model based on a set of (primary) insurance prices. More precisely, relying on an idea by Mullin and Philipson (1997), we use a large sample of U.S. term life insurance prices over several years for different ages and terms from a large number of companies to derive generalized method of moments (GMM) estimates of the model parameters. We include additional factors affecting life insurance prices such as expenses and selection/underwriting effects. Preliminary results suggest that implicit mortality rates are reasonable relative to statistical forecasts and that the role of mortality catastrophe components is unimportant.
Hua Chen	**Compressing or Expansion of Morbidity? Ambiguous Beliefs and the Demand for Insurance** **Abstract** Individual retirees face two important risks: rising health care costs and increased life expectancy. Health shocks and longevity risk are inherently connected since the death represents the end state in an individual's health state transition process. A longer life expectancy can be attributed to a prolonged time span during which the individual stays healthy, i.e., compression of morbidity (Fries 2005), or associated with a relatively more increase in the length of an unhealthy state, i.e., expansion of morbidity (Olshansky et al. 1991). A third hypothesis (the dynamic equilibrium theory) points to an overall stable relative length of unhealthy life expectancy. There is still no consensus in the literature on which pattern truly captures individuals' evolution of health states. In this paper, we use a life-cycle model to investigate how the health state transition process affects an individual's demand for long-term care insurance and life annuity, in addition to other standard investment products such as bonds and stocks. Our paper contributes to the existing literature in several ways. First, we develop a dynamic multistate transition model where the transition probabilities depend on age and calendar time. Second, we answer the question as to what is the demand for long-term care insurance and life annuity under the compression, expansion and dynamic equilibrium hypothesis, respectively. Third, we introduce ambiguity and ambiguity aversion into our benchmark model. Specifically, we assume that a retiree has ambiguous knowledge of the transition probabilities across health status and is also averse to this ambiguous information. We find that ambiguity aversion explains a large proportion of the so-called "annuity puzzle" and "long-term care insurance puzzle".
	Product Design 2
Wenjun Zhu	**Longevity Variance Swap** **Abstract** The capital market of longevity-linked securities has been emerging over the past decades to help facilitate the protection of the viability of the retirement income provisions and the development of the annuity markets (Blake et al., 2013). To date, the existing longevity-linked derivatives are mostly customized, i.e., the payoffs of such derivatives are linked to the mortality experience in the hedger's portfolio. Only a limited number of the existing derivatives are standardized, with payoffs that are linked to some pre-specified mortality indices. One possible reason refraining the popularity of the standardized longevity-linked derivatives is the mortality basis risk the risk that the cash flows of the hedged portfolio differ from those under the hedging instruments.

	The mortality indices underlying the standardized contracts normally consist of mortality experience of multiple countries. By offsetting risks from different countries, a multi-country index is able to diversify the idiosyncratic risks and hence reflects systematic mortality risks. Therefore, derivatives based on a multi-country mortality index would be less risky to the buyer. However, these derivatives are vulnerable to the mortality basis risk, especially for a local insurer whose mortality exposure is conned predominantly to its home country.
Jason Cheng-Hsien Tsai	**Embedding the Natural Hedging of Mortality/Longevity Risks into Product Design** **Abstract** How to manage mortality/longevity risks is essential to the long-term solvency of life insurance companies. The literatures proposed to hedge the products subject to the longevity risk (such as annuities) by using the products subject to the mortality risk (e.g., whole life insurance) sold by an insurer. Such natural hedging is intuitive but may be difficult to implement due to the rigid sales market and incentive issues. We propose to embed natural hedging into product design so that the hedging may occur within a product. The key is to offset the impact of mortality on the timing of death that in turn determines the present value of the death benefit by cleverly choose the growth rate of the death benefit. How much to pay while δ would reflect the time value of payment. We provide theoretical derivations, graphical illustrations, and numerical analyses to illustrate the idea of embedding natural hedging into product design.
