Pricing Long-Term Life Insurance in a Low Interest Rate Environment

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International Actuarial Association Webinar

Views not otherwise referenced are entirely my own
### Pricing Long-Term Life Insurance in a Low Interest Rate Environment: Session Roadmap

<table>
<thead>
<tr>
<th>Life Insurance</th>
<th>A couple of product examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pricing Life Insurance</td>
<td>Value liability using cost of buying assets that replicate the best estimate policy cashflows</td>
</tr>
<tr>
<td>Pricing Long-Term Life Insurance</td>
<td>Practical challenges and costs when liability longer than assets: Ideas from practical Quantitative Finance</td>
</tr>
<tr>
<td>Pricing Long-Term Life Insurance in a Low Interest Rate Environment</td>
<td>The impact of low interest rates in Life Insurance: Ideas from Economics Research</td>
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<tr>
<td>Beyond incremental thinking</td>
<td>Startup Culture Learning from the past Sociological Research Upskilling to succeed</td>
</tr>
</tbody>
</table>
Life Insurance
## Traditional and Modern Life Insurance Products

<table>
<thead>
<tr>
<th>Persons</th>
<th>Consumer</th>
<th>25</th>
<th>Consumer</th>
<th>Producer</th>
<th>65</th>
<th>Consumer</th>
</tr>
</thead>
</table>

### Needs and Products

<table>
<thead>
<tr>
<th>Needs</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>What if I die before my children grow up?</td>
<td>Mostly Protection</td>
</tr>
<tr>
<td>I want to protect my family</td>
<td>I want to plan for inheritance taxes</td>
</tr>
<tr>
<td>Buy: Term (Temporary)</td>
<td>Buy: Whole Life with profits (Permanent Participating)</td>
</tr>
<tr>
<td>I want to save for my children’s studies</td>
<td>Protection and Investment</td>
</tr>
<tr>
<td>and money available if I die before then</td>
<td>I want to plan for inheritance taxes</td>
</tr>
<tr>
<td>Buy: Endowment with-profits</td>
<td>Buy: Whole Life with profits (Permanent Participating)</td>
</tr>
<tr>
<td>I like Whole Life but I want investment</td>
<td>Mostly Investment</td>
</tr>
<tr>
<td>flexibility, transparency and cash-out</td>
<td>I want more investment flexibility and</td>
</tr>
<tr>
<td>Buy: Universal Life</td>
<td>transparency guaranteed min if I die</td>
</tr>
<tr>
<td>I want more investment flexibility and</td>
<td>Buy: Unit Linked</td>
</tr>
<tr>
<td>transparency guaranteed min if I die</td>
<td></td>
</tr>
<tr>
<td>Buy: Unit Linked</td>
<td>How can I guarantee a lifetime income</td>
</tr>
<tr>
<td>after retirement?</td>
<td>Buy: Annuity</td>
</tr>
</tbody>
</table>

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*Swiss Re*
Pricing Life Insurance

• Replicating portfolios
The yield curve

Figure 12.3 US government bond yield curve (spot rates), January 2002.

The yield curve

Figure 12.1 Canadian government bond yield curve (spot rates), May 2007.

Figure 12.2 UK government bond yield curve (spot rates), November 2006.

Valuation approach

Using a replication argument:

The value of the insurance should be the amount required to be invested now to produce payments which replicate the cashflow.

This is how we are implicitly valuing contracts when we discount at the rate of interest on assets.

When we used a flat term structure we use formula like $v^t$.

With a term structure we should discount each future payment using the spot interest rate appropriate to the term until that payment is due.

If we don’t replicate the cashflows, then interest rate risk is introduced – must be modelled and managed.
Pricing Long-Term Life Insurance

- Practical insights from Quantitative Finance
- An example: Replicating a 50-year-duration-liability with a 30-year-duration-asset
Example: Policy generates a DV01 of 1 million; looking at the impact of Convexity

*DV01 is the dollar amount of change in PV for 1/100 of a percent (bps) of change in interest rate
## Pricing long-dated cashflows – practical insights from quantitative finance

### Overview
- We price using replication – same as derivative pricing; an extrapolation of vanilla instrument pricing
- For discounting – simply using the last spot rate on a curve to discount long dated flows assumes ratings do not move over that time-frame
- But it gets complicated...

