Impact of Life Insurance Practices in Changing Actuarial Regime

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Actuarial Deterministic Processes

For Life Insurance,

- **Our Actuarial Science started with Commutation Functions,**
- **Later moved to Asset Shares,**
- **But it remained Deterministic in the past Century,**
- **And centred on Immunization Theory as practical conditions.**

$$A_x = A^{1}_{\overline{x:\infty|}} = \sum_{k=0}^{\infty} v^{k+1}\, {}_kp_x \cdot q_{x+k} = \sum_{k=0}^{\infty} \frac{v^{x+k+1}\,(l_{x+k} - l_{x+k+1})}{v^x\, l_x}$$

$$= \sum_{y=x}^{\infty} v^{y+1}\, \frac{d_y}{D_x} = \frac{M_x}{D_x}\,, \qquad M_x \equiv \sum_{y=x}^{\infty} v^{y+1}\, d_y$$

$$\ddot{a}_x = \ddot{a}_{\overline{x:\infty|}} = \sum_{k=0}^{\infty} v^{k+x}\, \frac{l_{k+x}}{D_x} = \frac{N_x}{D_x}\,, \qquad N_x = \sum_{y=x}^{\infty} v^{y}\, l_y$$

$$A_t = \frac{1}{p_{t-1}} \left\{ [A_{t-1} + GP(1 - E^p_t) - E^s_t](1+i) - q^d_{t-1}\left[1{,}000\left(1 + \frac{i}{2}\right)\right] - q^w_{t-1} CV_t \right\},$$

where

t = Policy year;
A_t = Asset share per $1,000 unit of coverage in force at the end of policy year t;
GP = Gross premium;
CV_t = Cash value available at the end of policy year t;
E^p_t = Percent-of-premium expense rate in policy year t;
E^s_t = Dollars-per-unit expense in policy year t;
i = Interest rate;
q^d_{t-1} = Probability of entrant to policy year t terminating because of death during policy year t;
q^w_{t-1} = Probability of entrant to policy year t terminating because of withdrawal during policy year t;
$p_{t-1} = 1 - q^d_{t-1} - q^w_{t-1}$
= Probability of entrant to policy year t entering policy year $t+1$ in force.

Suppose that at a single rate of interest the present values of the assets and liabilities are equal, i.e.

$$\int_0^\infty v^t A_t\, dt = \int_0^\infty v^t L_t\, dt. \qquad (1)$$

Let us examine the effect of a small change in the rate of interest by differentiating each side with respect to the force of interest δ.

$$d/d\delta \int_0^\infty v^t A_t\, dt = -\int_0^\infty t v^t A_t\, dt \qquad (2)$$

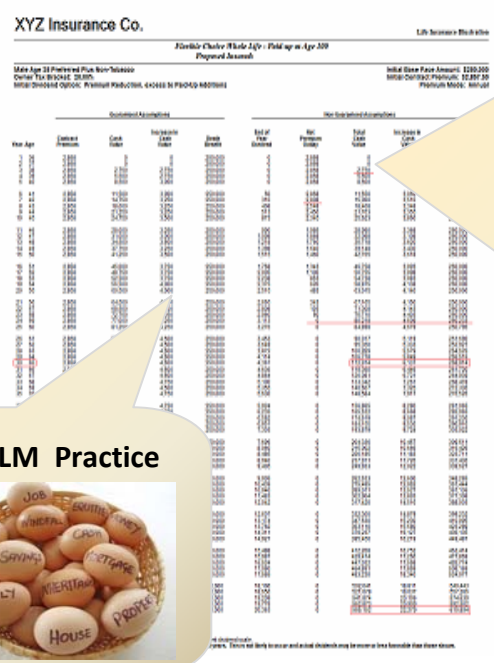
and similarly for L.