Sharon Yang	**Discussion on the Natural Hedging of Longevity Risk** **Abstract** Recent increase in longevity has increased pressures on defined benefit (DB) pension plan providers and annuity providers. Longevity risk has become non-negligible and its influence is increasing gradually and globally. Hedging longevity risks has taken on an increasingly important role for life insurance companies. Finding the way to hedge longevity risk has received great attention in both academic and practices. The study of hedging strategies for managing longevity risk has been explored in recent years. In general, the hedging strategy can be categorized as an internal or external method. Natural hedging is regarded as the internal hedging strategy that the insurer can hedge longevity risks with their own business products between life insurance and annuity because these two types of products are sensitive in opposing ways to the changes in mortality rates. If the future mortality of a cohort improves relative to current expectations, life insurers gain a profit because they can pay the death benefit later than initially expected, whereas annuity insurers suffer losses because they must pay annuity benefits for longer than they initially expected. Existing literature has explored the methodology to deal with natural hedging. Cox and Lin (2007) find the relation between the liabilities of life insurance and annuity moved in opposite direction in response to a change in mortality rate. They consider the finding an optimal ratio of life insurance and annuity that can hedge the longevity risk. However, the pricing is completed at the time of sale. Premium adjustment is unable to make according to the improvement of actual mortality rate. Richter and Weber (2009) thought that longevity risk can be diversified to policy holders so that the insurer will take less risk. They designed a new kind of annuity which can allow the insurers dynamically adjust the payment and share the longevity risk with policy holders. Wang et al. (2010) investigate the natural hedging strategy to deal with longevity risks for life insurance companies and propose an immunization model to investigate the natural hedging strategy by calculating the optimal life insurance–annuity product mix ratio to hedge against longevity risks. Tsai et al. (2010) further use a conditional Value at Risk to investigate the natural hedging strategy. Wang et al. (2013) propose a natural hedging model that can account for both the variance and mispricing effects of longevity risk at the same time. This model can avoid misallocating the portfolio of life insurance and annuity accrued from basis risk. Therefore, life insurance can serve as a dynamic hedge vehicle against unexpected mortality risk.
	Mortality Forecasting 2
Anthony Medford	**Projecting Maximum Country Life Expectancy using Provincial Data Only** **Abstract** In this paper we introduce a new approach to modelling and projecting life expectancy for a region using only information from subregions within this larger region by applying principles from the statistical theory of Extreme Values. The most popular mortality forecasting models, the Lee Carter Model (Lee and Carter, 1992) and its numerous extensions and variants e.g Li et al. (2004); Renshaw and Haberman (2003); Hyndman et al. (2007) fit trends to age-standardized (log) death rates. However, there is a strong argument for using life expectancy in forecasting. White (2002) found that linear trends in life expectancy give a better empirical fit to the experience of individual countries than linear trends in age-standardized (log) death rates in his study of 21 developed countries. The large and increasing family of Lee Carter type models have exhibited variable performance with respect to forecasting ability. In addition the time parameter (k_t) in these models can be unstable (some models have multiple time parameters) over time, making forecasting even more difficult.

	Among those who have forecast life expectancy are Alho and Spencer (2005); Andreev and Vaupel (2006); Lee (2006); Torri and Vaupel (2012). Extreme value theory has previously applied to the study of maximum life expectancies over a selection of dev developed countries by Medford (2015) (forthcoming) and this paper builds upon ideas presented therein.
Marius Pascariu	**Deriving Age-specifc Death Rates from Life Expectancy Forecasts** **Abstract** Predicting the human longevity level in the future by directly forecasting life expectancy of offers numerous advantages compared with methods based on extrapolation of age-specific death rates. However, the reconstruction of accurate life tables starting from a given level of life expectancy at birth or any other age is not straightforward. Model life table were extensively used in the past for estimating age patterns of mortality in data-poor countries. We propose a new model inspired by indirect estimation techniques that can be used to estimate full life tables given a predicted life expectancy at birth.
Johnny S.-H. Li	**The `Heat Wave' Model for Constructing Two-Dimensional Mortality Improvement Scales with Measures of Uncertainty.** **Abstract** Recently, the actuarial professions in Canada, the US and the UK have adopted an innovative two-dimensional approach to projecting future mortality. In contrast to the conventional approach, the two-dimensional approach permits mortality improvement rates to vary not only with age but also with time. Despite being an important breakthrough, the newly proposed two-dimensional mortality improvement scales are subject to several significant limitations, most notably a heavy reliance on expert judgments and a lack of measures of uncertainty. In this paper, we aim to develop a method for producing two-dimensional mortality improvement scales with more solid statistical justifications. To this end, we propose a `heat wave' model, in which short- and long-term mortality improvements are treated respectively as `heat waves' that taper off over time and `background improvements' that always exist. Using the model, one can derive two-dimensional mortality improvement scales with minimal expert judgment. Moreover, with likelihood-based inference or Bayesian methods, the uncertainty surrounding the best estimate improvement rates can be estimated.