Session 49: Best Practices in Managing Variable Annuity (VA) Financial Risk

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2019 LIFE & ANNUITY SYMPOSIUM

Sara Carstensen

May 21, 2019

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GMxBs – Complex Options

- Variety of variable annuity riders which offer some form of investment guarantee on the VA account value

VA Guarantee	Form of Benefit	Guarantee – regardless of account performance
GMDB	Death Benefit	Upon death, return of premium, or some enhanced amount
GMIB	Lifetime Income	Minimum lifetime income stream
Lifetime GMWB	Lifetime Income	Minimum lifetime income stream
GMWB	Withdrawal Benefit	Return of purchase payments via withdrawals
GMAB	Accumulation benefit	Sets a floor on account value, typically initial purchase payments

VA Guarantees vs. Options

- Investment guarantees in VA's create embedded optionality

	Feature	Equity Put	GMIB
1.	Pays when index below strike	Yes	Yes
2.	Strike Form	Lump Sum	Life Annuity
3.	Ratchets, Stepups	No	Yes
4.	Policyholder behavior: lapse, withdrawals, exercise	No	Yes
5.	Path dependency	No	Yes
6.	Basis Risk	No	Yes

- VA guarantees are much more complex than vanilla capital market derivatives
- Require stochastic simulations for valuation

Hedging – Considerations

- What's being hedged ?
- Dynamic vs. static hedging
- Active vs. passive hedging

Can cover multiple option “underlyings”

Equity

- Market index levels
- Single stocks
- Target volatility funds vary equity exposure

Interest Rates

- Parallel yield changes
- “Key rate” yield changes
- Credit spreads

Volatility/Other

- Volatility drives option value
- Volatility term structure
- Generally higher at longer tenors

Behavior

- “Base” dynamic behavior
- Alternative policyholder behavior

Insurers also need to consider multiple balance sheets

Statutory

- Change in stat reserve
  - AG43 standard
  - CTE(70)
  - Voluntary reserves
- Change in Stat capital / TAR
- Discontinuities impact liability "greeks"

GAAP

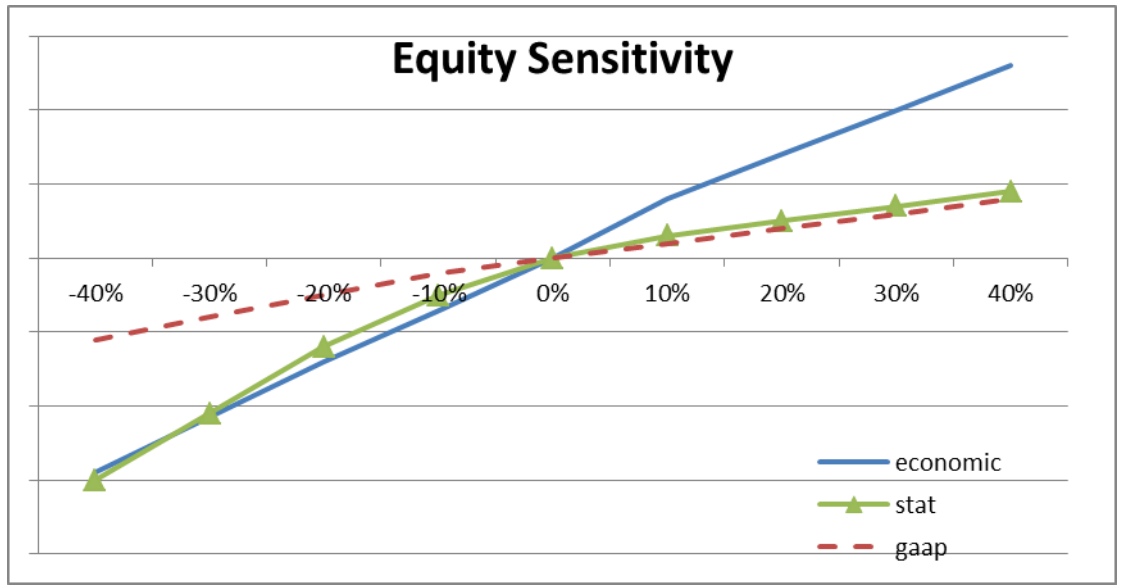
- FAS 133/157 for non-life contingent benefits
  - Risk neutral option value
  - Using h-ratio
  - Own credit and risk margins for FAS 157
- SOP03-1 applies to life contingent benefits

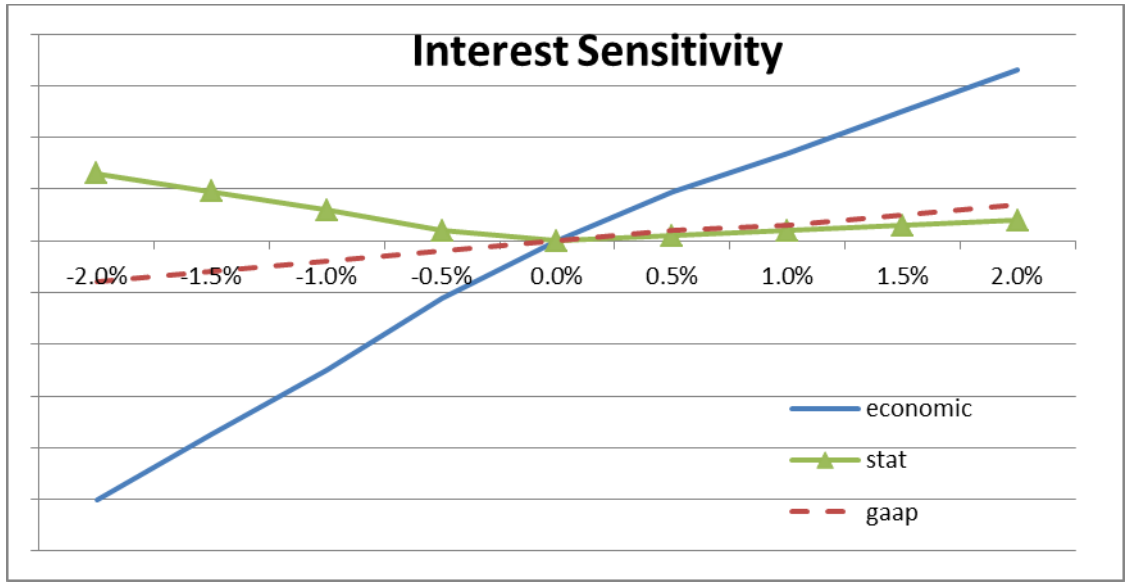
Economic

- Risk neutral valuation
  - PV claims minus PV fees
  - A range of discount rates possible

Stat, GAAP, Economic - Conflicting Objectives

- Stat, GAAP and economic risk profiles differ
  - SOP 03-1 and Stat generally less sensitive than economic
- <u>Not possible to simultaneously hedge all three balance sheets</u>





Can use multiple hedge programs

- "Core" program to stabilize income and balance sheet for modest market moves
  - Fully economic hedged usually means overhedged on Stat and GAAP
  - Stat or GAAP hedging generally underhedges economic risk

- Can overlay "macro" program to cover more extreme scenarios
  - Out of money options to cover extreme market moves
  - May need to define "deductible loss"
    - e.g., maintain 250% RBC in a 2008 crisis scenario

