Traditional, investment, and risk management actuaries in the life insurance industry

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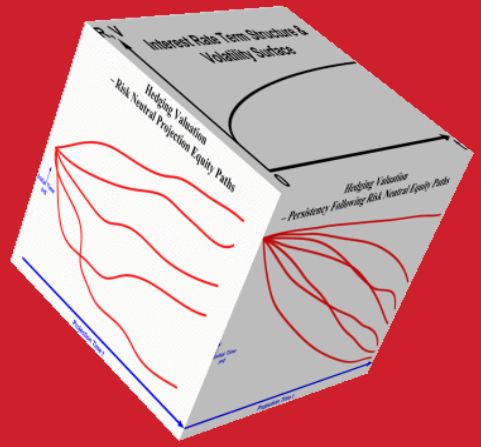

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Table of contents

Life insurance products

- Traditional insurance products with protections for mortality, longevity, morbidity, etc. may be diversified

- Life insurance products
  - ⇒ Life insurance – paid on death as wealth protection
  - ⇒ Annuity – asset accumulation with tax deferral as investment for retirement

- Life insurance companies are assets rich
  - ⇒ Customers deposit money to insurance companies
  - ⇒ Insurance companies invest prudently for the long term
  - ⇒ Insurance pay the claims many years down the road
  - ⇒ Safety is critical

Life actuaries – Traditional actuaries

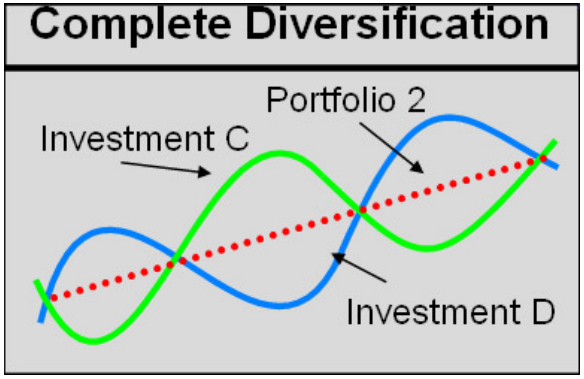
- Product pricing (engineers of the insurance company)
  - ⇒ To design products that generate economic value and have long-term profitability
  - ⇒ Need to be creative
  - ⇒ Responsible for profitable products
  - ⇒ Communication with sales and marketing

- Financial valuation and reporting
  - ⇒ To value and report insurance liabilities sold
  - ⇒ Need to be conservative
  - ⇒ Working closely with accounting and finance staff
  - ⇒ Not accountants but typically more knowledgeable than accountants on insurance liabilities (products)

Life insurance is based on diversification

- Most products can be safely priced based on actuarial expected values (averages) and standard deviation

- The power of diversification

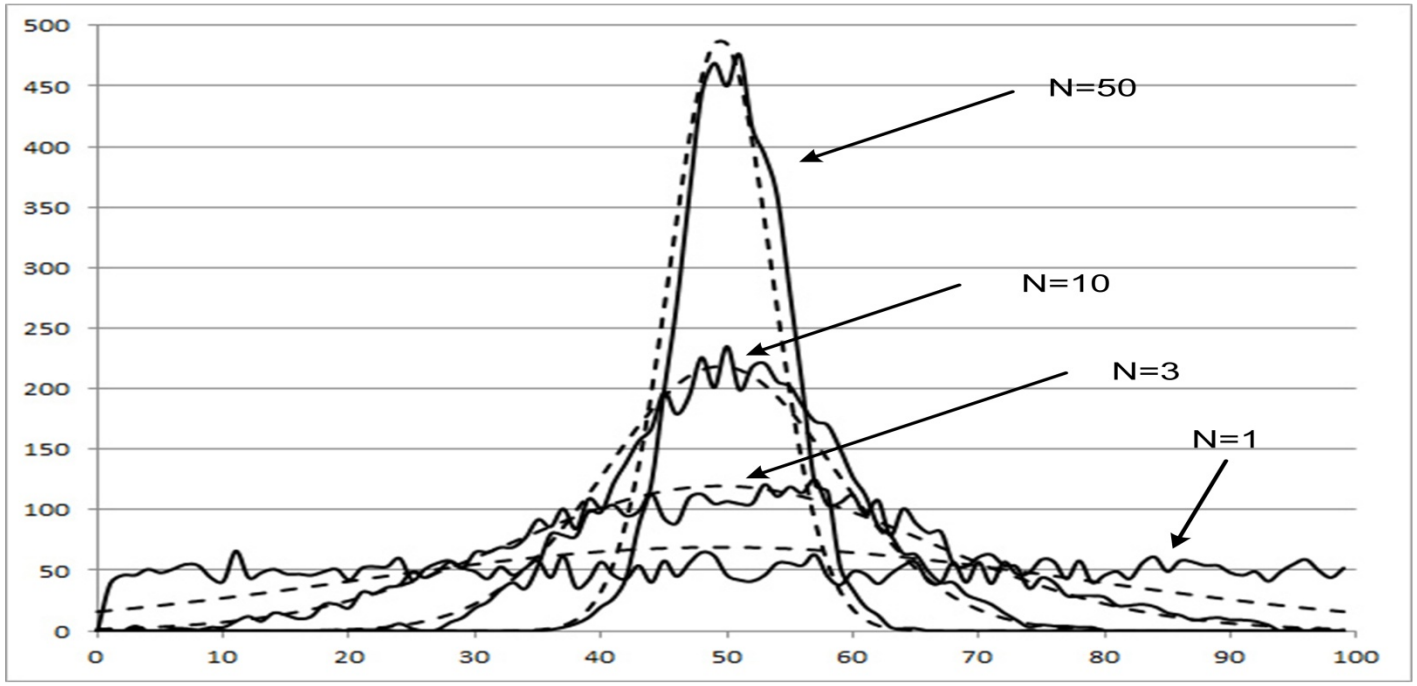


- The risk of systemic exposure

Law of large numbers

- To reduce the uncertainty (risk or standard deviation) of the expected outcome
  - ⇒ **Sell a large number of small amount of insurance**

