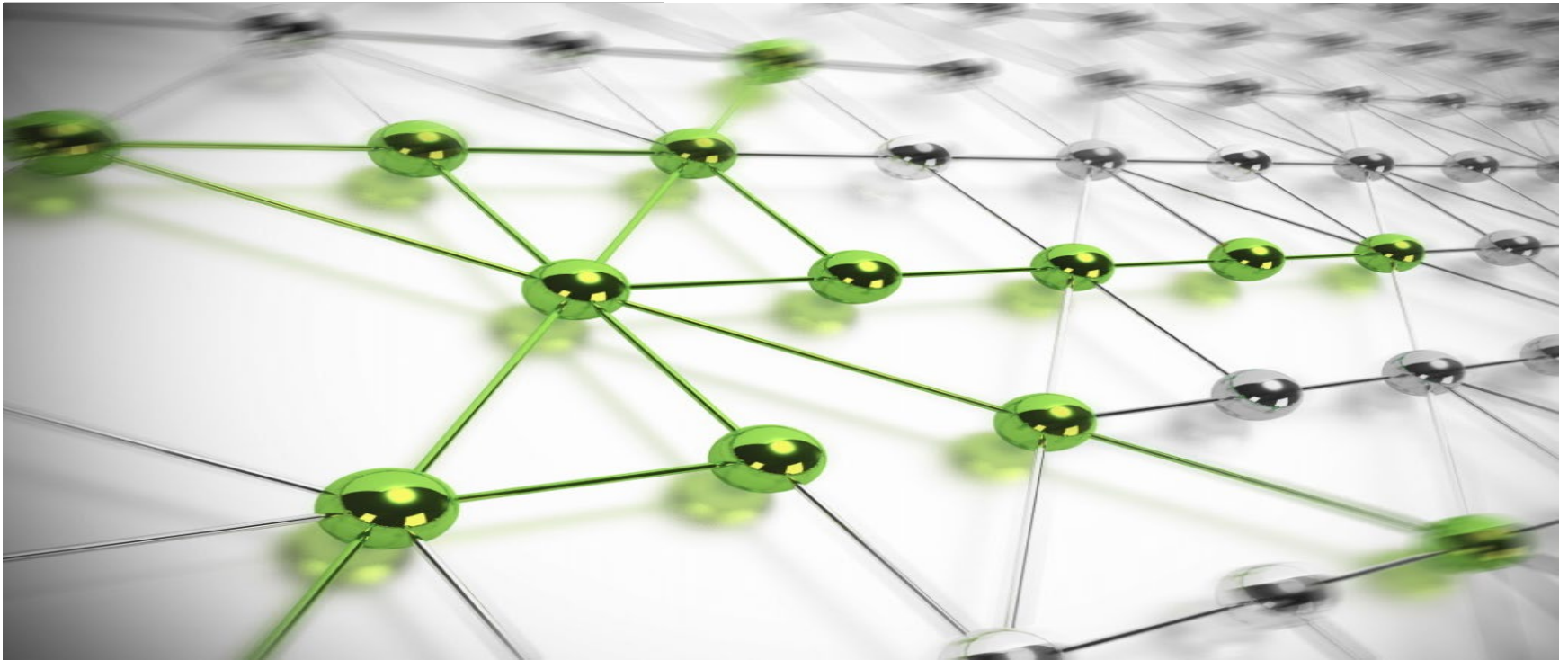# Modelling and Hedging Variable Annuity Guarantees – Challenges and Opportunities

Biography and Disclaimer

Jeanine Kwong, CMA, PRM
Global Head of Investment Risk Oversight
Manulife Investment Management

- 15 years of industry experience, including 4 years in Canada as Global Head of Equity Risk overseeing C$100B variable annuity and segregated funds risks in US, Canada and Asia and C$20B General Accounts Public Equity on balance sheet; 7 years in Japan and the Netherlands as Head of Financial Engineering for Japan closed-block variable annuity hedging.

- Current responsibilities include leading the development of a robust investment risk governance framework, spearheading large-scale risk infrastructure transformation project, and enabling independent oversight of market, liquidity and counterparty risks across Manulife's Global Wealth and Asset Management businesses servicing retail, institutional and retirement clients.

- Jeanine holds a Master's degree in Mathematics/Statistics (Quantitative Finance) and a Bachelor degree in Mathematics/Business Administration from the University of Waterloo. She also holds the professional designations of Professional Risk Manager (PRM) and Certified Management Accountant (CMA).

Disclaimer:
The opinions, beliefs and viewpoints expressed in this presentation are solely my own, and do not necessarily reflect the opinions, beliefs and viewpoints of my past and current employers or affiliates. The modelling framework and processes described in this presentation are generalized, and may not represent past, present of future practices.

