Annuity Risk Management with Options: Investment and Hedging Perspectives

Alex Zeng
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November 5, 2018
## Overview of annuity products

<table>
<thead>
<tr>
<th>Value Proposition</th>
<th>Equity Exposure</th>
<th>Upside Potential</th>
<th>Downside Protection</th>
<th>2017 Sales (B)</th>
<th>Market Growth¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA w/o GLB</td>
<td>Accumulation focused. Tax efficient investing for nonqualified + investing flexibility</td>
<td></td>
<td></td>
<td>$30.5</td>
<td>-7%</td>
</tr>
<tr>
<td>VA w/ GLB</td>
<td>Guaranteed lifetime income</td>
<td></td>
<td></td>
<td>$39.3</td>
<td>-21%</td>
</tr>
<tr>
<td>Indexed / Hybrid VA²</td>
<td>Principal protection + growth potential</td>
<td></td>
<td></td>
<td>$9.2</td>
<td>68%</td>
</tr>
<tr>
<td>FIA</td>
<td>Principal protection + income</td>
<td></td>
<td></td>
<td>$55.0</td>
<td>5%</td>
</tr>
<tr>
<td>Fixed-Rate</td>
<td>Principal protection &amp; accumulation</td>
<td></td>
<td></td>
<td>$44.7</td>
<td>1%</td>
</tr>
</tbody>
</table>

2 Aka: Structured VA
Annuity: account value growth profile

Source: Oliver Wyman
# Annuity risk management

## Manage risk
- Product design
- Investment (fund/index design)
- Hedging / ALM

## Transfer risk
- Full or partial transfer
- Reinsurance
- Outsourcing

## Retain risk
- Not hedged/hedgeable
- Not transferred

## Market Risk
- Equity
- Interest rate
- Basis...

## Insurance Risk
- Longevity
- Mortality
- Morbidity

## Behavioral Risk
- Lapse
- ...
Holistic market risk management through product life cycle and across functional units

Product
- Risk avoidance through product design
- Asset allocation requirements
- Risk allocation across product components and life cycle

Investment (Fund/Index)
- Diversification among asset classes, markets, sectors, factors, ...
- Risk budgeting
- Built-in downside protection
- Explicit risk/volatility control

Hedging/ALM
- Simple put options
- Static hedging
- Advanced dynamic hedging
- Customized solutions
Using options for market risk management

<table>
<thead>
<tr>
<th>Information/Signals for risk management modeling and strategy design</th>
<th>Investment</th>
<th>Hedging</th>
</tr>
</thead>
</table>
| • Risk/volatility modeling and forecasting  
• Investment strategy design for better risk-adjusted performance | | • Hedging strategy design and development |

<table>
<thead>
<tr>
<th>Instruments for risk management implementation</th>
<th>Investment</th>
<th>Hedging</th>
</tr>
</thead>
</table>
| • Complementary option usage  
• Option overlay for risk control  
• Options-based investment portfolios/funds for VA | | • FIA/Indexed VA product manufacturing  
• VA hedge program |
Growth and maturation of option markets

Listed Equity Options Annual Volume and Open Interest

Source: Options Clearing Corporation. 2018 volume is estimated pro rata, as of Sep 30 2018.
Listed SPX index option market

SPX Options Average Daily Volume (ADV)

SPX Options ADV Notional Value ($B)

Source: CBOE
### Information/Signals: Option-based volatility models

- Predictive power of options implied volatility (including VIX) in forecasting future realized volatility
  - Time-series volatility forecasting models (historical volatility, ARCH class, and stochastic volatility)

