

Variable Annuities Risk Management






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VA Key Features



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VA Key Features

What is a Variable Annuity?

- VAs are
 - Unit-linked products;
 - With customizable guarantees;
 - In 2 phases: Accumulation and Income (Annuitisation).
- 4 types of guarantees (that can be enhanced by additional options):
 - Death Benefit (GMDB)*: Minimum payout on death guaranteed;
 - Withdrawal Benefit (GMWB): Minimum annual withdrawals guaranteed;
 - Income Benefit (GMIB): Minimum annual payments guaranteed in the inc. ph.;
 - Accumulation Benefit (GMAB): Minimum payout guaranteed at the end of a guarantee period.

Popularity ↑



*GMxB: Guaranteed Minimum x Benefit 4

VA Key Features

Why Variable Annuities?

- Policyholder perspective:
 - Upside potential;
 - Guarantees on downside risk;
 - Flexibility;
 - Death Insurance and annuity payments.
- Insurance Company perspective:
 - High fees - both M&E/Administration fees (1.3% - 2.4%)* and guarantee fees;
 - Less capital Intensive than traditional fixed annuities;
 - However, VAs are risky products: risk management and pricing are key.
- Distributor perspective:
 - Very high fees (even 50bps).



*Source BoA 5

VA Key Features

Main Guarantees

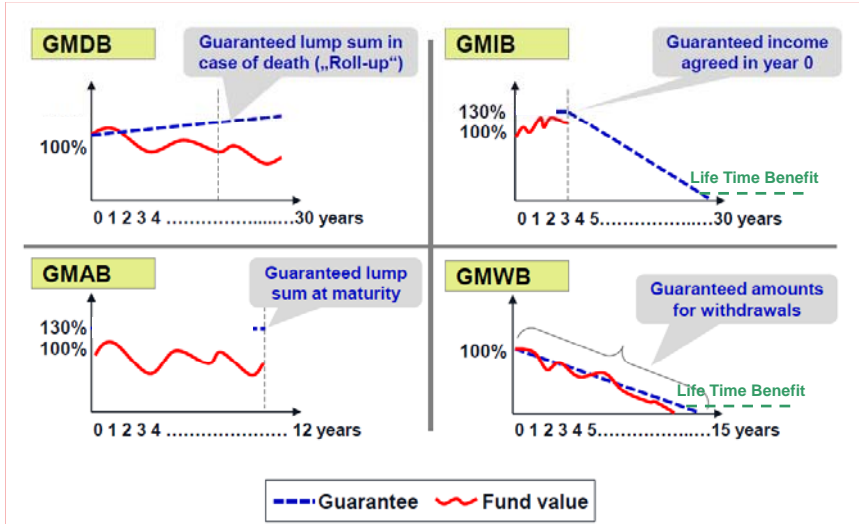
- **GMDB - Guaranteed Minimum Death Benefit** : guaranteed lump sum received when the owner of the contract dies.
- **GMIB - Guaranteed Minimum Income Benefit**: guaranteed minimum income stream upon annuitisation at a particular point in the future.
- **GMWB - Guaranteed Minimum Withdrawal Benefit**: guarantee similar to the income benefit, but that doesn't require annuitising. The policyholder has the right to withdraw up to a maximum guaranteed amount every year.
- **GMAB - Guaranteed Minimum Accumulation Benefit**: guaranteed lump sum at a certain point in the future.



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VA Key Features

Main Guarantees

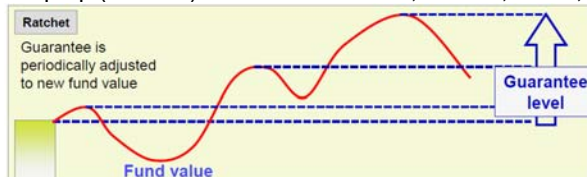


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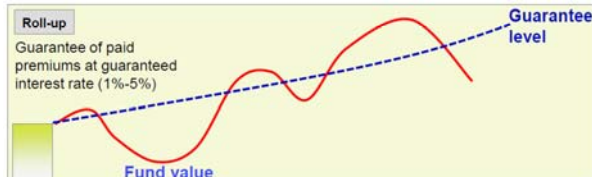
VA Key Features

Additional Options

- Life Time Guarantee - GMWB, GMIB;
- Fund Switch;
- Step-up (Ratchet) Guarantee - GMDB, GMWB, GMIB;



- Roll-up Guarantee – GMDB.



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Post 2008 VA

Re-design of the products

- Lower guarantees:

- Accumulation and Income benefits limited/no longer offered;
- Guaranteed withdrawal and roll-up rates reduced, Step-up periodicity increased.

On the other hand:

- In Europe, premiums are still explicitly guaranteed (GMIB widespread).

- Higher fees (especially guarantee fees).