Agenda

1. Terminology & Product Characteristics

2. Variable Annuity Guarantee Risk Management

3. Modelling Variable Annuity Liabilities for Dynamic Hedging
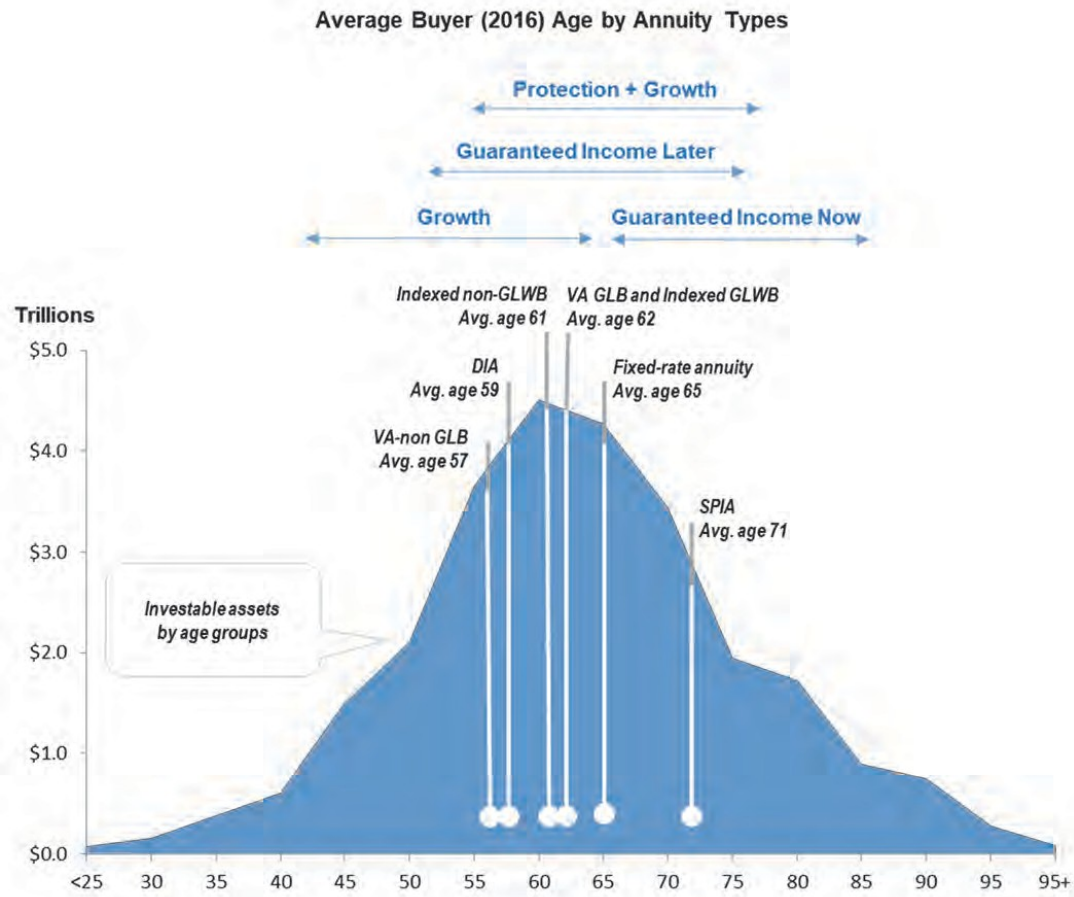
4. Challenges and opportunities