- The old and true statistical principle of **“law of large numbers”**
  - ⇒ Statistically speaking, larger samples reduce “sample error”

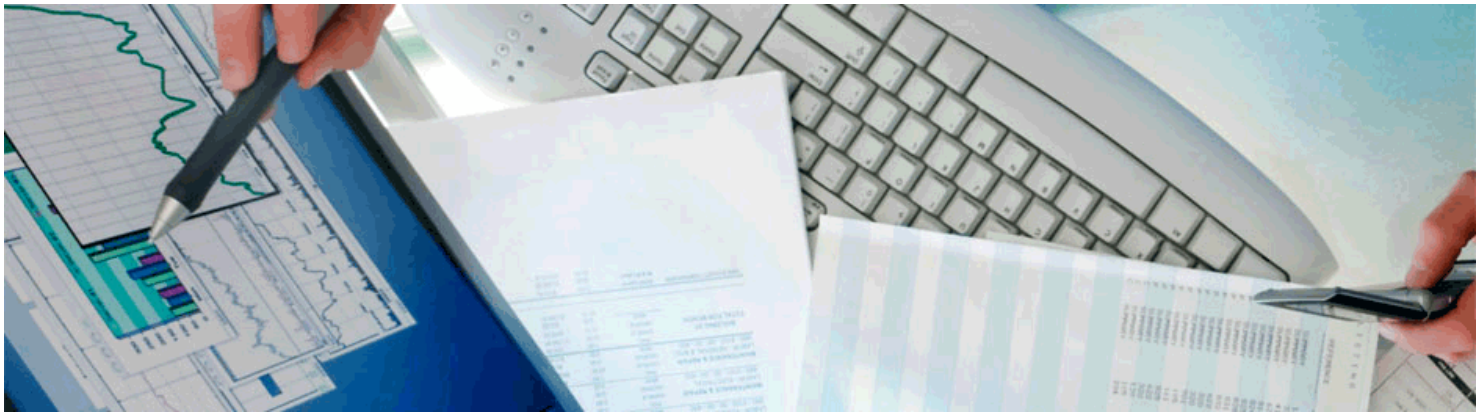


Actuaries are engineers in insurance companies

- Actuaries develop the tools used to build the insurance products (not widgets)
- Actuarial tools are financial models (not machine tools)
- Financial modeling is like computer game of financial cash flows (not soldiers and arms)
  - ⇒ Using software to model the events and activities
  - ⇒ Objects are financial cash flows (initial cash received and invested and later claims paid)
  - ⇒ Cash flows are simulated and analyzed
  - ⇒ Analysis focus on profitability (averages) and risks (tails)

Actuarial modeling

- All actuarial modeling work is on computer
  - ⇒ Widespread use of Excel spreadsheet models
  - ⇒ Some specialized actuarial software
  - ⇒ Extensive use of computer programming and database software
  - ⇒ All insurance products and their projected financials are modeled
  - ⇒ Based on actuarial and economic assumptions
  - ⇒ However, actuaries are not programmers – Programming is a tool for actuaries



Investment and risk management actuaries

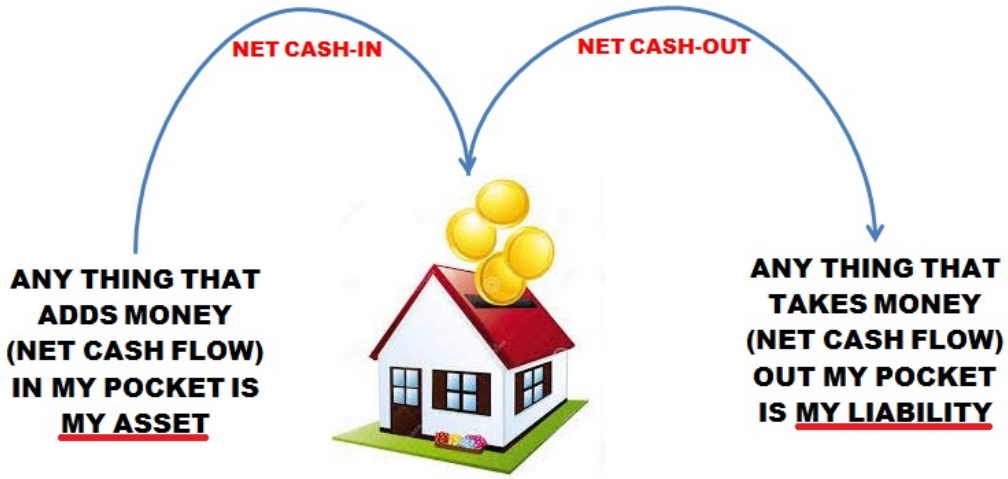
- Life actuaries – Investment and risk management
  - ⇒ Most life insurance and annuity products have long term obligations (liabilities)
  - ⇒ Insurance companies are cash rich and big investors
  - ⇒ Insurance companies invest the monies received to pay for future claims