Dynamic vs. Static Hedging

Dynamic

- Continuous rebalancing
- Used to hedge smaller market moves
- Linear instruments
- Replicates an option
- Pay realized volatility
- Cost very sensitive to volatility movements

Static

- Fixed positions
- Can hedge different degrees of option “moneyness”
- Option – like instruments
- Buys the option outright
- Pay market implied volatility
- Volatility cost more locked in

Upcoming Changes to Valuation Frameworks

Statutory

Effective 1/1/2020

- Aligned calculations and scenarios for CTE 90/70
- Redefined standard scenario
- Changes to accounting for interest rate derivatives (SSAP NO.108) will reduce asset/liability mismatch
- Likely to better align stat and economic liability calculations

GAAP

Effective 1/1/2021

- Market risk benefits cover all liabilities with material capital market exposure
- VA SOP 03-1 benefits moving from accrual to fair value treatment
- Will increase GAAP net income sensitivity to market movements

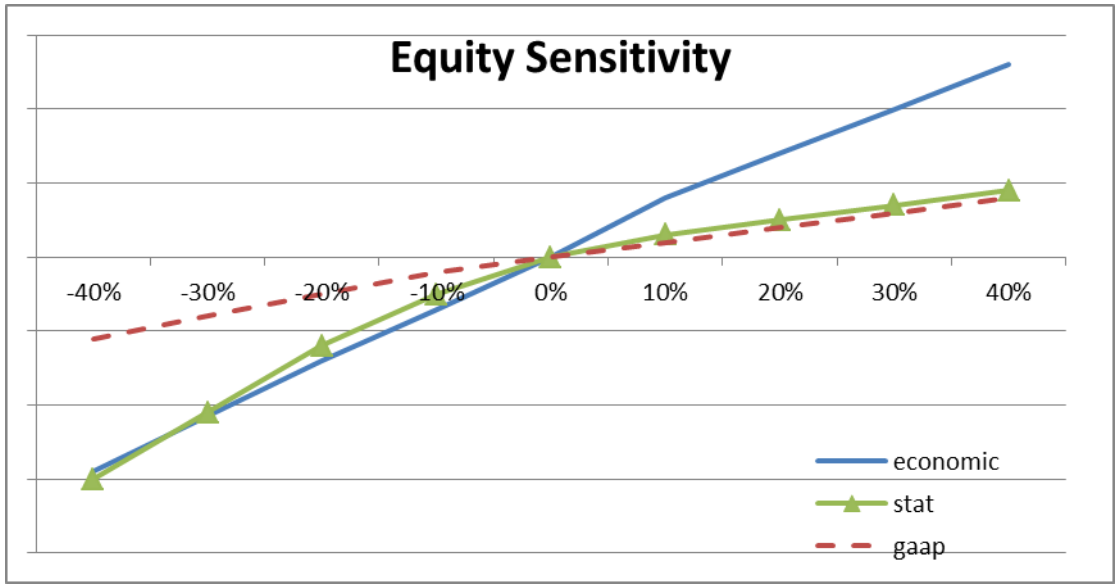
Economic

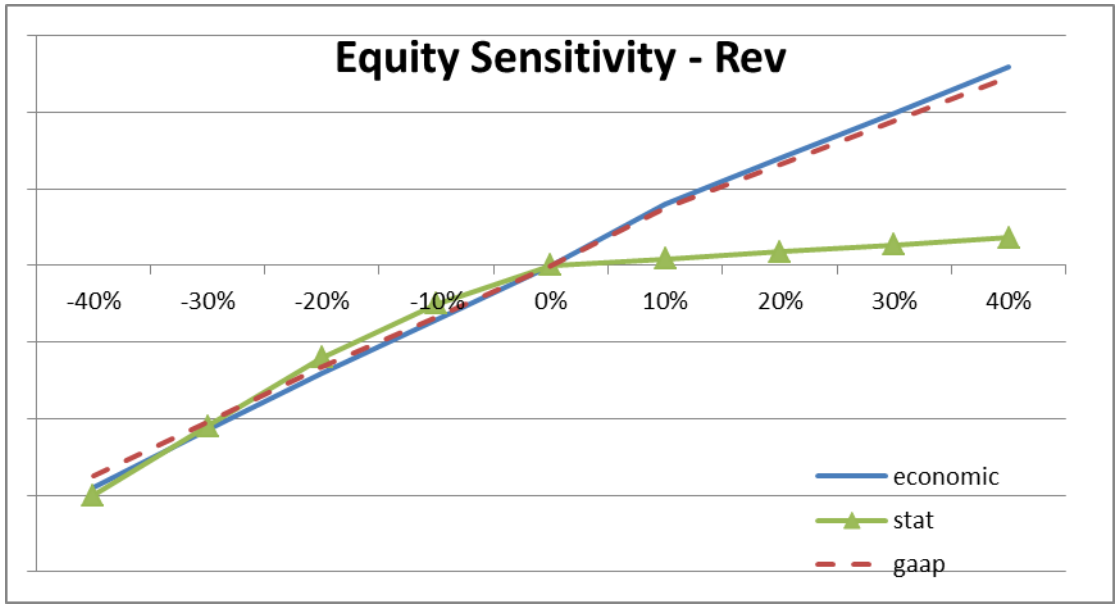
No Changes

The frameworks are converging towards economic, but differences will remain.

Better alignment of Stat, GAAP, Economic metrics

- GAAP net income much more closely aligned with and economic risk in new framework





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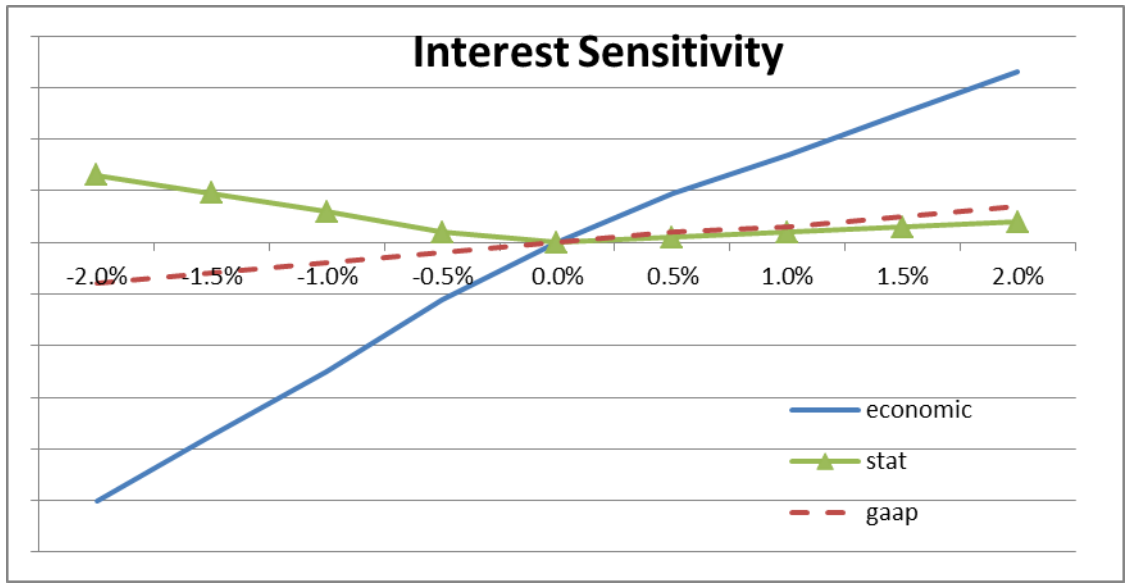