Define the mean term of the assets as

$$\tau_A = \int_0^\infty t v^t A_t\, dt \Big/ \int_0^\infty v^t A_t\, dt \qquad (3)$$

and similarly for the liabilities. Then another way of stating Redington's theorem is that the fund is immunized if

$$\tau_A = \tau_L, \qquad (4)$$



Immunization ALM Practice under Stable Investment Conditions:-

Products:-

- **Long Term Cover;**
- **Underwriting against anti-selection on Insurance Risk not Investment Risk;**
- **Higher Early Surrender Penalties;**
- **Illiquid to trade for Immediate Fair Value w/ 3rd party;**
- **Market Value Adjustment ("MVA"), if any.**

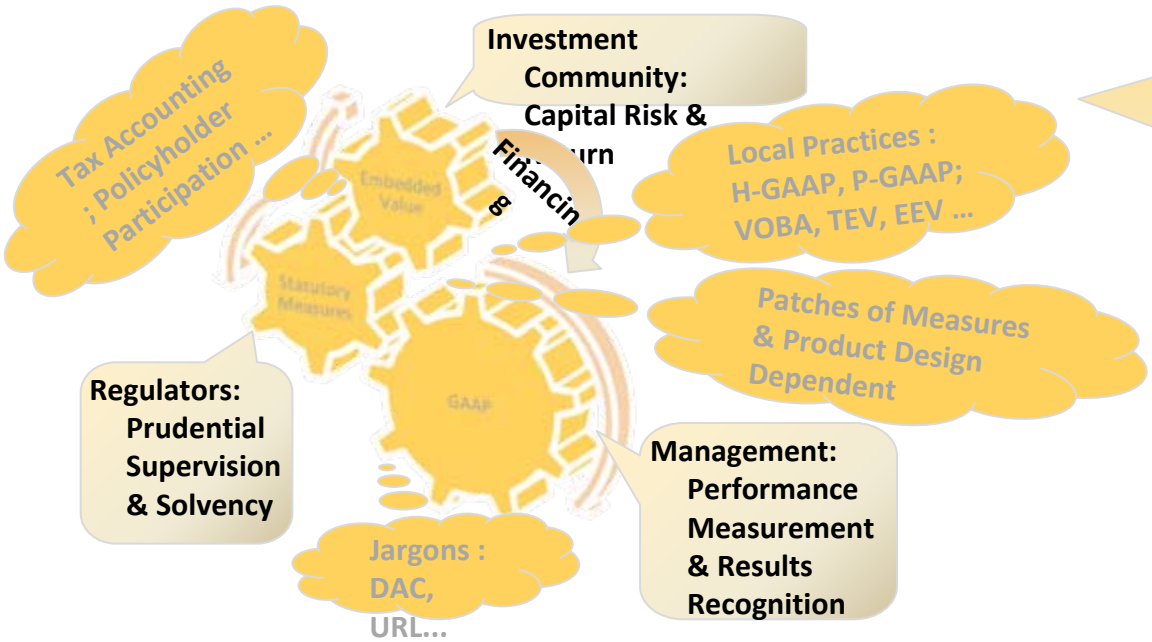
Life Insurance is Illiquid.

Different Financial Measurements

- Deterministic Techniques use Implicit Margins for Product Pricing and Risk Management.
- This involves Professional and/or Subjective Judgement; and
- On-going Review of Experiences for Periodic Update of Assumptions and Margins.
- Management not interested in details. Actuaries being responsible for the Margins, leading to a Conservative Image !!!
- Different Stakeholders, Different Financial Focuses, Different Measurement Requirements, leading to Different Margins, which result in many but less collaborated Numbers for easy understanding other than by Actuaries.

PAD

$$
\begin{aligned}
{}_tV &= 1000A_{x+t} \\
&+\sum_{s=t}^{w} v^{s+1-t}\,{}_{s-t}p^{T}_{x+t}(1-q_{x+s})w_s CV_s \\
&+\sum_{s=t}^{w} v^{s-t}\,{}_{s-t}p^{T}_{x+t}E^{ADM} \\
&-GP\ddot{a}_{x+t}
\end{aligned}
$$



➔ Product Proliferation & Arbitrage

1982- FAS 60, Accounting and Reporting by In...
1987- FAS 97, Accounting and Reporti... Limited Payment Contracts; Universal Life Type Con...
1992- FAS 113, Accounting and Reporting for Re...
1993- FAS 115, Accounting and Reporting for Certain Inve... Equity Securities
1995- FAS 120, Accounting and Reporting by Mutual Life Insurance Ente...
1995- SOP 95-1, Accounting and Reporting for Participating Contracts
2001- FAS 133, Accounting for Derivative Instruments and Hedging Activities
2001- FAS 141, 142 Accounting for Business Combinations, Goodwill and Other Intangible Assets
2003- SOP 03-1, Accounting and Reporting by Insurance Enterprises for GMxBs, No Lapse Guarantees in Universal Life Type Contracts and for Separate Accounts
2005- SOP 05-1, Accounting by Insurance Enterprises for Deferred Acquisition Costs in connection with Modifications or Exchanges of Insurance Contracts
2006- FS 157, Fair Value Measurements

Product Innovation challenges Deterministic Margins

Traditionally, Life Insurance is Illiquid.