- Investment
  - ⇒ Most insurance company investments are in fixed income assets (bonds)
  - ⇒ Most insurance company liabilities are also long term fixed income in nature

Asset liability management

- Investments by insurance companies need to provide both solid returns to support the future claims, business profits, and high degree of safety if things go wrong

- Asset liability management (ALM)
  - ⇒ Need to work with both actuarial insurance liabilities and portfolio investments
  - ⇒ ALM is art and science to balance assets and liabilities
  - ⇒ Actuaries doing ALM are “investment actuaries”
  - ⇒ Net asset and liability exposures to interest rate are immunized
    - Portfolios are managed with limited exposure to large interest rate moves (either up or down)



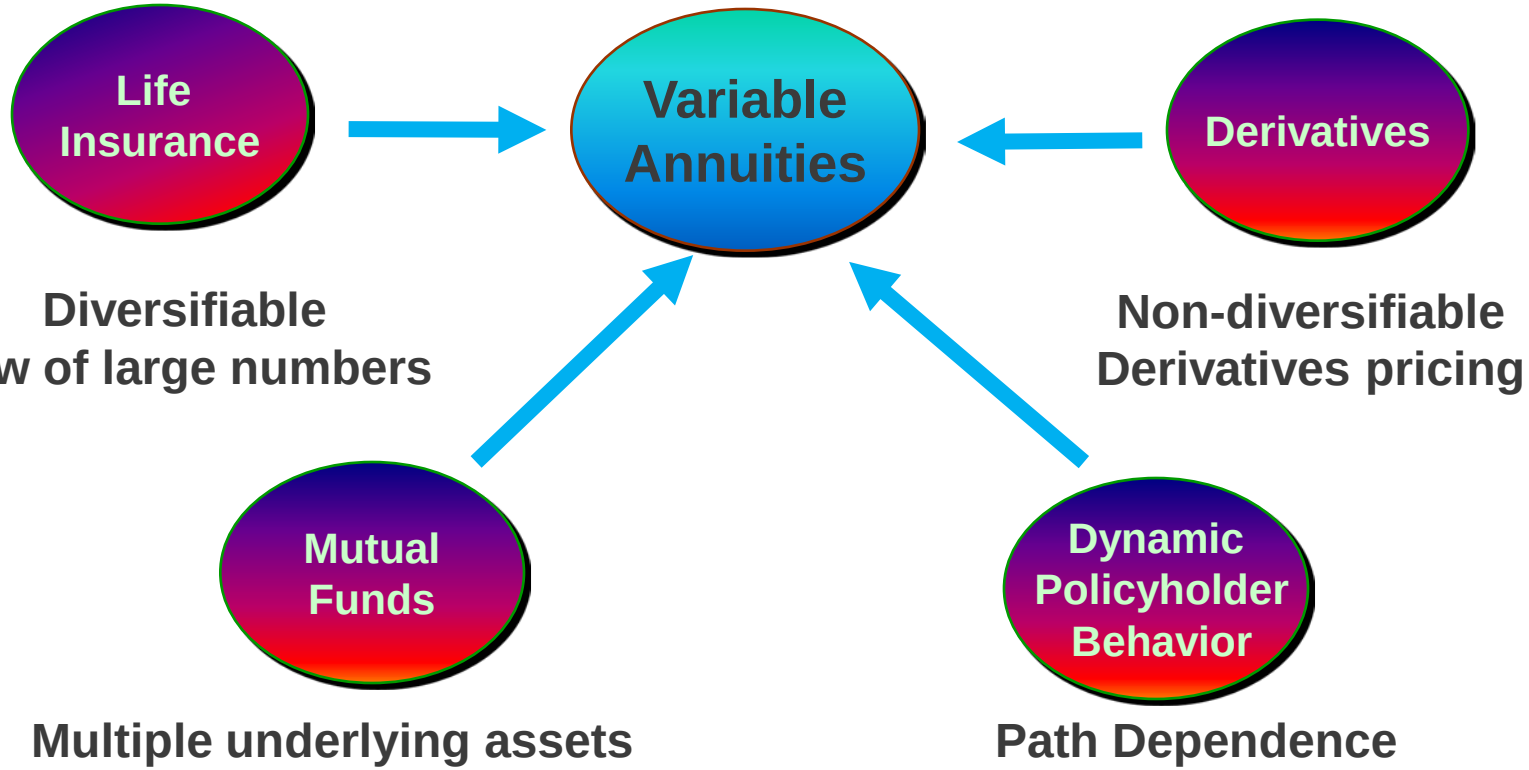
Investment knowledge for ALM

- Finance and investment knowledge
  - ⇒ Investment knowledge has been the core of actuarial science
  - ⇒ Actuaries work closely with portfolio managers (mostly fixed income investments)
  - ⇒ Actuaries can model sophisticated investment assets and their interactions with market interest rate drivers

Table of contents

Life insurance or derivatives?