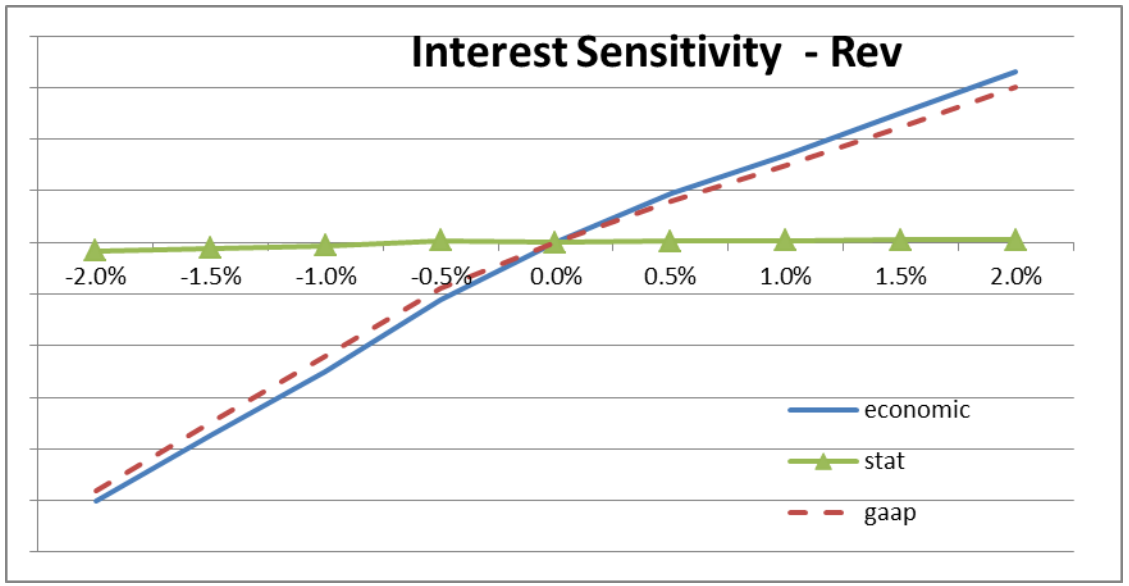

Potential impacts

- Greater analyst focus on net income
- Greater focus on economic values
- Higher hedge targets in “core” hedge programs
- Greater demand for volatility instruments

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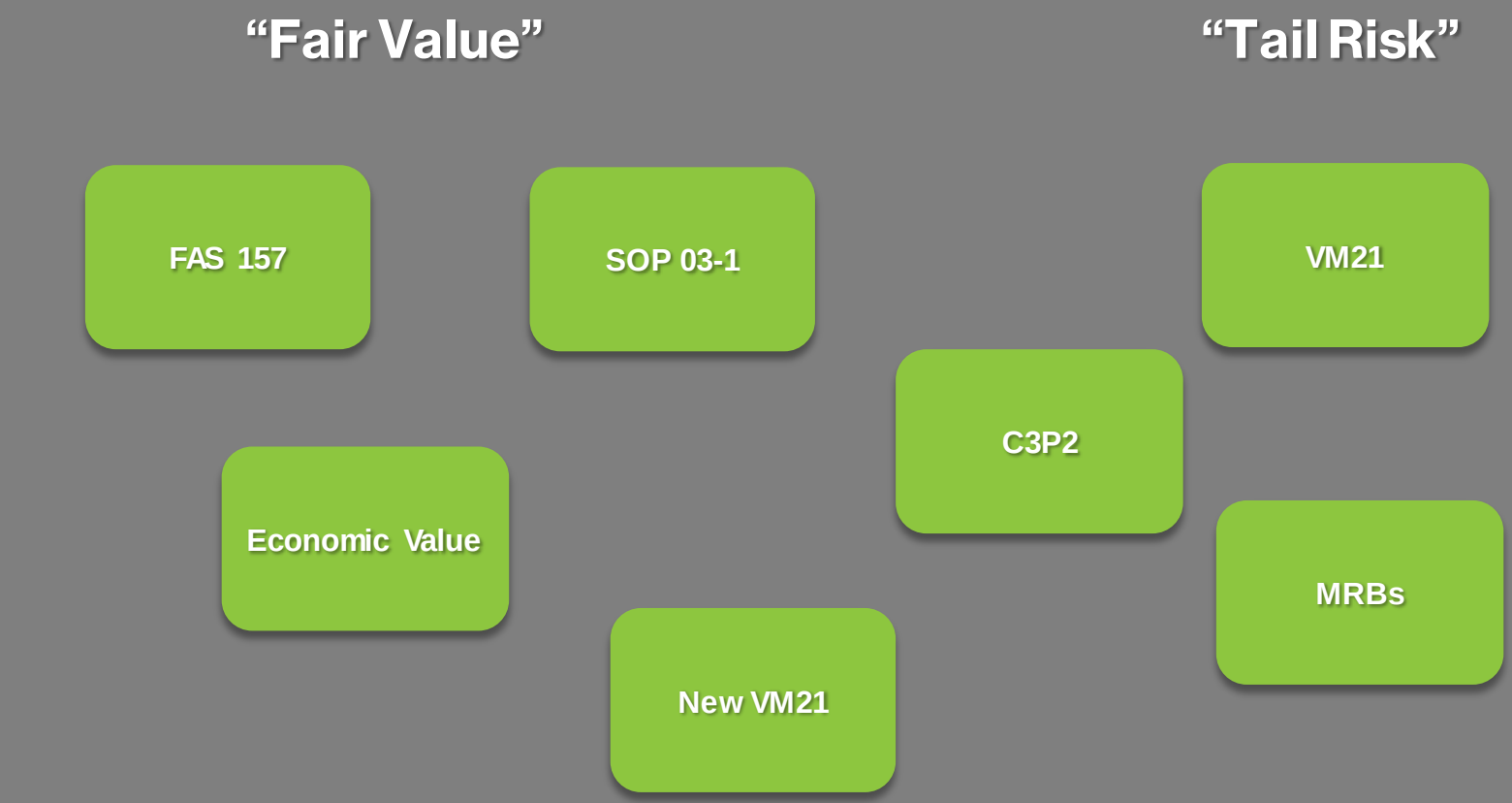
Best Practices in Managing VA Financial Risk

A Software Vendor's Perspective

Sean Hayward
May 3, 2019

Empowering the Financial World

FIS


“Fair Value”
“Tail Risk”
FAS 157
SOP 03-1
VM21
C3P2
Economic Value
MRBs
New VM21

“Fair Value”

“Tail Risk”

FAS 157

Economic Value

MRBs

SOP 03-1

Who Knows?!