- Less risky investments:

- Reduced equity proportion (US VA Avg EBR: 45.6% in 2010 vs 60% in 2009)*;
- Target volatility funds (reduced hedge cost);
- Indexed funds (reduced basis risk).

*Source Munich Re 9



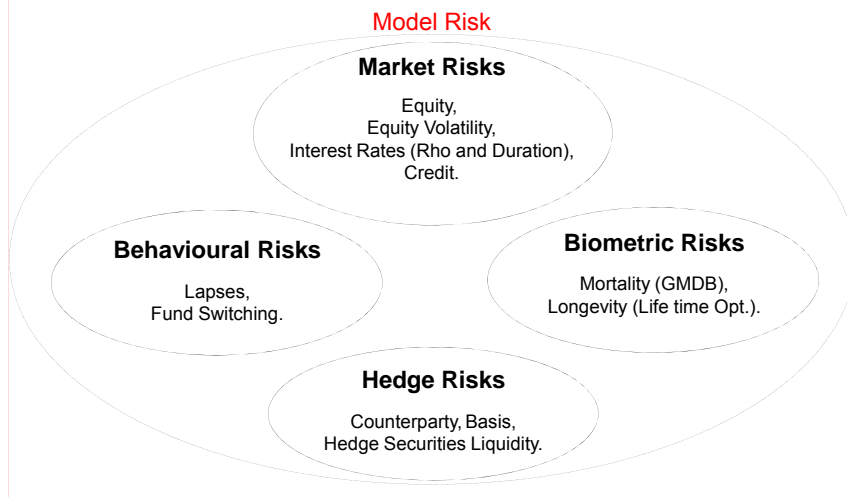
VA Risk Management



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VA Risk Profile

Risk Overview



Scylla and Charybdis

Model Risk



Risk Management

General approaches, which may occur together

- Product design:
 - Pricing (e.g. dynamic fees), guarantees fine tuning, asset allocation;
 - If over engineered, it may imply an higher model risk.
- Hedge:
 - Static/dynamic, global/local (Tail), over all/some risk factors;
 - It needs resources and expertise.
- Investment banks hedge packages:
Losing margins to Investment banks and potential hedge inefficiency.
- Reinsurance:
Losing margins to reinsurer.



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Market Risk Hedge

Types of Hedging Strategies

- Hedging is based on the following Taylor approximation:

$$\begin{aligned}\Delta f(S, t, r, \sigma) = & \underbrace{\frac{\partial f}{\partial S}}_{\text{Delta}} \Delta S + \underbrace{\frac{\partial f}{\partial t}}_{\text{Theta}} \Delta t + \underbrace{\frac{\partial f}{\partial r}}_{\text{Rho}} \Delta r + \underbrace{\frac{\partial f}{\partial \sigma}}_{\text{Vega}} \Delta \sigma \\ & + \frac{1}{2} \underbrace{\frac{\partial^2 f}{\partial S^2}}_{\text{Gamma}} (\Delta S)^2 + \dots\end{aligned}$$

- Depending on which terms are hedged, the different approaches can be classified into:
 - Delta hedge,
 - Delta, gamma hedge,
 - Delta, gamma, rho hedge,
 - Delta, gamma, rho and vega hedge, . . .

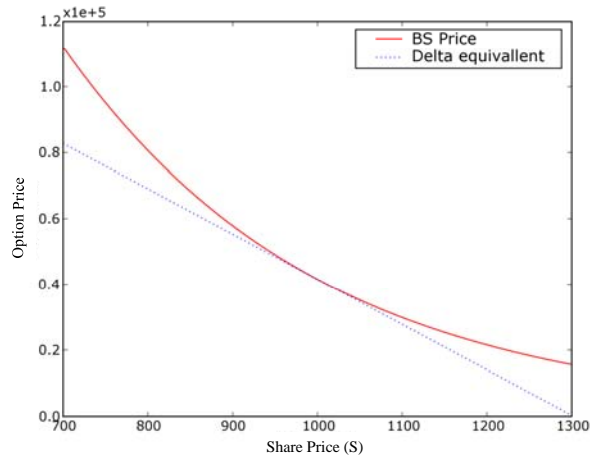


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Market Risk Hedge

Delta Hedge

- The idea is to use a hedging portfolio for which the partial derivative with respect to equity price S is the opposite of the liability options portfolio.



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Market Risk Hedge

Delta Hedge vs Delta-Gamma Hedge

- If the stock market does not move significantly before the updating of the replicating portfolio, the gamma impact is much smaller than the delta effect.
- Hence, in a low volatility market the delta hedge is not considerably less effective than a delta-gamma hedge.
- Conversely, the delta hedge is considerably less effective than a delta-gamma hedge when the equity volatility is high.
- Furthermore, the gamma impact is higher when the underlying is around the option strike and when the option is closer to its maturity.
- VA liabilities usually are out of the money long term options. Hence, generally the delta hedge is a reasonable approach.
- However, the hedge has to be monitored carefully because the gamma impact can surge in fast moving markets.