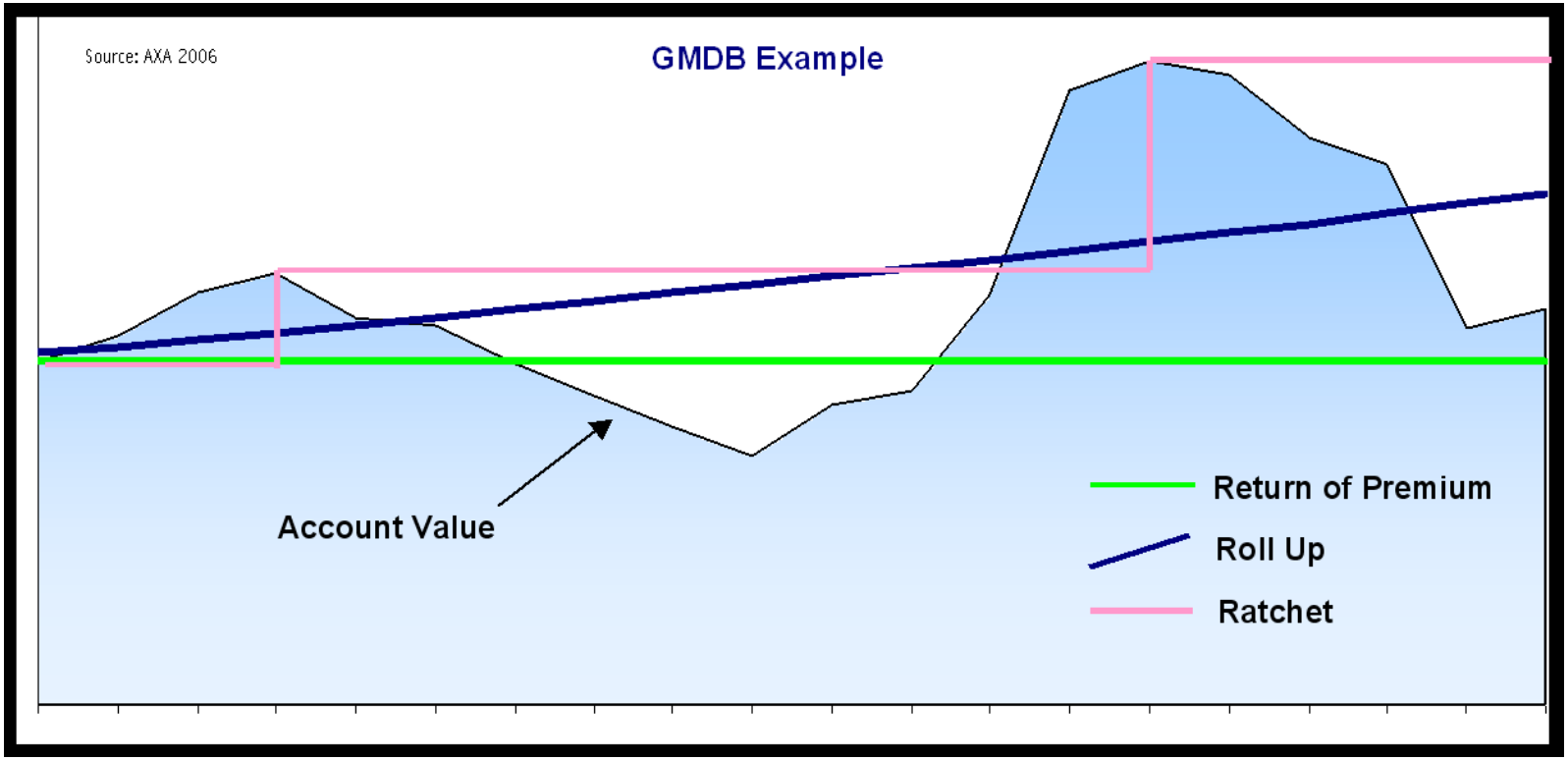
Variable annuity (VA) guarantees blur the boundary between derivatives products and traditional life insurance products: **Living or dying!**



VA contracts invest in mutual funds, paying fees to insurer, and getting guarantee benefits
GMDB (Guaranteed Minimum Death Benefit) => Payable at death
VAGLB (Variable Annuity Guaranteed Living Benefit) => Payable Under Predefined Conditions:
GMAB (Guaranteed Minimum Accumulation Benefit) for account value guarantee
GMIB (Guaranteed Minimum Income Benefit) for annuitized payouts guarantee
GMWB (Guaranteed Minimum Withdrawal Benefit) for withdrawals guarantee