- **It used to be Sold, rather than Bought**
- **Distribution is to sell Product Illiquidity**
  (Long Term Cover for Death & Disability Protection, and Accumulation of Long Term Savings for Retirement Use)
- **Illiquidity creates great Value to Insurer**
- **Value of Business is Distribution driven**

Increasing Competition due to:-

- Value Chain Management
- 3rd party Channels
  (Bancassurance, Internet, Direct, IFAs, etc)
- Distribution Channel Conflicts
- Other Financial Products within Channel
- Increase in Customer Expectations

Creating Risks for Life Insurers to

- Run for Scale as Manufacturer
- Focus on Volume than Margins
- Turn for easy Product Selling
- Improper Choice of Implicit Margins
- Overlook Value of Illiquidity

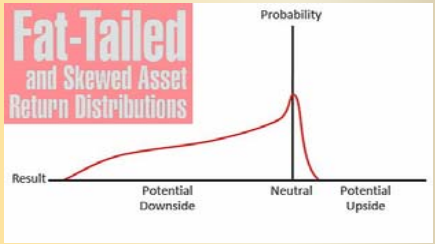
Use of Implicit Margins in Deterministic Processes easily creates Diversified Product Designs, including

- Lapse-supported Products
- Variable Annuities
- Universal Life with no Lapse Guarantee
- Annual Ratchet Guarantees
- Geared CPPI
- Equity Indexed Linked Annuities

Effects of the Newer Designs:-

- **Price Competition**
  => Reduction of Implicit Margins
- **More Guarantees**
  => Skewed & Fat Tailed Losses
- **Removal of Illiquid Product Features**
  => Remove its Protection Shield against direct Market Volatilities
- **Regulatory Arbitrage on Designs**
  => Expose to Customer Anti-selection

Innovative Product Designs challenging Traditional Actuarial Practice



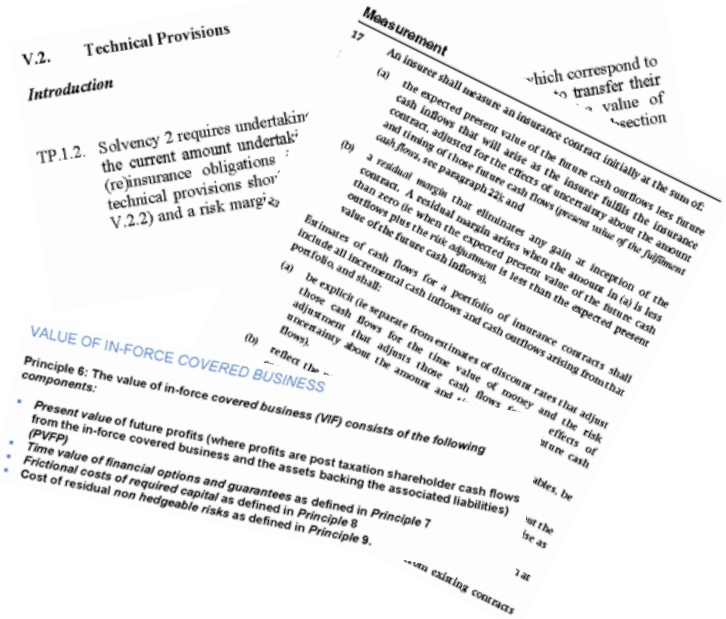
Pre-requisite Conditions for the use of Deterministic Approach disappear for some newer life insurance product designs.

This has even drawn the Industry being challenged to use any easier techniques such as Risk-based Capital, Dynamic Solvency Testing, Capital Adequacy Testing, etc with deterministic valuation of liabilities for financial management.

Call for Actuarial Stochastic Processes under IFRS (phase 2), Solvency II, MCEV even for highly illiquid product designs, potentially driving the Industry into Modelling & Black Box Competitions.