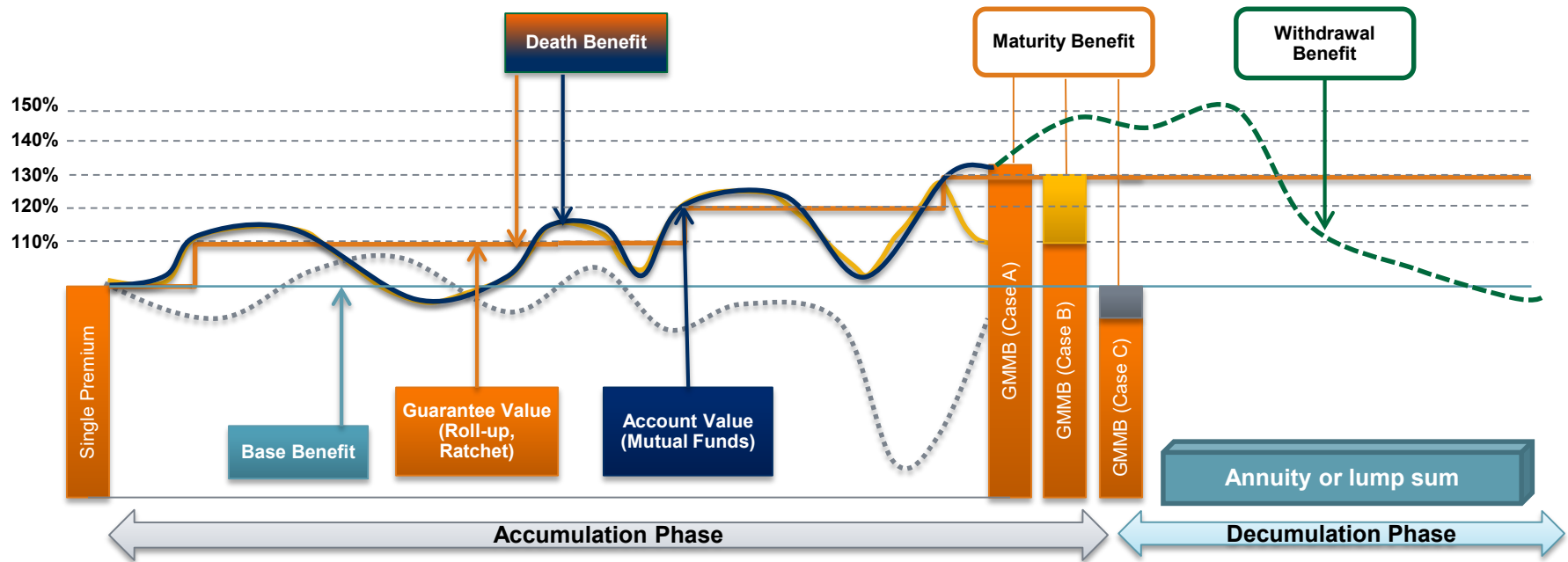# Terminology & Product Characteristics

Why People Buy Annuity

Source: LIMRA's Secure Retirement Institute, "Annuity Buyer Metrics, Summary Report"

Terminology & Product Characteristics

- **Variable Annuity:** Investment-linked product with insurance features.
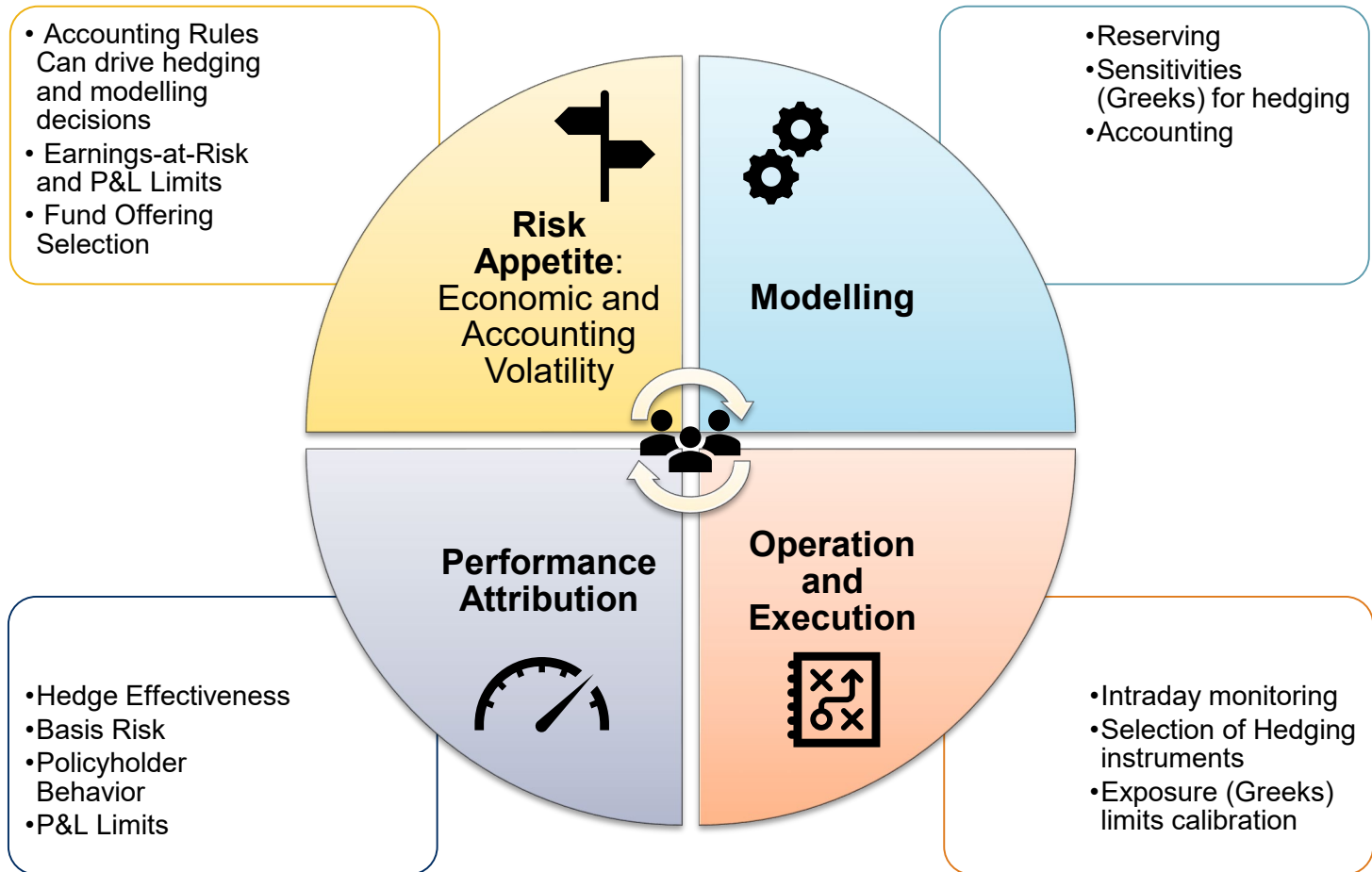