Sample VA GMDB designs

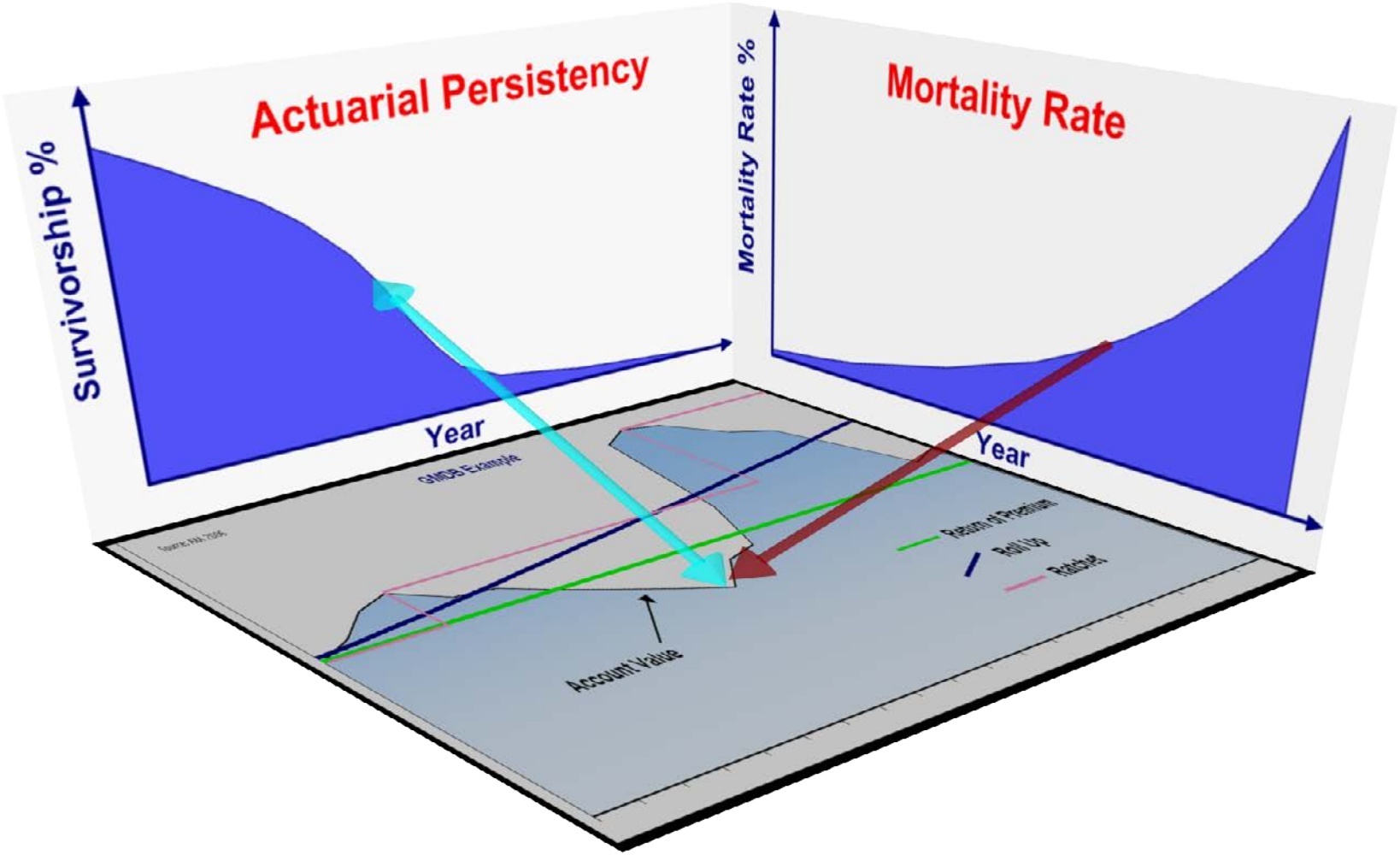
- **Different strikes for different designs**
  - **Return of premium**: strike = initial AV = initial premium deposits
  - **Ratchet**: discrete look back strike = max (sample AVs during the contract life)
  - **Rollup**: increasing strikes at an annual rate x: strike $_t = (1+x)^t$
  - **Combinations**: strike = max of ratchet and rollup



How to price VA embedded derivatives

Risk neutral valuation using stochastic simulations

GMDB is paid only If GMDB is in the money and still In force at death
Price = sum of all future possible death payoffs on surviving contracts (by simulations)

