MANAGING LONGEVITY RISK

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Chief Pricing Actuary, Life Asia

ASHK 10TH APPOINTED ACTUARIES SYMPOSIUM
HONG KONG, 3 NOVEMBER 2010
Evolution of the Actuarial Profession...

<table>
<thead>
<tr>
<th>The Evolution of the Actuary</th>
<th>Emergence</th>
<th>Description</th>
<th>Time to Emerge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuary of the 1st kind</td>
<td>17th century</td>
<td><em>life insurance</em> actuaries using deterministic methods</td>
<td></td>
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<tr>
<td>Actuary of the 2nd kind</td>
<td>20th century</td>
<td><em>casualty</em> actuaries using probabilistic methods</td>
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<tr>
<td>Actuary of the 3rd kind</td>
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<td><em>investment</em> actuaries applying financial economics (Bühlmann)</td>
<td>70</td>
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<tr>
<td>Actuary of the 4th kind</td>
<td>current</td>
<td>actuaries working in <em>ERM</em> (Embrechts)</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: Stephen P. D'Archy, CAS Presidential Address, 2005
The CERA Actuarial Designation

started by the SoA...www.ceranalyst.org

An Enterprising Approach to Risk

The Chartered Enterprise Risk Analyst (CERA) credential is the most comprehensive and rigorous demonstration of enterprise risk management expertise available.

The CERA credential reflects the actuary’s evolution - from helping the world better understand risk to leading an organization’s risk strategies using the framework of enterprise risk management.

CERAs don’t merely speak to what we can lose; they focus on what we can gain.
The CERA Actuarial Designation

evolving into the 1st truly GLOBAL actuarial designation...

Signatories to Global treaty:

1. The Institute of Actuaries of Australia (Australia)
2. Canadian Institute of Actuaries (Canada)
3. Deutsche Aktuarvereinigung e.V. (Germany)
4. Institut des Actuaires (France)
5. Israel Association of Actuaries (Israel)
6. Institute of Actuaries of Japan (Japan)
7. Colegio Nacional de Actuarios A.C. (Mexico)
8. Het Actuarieel Genootschap (Netherlands)
9. Actuarial Society of South Africa (South Africa)
10. Svenska Aktuarieföreningen (Sweden)
11. Institute and Faculty of Actuaries (UK)
12. Casualty Actuarial Society (USA)
13. Society of Actuaries (USA)
The CERA Actuarial Designation
the new global designation website...www.ceraglobal.org

Chartered Enterprise Risk Actuary
The benchmark of ERM expertise

Announcements

The role of actuaries in enterprise risk management. News release from the IAA.
08/2010  Read more

CERA credential gathers pace
05/2010  Read more

Find a participating association

Home

The CERA risk management credential is the most comprehensive and rigorous globally-recognised Enterprise Risk Management (ERM) designation and is supported by 13 member associations in 12 countries worldwide, including many of the major economies.

The CERA credential combines a robust and forward-looking curriculum underpinned by actuarial science with a strong code of professional conduct and continuing professional development requirements, making it the most advanced and rigorous ERM credential in the world. Businesses that rely on CERAs can make smarter decisions based on sound analysis and understanding of their risks.

Meet a CERA

Steve Mathews

Steve Mathews is an actuary and director at EMB Consultancy LLP. He became one of the first nine actuaries in the UK to qualify as a Chartered...
The SoA’s Curriculum provides some good reference material...

Economics

P – Probability
FM – Financial Mathematics

MFE – Models for Financial Economics

C – Construction of Actuarial Models

Advanced Finance/ERM Exam (AFE)

Operational Risk Module

EXAM MODULE
COURSE
Validation by Educational Experience (VEE)
*APC can be taken with one FSA component left

APC – Associateship Professionalism Course*
CERA
The ERM Cycle

can be used to structure the talk…

1. Context & Governance
2. Risk Identification
3. Risk Quantification
4. Risk Response
5. Risk Monitoring, Reporting & Rewarding
6. Review & Improvement
Longevity Making Headlines…

French Unions Test Sarkozy in Pensions Row…

Source: FT.com
Longevity Making Headlines...

beyond actuarial circles...

As life expectancy increases so does the need to hedge longevity risk. Can capital markets provide a solution?

ADVANCES in technology and medicine have contributed to a significant rise in life expectancy during the past few decades, and the implications for pension liabilities are profound as an increasing number of companies and organizations are beginning to seek solutions.

Longevity risk is the risk of unanticipated increases in life expectancy (see Figure 1). For individuals preparing for retirement, managing longevity risk involves proper planning, saving, investing, and, in many cases, purchasing a life annuity. For organizations that are on the line for pensions or annuities, however, longevity risk is more complex. These organizations—annuity providing insurance companies, corporate pension providers, and local and national governments—face a risk that is vast and unique.

In the United Kingdom, for example, every additional year of life expectancy beyond age 65 adds 3 percent to pension liabilities, equivalent to about £30 billion for private-sector employers.