Death Benefits from a **GMDB** on death: **MAX(GV- AV,0)**

Maturity Benefit for a **GMMB** on maturity: **MAX(GV- AV,0)**

Withdrawal Benefits for a **GMWB** (or **GLWB**) if AV = 0: periodic **Withdrawal Amounts** until maturity (or Death)

Variable Annuity Guarantee Risk Management Considerations

- Accounting Rules Can drive hedging and modelling decisions
- Earnings-at-Risk and P&L Limits
- Fund Offering Selection

Risk Appetite: Economic and Accounting Volatility

Modelling
- Reserving
- Sensitivities (Greeks) for hedging
- Accounting

Performance Attribution
- Hedge Effectiveness
- Basis Risk
- Policyholder Behavior
- P&L Limits

Operation and Execution
- Intraday monitoring
- Selection of Hedging instruments
- Exposure (Greeks) limits calibration

Remarks on Global Pandemic

- Entering 2020, US equity market experienced the longest bull run ever. In March, equity market volatility hit record highs and bond markets experience liquidity strains. By mid-August, while SP500 level returned to pre-COVID high, short term volatility remains elevated.

- 10-year US treasury rate remained well below 1 percent through April 2020.

- Diversification across asset classes doesn´t work anymore. Bonds lost their diversification benefits over the last couple of years, which leads to higher overall risk in Multi Asset portfolios.

- Hedging program and managed volatility strategies are generally effective in mitigating equity risk.

- Lower interest rate increases sensitivities to interest rate level, increase cost of hedging and reduces profitability