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Market Risk Hedge

Hedging equity volatility (vega)...

- On the one hand, higher volatility causes an increase of the present value of the VA liabilities (economic loss).
- On the other hand, the fund performance does not depend explicitly on the equity volatility. Hence, if no correlation is assumed between the equity volatility and the fund return, a high equity volatility can not cause the guarantee to go in the money.
- The hedging options can be short or long dated:
 - Long-term options usually match VA liabilities better. However, they are expensive and illiquid.
 - Short-term options are cheaper and liquid. However, they have to be rolled over. In this case, higher volatility implies a higher hedge cost, i.e. an actual loss due to the higher premiums paid to roll over the hedge.
- Hence, hedging vega is not a trivial choice.



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Market Risk Hedge

.. and hedging interest rates (rho)

- Decreasing IRs cause an increase of the present value of the VA liabilities (economic loss).
- The fund performance depends on both equity and fixed income investments.
- If no correlation is assumed between equities and IRs (which is a tough assumption) the equity fund return is not affected by low IRs.
- Conversely, the fixed income investments generally have to be rolled over. Hence, lower IRs imply an actual loss due to the lower cash flows received in the future.
- Hence, hedging rho is not a trivial choice.
- It is worth noting that, since the VA investments have a lower fixed income proportion than the traditional annuities investments, the IRs impact on VAs cash flows is lower.



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Market Risk – Current Scenario

Current scenario Impact on VA

- Low IRs:
 - On an economic basis, low interest rates are strongly increasing the value of guarantees, especially in the long term (rho risk);
 - Low IRs impact the fixed income investments roll-up;
 - However, it will likely take more than 10 years for economic claims from new VAs.
- Low equity level:
 - Guarantees in the money;
 - May be seen as positive for new VA business (Upside potential).
- High equity volatility:
 - Increases the value of the guarantees on an economic basis;
 - Increases the hedge costs.



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Market Risk – Current Scenario

Market Risk Management in the current scenario

- A 3 greeks (Delta, Vega, Rho) hedge approach is widespread among insurers.
- Some insurers are under hedging rho risk (assuming that IRs will rise) to avoid locking-in IRs at historical lows.
- A study by Oliver Wyman suggests that hedging only the tail risk offers a higher risk based return than an engineered hedge*.
- The Hedge transactions in place mainly consists of short term (<5Y) puts and futures**.



*Source UBS 20
**Source BofA

Conclusions



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Variable Annuities Risk Management

Conclusions

- VAs are unit-linked products with customizable guarantees;
- Potentially VAs are very profitable products;
- Despite the post 2008 re-design, VAs are still very risky products;
- Risk management and pricing are key;
- VAs are exposed to many types of risk, which can be managed by different RM strategies;
- Exposure needs to be monitored carefully: greeks and hedge effectiveness;
- Hence, have the right people and tools!



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Thank You

Any Questions?



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Appendix A VA Option Valuation – An Example



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VA Option Valuation – An Example

Valuation

- In general terms the value of the option $\pi(Y)$ is the expected value $E^Q[\]$ of the present value of the future cash flows due to the option. In formulas:

$$\pi(Y) = E^Q \left[\sum_{\tau} (1 + r(\tau))^{-\tau} * X(\tau) \right]$$

where

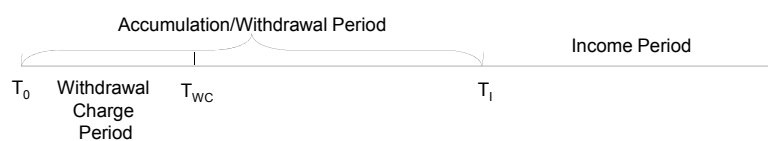
- $X(\tau)$ is the cash flow at time τ , which is typical of the particular option;
- $r(\tau)$ represents the risk free interest rate between $[0; \tau]$.
- This calculation is normally performed by means of simulation.



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VA Option Valuation – An Example

Withdrawals and GMWB



- In the Accumulation Period the policyholder can withdraw an amount up to the Account Value. This amount has not a guaranteed minimum, unless the policyholder buys a guaranteed minimum withdrawal benefit (GMWB).
- Any withdrawal before the end of the withdrawal charge period (T_{WC}) implies a fee.
- If the policyholder buys a GMWB, he is entitled to:
 - A total guaranteed amount available for future periodic withdrawals during the Accumulation phase, the Guaranteed Withdrawal Balance (GWB);
 - A Guaranteed Annual Withdrawal Amount (GAWA), that is a percentage of GWB (depending on contract and age at the date of first withdrawal).