Until recently, longevity risk was mostly an abstract concept. What the World Economic Forum defined as the 20 core global risks, longevity was not among them. Now, however, the topic has begun to hit the radar. The WEF addressed longevity risk in a 2009 report, and respected author Roger Lowenstein says pension debts—which have burdened General Motors, stopped the New York City subway, and bankrupted San Diego—loom as the next financial crisis. Indeed, global pension plan liabilities are estimated at US$23 trillion.

Organizations faced with longevity risk use a wide variety of methods to quantify it. There is no transparent way to price longevity risk, and until recently, there were few options for effectively hedging it.

To limit their risk, many companies have stopped offering defined benefit plans and have switched to defined-contribution plans instead. Thus far, many companies have chosen to buy longevity risk by purchasing longevity insurance (which can in some cases be quite expensive).

Some companies choose to buy longevity insurance (which can in some cases be quite expensive).

Longevity Swaps

Recently, another instrument has been gaining traction: the longevity swap. It differs from a buyout or buy-in (which are solutions offered by insurers) because neither the pension assets nor the pension liabilities are transferred. In a buyout, both the assets and the liabilities are transferred to the insurer. In a buy-in, existing assets are exchanged for annuities provided by the insurer.

Longevity swaps are similar to interest rate swaps, which trade floating interest rates for fixed ones. Companies forecast the mortality of their groups and enter into a counterparty agreement with an investment bank. If more people survive than predicted (i.e., the forecast is the “fixed side” agreed to in the swap), the company will receive payments from the investment bank. If more people die than anticipated, the company will make a payment to the investment bank.

Once the swap is in place, investment banks pass the longevity risk on to insurers, such as annuities for defined benefit plans. These insurers—who make the “floating rate” payments in the swap based on subsequently realized mortality experience—receive a better risk-return trade-off than if they had to directly fund longevity risk.
UK Life Expectancy at Birth

the trend is clear...

Life Expectancy from Birth in ages

- Female
- Male
Development of the Mortality in the 20th Century with advances in medicine...

[Graph showing age-standardised death rates, US males per 100,000, from 1900 to 2000. Key events and causes are indicated, such as vaccines & antibiotics affecting younger/middle ages from 1910 to 1930, and CHD affecting middle/older ages from 1960 to 2000.]

04/11/2010
Evolution of Old Age Care in the UK

*a series of broken promises*

<table>
<thead>
<tr>
<th>Decade</th>
<th>Agricultural</th>
<th>Industrial</th>
<th>Manufacturing</th>
<th>Service</th>
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<tbody>
<tr>
<td>1700</td>
<td>Family</td>
<td>Employer</td>
<td>State</td>
<td>Self</td>
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<td>1950</td>
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<td>2000</td>
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</tbody>
</table>

Source of Care for old age

Decade: 1700, 1850, 1950, 2000
Living Longer & Working Shorter
less time to save for retirement...

- **Agricultural**
  - Working all life long: 34
  - Introduction of a short retirement: 53

- **Industrial**
  - Working all life long: 4
  - Introduction of a short retirement: 55

- **Manufacturing**
  - Working all life long: 10
  - Introduction of a short retirement: 65

- **Service**
  - Working all life long: 25
  - Introduction of a short retirement: 85

**Expected years in retirement**

- **Men**
  - France: 25
  - Italy: 25
  - UK: 25
  - Germany: 25
  - Greece: 25
  - Spain: 25
  - US: 25
  - Japan: 25

- **Women**
  - France: 30
  - Italy: 30
  - UK: 30
  - Germany: 30
  - Greece: 30
  - Spain: 30
  - US: 30
  - Japan: 30

*Source: OECD Society at a Glance 2009*
A Famous Longevity Case Study

with a reverse mortgage contract...

- 1965 Mme Jeanne Calment (90) signed a contract with M. Raffray (47) on a reverse mortgage
  - Mme Calment got a life long right of abode
  - M. Raffray had to pay a life long annuity
- The value of the apartment was equal to approx. 10 years of rental and annuity payments
- M. Raffray died 1995, Mme Calment survived him by 2 years

Jeanne Calment (1875 – 1997)
(© Wikipedia, GNU Free Documentation License, Version 1.2)
Longevity Risk Context in Asia… one of the biggest challenges to the insurance industry…

Living Longer
(More time to contract a critical illness / disability)

+ Over aged 80
(Users of Long Term Care)

+ Increased Dependency Ratio
(Less tax payers to pay for government benefits or family support)

= INCREASING LONGEVITY RISK
The larger the bubble, the higher the percentage of the population aged over 65.