  - De-risking effort within insurance writers will continue

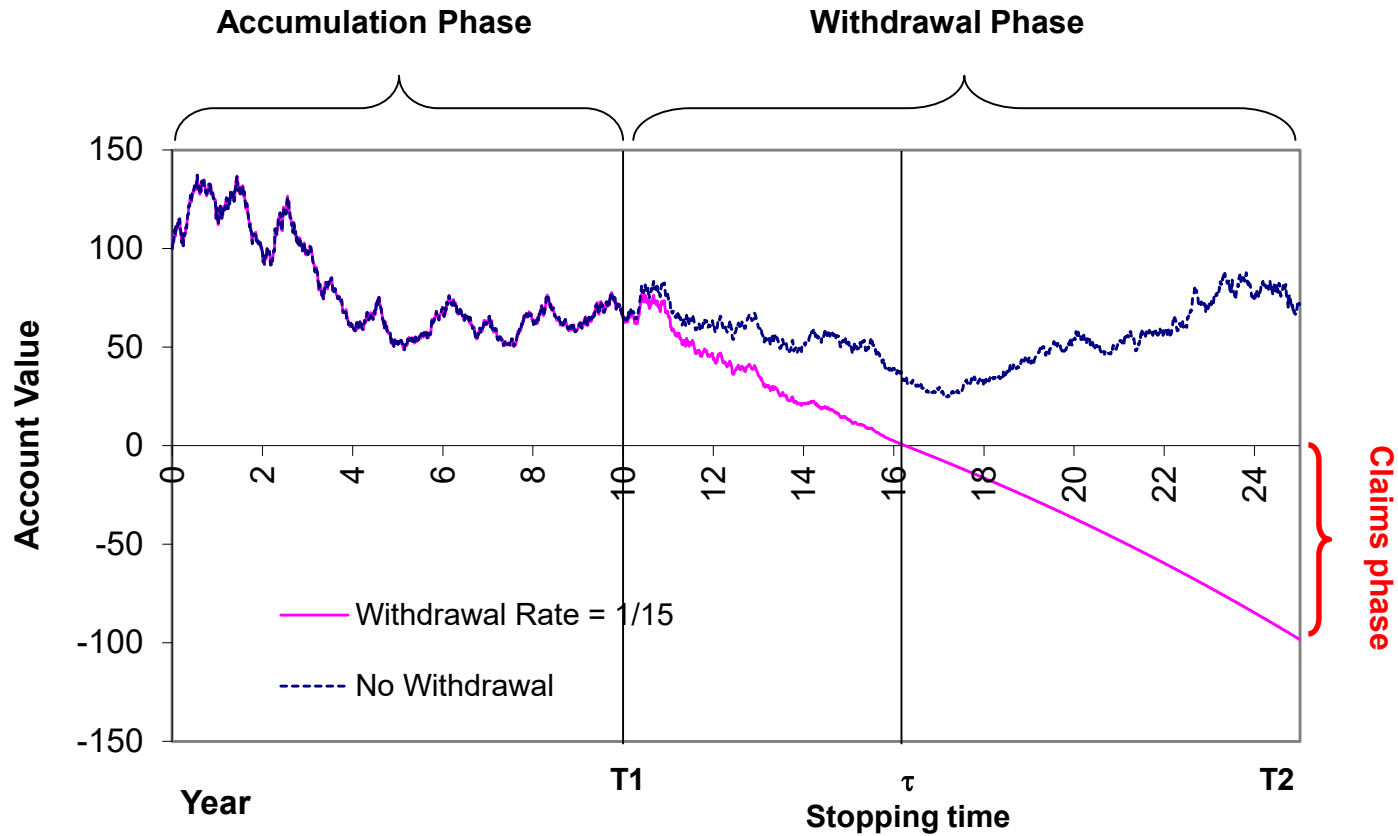- Economic uncertainty means model assumptions need to be adjusted.

Modeling Variable Annuity Liabilities for hedging

A GMWB simple example: account value illustration

A simple GMWB example

- **The account value:**
  - Accumulation phase $[0, T_1]$: $dV_t = (r - m - q)V_t dt + \sigma V_t dB_t$
  - Payout phase $(T_1, \text{Min}(T_2, \tau)]$: $dV_t = (r - m - q)V_t dt - \boxed{wdt} + \sigma V_t dB_t$
  - τ stopping time: $V_t = 0$, for $t \geq \tau$.
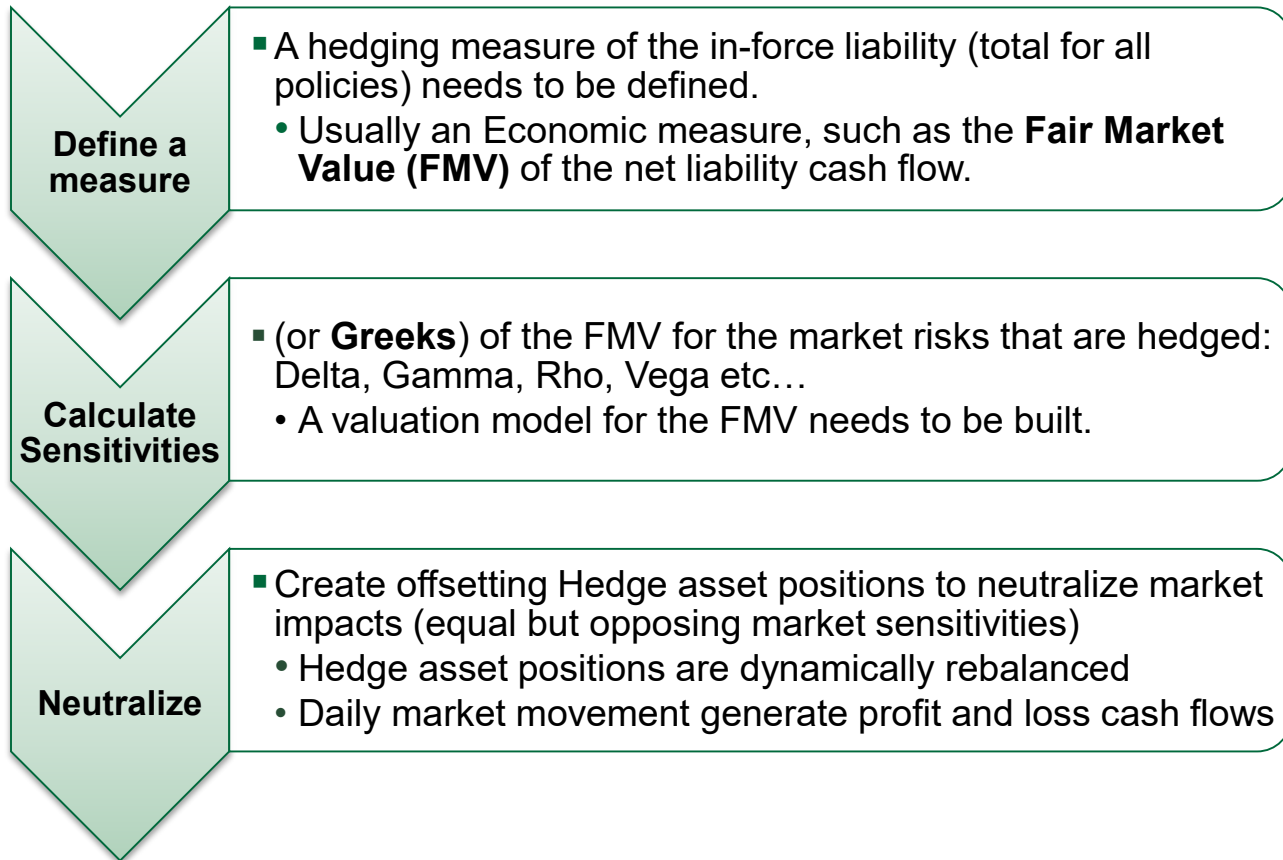 - B_t Brownian Motion, represents the randomness of market returns