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VA Option Valuation – An Example

GMWB - Valuation

- For the GMWB, each cash flow (withdrawn) is

$$X(t) = \min\{ \min\{R(t), \text{GAWA}(t)\}, \text{GWB}(t) \}$$

Usually

- $\text{GAWA}(t) = \text{GWB}(0) * f(t_w)$;
 $f(t_w)$ is a percentage which depends on the time (ph's age) of the first withdrawal t_w .
- $\text{GWB}(0)$ = Initial Premium;
- $R(t)$ is the actual amount withdrawn, that is
 - $R(t) = 0$ for $t < t_w$,
 - $0 \leq R(t) \leq \text{GAWA}(t)$, for all $t \in [t_w, T_1]$,
 - and $R(t) = \text{GAWA}(t)$, for all $t \geq T_1$, assuming the "for life option".



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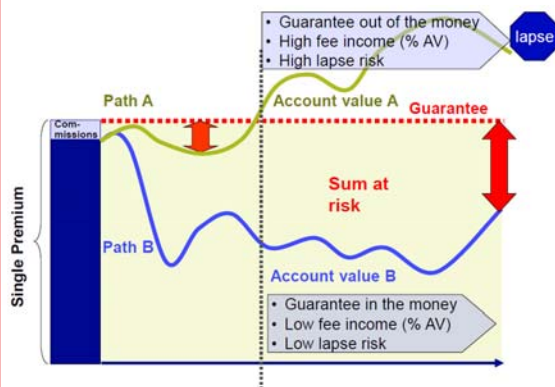
Appendix B



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Lapse Risk and Step-up Options Strategy

- Guarantees Out of the Money are likely to imply lapses, hence loss of future profits;
- The insurer can keep the guarantees about At the Money selling step-up options;
- If markets go down, the new guarantees go deep In the Money. To avoid losses, the Insurer has to hedge buying step-up options;
- The cost of this hedge may be passed to the client through higher fees.



However

- In a volatile market this hedge cost will be very high, and so the fees. Would clients still buy the product?
- This strategy is considerably subject to model risk, increase in volatility and availability of the required options in the market.

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Market Risk Hedge

Variable Annuities – Greeks in the Black-Scholes Model

$$\begin{aligned}
 \Delta_P &= \frac{\partial P}{\partial S} \\
 &= \Phi(d_1), \\
 \Gamma &= \frac{\partial^2 P}{\partial S^2} \\
 &= \frac{\Phi'(d_1)}{S \times \sigma \times \sqrt{T}}, \\
 \Lambda &= \frac{\partial P}{\partial \sigma} \\
 &= S \times \Phi'(d_1) \times \sqrt{T-t}, \\
 P_P &= \frac{\partial P}{\partial r} \\
 &= -(T-t) \times K \times e^{-r \times (T-t)} \times \Phi(-d_2),
 \end{aligned}$$

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Model Risk

A well known example: Fat tails

- On Thursday 6.5.2010 the NYSE (Dow Jones Industrial Average) fell temporarily over 9%, as a consequence of such fears and automated trading.
- On Monday 10.5.2010 the Euro Stoxx index performed 10.35% within one day, after the announcement of a EUR 750bn bail-out plan.
- Assuming a volatility of 20% and log-normally distributed equity-market returns, this represents a 9.8 σ -event.
- Such an event has a return period of 5.9×10^{17} years. This number is considerably bigger than the age of the universe which is 1.4×10^{10} years.
- Hence, the log-normally distributed model is not correct in the tails.
- Many VA hedge strategies are based on the log-normal distribution assumption. This is a clear example of model risk.

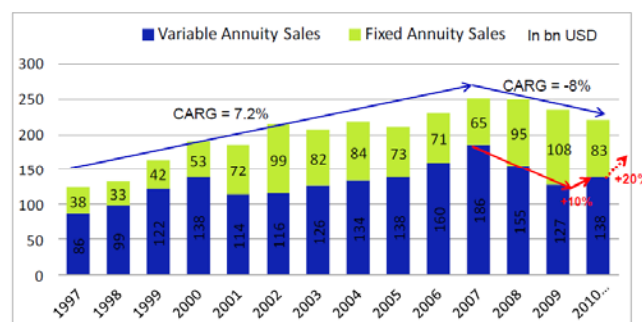


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VA US Market (up to 2010)

Some numbers

- The US market is definitely the largest one for VA:
 - 2010 Assets under Management: \$1.5 trillion (US GDP ~ \$14 trillion);
 - 2010 Sales: \$138bn (about 90 times UK VA Market)*.
- VA market has been progressively exceeding FA sales over the past 15 years.
- VA sales track equity market.



2010 UK VA Sales ~ £1bn

*YE2010 GBP/USD = 0.64 32
2010 Europe VA Sales ~ €2.6bn