The further the bubble is to the right, the longer the life expectancy, and

the higher up the chart, the higher the elderly dependency ratio (the ratio of people over age 65 divided by the working population).
Who provides cover

1st Pillar  
Public and Social System

2nd Pillar  
Company Plan

3rd Pillar  
Private Insurance

The relevance of the three pillars varies extremely

Shares of the three pillars in the total premium income

- Old-age provision system is organized very differently in the European countries
- The volume for old-age provision varies also extremely
- Cultural and social differences are the main drivers for this
Higher Spending by Governments on old age related costs...but not enough
The Size of the LONGEVITY Problem...  
**it’s a potentially BIG problem...**

<table>
<thead>
<tr>
<th>Private Pension Liabilities</th>
<th>Life Insurance Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DB Liabilities</strong></td>
<td><strong>Annuity Reserves</strong></td>
</tr>
<tr>
<td>US$bn</td>
<td>US$bn</td>
</tr>
<tr>
<td>US</td>
<td>6 000</td>
</tr>
<tr>
<td>UK</td>
<td>1 300</td>
</tr>
<tr>
<td>Total</td>
<td>7 300</td>
</tr>
</tbody>
</table>

Under-reserving of certain risks could lead to a 50% increase in liabilities for UK life insurers...

...which would lead to a capital shortfall that needs to be compensated.

Systemic Risk in Insurance  
An analysis of insurance and financial stability  
Longevity Risk & the Insurance Product Space

annuities & care products...

- Funds / VA
- Endowment / Universal Life
- Private insurance
- Company plan
- Public and social system
- Term Life / Terminal Illness
- Funeral benefit

Flexible transition

- Deferred annuity:
  - Increasing benefits
  - Lump-sum option

- Immediate annuity:
  - Enhanced / Impaired annuity

- Single life
- Temporary annuity
- Guaranteed time
- Benefit on death

- Monthly premium
- Variable premium

- Unit linked
- Variable annuity

- Joint life
- Pure life annuity
- Single premium
- Traditional product

Risk cover

- Health Care
- Contingent rights
- DI / LTD / CI / Accident
- Accident

Old-age provision

- Educational endowment
- Temporary annuity

Savings

- VA

2. Risk Identification

Munich RE
Impact of Changing Demographics on Products & Liabilities

- **Income annuity** products will be in higher demand – longevity risk
- Products like **LTC** & **DI** will be in greater demand as populations age & social structures change
- Liabilities **duration** will be extended
- Will there be **available assets** to match this?
- Decreased **mortality** can mean higher incidences longer periods of **morbidity** – DI/CI/LTC

- **Pricing** and **Reserving** can be a challenge

<table>
<thead>
<tr>
<th>Age Diagnosed with Alzheimer’s’</th>
<th>Number of years to live</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
</tr>
<tr>
<td>Age 70</td>
<td>8</td>
</tr>
<tr>
<td>Age 85</td>
<td>3.9</td>
</tr>
<tr>
<td>Overall</td>
<td>6</td>
</tr>
</tbody>
</table>
Longevity Risk in the Risk Space of Insurers

explicitly identified in Solvency II framework...

---

**SCR**: Solvency Capital Requirement

**Adj**: Adjustments for loss absorbing effects

**BSCR**: Basic Solvency Capital Requirement

**SCR**_{op}**: Operational risk

**Market** (Scr_{market}):
- Currency (Mkt_{fx})
- Property (Mkt_{prop})
- Fixed interest (Mkt_{int})
- Equity (Mkt_{eq})
- Concentrations (Mkt_{conc})
- Spread risk (Mkt_{sp})

**Health** (Scr_{health}):
- Similar to life techniques (Health_{SLT})
- Non-Similar to life techniques (Health_{NonSLT})
- Catastrophe (Health_{Cat})

**Counterparty/Default** (Scr_{def}):

**Life** (Scr_{life}):
- Mortality (Scr_{mort})
- Longevity (Scr_{long})
- Disability / Morbidity (Scr_{Dis/Morb})
- Lapse (Scr_{Lapse})
- Expense (Scr_{Exp})
- Revision (Scr_{Rev})
- Catastrophe (Scr_{Cat})

**Non-Life** (Scr_{non-life}):
- Premium and Reserve (NL_{Prem&Res})
- Lapse (NL_{Lapse})
- Catastrophe (NL_{cat})

**Intangible assets risks** (Scr_{intang})

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Source: Munich RE

---

Adjustment for the risk mitigating effect of future profit sharing
Understanding the Nature of Longevity Risk

need to decompose the risk…

- **Traditional Mortality Risk**
  - assumes survival distribution is fixed & known
  - risk is random fluctuations around the fixed & known distribution
  - the law of large numbers works

- **Longevity Risk**
  - risk is mainly the error in estimating future mortality – the TREND
  - affects all policies in force
  - the LLN does NOT work
  - systemic & non-diversifiable
  - to handle risks like pandemic/longevity require knowledge on hedging; securitization; etc.

- voluntary schemes also have self-selection
- risk highlighted with new table – and significant reserve strengthening
- low interest rate environment also highlights longevity risks.
- Move from DB to DC pension plans,
How Certain can we be in Projecting Mortality
distinguishing between risk & uncertainty...