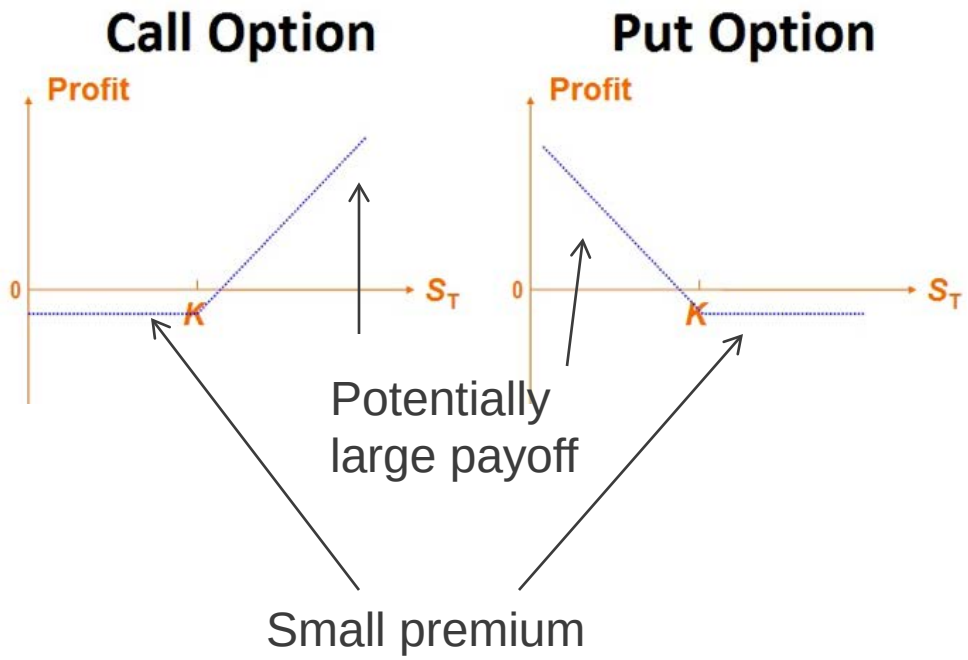


Capital market risk management

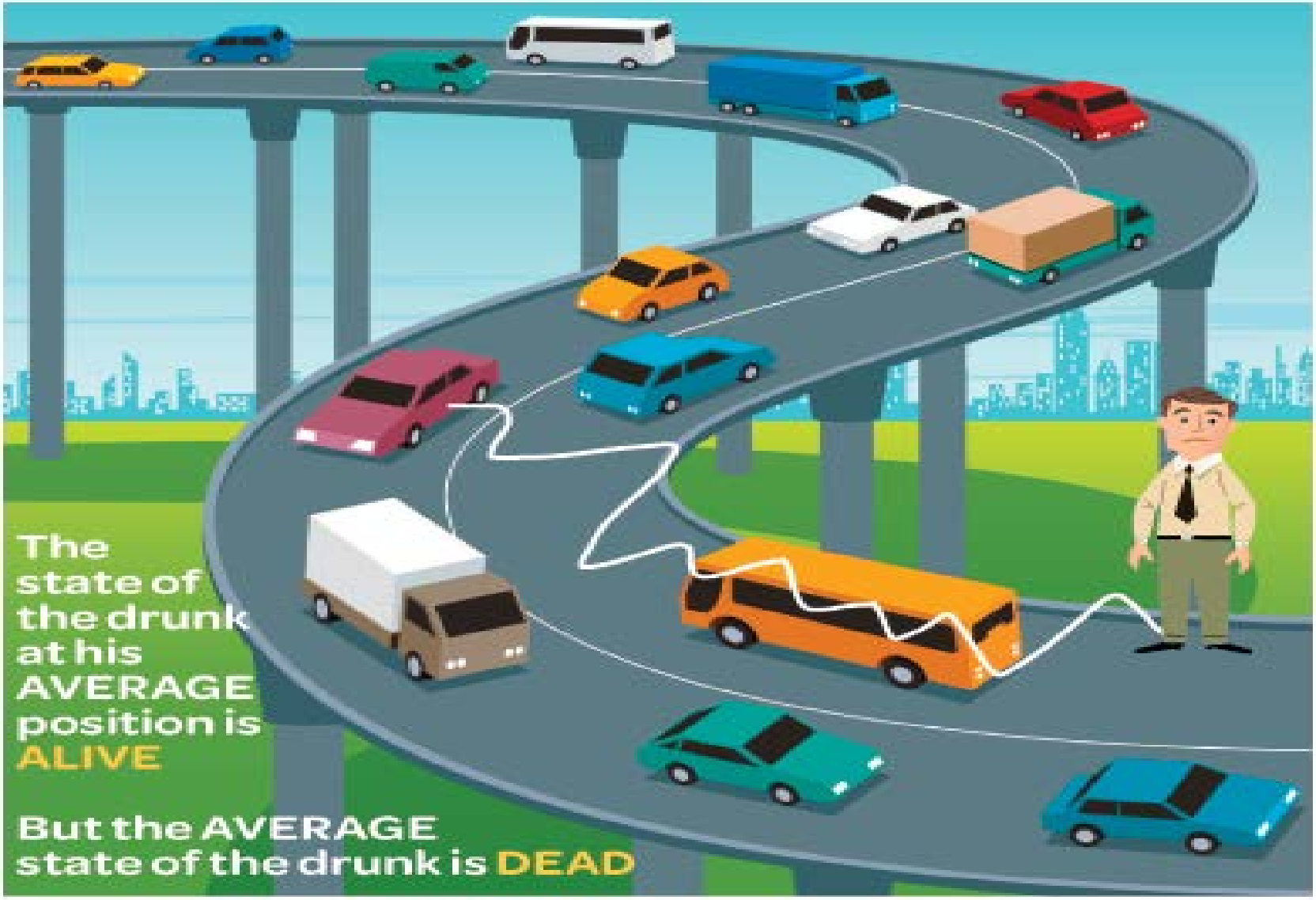
- Capital markets are typically represented by Wall Street and portfolio investments
- Traditional investments in fixed income (bonds), equity (stocks), and modern derivatives (options)
  - ⇒ Fixed income portfolio management focuses on interest rate risk and credit risk
  - ⇒ Equity investment focuses on systematic risk (measured by beta)
  - ⇒ Derivatives are priced using financial engineering techniques
- Financial engineering is based on “law of one number” or no arbitrage
- Wall Street has used financial engineering to price and manage the risks for derivatives

Derivatives, VA and fixed indexed annuities

- Options are capital market instruments
- Puts and calls have non-linear payoffs
  - ⇒ Only when stock price ends below or higher than the put/call strike respectively
  - ⇒ The options are highly leveraged with small option premium for potentially large payoffs
- VA writers sold short put options in GMDB and VAGLB as embedded benefits
- Fixed indexed annuity (FIA) writers sold short of call/call spread options