VM21

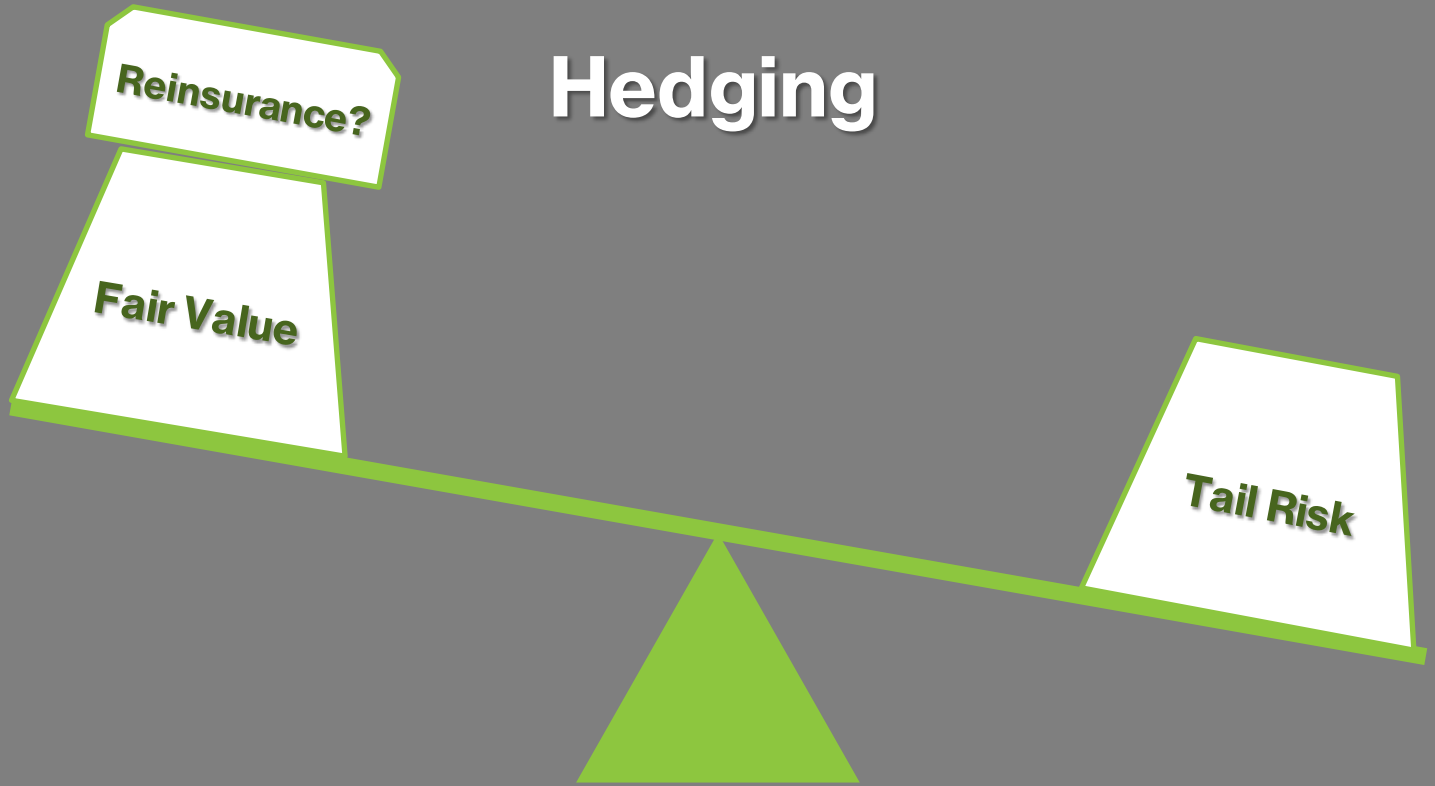
New VM21

C3P2

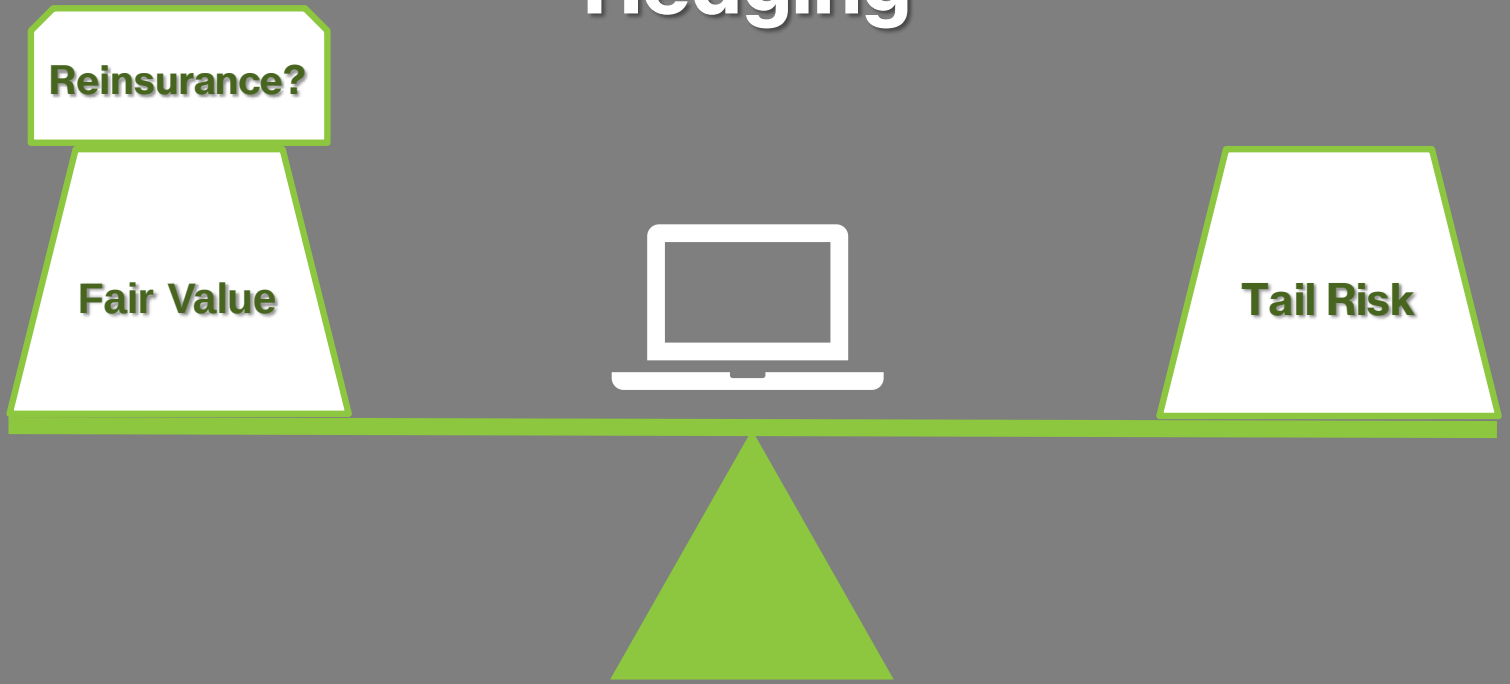
Hedging

Hedging

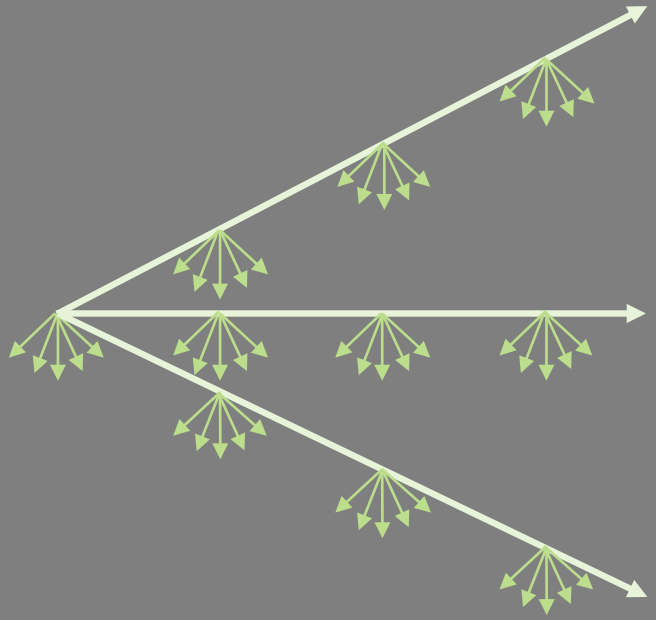
Hedging



Hedging



Can’t hedge what you can’t model