Longevity risk is driven by three underlying risks

- **Modeling risk**: risk that arises from the choice of model used for forecasting mortality improvements
- **Trend risk**: risk that large unanticipated changes in socioeconomic environment or health care significantly improve longevity
- **Random variation risk**: risk that mortality rates differ from the expected outcome as a result of chance

Source: Prudential UK

The by now famous, distinction in Knight’s work between:

- **Risk**: randomness with **knowable** probabilities, and
- **Uncertainty**: randomness with **unknowable** probabilities
Past Record on Projecting Longevity

underestimation of longevity to date

Life Expectancy, male age 65

Source: GAD, UK
Rating Process – Risk Factor Analysis

The process...

- Mortality levels are determined taylormade for each portfolio

- The dependence of mortality rates on many risk factors is investigated

- Double-tracked approach to ensure sound mortality basis

- In addition third-party consultation might be sought
Rating Process – Risk Factor Analysis

by factors...

Postcode Rating

Socio-Economic Differentials

Analysis of groups of 7200 people

Further segregation within groups

Combination of Postcode Rating and socio-economic differentials

→ „individualized“ mortality rates
Rating Process – Risk Factor Analysis

by socio-economic groups...

Table 4. Ratio of mortality rates (q_r) by pension amount

<table>
<thead>
<tr>
<th>Age</th>
<th>&gt; £13,000</th>
<th>£8,500 - £13,000</th>
<th>£4,500 - £8,500</th>
<th>&lt; £4,500</th>
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</thead>
<tbody>
<tr>
<td>60 – 64</td>
<td>1.00</td>
<td>1.60</td>
<td>2.10</td>
<td>1.95</td>
</tr>
<tr>
<td>65 – 69</td>
<td>1.00</td>
<td>1.35</td>
<td>1.85</td>
<td>1.85</td>
</tr>
<tr>
<td>70 – 74</td>
<td>1.00</td>
<td>1.30</td>
<td>1.65</td>
<td>1.90</td>
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<tr>
<td>75 – 79</td>
<td>1.00</td>
<td>1.10</td>
<td>1.45</td>
<td>1.60</td>
</tr>
<tr>
<td>80 – 84</td>
<td>1.00</td>
<td>1.20</td>
<td>1.40</td>
<td>1.45</td>
</tr>
<tr>
<td>85 – 89</td>
<td>1.00</td>
<td>1.00</td>
<td>1.25</td>
<td>1.30</td>
</tr>
</tbody>
</table>

Source: CMI (2005)

Table 5. Calculated annuity rate increases based on mortality multiplies in table 1: PA90(M)

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>&gt; £13,000</th>
<th>£8,500 - £13,000</th>
<th>£4,500 - £8,500</th>
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<tbody>
<tr>
<td>0%</td>
<td>0.0%</td>
<td>11.9%</td>
<td>31.1%</td>
<td>36.7%</td>
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<tr>
<td>2%</td>
<td>0.0%</td>
<td>10.7%</td>
<td>27.5%</td>
<td>32.1%</td>
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<tr>
<td>4%</td>
<td>0.0%</td>
<td>9.7%</td>
<td>24.4%</td>
<td>28.2%</td>
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<tr>
<td>6%</td>
<td>0.0%</td>
<td>8.8%</td>
<td>21.8%</td>
<td>25.0%</td>
</tr>
<tr>
<td>8%</td>
<td>0.0%</td>
<td>9.0%</td>
<td>19.6%</td>
<td>22.3%</td>
</tr>
<tr>
<td>10%</td>
<td>0.0%</td>
<td>7.3%</td>
<td>17.8%</td>
<td>20.1%</td>
</tr>
</tbody>
</table>

Source: CMI (2005) and author calculations. Mortality for the wealthy assumed in line with PA90(M). All calculations apply to an annuitant aged 65.

Note: percentages are higher at higher ages, lower at lower ages and lower assuming lighter mortality (for females, for example). See tables in appendix.
Experience Analysis... the process...

For each **annuitant** we would need the following details:
- Unique id number
- Date of Birth
- Gender
- Occupation
- Postcode

For each **annuity in payment**, we will need the following details:
- Annuity Start Date
- Current Benefit Amount
- Payment Frequency
- Payable in Advance or Arrears
- Benefit Escalation Rates, Ceilings & Floors
- Benefit Escalation Frequency and Next Escalation Date
- All Relevant Guarantee Details
- Any enhanced or impaired life benefits
Longevity Risk Modelling
cause of death modelling – medical & actuarial input needed

Mortality of typical male annuitant in payment portfolio

- Cardiovascular
- Cancer
- Other
- Stroke
- Respiratory

- Mental Nervous
- Other
- Cardiovascular
- Infections
- Cancer
- Respiratory
Mortality Projections for 75 – 79 year olds