Stochastic Processes for Capital Market Transfers

The new Financial Management Regime (portrayed by Solvency II, IFRS (phase2), MCEV in CFO Forum) emphasizes to Market-Value Insurance Liabilities,


V.2. Technical Provisions

Introduction

TP.1.2. Solvency 2 requires undertakin
the current amount undertak
(re)insurance obligations
technical provisions show
V.2.2) and a risk margi

Measurement

17 An insurer shall measure an insurance contract initially at the sum of:

(a) the expected present value of the future cash outflows less future cash inflows that will arise as the insurer fulfils the insurance contract, adjusted for the effects of uncertainty about the amount and timing of those future cash flows (present value of the fulfilment cash flows, see paragraph 22); and

(b) a residual margin that eliminates any gain at inception of the contract. A residual margin arises when the amount in (a) is less than zero (ie when the expected present value of the future cash outflows plus the risk adjustment is less than the expected present value of the future cash inflows).

Estimates of cash flows for a portfolio of insurance contracts shall include all incremental cash inflows and cash outflows arising from that portfolio, and shall:

(a) be explicit (ie separate from estimates of discount rates that adjust those cash flows for the time value of money and the risk adjustment that adjusts those cash flows for uncertainty about the amount and

(b) reflect the

VALUE OF IN-FORCE COVERED BUSINESS

Principle 6: The value of in-force covered business (VIF) consists of the following components:

- Present value of future profits (where profits are post taxation shareholder cash flows from the in-force covered business and the assets backing the associated liabilities) (PVFP)
- Time value of financial options and guarantees as defined in Principle 7
- Frictional costs of required capital as defined in Principle 8
- Cost of residual non hedgeable risks as defined in Principle 9.

Centres on Mark-to-Market (Assets & Liabilities) for Risk Measures , and

Uses Observable Liquid Asset Market parameters (& extrapolates to longer terms) in the Stochastic Processes for Insurance Liability Valuation.

Before any Stochastic Process, it may be relevant for Actuaries to consider the following: -

Life Insurance	Financial Products
Protection Purpose	Trading Purpose & Profit-Oriented
Long Term	Much Shorter Term, Tenor of 5-10 year already considered long
Less liquid & High exit penalties	Trading on Market or OTC
under Actuarial Methods	under Modern Finance Theory
Economic Cycle	Independent Random Walk
Depending on Product Designs, Illiquid for Arbitrage to happen	No Arbitrage Opportunity

Liquidity (Short term) ≠ Illiquid -> Liquid (Long term)

$$\text{Volatility}_{\text{Liquid Unit}} = \text{Volatility}_{\text{Illiquid Unit}} + \text{Volatility}_{\text{Liquid Premium}}$$

Current (Trade) Price = Theoretical Price + Psychological (Irrational) Customer Behaviour

To simply take the modelling practice for liquid instruments and allow some simple adjustment applicable for short term liquidity to value illiquid instruments, or should it be the other way round to start from the perspective of illiquidity of the instrument for the valuation ?

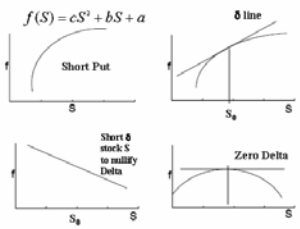
Product Illiquidity versus Market Volatility

- **In substance, the new Regime is to market-value Volatility (σ) of life insurance for the purpose of Risk Management (Hedging & Trading).**
- **Volatility $_{\text{Liquid Unit}}$ = Volatility $_{\text{Illiquid Unit}}$ + Volatility $_{\text{Liquid Premium}}$**
- **For life insurance, its Volatility should be Product Design dependent (depending on whether the features of the product are highly integrated to market movements or whether hedging with financial markets is possible).**
- **No proper Mechanism to quantify Volatility $_{\text{Liquid Premium}}$ for life insurance !**
- **Liquid Premium fluctuates tremendously during time of financial stress, which shall reduce the illiquid liabilities as valued, when the asset value is in distress (especially if the instrument in itself is illiquid, the real risk of being called to market for trade or settlement does not exist).**
- **Actuarial Treatment between Traditional Par WL and Variable Annuity can reasonably be very different (depending on the Process being started from which end of the equation -- Volatility $_{\text{Illiquid Unit}}$ or Volatility $_{\text{Liquid Unit}}$) .**
- **Volatility $_{\text{Traditional Par WL}}$ ≈ Volatility $_{\text{Illiquid Unit}}$**
- **Volatility $_{\text{VA}}$ ≈ Volatility $_{\text{Liquid Unit}}$ + Volatility $_{\text{Smile}}$**