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<table>
<thead>
<tr>
<th>Detail</th>
<th>Actuarial Use of Discounting</th>
<th>Reality</th>
<th>Market Replication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 yr bonds available</td>
<td></td>
<td>We buy shorter; convexity costs (buy high/sell low)</td>
</tr>
<tr>
<td></td>
<td>Occurs at mid</td>
<td></td>
<td>Presence of bid/offer</td>
</tr>
<tr>
<td></td>
<td>No size dimension</td>
<td></td>
<td>Long-dated bond trade size restrictions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>additional operational costs</td>
</tr>
</tbody>
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Life Insurance in a Low Interest Rate Environment

• Ideas from Economics research
Two Swiss Re Institute publications on low interest rates 2012 & 2020

sigm

No 4/2012

Facing the interest rate challenge

Click images to access publications
The history of interest rates since 1900 (UK and US)

Figure 1: Nominal and real 10-year government bond yields for the US and the UK from 1900 to 2011

US

- 15%
- 10%
- 5%
- 0%
- 5%
- 10%
- 15%

Gold Standard abandoned
WW I
WW II
Break-up of Bretton-Woods

UK

- 15%
- 10%
- 5%
- 0%
- 5%
- 10%
- 15%

Gold Standard abandoned
WW I
WW II
Break-up of Bretton-Woods

Sources: Datastream, Homer Sidney and Richard Sylla, A History of Interest Rates (New Jersey: Wiley Finance, 2005), Swiss Re Economic Research & Consulting

Source: Swiss Re sigma No 4/2012 Facing the interest rate challenge
Total investment yields, 1999-2019

Based on statutory data. Total investment yields include realised capital gains.
Source: Swiss Re Institute

Source: Swiss Re Institute Lower for even longer: what does the low interest rate economy mean for insurers? September 2020
Interest rate sensitivity of various life insurance products

**Figure 10**
Sensitivity of life products to interest rates by product type, ranked from highest impact to lowest impact

Source: CIPR, Standard & Poor’s, Swiss Re Institute

Source: Swiss Re Institute Lower for even longer: what does the low interest rate economy mean for insurers? September 2020
The importance of investment income for life insurance products

Figure 6:
Sources of profit for typical life risk and savings products, Germany

Term insurance (a typical risk product)
80% % of premiums earned
60%
40%
20%
0%
-20%
-40%
-60%
-80%
Investment margin
Underwriting margin
Policyholder profit
Other

Endowment insurance (a typical savings product)
15% % of premiums earned
10%
5%
0%
-5%
-10%
-15%
Investment margin
Underwriting margin
Policyholder profit
Other

Sources: Bundesanstalt für Finanzdienstleistungen (BaFin), Swiss Re Economic Research & Consulting

Source: Swiss Re sigma No 4/2012 Facing the interest rate challenge
Life insurers have a high portion of saving business

Figure 9
Global life premiums split (2008 versus 2019)

Source: Swiss Re Institute

Source: Swiss Re Institute Lower for even longer: what does the low interest rate economy mean for insurers? September 2020
An illustration of the impact of interest rates on savings business

Figure 7:
A simplified illustration of the link between interest rates and life insurance savings business

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>6%</td>
<td>Market yield</td>
<td>Portfolio yield</td>
<td>Guarantee</td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>Demand low but rising</td>
<td>Lapses high, but declining Profitability improving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4%</td>
<td>Demand high but falling Lapses low, but increasing Profitability deteriorating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3%</td>
<td>Demand high and rising Lapses low and declining Profitability deteriorating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2%</td>
<td>Demand low and falling Lapses high and increasing Profitability improving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Swiss Re Economic Research & Consulting

Source: Swiss Re sigma No 4/2012 Facing the interest rate challenge
Duration mismatch and impacts on solvency

Figure 12
Life insurers guaranteed return spreads (%) and duration mismatches (years)

Duration gap (years, liabilities minus assets)
12
10
8
6
4
2
0

Return gap (%: 10-year yields on sovereign bonds minus average guarantee returns)

Source: Global Financial Stability Report, IMF, October 2019, and Swiss Re Institute

Source: Swiss Re Institute Lower for even longer: what does the low interest rate economy mean for insurers? September 2020
How can insurers mitigate interest rate risk?