Trend Risk

Trend Risk - Modelling

mortality by cause
Rate of Mortality Improvements in the UK...

evidence of so called “Golden Cohorts”

Trend Risk

Cause of Death Model: Resulting Trend Heat Map captures experience of “Golden Cohorts”

Projection For Males Lives Library 2: COD_ONS_Males_Long_Team

Key

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<th>Colour</th>
<th>≥ -100%</th>
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<th>0.50%</th>
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<th>1.50%</th>
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<th>3.00%</th>
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<td>6</td>
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<td>1</td>
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<tr>
<td>Upper Bound</td>
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<td>4</td>
<td>3</td>
<td>2</td>
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<td>0</td>
<td>-1</td>
<td>-2</td>
<td>-3</td>
<td>-100</td>
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Historic Population Improvement Rates to Date

Projection Based on Library 2: COD_ONS_Males_Long_Team

Age + Year

<table>
<thead>
<tr>
<th>Age</th>
<th>82 - 85</th>
<th>86 - 90</th>
<th>91 - 95</th>
<th>96 - 00</th>
<th>01 - 05</th>
<th>06</th>
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</thead>
<tbody>
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<td>41 - 45</td>
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<td>46 - 50</td>
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<td>51 - 55</td>
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<td>56 - 60</td>
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<td>61 - 65</td>
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<td>66 - 70</td>
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<td>71 - 75</td>
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<td>76 - 80</td>
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<tr>
<td>81 - 85</td>
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<td>86 - 90</td>
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<td>91 - 95</td>
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<tr>
<td>96 - 100</td>
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</tbody>
</table>

For comparison
Average Medium & Long Cohort with 1.25% floor

CoD Model captures cohort effect, but predicts reduced impact in future
ERC Risk Quantification Techniques

- key modern technique is Economic Risk Capital (ERC)
- using VaR; CTE; etc, techniques
- increasingly stochastic modeling
- VaR is well established for financial risks
- one year view sometimes difficult to apply for business with long term insurance risks
Risk Quantification - Solvency II, Pillar 1

change of Net Asset Value

The Solvency II Economic Balance Sheet

- Net Assets Value = Assets minus Best Estimates Liabilities

Longevity Risk - Pure Liability Stress

- Net Assets Value
- Own Funds
- Risk Marg

Distribution of NAV => Solvency Capital Requirement

- Cum Prob = 99.5%
- NAV(1) @ 99.5%
- NAV(0)
- SCR = \( \Delta \text{NAV} @ 99.5\% \text{ VaR} \)

\[ \Delta \text{NAV} = \text{NAV} (@ \text{balance sheet date}) - \text{NAV} (@ \text{worst 1 year scenario}) \]
### Risk Quantification - Solvency II, Pillar I

**scenarios for Standard Formula approach...**

<table>
<thead>
<tr>
<th>Sub module</th>
<th>QIS4</th>
<th>CEIOPS Level 2 (Oct 2009)</th>
<th>IM 24 (draft June 2010)</th>
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<tbody>
<tr>
<td><strong>Mortality</strong></td>
<td>+10% mortality rate</td>
<td>+15% mortality rate</td>
<td>As CEIPOS Level 2 Advice</td>
<td></td>
</tr>
<tr>
<td><strong>Longevity</strong></td>
<td>- 25% mortality rate</td>
<td>As QIS 4</td>
<td>- 20% mortality rate</td>
<td></td>
</tr>
<tr>
<td><strong>Disability/ Morbidity</strong></td>
<td>1st year: + 50% disability rate</td>
<td>1st year: + 50% disability rate</td>
<td>1st year + 35% disability rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Subs. yrs. + 25% disability rate</td>
<td>Subs yrs.+ 25% disability rate</td>
<td>Subs yrs.: + 25% disability rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 20% recovery rate</td>
<td>- 20% recovery rate</td>
<td></td>
</tr>
<tr>
<td><strong>Lapse</strong></td>
<td>+50% lapse rate</td>
<td>As QIS 4</td>
<td>As CEIPOS Level 2 Advice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-50% lapse rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass lapse event 30% with positive surrender strain</td>
<td>Additional: 70% for non-retail with positive surrender strain</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Expense</strong></td>
<td>+ 10% future expense</td>
<td>As QIS 4</td>
<td>As CEIPOS Level 2 Advice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 1% p.a. expense inflation rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Revision</strong></td>
<td>+3% annual amount payable</td>
<td>As QIS 4</td>
<td>As CEIPOS Level 2 Advice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(in practice immaterial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Catastrophe</strong></td>
<td>+1.5 % mortality rates over following year</td>
<td>As QIS 4</td>
<td>As CEIPOS Level 2 Advice</td>
<td></td>
</tr>
</tbody>
</table>
### Solvency II & UW Risks