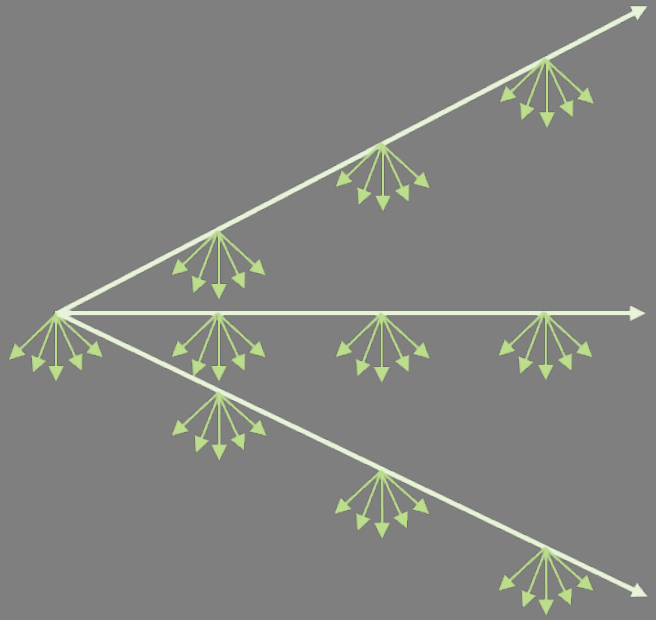
1000's of simulations

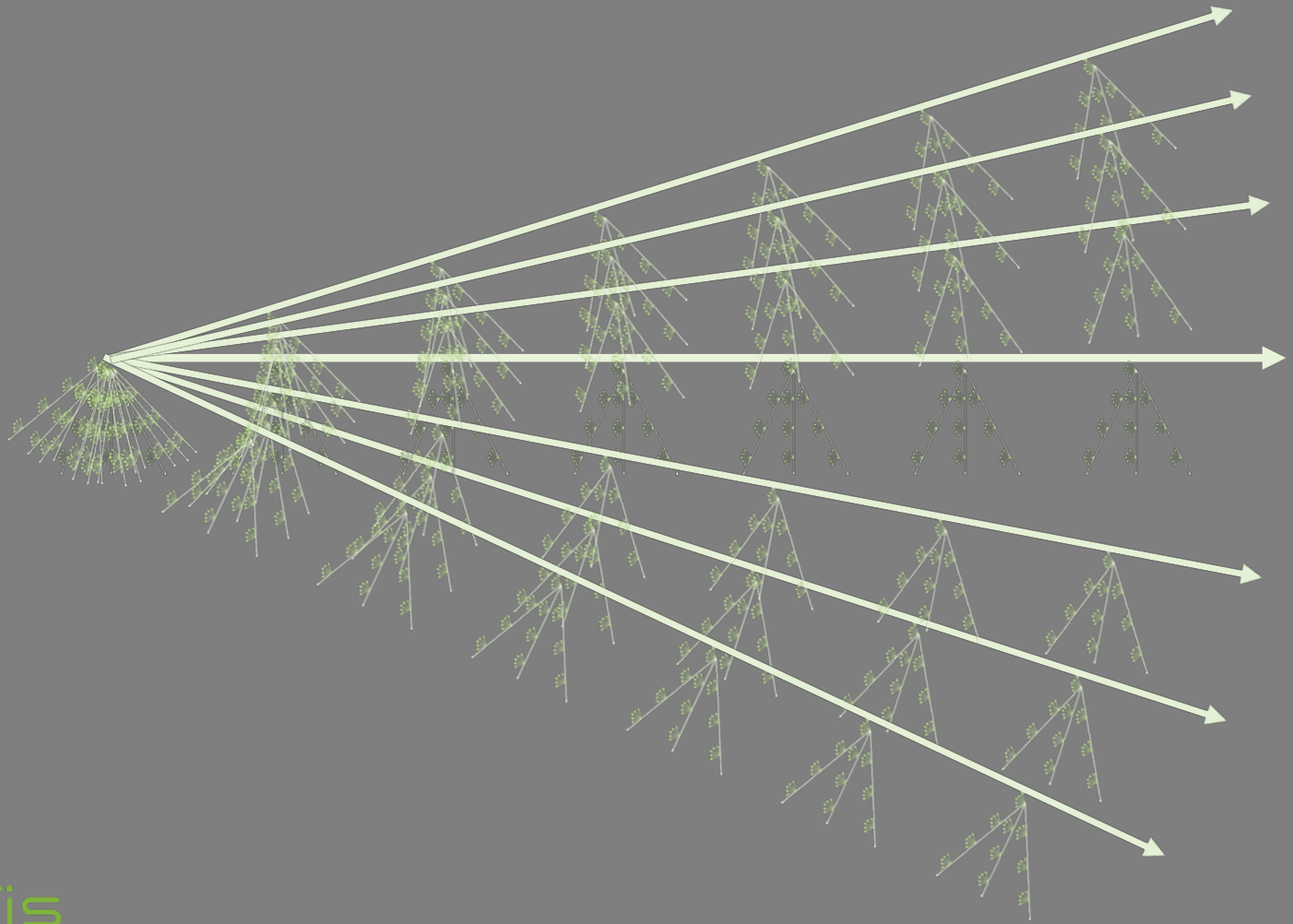
Nested hedging projections

Multiple shocks

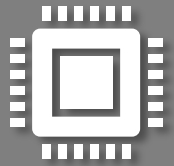
Withdrawal cohorts?

This is just one statutory valuation!