  ≈ Volatility $_{\text{Illiquid Unit}}$ + Volatility $_{\text{Liquid Premium}}$ + Volatility $_{\text{Smile}}$

  (but being priced @ Volatility $_{\text{Constant}}$)

Dynamic Hedging



By Taylor Expansion

$$\Delta f = \frac{\partial f}{\partial t}\Delta t + \frac{\partial f}{\partial S}\Delta S + \frac{\partial f}{\partial \sigma}\Delta\sigma + \frac{\partial f}{\partial r}\Delta r + \frac{1}{2}\frac{\partial^2 f}{\partial S^2}(\Delta S)^2 + \ldots$$

By Delta Hedging using Linear Instruments

$$\Delta f - \frac{\partial f}{\partial S}\Delta S = 0 = \frac{\partial f}{\partial t}\Delta t + \frac{\partial f}{\partial \sigma}\Delta\sigma + \frac{\partial f}{\partial r}\Delta r + \frac{1}{2}\frac{\partial^2 f}{\partial S^2}(\Delta S)^2 + \ldots$$

Theta Decay Vega Rho └ Gamma Management ┘

Writing a VA is equivalent to a Short Put. Short Put creates Negative Gamma.

Dynamic Delta Hedging for Negative Gamma will lead to Gamma Loss.

At time 0, for the delta hedged portfolio,

$\pi_0 = f(S_0) - \delta * S_0$ and $\delta = \frac{\partial f}{\partial S}\Big|_{S=S_0}$

At time 1,

a) If S_0 moves up to $S_0 + \Delta S$, $\pi_1 = f(S_0 + \Delta S) - \delta * (S_0 + \Delta S)$

Given Negative Gamma, $\frac{\partial f}{\partial S}\Big|_{S=S_0+\Delta S} < \frac{\partial f}{\partial S}\Big|_{S_0<S<S_0+\Delta S} < \delta$

$\triangleright\ \pi_1 - \pi_0 = f(S_0 + \Delta S) - \delta * (S_0 + \Delta S) - f(S_0) - \delta * S_0$

$= \left[f(S_0 + \Delta S) - f(S_0)\right] - \delta * \Delta S$

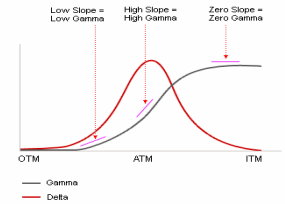
$= \left[\frac{\partial f}{\partial S}\Big|_{S_0<S<S_0+\Delta S} - \delta\right] * \Delta S$ = Negative Value * ΔS = Loss;

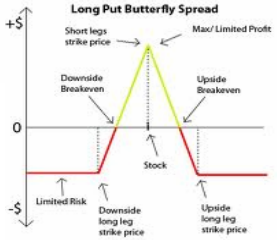
b) If S_1 moves down to $S_0 - \Delta S$, $\pi_1 = f(S_0 - \Delta S) - \delta * (S_0 - \Delta S)$

Given Negative Gamma, $\frac{\partial f}{\partial S}\Big|_{S=S_0-\Delta S} > \frac{\partial f}{\partial S}\Big|_{S_0>S>S_0-\Delta S} > \delta$

$\triangleright\ \pi_1 - \pi_0 = \left[f(S_0 - \Delta S) - f(S_0)\right] - \delta * \Delta S$

$= \left[\frac{\partial f}{\partial S}\Big|_{S_0>S>S_0-\Delta S} - \delta\right] * (-\Delta S)$ = Positive Value * $(-\Delta S)$ = Loss





The hedge ratio will be off if the non-linear position is dynamically hedged without incorporating the effect of Volatility Surface into the delta calculation.