- **The claims:**
  - $\tau \geq T_2$: No withdrawal claims. A maturity claim at T_2 if $V_{T_2} < GV$.
  - $\tau < T_2$: No maturity claim. Withdrawal claims for $t \geq \tau$.

- **The fee**: not paid for $t \geq \tau$.

- **Decrements**: all cash flows incur conditional on policy not lapsed and policyholder still alive.

Hedging Variable Annuities in 3 Steps

Define a measure
- A hedging measure of the in-force liability (total for all policies) needs to be defined.
  - Usually an Economic measure, such as the **Fair Market Value (FMV)** of the net liability cash flow.

Calculate Sensitivities
- (or **Greeks**) of the FMV for the market risks that are hedged: Delta, Gamma, Rho, Vega etc…
  - A valuation model for the FMV needs to be built.

Neutralize
- Create offsetting Hedge asset positions to neutralize market impacts (equal but opposing market sensitivities)
  - Hedge asset positions are dynamically rebalanced
  - Daily market movement generate profit and loss cash flows

A simple GMWB example: cash flows illustration

Month	Account Value		Policyholder		Insurer		Fund Company
	In	Out	In	Out	In	Out	In
0	V(0)			V(0)			MER
1	Mkt Return	Fee+MER			Fee		MER
2	Mkt Return	Fee+MER			Fee		MER
...	Mkt Return	Fee+MER			Fee		MER
T1	Mkt Return	Fee+MER			Fee		MER
T1+1	Mkt Return	Fee+MER+Withd	Withd		Fee		MER
...	Mkt Return	Fee+MER+Withd	Withd		Fee		MER
tau	Mkt Return	Fee+MER+Withd	Withd		Fee		MER
tau+1			Withd			Withd	
...			Withd			Withd	
T2			Withd			Withd	