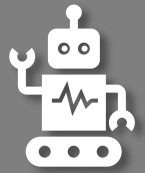


Leverage Cloud



Advanced Compute

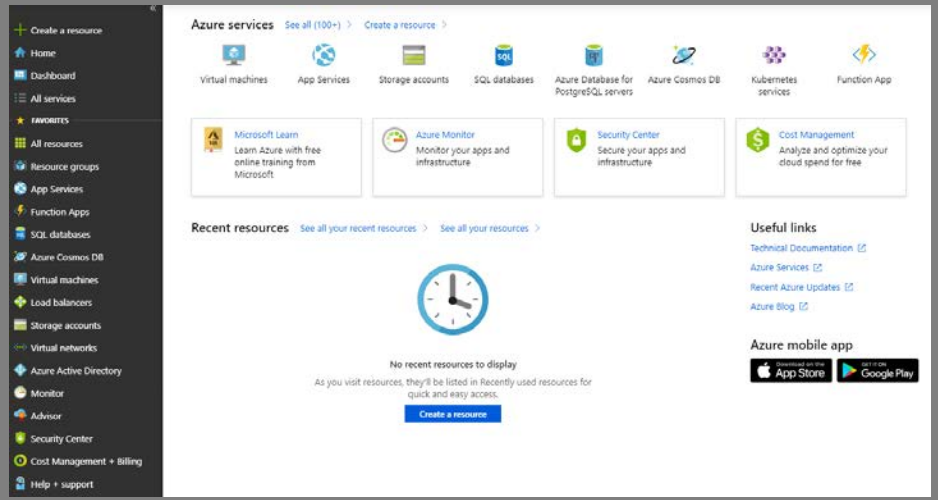
Results Storage

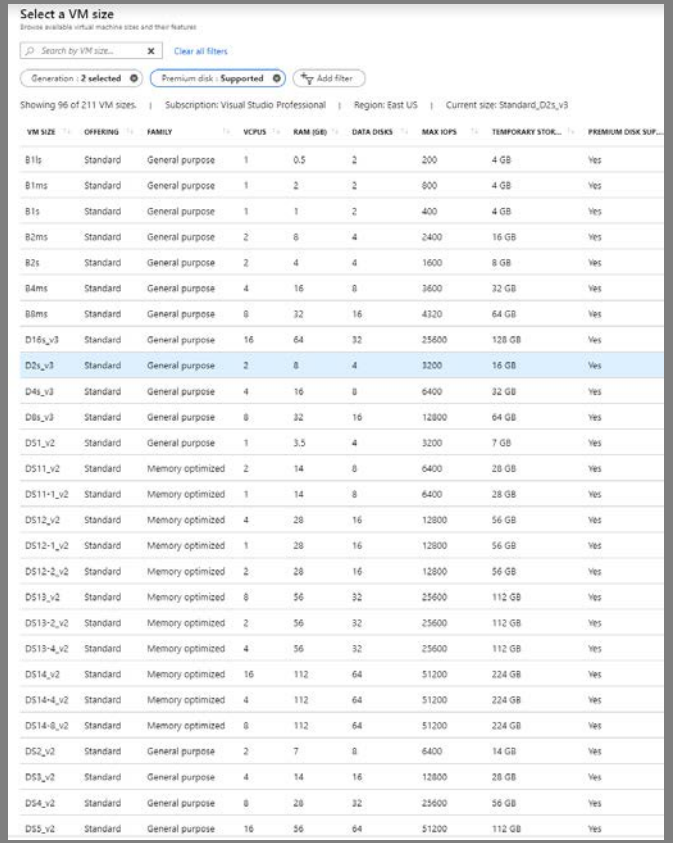


Automation

Leverage Cloud

Cloud = More compute cores, right?





Select a VM size

Browse available virtual machine sizes and their features

Search by VM size... | Clear all filters

Generation : 2 selected | Premium disk : Supported | Add filter

Showing 96 of 211 VM sizes. | Subscription: Visual Studio Professional | Region: East US | Current size: Standard_D2s_v3

VM SIZE	OFFERING	FAMILY	VCPUS	RAM (GB)	DATA DISKS	MAX IOPS	TEMPORARY STOR...	PREMIUM DISK SUP...
B1ls	Standard	General purpose	1	0.5	2	200	4 GB	Yes
B1ms	Standard	General purpose	1	2	2	800	4 GB	Yes
B1s	Standard	General purpose	1	1	2	400	4 GB	Yes
B2ms	Standard	General purpose	2	8	4	2400	16 GB	Yes
B2s	Standard	General purpose	2	4	4	1600	8 GB	Yes
B4ms	Standard	General purpose	4	16	8	3600	32 GB	Yes
B8ms	Standard	General purpose	8	32	16	4320	64 GB	Yes
D16s_v3	Standard	General purpose	16	64	32	25600	128 GB	Yes
D2s_v3	Standard	General purpose	2	8	4	3200	16 GB	Yes
D4s_v3	Standard	General purpose	4	16	8	6400	32 GB	Yes
D8s_v3	Standard	General purpose	8	32	16	12800	64 GB	Yes
DS1_v2	Standard	General purpose	1	3.5	4	3200	7 GB	Yes
DS11_v2	Standard	Memory optimized	2	14	8	6400	28 GB	Yes
DS11-1_v2	Standard	Memory optimized	1	14	8	6400	28 GB	Yes
DS12_v2	Standard	Memory optimized	4	28	16	12800	56 GB	Yes
DS12-1_v2	Standard	Memory optimized	1	28	16	12800	56 GB	Yes
DS12-2_v2	Standard	Memory optimized	2	28	16	12800	56 GB	Yes
DS13_v2	Standard	Memory optimized	8	56	32	25600	112 GB	Yes
DS13-2_v2	Standard	Memory optimized	2	56	32	25600	112 GB	Yes
DS13-4_v2	Standard	Memory optimized	4	56	32	25600	112 GB	Yes
DS14_v2	Standard	Memory optimized	16	112	64	51200	224 GB	Yes
DS14-4_v2	Standard	Memory optimized	4	112	64	51200	224 GB	Yes
DS14-8_v2	Standard	Memory optimized	8	112	64	51200	224 GB	Yes
DS2_v2	Standard	General purpose	2	7	8	6400	14 GB	Yes
DS3_v2	Standard	General purpose	4	14	16	12800	28 GB	Yes
DS4_v2	Standard	General purpose	8	28	32	25600	56 GB	Yes
DS5_v2	Standard	General purpose	16	56	64	51200	112 GB	Yes

Leverage Cloud

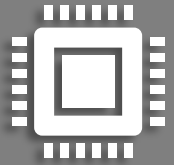
Not “one size fits all”, even within a single modelling exercise!

Need to understand the problems being solved, choose hardware accordingly

Considerations:

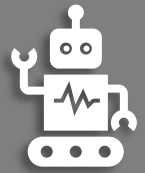
- RAM requirements
- I/O needs
- Reporting granularity
- Computational intensity

Leverage Cloud



Advanced Compute

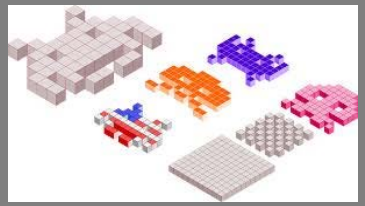
Results Storage



Automation

Advanced Compute

GPUs have come a long way!



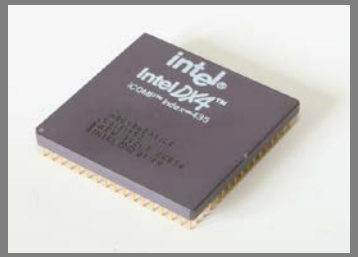
- In the early days GPU accuracy wasn't good enough for intensive compute resources like actuarial modelling
- GPU cards are efficient in performing floating point calculations
- The calculations need to be highly independent and have low memory requirements
- There are two options for GPU compute:
- Dedicated GPU cards installed in server boxes or utilising specific "GPU Compute" cores in the public cloud
- Latest cards like Nvidia's Quadro GV100 are extremely powerful

GPUs are the answer to everything! (Maybe not……)

- Extremely specialized, both in configuration and problems it is able to address
- Limited RAM availability
- Results need to be passed back to CPU, which is typically slow

Advanced Compute

....so have CPUs

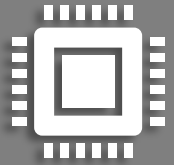


- Intel's AVX behaves similarly to GPU, but with less constraints and scalability
- AVX (Advanced Vector Extensions) is an evolution of SIMD (Single instruction, multiple data) which could operate on a vector of data with a single instruction
- AVX-512 is included in the latest chipsets from Intel
- Utilising AVX more effectively will make best use of the available hardware and more cost effective deployment

Or did GPUs just cause CPU makers to wake up.....