Delta-Gamma Hedging ≈ Long Butterfly => Vega

Vega Hedging versus VA Constant Volatility Charge

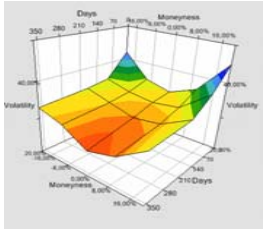
Volatility Impact on Balance Sheet Management

Bank (Loans & Deposits) : **Asset** $_{\text{Less Liquid}}$ vs **Liability** $_{\text{Liquid}}$ => **Risk = Bank Run**

Insurer (Life Insurance) : **Asset** $_{\text{Liquid}}$ vs **Liability** $_{\text{Less Liquid}}$ => **Risk = Technical Insolvent**

Bank (Loans & Deposits) : **Liability Duration (Short)** => **Force Asset Duration to stay short**

Insurer (Life Insurance) : **Liability Duration (used to be Long)** => **Require Longer Asset Duration to match**



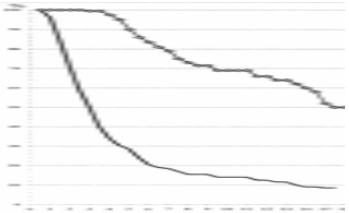
On a Liquid (fully tradable) basis, Volatility (σ) is

- **Only dependent on the underlying**
- **Independent of Investors (Individual or Organisation)**
- **Independent of immediate history & Random in time/nature under Modern Finance Theory**

Ignoring Product Illiquidity,

Duration (Bank/Financial Products) << Duration (Life Insurance) implying

Volatility (Bank/Financial Products) << Volatility (Life Insurance) if same underlying



For the Same Risk Reward if on a fully Liquid basis, Life Insurance (including Variable Annuity) has to either

- **Reduce Duration => Term Insurance , short term Renewable Guarantee, J-shaped (or deferred) Insurance Risk ; or**
- **Reduce Product Volatility for longer term Savings Products => Non-guarantee (or weak guarantee) Unit Linked**

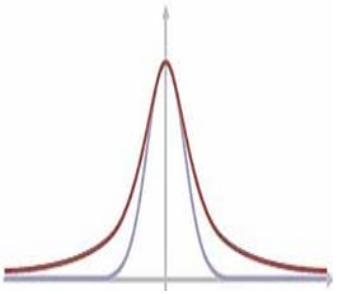
Financial Risk Utility in Risk Neutral environment

Back to Basics, why Individuals (or the Community) buy Life Insurance :-

Risk Utility Function of Individual (Fat-tailed) >> Risk Utility Function after pooling

Pooling can diversify Insurance Risk, but will concentrate Financial Risk if Life Insurance is liquid

Product Illiquidity is suppose to dilute the concentration impact of the underlying Volatility (σ)



Real World :-

Individual generates Human Value through work. Human Value helps to weather against losses in Financial Value

When Young, huge Human Value potential. Invest aggressively and best use the Dollar Cost Averaging concept

Getting Old, potential Human Value conversion reduces. Turn risk adverse , Invest in deposits or Convert $ into annuities

Risk Neutral :-

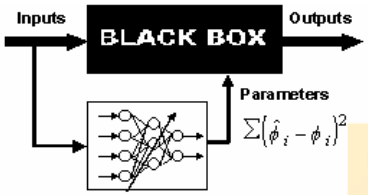
Corporate uses Financial Value to generate Financial Value, and no Human Value as buffer for risk taking

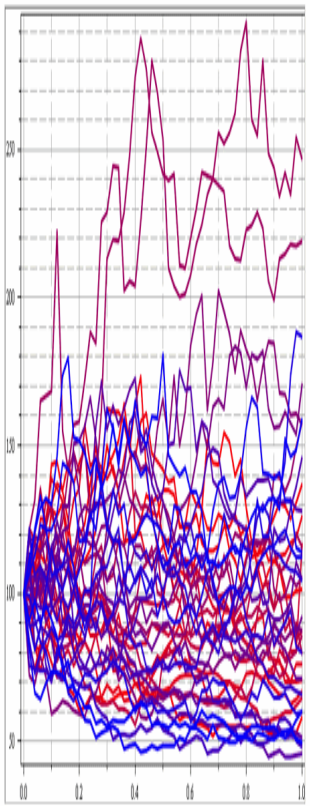
Financial Risk - Volatility (σ) in itself is independent of Investors (Individual (Young or Old) & Corporate)

Compared with Individuals, Corporate (from Shareholder capital perspective) gears.

Financial Risk Utility Function (Corporate) << Financial Risk Utility Function (Old Man)

Independent Random Walk versus Bayesian Statistics





Before jumping into the Black-box to enjoy numeric modelling and the theory of Martingale, we should ask what the whole Actuarial Process may mean.