Not all things can be averaged



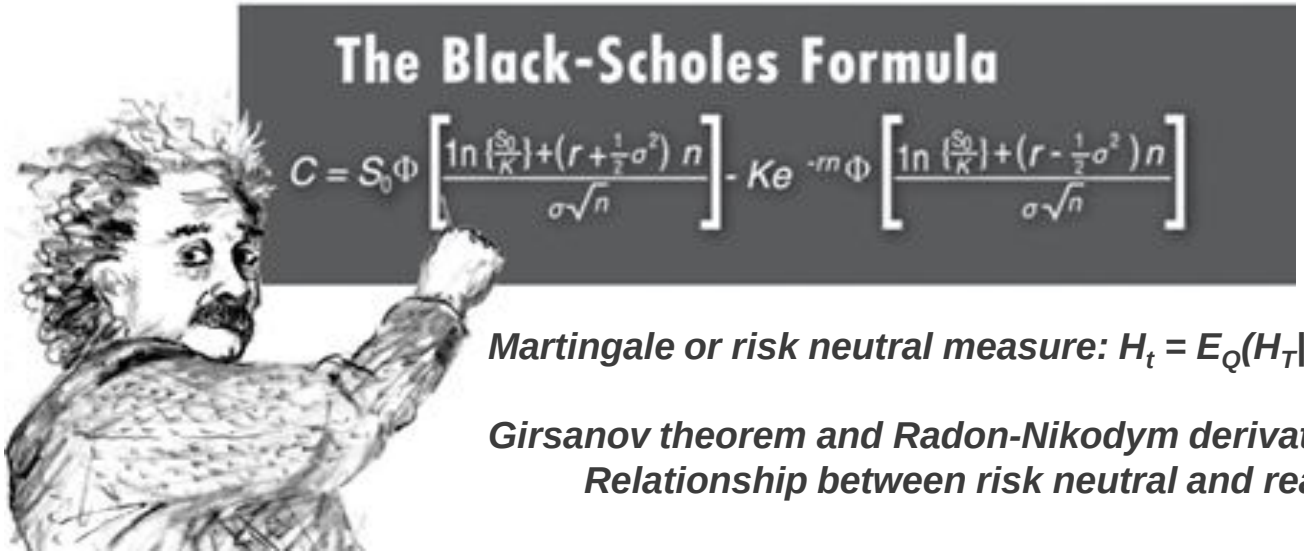
Source: Simon Proctor

Capital market law of one number (price)

- Financial engineering is based on **“law of one number” or no arbitrage**
- No arbitrage means no risk-free way of making money and there is only one price that is the market price

Capital market one price – Risk neutral valuation

- Derivatives can be replicated **using** risk free instruments
- It turns out risk neutral pricing is a **very convenient trick** to **simplify derivatives** calculations
- Risk neutral replications is dynamic hedging
- Derivatives pricing using risk neutral does NOT assume risk free market outside this mathematical exercise



Martingale or risk neutral measure: $H_t = E_Q(H_T|F_t)$

Girsanov theorem and Radon-Nikodym derivative:
Relationship between risk neutral and real world measures

Derivatives cannot be diversified

- **Diversification by derivatives product offering is very limited**
  - ⇒ Shorting 100,000 put options with varying strikes and maturity dates
    - **Add, but not reduce, the main exposure to the block – systemic exposure to equity**
  - ⇒ Selling VA and FIA
    - Might offset to some degree of the directional exposure to equity but not the volatility

- **Derivatives risks are systemic**
  - ⇒ Time diversification is not very reliable – still the same market exposure

Derivatives are hedged but not diversified

- **Sound risk management practice is**
  - ⇒ To neutralize the systemic capital market exposure by **hedging** (hope we have priced adequately)
  - ⇒ The best "diversification" for derivatives is hedging

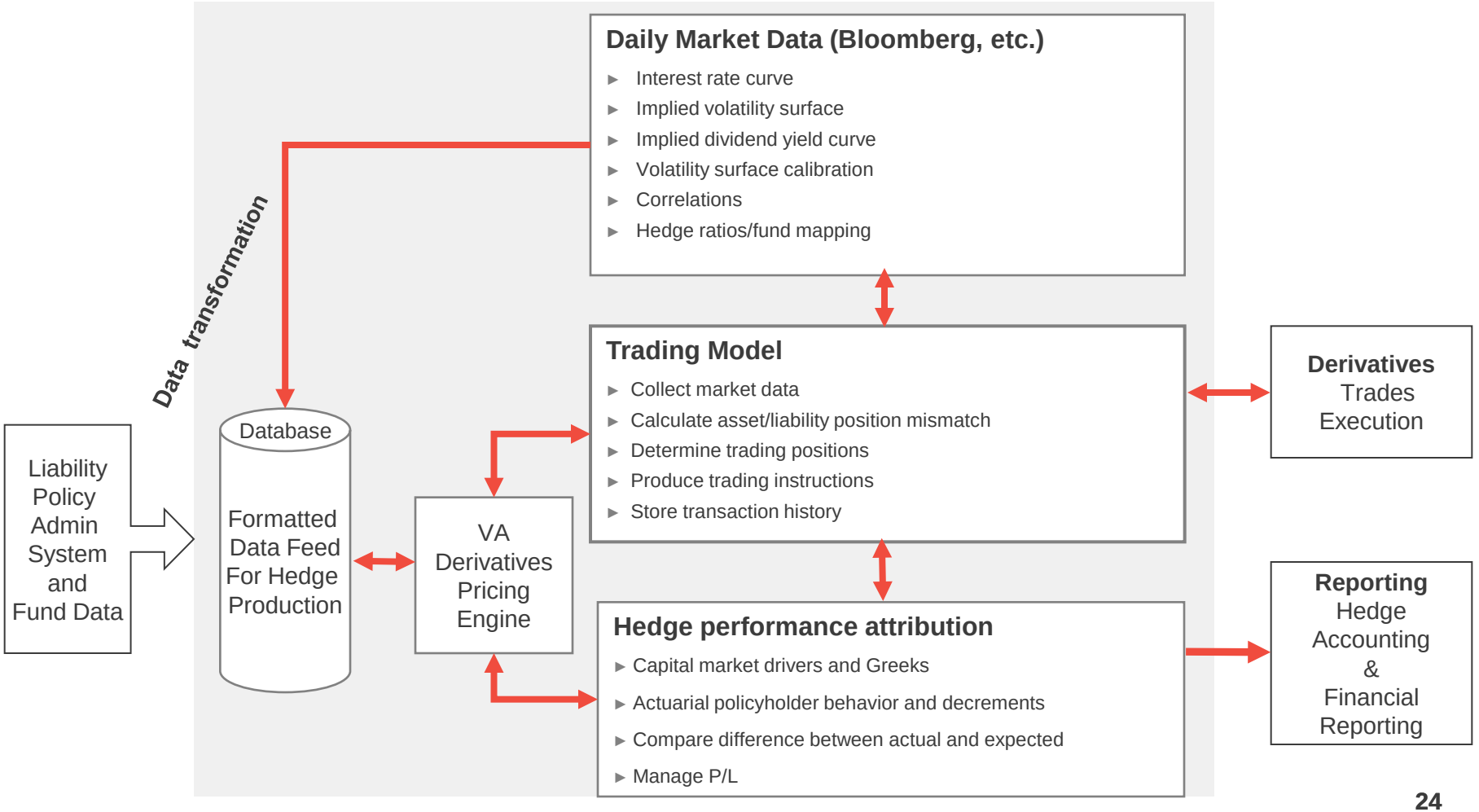
- **Hedging with risk neutral valuation is the most reliable way to offload the risks**
  - ⇒ Risk neutral valuation of derivatives ensures consistent results
  - ⇒ No matter what happens - real world or risk neutral path or good/bad scenario
  - ⇒ Without taking any bets of market directions