#### Solvency II (QIS4 results)

<table>
<thead>
<tr>
<th>Risk Type</th>
<th>% of SCR</th>
<th>% of UW-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Risk</td>
<td>81.7%</td>
<td></td>
</tr>
<tr>
<td>Counterparty Risk</td>
<td>4.7%</td>
<td></td>
</tr>
<tr>
<td>Underwriting Risk</td>
<td>38.7%</td>
<td>100%</td>
</tr>
<tr>
<td>Lapse risk</td>
<td>59.1%</td>
<td></td>
</tr>
<tr>
<td>Expenses risk</td>
<td>19.9%</td>
<td></td>
</tr>
<tr>
<td>Mortality risk</td>
<td>10.2%</td>
<td></td>
</tr>
<tr>
<td>Longevity risk</td>
<td>23.9%</td>
<td></td>
</tr>
<tr>
<td>Disability risk</td>
<td>9.2%</td>
<td></td>
</tr>
<tr>
<td>Catastrophe risk</td>
<td>15.8%</td>
<td></td>
</tr>
<tr>
<td>Diversification effects</td>
<td>−25.1%</td>
<td>−38.0%</td>
</tr>
</tbody>
</table>

#### Sub module QIS4

<table>
<thead>
<tr>
<th>Risk Type</th>
<th>QIS4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>+10% mortality rate</td>
</tr>
<tr>
<td>Longevity</td>
<td>−25% mortality rate</td>
</tr>
</tbody>
</table>

\[
SCR_{life} = \sqrt{\sum_{r=1}^{n} CorrLife^{i,r} \cdot Life_{r} \cdot Life_{c}}
\]

![Correlation Table](image)

Source: JP Morgan European Equity Research, Jan 19 2010
CEIOPS Report on QIS4 for Solvency II, page 193
Models

3 main projection models...

- **Lee Carter model (LC):**
  
  \[
  \log(q_{x,t}) = a_x + b_x \kappa_t + \text{error}
  \]

- **Bayesian Lee Carter (BLC):**

  Lee Carter including parameter uncertainty

- **Cairns, Blake & Dowd (CBD) model:**

  \[
  \logit(q_{x,t}) = \log\left(\frac{q_{x,t}}{1-q_{x,t}}\right) = \kappa_t^{(1)} + \kappa_t^{(2)}(x - \bar{x}) + \text{error}
  \]

<table>
<thead>
<tr>
<th>Desirable model features</th>
<th>Lee Carter Baysian Lee Carter Cairns Blake Dowd</th>
<th>QIS 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk capital increasing with projection horizon – to avoid mis-steering business</td>
<td>✓</td>
<td>not the case</td>
</tr>
<tr>
<td>Model can be used for calibrating limits and budgets</td>
<td>✓</td>
<td>stochastic model deterministic model</td>
</tr>
<tr>
<td>Ability to model age and cohort effects</td>
<td>can be extended to allow for those effects</td>
<td>not the case</td>
</tr>
<tr>
<td>Deeper understanding of future trend developments</td>
<td>not the case</td>
<td>not the case</td>
</tr>
</tbody>
</table>
## 99.5% Percentiles of Annuity Payments

<table>
<thead>
<tr>
<th>Model</th>
<th>Immediate annuity payments starting at age 65</th>
<th>Annuity payments starting at age 65, 35 years deferment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% BE</td>
<td>%BE</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best Estimate</td>
<td>23.61</td>
<td>27.63</td>
</tr>
<tr>
<td>QIS 4: 75% BE</td>
<td>25.51 + 8.0%</td>
<td>29.04 + 5.1%</td>
</tr>
<tr>
<td>LC</td>
<td>25.01 + 5.9%</td>
<td>29.50 + 6.8%</td>
</tr>
<tr>
<td>BLC</td>
<td>25.54 + 8.2%</td>
<td>30.51 + 10.4%</td>
</tr>
<tr>
<td>CBD</td>
<td>26.79 + 13.5%</td>
<td>31.76 + 14.9%</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best Estimate</td>
<td>18.85</td>
<td>22.53</td>
</tr>
<tr>
<td>QIS 4: 75% BE</td>
<td>21.09 + 11.9%</td>
<td>24.56 + 9.0%</td>
</tr>
<tr>
<td>LC</td>
<td>20.00 + 6.1%</td>
<td>24.51 + 8.8%</td>
</tr>
<tr>
<td>BLC</td>
<td>20.71 + 9.9%</td>
<td>26.00 + 15.4%</td>
</tr>
<tr>
<td>CBD</td>
<td>21.96 + 16.5%</td>
<td>27.82 + 23.5%</td>
</tr>
</tbody>
</table>
Internal Models

Up to now naive approach: models for run off

Solvency II:  \[ \text{SCR} = 99.5\% \text{ VaR of available capital over 1-year time horizon} \]

\[
\text{SCR} = \text{1-year result} + \text{change of portfolio value due to change of mortality assumptions (nested stochastic projections)}
\]
## Risk Response