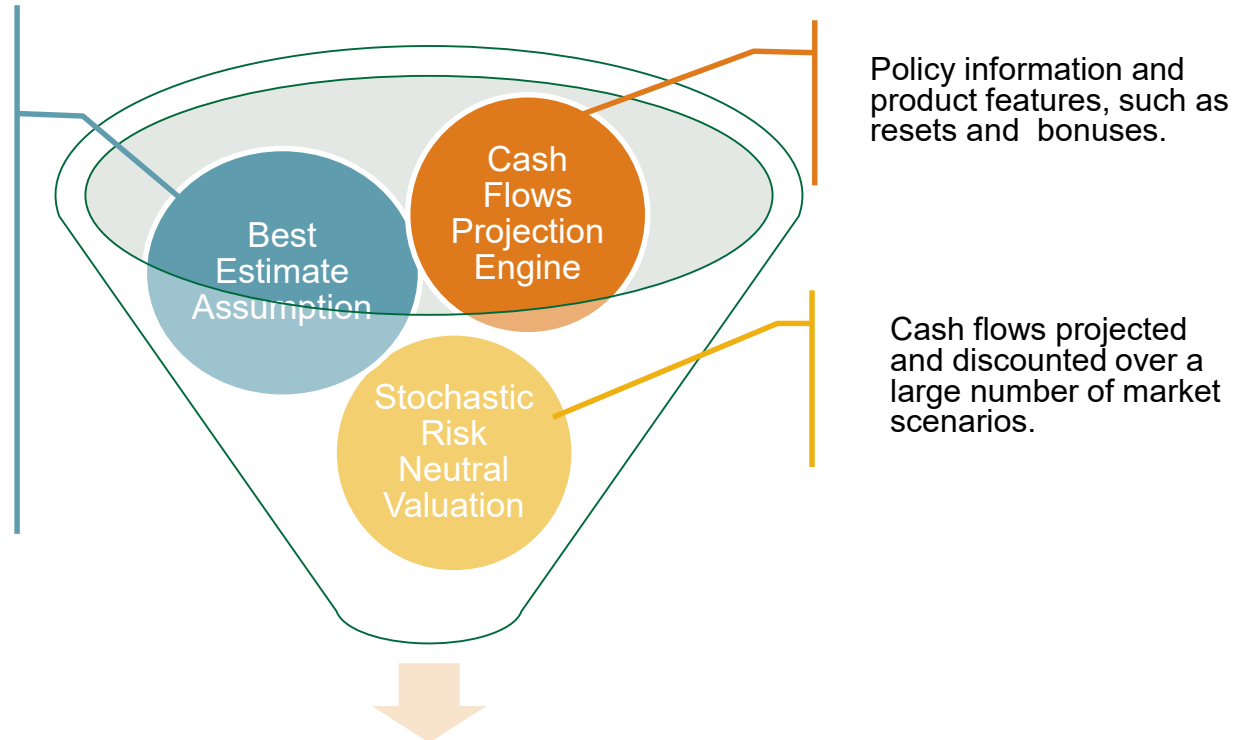**Net Liability cash flow**: Withdrawal – Fee

FMV = CTE0 {PV of (Withdrawal – Fee**)}**

Elements in the calculation of the Fair Market Value (FMV)

Actuarial assumptions:
mortality and policyholder behaviors such as lapse

Investment Portfolio Return Assumptions:
- Market Indices for the Segregated Funds
- Expected Growth Rate (risk free rate in Risk Neutral pricing)
- Return Volatility
- Return Correlations among indices
- Basis Risk
- Fund Mapping assumption

Policy information and product features, such as resets and bonuses.

Cash flows projected and discounted over a large number of market scenarios.

Best Estimate Assumption

Cash Flows Projection Engine

Stochastic Risk Neutral Valuation

Fair Market Value of the liability
- **FMV = CTE0 (PV of Net Cash Flow)**

Challenges with Model Assumptions

- **Hedging is based on best estimate assumptions:**
    - Conservative margins are supposed to release as profit, so not hedged.

- **Assumption are not necessarily accurate:**
    - Actual experience may not pan out as expected.
    - Hedging on the wrong basis (accounting losses vs. fair value losses)
    - Inefficient hedging as actual experience unfolds differently from what was assumed.
    - Bigger impacts after drops in interest rates and underlying asset values.

- **Dynamic lapse / surrender assumption presents unique challenges:**
    - The lapse assumption is difficult to model and requires frequent monitoring
    - 2018 LIMRA research* on indicators of more-than-expected surrenders:
        - Higher withdrawals in excess of systematic withdrawals
        - Lower account values or less premiums paid
        - Higher fees
        - Lower surrender penalties after year 4 and 7 in-force
        - Older contracts
        - Youngest (under 50) and oldest customers (over 80)
        - Distributed through Independent agents vs. career agent

*2018 LIMRA Center of Excellence for Analytics *Predicting and preventing variable annuity surrenders*