Hedging is to create opposite economic payoffs of the liability guarantees

- *Through matching the sensitivities (Greeks) of the VA/FIA*
- *Greeks are capital market drivers of equity, interest rates, volatility, etc.*

A dynamic hedging program (a “trading book”)

- There may be hundreds of thousands or millions of derivatives contracts in a book
- No closed form solutions but stochastic simulations for path dependent, long-dated, and basket options in VA book.
- Need very large computing grid for overnight simulation runs
- Maybe active derivatives trading to hedge the Greeks



Financial engineering and actuarial science

- **Law of large numbers does not work effectively with derivatives**
  - ⇒ Capital market risks are now dominate risks in many life insurance companies

- **Law of one number is critical for insurance derivatives products**
  - ⇒ Derivative contracts will be priced and risk is mitigated individually (not by average)
  - ⇒ Derivatives are priced with no-arbitrage and risk neutral hedging replication
  - ⇒ Dynamic hedging is used to manage the derivatives risks sold

- **Variable annuities and many current life insurance products need both law of large numbers and law of one numbers**
  - ⇒ New practice requires both financial engineering and actuarial science
  - ⇒ The non-market components are somewhat diversifiable
  - ⇒ Capital market derivatives exposure long dated and path dependent
  - ⇒ Imperfectly defined derivatives with many moving parts
  - ⇒ New practical and theoretical challenges and opportunities

Table of contents

Critical skills, education and knowledge needed

- **Actuarial exams and actuarial internship experience**
  - ⇒ Entry level job typically require 1-3 actuarial exams
  - ⇒ Actuarial internship experience before graduation extremely helpful
  - ⇒ Communication skills very helpful

- **Risk management and investment actuaries**
  - ⇒ Advanced degree can be helpful
  - ⇒ Option pricing, financial mathematics, investment
  - ⇒ Computer programming (C++, C#, JAVA, VBA)

- **Major advantage with actuarial science education**
  - ⇒ Mathematics, statistics, accounting, finance, computing
  - ⇒ Most efficient education option with preparation for actuarial exams

Where do life actuaries work

- **Mostly in life insurance or reinsurance companies**
  - ⇒ Most work as pricing and valuation actuaries
  - ⇒ Large companies have formal or informal actuarial rotation program
  - ⇒ Actuaries are supported with actuarial study time during work days
  - ⇒ Actuaries are paid exam raises, in addition to annual salary increases
  - ⇒ Some companies CEOs are actuaries
- **Some in actuarial consulting**
  - ⇒ Actuarial insurance consulting firms
  - ⇒ Actuarial auditing (Big Four Accounting Firms)
  - ⇒ Life, benefit, health insurance, and pension consulting firms
- **Few in investment bank**
  - ⇒ Portfolio management with insurance companies
  - ⇒ Insurance related securitization
  - ⇒ M&A transactions
  - ⇒ Derivatives and trading

Actuaries are mathematicians who work in business to solve world's problems!

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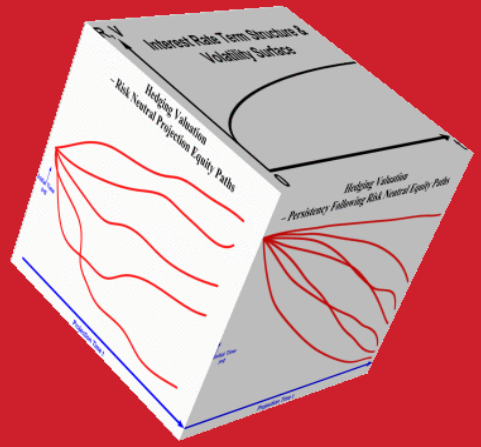

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