### the basics...

<table>
<thead>
<tr>
<th>Steer business</th>
<th>Avoid</th>
<th>Diversify</th>
<th>Mitigate or Hedge</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Long-term risk more threatening than short-term risks</td>
<td>• Product design:</td>
<td>• Mortality risks</td>
<td>• Suitable mortality portfolio</td>
</tr>
<tr>
<td>• Has to be reflected in steering business</td>
<td>• Short term guarantees</td>
<td>• Interest rate</td>
<td>• Longevity bonds or swaps</td>
</tr>
<tr>
<td>• Bonus and incentive system should be long-term</td>
<td>• Minimal guarantees</td>
<td>• Investments profiting from increasing longevity (e.g. nursing homes)</td>
<td>• Reinsurance</td>
</tr>
<tr>
<td></td>
<td>• Include substantial margins and flexible profit participation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Who will take Longevity Risk
the basics...

- long term investors – through the capital markets...
  - Hedge funds
  - Endowments
  - Pharma

- pension buyout funds – earn spread on the assets

- reinsurances – it’s a (pandemic) capital diversification play

- life Insurers – annuity providers

- government – already over-exposed

- etc.
Product Design

design products to pass on more longevity risk...
Is Mortality a Natural Hedge

the basics...

- mortality should be a natural hedge for longevity
- however, impacts may apply to different age groups – young vs. old
- may be some benefit in internal capital models for offsets between catastrophic mortality risk (e.g. pandemics) & longevity – a diversification play
Longevity Swaps
the basics...

Transaction structure

J.P. Morgan (fixed rate payer) → Lucida (fixed rate receiver)

Notional x fixed mortality rate

Notional x realized mortality rate

“Lucida, the specialist insurer of pension liabilities set up by Jonathan Bloomer, the former Prudential chief executive, has struck a deal with J.P. Morgan to hedge longevity risk through a derivative contract. Under the terms of the deal, Lucida is protected if policyholders live longer than expected.”

Financial Times 15/2/08

“This innovative transaction demonstrates that Lucida is at the forefront of the emerging secondary market in longevity risk. By selectively entering into longevity swap contracts we can maximise the value we offer our clients. We look forward to being part of this market as it develops.”

Jonathan Bloomer, Lucida

Reasons for a longevity swap
- Insurance solutions may not meet the needs:
  - Global insurance capacity and reinsurance capacity scarce compared with total exposure
  - No mark-to-market pricing
  - Understanding of longevity in most countries in development
- Capital markets solutions may provide:
  - Capacity and liquidity
  - Credit counterparty risk management
  - Mark-to-market pricing

Challenge: Matching the interests

<table>
<thead>
<tr>
<th>Sponsor</th>
<th>Investor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long duration to cover trend risk</td>
<td>Short duration (max 10 years)</td>
</tr>
<tr>
<td>Cover based on insured portfolio</td>
<td>Cover based on population index</td>
</tr>
<tr>
<td>No basis risk</td>
<td>Basis risk assumed by sponsor</td>
</tr>
</tbody>
</table>
### Insurance Linked Securities (ILS)

#### Reinsurance vs. ILS...

<table>
<thead>
<tr>
<th>Category</th>
<th>Reinsurance</th>
<th>ILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit risk</td>
<td>Will depend on rating of the reinsurer</td>
<td>Cat bonds avoid credit risk to the issuer</td>
</tr>
<tr>
<td>Basis risk</td>
<td>None – as reinsurance is based on company’s actual portfolio</td>
<td>Significant – as insurer pays own losses but receives payoff on index</td>
</tr>
<tr>
<td>Moral Hazard</td>
<td>Primary firm may be lax in uw – reinsurer needs to align interests</td>
<td>Defining ILS on index controls moral hazard</td>
</tr>
<tr>
<td>Size &amp; Costs</td>
<td>Could be done for smaller deals &amp; on a less costly basis.</td>
<td>Need to be of a certain size to be economically viable. Costly.</td>
</tr>
<tr>
<td>Capacity</td>
<td>Limited capacity</td>
<td>Independent capacity</td>
</tr>
<tr>
<td>Price Dependency</td>
<td>Prices may depend on market cycle</td>
<td>Limited dependency on insurance market cycle</td>
</tr>
</tbody>
</table>

#### Part 1: Simulation

1. Mortality Experience Data
   - Exposed Population
2. Best Estimate
   - Mortality Rates
   - Exposed Population
3. Simulation of Mortality Rates (For both populations)
4. Scenarios for Mortality Rates
   - Exposed Population

#### Part 1: Evaluation

1. Model of Pension Liability
2. Scenarios for Pension Claim flows & Values
3. Model of Hedging Instrument
4. Scenarios for Hedge Cash flow & Values

#### Part 1: Hedge Effectiveness Calculation

- Graph showing variance in hedge effectiveness.
## Risk Response - Solvency II, Pillar 2
### Risk management & actuarial function...