If Life Insurance is Liquid and Tradable, it should exhibit a Martingale property. The Principle of No Trading Arbitrage leads to Risk Neutral Valuation of Liabilities.

Given the fact that (To illiquid cash ≠ To liquid long term illiquidity), it may not be relevant to just add a simple liquidity margin to model illiquid liabilities as liquid?

If so, is it relevant to simply use a model of Independent Random Walk & No History and allow for a simple adjustment (where no fine Mechanism exists) to turn Illiquid Long Term Insurance as liquid?

Why do we ignore the beauty of Bayesian Statistics in our Actuarial Process for Illiquid Long Term Insurance?

Why any disproportional increase in Liquid Premium (at the time of financial distress when Assets are impacted by irrational/psychological behaviour) is not considered in valuing Liabilities for Illiquid Long Term Insurance , where untimely surrenders are less likely & Bayesian Statistics are relevant?

Is it because of proliferation of life insurance product designs, some products may cross the line of Liquid design and are more akin to Liquid Investment Products? If so, how the design line should be drawn for life insurance to differentiate its start point of the valuation practice (Liquid vs Illiquid) ?

If Life Insurance is assumed Tradable, the Black-box modelling for Liquid & Tradable instruments will only prove Financial Risk Utility Function (Corporate) << Financial Risk Utility Function (Individual) .

Risk Transfer in Risk Neutral environment

Does the new Financial Management Regime
try to prove for Life or Long Term Insurance,

Financial Risk Utility Function (Corporate)
<< Financial Risk Utility Function (Individual)
<< Financial Risk Utility Function (Pooling of Individuals)
<< Financial Risk Utility Function (Community) ?

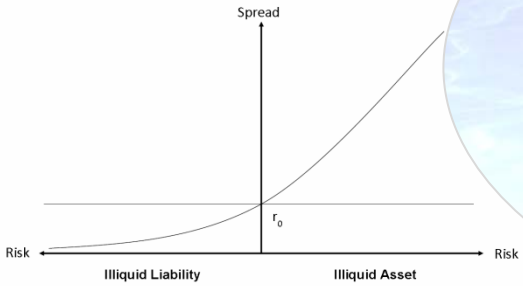
Would this mean that:-

Stock Company is a wrong concept for Long Term Insurance
(In fact, the risk transfer should be the other way round per above).

Mutual Company (Pooling of Individuals) is the relevant way for Life Insurance (particularly Old Age Insurance). Stock Company is better to deal with Term Protection Insurance & non-guarantee Unit linked.

If Mutual does not work, we have to rely on Social Insurance.

If so, why we demutualised Insurance Companies before? Why do we push for Commercial Insurance to replace Social Insurance?



Implications of the New Regime for Long Term Insurance

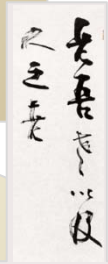
The western societies previously used Social Security and Social Insurance to address the issue of Old Age.

This kind of unfunded systems has had the issue of Sustainability. Funded systems have therefore been encouraged.

Areas like Australia, Singapore, Malaysia, Hong Kong have compulsory Provident Funds to force the work-force to save monies for retirement. However, Individuals have to take their own investment risks on both pre and post retirement.

It is expected that the Commercial Sector would provide relevant life insurance products to bridge the risk gaps when the funded system reaches its run-down phase.

The new Regime for Life Insurance will now effectively shift Old Age Insurance back to Individuals and the Community.



Apart from the numeric aspects which Actuaries used to be interested in, would it be relevant for our Profession to consider the social aspects of the new Regime :-

- Whether the new Practice is more to rectify the wrong practices (or changes) that were introduced in the past?
- Whether the implications between Risks and Illiquidity have been well considered in the new Regime?
- For Old Age Insurance, whether the insurance model of (Finance → Finance) should be changed to the practice of insurance service (Finance → Service), so that no financial trading can be assumed in the system for arbitrage?
- Whether the Financial Management system for Life Insurance (especially for Old Age Insurance) should take account of the Social Aspects to balance the different needs of the community to strive for a stable and long term system?
- Whether the assumption that Financial Practice is independent of Culture (i.e. community belief) is over-simplified? Whether Regulators (depending on their mandates) should take account of local conditions to refine any practice. If so, whether we are hitting the Culture bottleneck on Globalisation of Financial Practice for Old Age Insurance.

~ Thank You ~