The Net Liability Cash Flows Projected

Net Liability
Cash Flow

$=$

Claims

$-$

Fees

☐ Withdrawal benefit

☐ Rider fee

☐ Death benefit

☐ Risk charge

☐ Maturity benefit
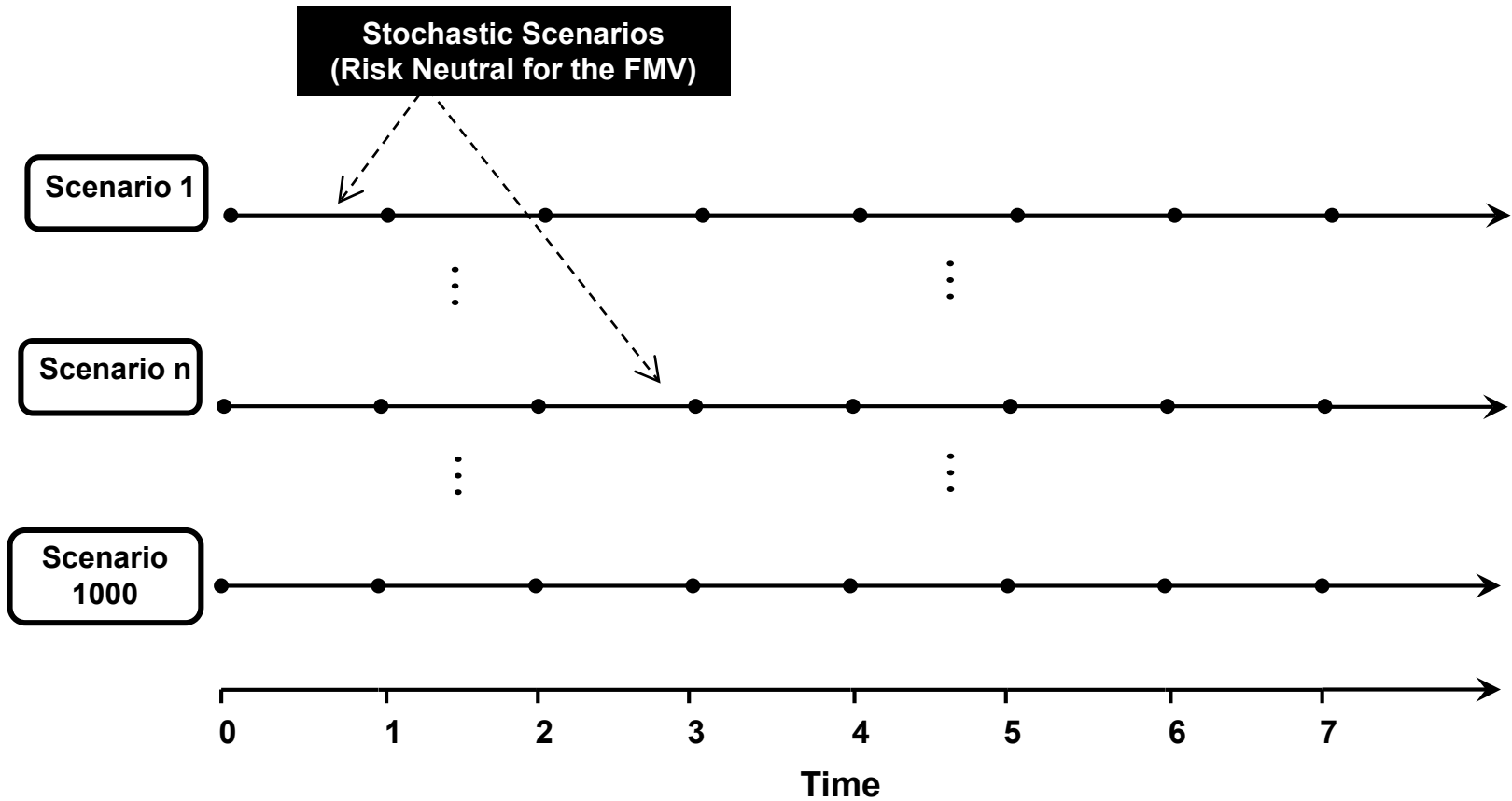
☐ Other allocated fees

The Net Liability Cash Flows Projected

- **Claim = Benefit Payment from the Guarantee (if in the money):**
  - Death Benefits from a **GMDB** on death: **MAX(GV- AV,0)**
  - Maturity Benefit for a **GMMB** on maturity: **MAX(GV- AV,0)**
  - Withdrawal Benefits for a **GMWB** (or **GLWB**) if AV = 0: periodic **Withdrawal Amounts** until maturity (or Death)

- **Guarantee Fees** (or **Allocated Fees)**
  - A **portion** of fees collected by the guarantee writer allocated to the guarantee **and** recognized in the reserve calculation.

- Different fees collected
  - Management Expense Ratio (MER) charges from the Segregated Funds
  - Rider Charges (charges for optional guarantees)
  - Other, such as for Surrender and administrative expenses.

Cash Flows are projected on a set of stochastic scenarios

Stochastic Valuation of the liability

Closing remarks

- Products with protection features will be in high demand

- Lower interest rate increases cost of hedging

- De-risked product to meet profitability target while offering "peace of mind". Registered index-linked annuity are gaining popularity

  - Returns are not guaranteed, but rather are linked to a stock market index with capped gains and limited losses