### Supervisory practices (Pillar 2)

<table>
<thead>
<tr>
<th>Governance processes of the insurance company</th>
<th>Risk Management (Art. 44) – must have an effective risk management system...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business organization</td>
<td>• comprising strategies, processes and reporting procedures monitor, manage and report the risks on a continuous basis.</td>
</tr>
<tr>
<td>outsourcing</td>
<td>• well integrated in the organizational structure</td>
</tr>
<tr>
<td>Fit and proper of management and key personalities</td>
<td>• contain contingency plans</td>
</tr>
<tr>
<td>Actuarial function</td>
<td>• cover all material risks and inform about risk mitigating techniques</td>
</tr>
<tr>
<td></td>
<td>• implement an independent risk management function</td>
</tr>
<tr>
<td>Actuarial function</td>
<td>• for partial or internal model: a risk modelling function needed - design, implementation, testing, validation, documentation and for the integration of the internal model in the risk management system (use test)!</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Early warning system</th>
<th>Actuarial function (Art. 48) – must have an effective actuarial function...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk management</td>
<td>• understanding of the stochastic nature of the business (risk, finance, ALM) and the use of actuarial methods (probabilities of insurance risks, statistical methods, risk mitigation, discounted cash flows etc.)</td>
</tr>
<tr>
<td>“Own Risk &amp; Solvency Assessment” (ORSA)</td>
<td>• assessment of: underwriting and investment policy; risk mitigation techniques; claims management procedures; appropriateness of methods, models, assumptions and sufficiency and quality of the data used in the calculation of technical provisions</td>
</tr>
<tr>
<td>Internal controls</td>
<td>• comparison of the best estimate against experience</td>
</tr>
<tr>
<td></td>
<td>• actuarial function shall deliver a written report to the management with its findings and recommendations</td>
</tr>
</tbody>
</table>
### Regulations shaping risk management

**IFRS, MCEV & Solvency II – convergence to economic basis?**

<table>
<thead>
<tr>
<th>IFRS II</th>
<th>MCEV</th>
<th>Solvency II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets</td>
<td>Assets</td>
<td>Assets</td>
</tr>
<tr>
<td>Equity</td>
<td>Emb. Value</td>
<td>Own Funds</td>
</tr>
<tr>
<td>Resid. Margin</td>
<td>ANW</td>
<td>Risk Marg</td>
</tr>
<tr>
<td>Risk Marg</td>
<td>PVFP</td>
<td></td>
</tr>
<tr>
<td>Best Estim. L.</td>
<td>CoC</td>
<td>Best Estim. L.</td>
</tr>
<tr>
<td><strong>• Lock-in of margins only</strong></td>
<td><strong>• CoC = Explicit risk margin</strong></td>
<td><strong>• Risk Margin ≈ CoC</strong></td>
</tr>
<tr>
<td><strong>• No gain at inception (covered by residual margin)</strong></td>
<td><strong>• Gain at inception (VANB)</strong></td>
<td><strong>• Gain at inception</strong></td>
</tr>
<tr>
<td></td>
<td><strong>• Current estimates</strong></td>
<td><strong>• Current estimates</strong></td>
</tr>
</tbody>
</table>

CoC = Coefficient of Capital (Risk Margin), VANB = Value at Net Best Estimate.
ERM Step #5: Risk Reporting & Rewarding...

- Market Consistent pricing – risk management @ point of sale
- Explicit risk capital (CoNHR) – based on ERC & frictional charges based on Reg. Capital
- Also values options & guarantees – optionality.
- Value added can be used for value based management
- Various issues including:
  - liquidity premium – for annuities
  - stability of results; etc.

VANB = PVFP – CoNHR – PV_TaxCoC – PV_IExpCoC

<table>
<thead>
<tr>
<th>Allowance for non-hedgeable risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of non-hedgeable risks</td>
</tr>
<tr>
<td>Annual charge</td>
</tr>
<tr>
<td>Economic risk capital for non-hedgeable risk</td>
</tr>
<tr>
<td>x Non-hedgeable risk rate</td>
</tr>
<tr>
<td>Cost of non-hedgeable risk</td>
</tr>
<tr>
<td>Present value of annual charge discounted at risk-free interest rate</td>
</tr>
</tbody>
</table>

TaxCoC: Reflects the fact that the investment return on the assets
IExpCoC: Reflects the expenses related to the investment of the assets backing RC

Replicating Portfolio

Approach to calculating cost of non-hedgeable risk entirely in line with Munich Re’s risk capital model
References

many – but here a a few good ones...

Coping with Longevity:
The New German Annuity Valuation Table DAV 2004 R
Ulrich Pawlik and Jürgen Wolff
Cologne, Germany and Atlanta, Georgia

Presented at The Living to 100 and Beyond Symposium
Sponsored by the Society of Actuaries
Orlando, Fla.
January 12-14, 2005
THANK YOU VERY MUCH FOR YOUR ATTENTION

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