- Enhanced vectorization capabilities provide some of the upside of GPUs with a fraction of the development cost
- Still requires some code updates, though likely changes that should have been made anyway
- Still may not be fast enough for some very specialized problems

Leverage Cloud



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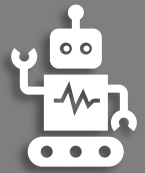
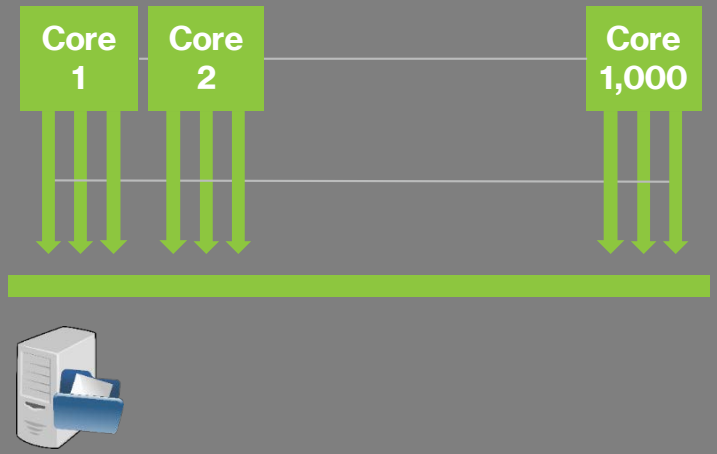


Automation

Results Storage

Standard File Server

File I/O is handled by the Windows file system.



Depending on the model, I/O can be more time consuming than calculations

Adding cores shares the compute load, but shifts the bottleneck to the file system

Distributing homogenous calculations evenly means many cores completing at same time

Simultaneous updates of data unique to actuarial models?

Facebook / Google?

Distributed database technology created to address this (and other) problem

Results Storage

Standard File Server

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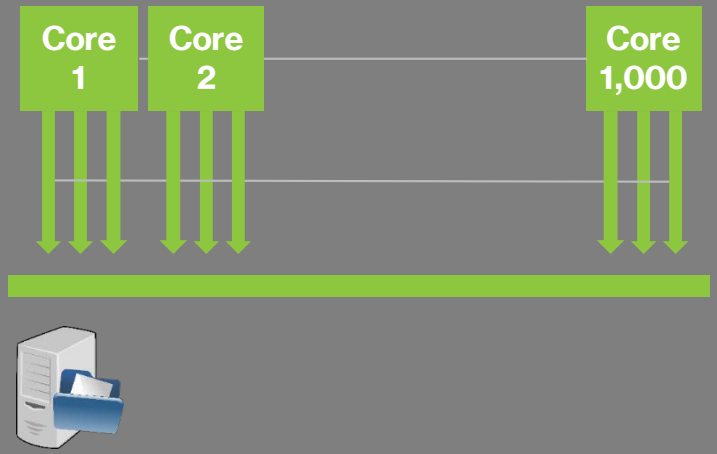
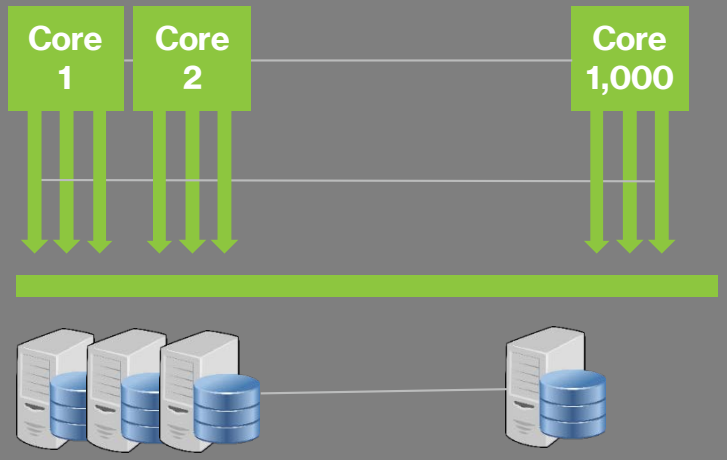


Distributed Databases

Compressed results are written to a network of database servers managed by a dedicated database manager. The architecture is designed to support parallel reads and writes.



Results Storage

Many different options available, each with different pros & cons

- Hadoop
- MongoDB
- ArangoDB

Most are open source, with varying levels of support for Windows & Linux

Can be interdependence with cloud provider, should be part of broader design decision

Software vendors should all be moving in this direction

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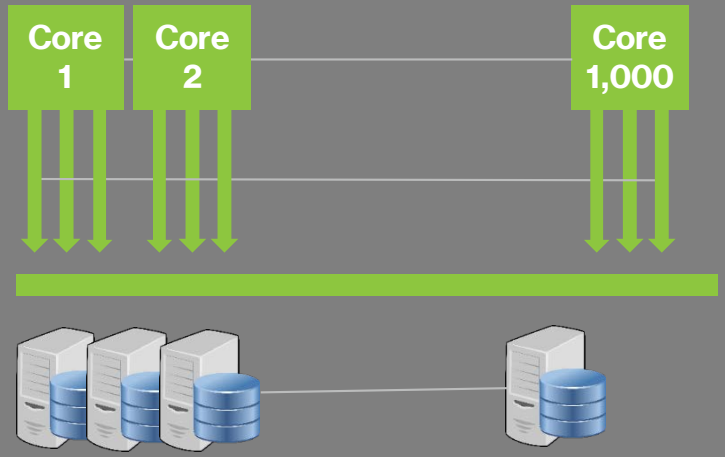
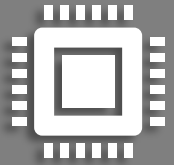
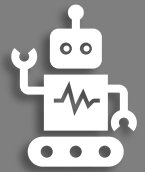