**Asset-Liability Management**

- Liquidity, inflation, interest rate risk
- Lack of sufficiently long duration financial instruments
- Use of derivatives for duration matching introduces additional counterparty risk
- May tolerate some ALM mismatch as a strategy to generate incremental returns
- But regulatory requirements make it expensive

**Hedging policyholder risk**

- Policyholder behaviour increases uncertainty surrounding future cashflows
- Dynamic hedging entails additional risks
- Changing product design provides alternative to complex hedging strategies

**Repricing is key, but not easy for life insurers**

**Product design**

- Need to strike balance between policyholder options and insurer hedgeability
- Product features significantly affect the interest rate sensitivity of life insurance products
- Balancing the cost and benefits of options and guarantees
Beyond incremental thinking

• Startup culture
• Learning from the past
• Sociological research
• Upskilling to succeed
• “people find value in unexpected places and they do this by thinking about business from first principles instead of formulas” Peter Thiel

• What is the company product that nobody is building

• Distribution
Learning from the past: mortality protection commoditised – interest turned to investments


The two principal sources of profit to an Assurance company are the selection of lives and the accumulation of the excess of the premiums at a higher rate of interest than is assumed as the basis of the Company’s operations…

With regard to the [selection of lives], it is impossible not to feel that the margin of profit has very much diminished of late years…

This makes the question of the rate of interest obtained from investment so much more important; it is, in fact, the principal source of profit.

- Can mortality be de-commoditised?
- Can advances in our understanding of biology and advances in technology be used to extract profit?
- What other underwriting risks can I live have that can be insured?
Learning from the past: Actuaries and Interest Rate Risk

- Actuarial awareness of interest rate risk was first heightened early 19th century during the Napoleonic Wars
- Long and substantial decline for the following next forty years (‘halved within the memory of man’)
- Interest turned to equities


Source: A History of British Actuarial Thought
Learning from the past: Actuaries and Equities

- British life offices increased their equity allocations from under 2% in 1920 to 21% by 1952
- 19th Century: equities were an unsuitable asset class for life assurance business – too risky
- 1920s: post-war high inflation led to substantial falls in long-term bond prices and losses for life offices
- Burst of inflation motivated actuaries’ reappraisal of equities as a potentially useful asset class

Source: A History of British Actuarial Thought
“Marketing systems do not develop in a sociological vacuum, are deeply interrelated with customers’ social and cultural backgrounds” Viviana A. Rotman Zelizer
Learning from Sociological research: Ideological resistance to life insurance

- Fire and marine sold with small agent participation
- Saving banks attracted clients through advertising
- No bankruptcies of insurers
- Disposable income available

- Persuasive and persistent personal solicitation broke through the ideological and superstitious barriers against insuring life
- The impersonality of the life insurance company was offset by the presence of the agent

*Figure 7.3 “You may drop off any minute and leave your family unprovided for.”*  
Is there an ideological resistance to buying ready-made food? Are the Super Markets now closing the ready-made food gap?
Upskilling to succeed

• How to do it
• Informal Learning and power of networking and relationships
Upskilling to succeed

- Master the basics of Mathematical, Statistical and Actuarial Concepts
- Be Informed of the regulatory and market landscape
- Use the lenses of Quantitative Finance
- Remember and utilise statistical modelling to build a strong foundation for statistical learning
- Don’t ignore Humanities, Social Sciences and Art
- Learn how to code (R is plenty)
- Learn how to communicate insights with impact

How? An example from Swiss Re

Set up a Framework

Bring it to life

Community-driven; combine domain knowledge with best practice programming, data science and communication in daily work

Based on International Actuarial Association Syllabus for global consistency
In a post-COVID era we shouldn’t forget the impact of informal learning and the significance of networking and relationships for us and our customers.

“Loyalty to individuals. Relationships. That’s what makes the world go ‘round.”
Raymond Reddington, Blacklist episode aired May 21, 2021
In Conclusion
In Conclusion: For Pricing (and Designing) Long-Term Life Insurance products in a low interest rate environment

Using an Incremental improvement approach

- We have adopted a replicated-portfolio approach to pricing
- Using stochastic techniques for embedded options and guarantees
- More attention needs to be given to ultra-long cashflows where no replicating portfolio exists
- Also on other cost for hedging interest rate guarantees
- Rethink whether some guarantees add value to the policyholders (willing to pay for them)

Contemplating a Zero to One mindset

- What is the product that nobody is building that people want and can be profitable?
- Understand Quantitative Finance better
- Look at the sociological and cultural aspect of life insurance
- Learn from the past
- Improve technical skills through formal and informal settings
- Personal relationships matter (to our clients and to us)
Any questions?
Thank you!

Contact us

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