<table>
<thead>
<tr>
<th>Name</th>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIX</td>
<td>$\sigma_t = \text{VIX}_{t-1}$</td>
<td>VIX Index</td>
</tr>
<tr>
<td>VIX Linear</td>
<td>$\sigma_t = a \cdot \text{VIX}_{t-1} + b$</td>
<td>VIX Index adjusted for bias</td>
</tr>
<tr>
<td>EVMA-VIX Hybrid</td>
<td>$\sigma_t^2 = \lambda \sigma_{t-1}^2 + \gamma \text{VIX}_{t-2}^2$</td>
<td>EWMA with information content from VIX</td>
</tr>
<tr>
<td>GARCH-VIX Hybrid</td>
<td>$\sigma_t^2 = \kappa + \beta \sigma_{t-1}^2 + \gamma \text{VIX}_{t-2}^2$</td>
<td>GARCH with information content from VIX</td>
</tr>
<tr>
<td>GJR-VIX Hybrid</td>
<td>$\sigma_t^2 = \kappa + \beta \sigma_{t-1}^2 + \alpha \varepsilon_{t-1}^2 + \xi \cdot I_{{\varepsilon_{t-1} &lt; 0}} \cdot \varepsilon_{t-1}^2 + \gamma \text{VIX}_{t-2}^2$</td>
<td>GJR with information content from VIX</td>
</tr>
</tbody>
</table>

Source: GSAM, Navigating Market Turbulence: An Analysis of Target Volatility Funds, 2015
Volatility forecasting models

Time series volatility model

- Historical volatility
  - Historical average
  - Random walk
  - Exponential smoothing
  - Exponential weighted moving average

- ARCH class
  - ARCH
  - Generalized ARCH
  - Exponential GARCH
  - Threshold GARCH or GJR-GARCH
  - Quadratic GARCH
  - Regime Switching GARCH

- Stochastic volatility
  - Quasi-maximum likelihood estimation
  - Generalized methods of moments
  - Monte Carlo integration
  - Heston model
  - SABR model
  - Markov chain

Option-based volatility model

- Volatility index
- Black-Scholes implied volatility

Information/Signals: looking beyond VIX

- Informational content of the option market
  - Implied volatility surface, trading volume, bid-ask spread, put/call ratio...

Source of charts: Bloomberg
## Instruments for VA fund risk management

<table>
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<tr>
<th>Illustration</th>
<th>Implementation form</th>
<th>Objectives</th>
<th>Option strategies</th>
</tr>
</thead>
</table>
| ![Complementary option usage](image) | Complementary option usage | • Hedge specific risks  
• Enhance yield / performance  
• Leverage | • Covered call  
• Married put  
• Protective collar  
• ... |
| ![Option overlay for risk control](image) | Option overlay for risk control | • Mitigate downside risk  
• Reduce portfolio volatility | • Rule-based put buying for downside protection  
• Others to offset cost of protection |
| ![Option-based investment portfolios/funds for VA](image) | Option-based investment portfolios/funds for VA | • Provide unique investment solution  
• Income generation  
• Enhance alpha | • Covered call  
• Put writing  
• Spreads  
• Combinations  
• Sophisticated trading... |
Option overlay for risk control

• Risk management overlay with linear derivatives (futures, forwards, swaps, etc.)
  • Widely applied to volatility control strategies (target volatility and capped volatility)
  • Dilemma between upside capture vs. downside protection

• Risk management overlay with options
  • Nonlinear payoff profile
  • Rule-based put option buying to mitigate downside risk
  • Dynamic use of various option strategies to offset cost
  • Reduce portfolio volatility without precise volatility targeting

• Combination / rotation between linear and nonlinear (options) derivatives
Option-based funds/indices: performance

Source: Bloomberg
Option-based funds: AUM growth ($million)

Source: Black & Szado, Performance Analysis of Option-Based Equity Mutual Funds, CEFs, and ETFs: An Update, Mar 2018.
Instruments for hedging

**FIA / Indexed VA**
- General account liability
- OTC/listed/bespoke options, plus futures
- European call, call spread, Asian, cliquet, call spread collar

**VA**
- Separate account liability
- Vega hedging: put options, variance swaps
- Options to supplement 3-Greek (delta, rho, vega) hedging: basket options, lookback options etc.
- Potential of recovering loss with less offsetting of gains
Limitations of using options for annuity market risk management

- Liquidity and market depth
- Transaction cost
- Complexity in modeling, execution, and communication
- Operational risk
- Upfront capital in buying options and risks in writing options
- Real world vs. risk neutral
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