Leverage Cloud



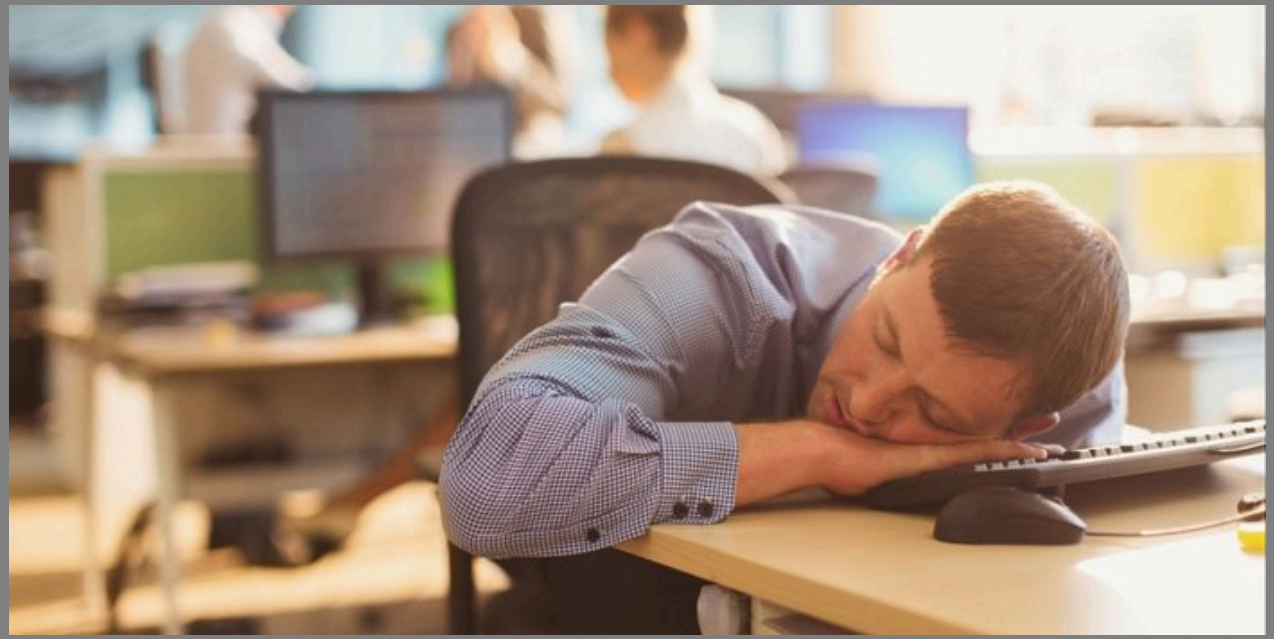
Advanced Compute

Results Storage



Automation

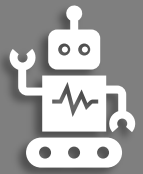
Automation



Nothing slower than a stalled task waiting for a person

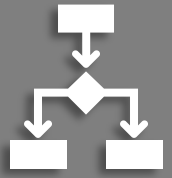
Automation

Automation isn’t a new topic, but tools have come a long way



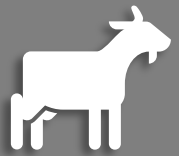
Automation

Approvals



Branching

Proactive Notifications

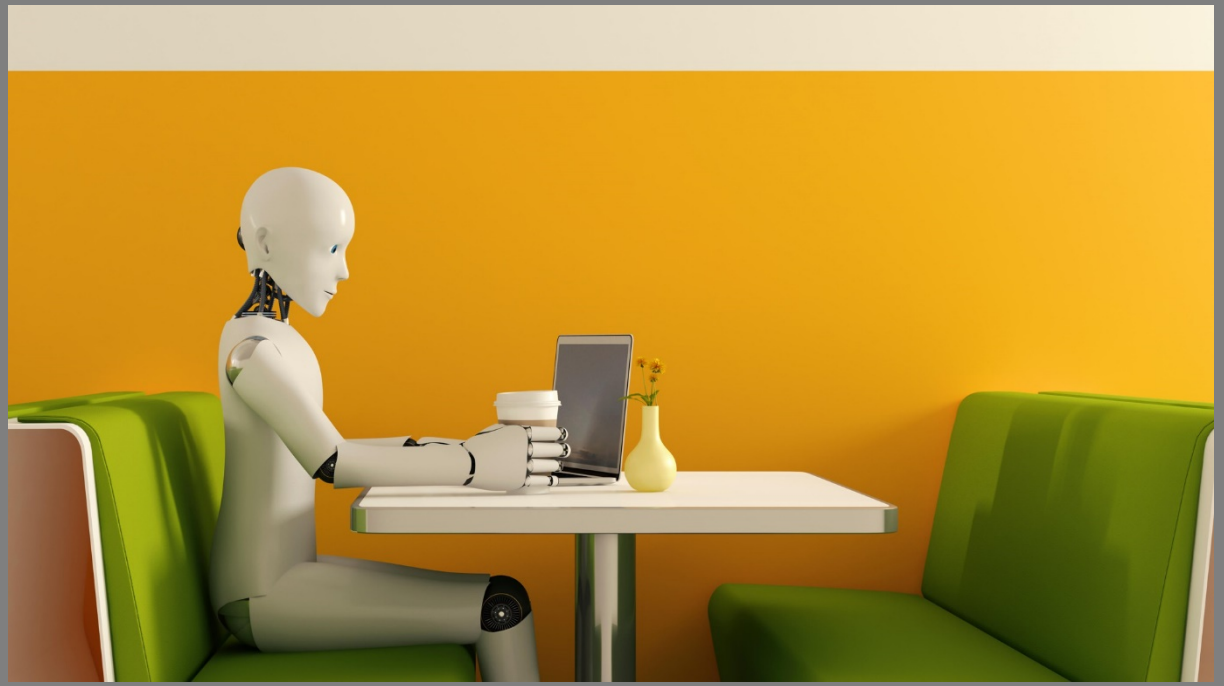


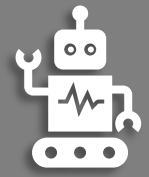
Audit Trails

Automation

Latest Buzzword:
Robotics

Many Companies now have actual robots working for them!





Automation

Robotics Process Automation (RPA)

The application of technology that allows employees in a company to configure computer software or a "robot" to capture and interpret existing applications for processing a transaction, manipulating data, triggering responses and communicating with other digital systems.

Old "Automation" → Humans write rules, computer executes rules

New "RPA" → Humans perform tasks, computer learns, computer performs tasks

Can’t manage what you can’t model

Technology is your friend

The robots are coming

Empowering
the Financial World

CONNING®

Best Practices in Variable Annuity Financial Risk Management

May 21, 2019

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BRIEF REVIEW OF VA AND UPCOMING REGULATORY CHANGES

VA Guarantees: Path Dependent, Complex Options

VA Guarantee	Form of Benefit	Guarantee Details
Guaranteed Minimum Death Benefit (GMDB)	Lump Sum Payment	If death occurs during the accumulation phase, provides the greater of: account value, premium, and in some cases an enhanced benefit
Guaranteed Minimum Accumulation Benefit (GMAB)	Floor on account value after a specific period of time	Floor is typically set to total premium contributions net of withdrawals
Guaranteed Minimum Income Benefit (GMIB)	Lifetime income stream	Upon annuitization, provides a minimum benefit base that can be enhanced by step-ups, roll-ups or ratchets
Guaranteed Minimum Withdrawal Benefit (GMWB)	Income stream over a certain period of time or the policyholder's lifetime	Guarantees a minimum percentage of the benefit base can be withdrawn annually. Benefit base is often enhanced with step-ups, resets, etc.

Key Risks and Modeling Components

Market & Investment Risk

- **Interest Rates**
  - Stochastic Discounting of path dependent liabilities
  - Derivatives and Greeks
- **Credit Spreads**
  - Significant portion of S/A invested in corporates
  - Robust Credit model
- **Equity**
  - Drives the value of guarantees: GLBs, GMDBs, etc.
  - Drives value of account value-based fees

Policyholder Behavior & Mortality

- Performance driven or dynamic lapse
- Shock lapse
- Utilization rates associated with guarantees
  - GMWB, GMIB, etc.

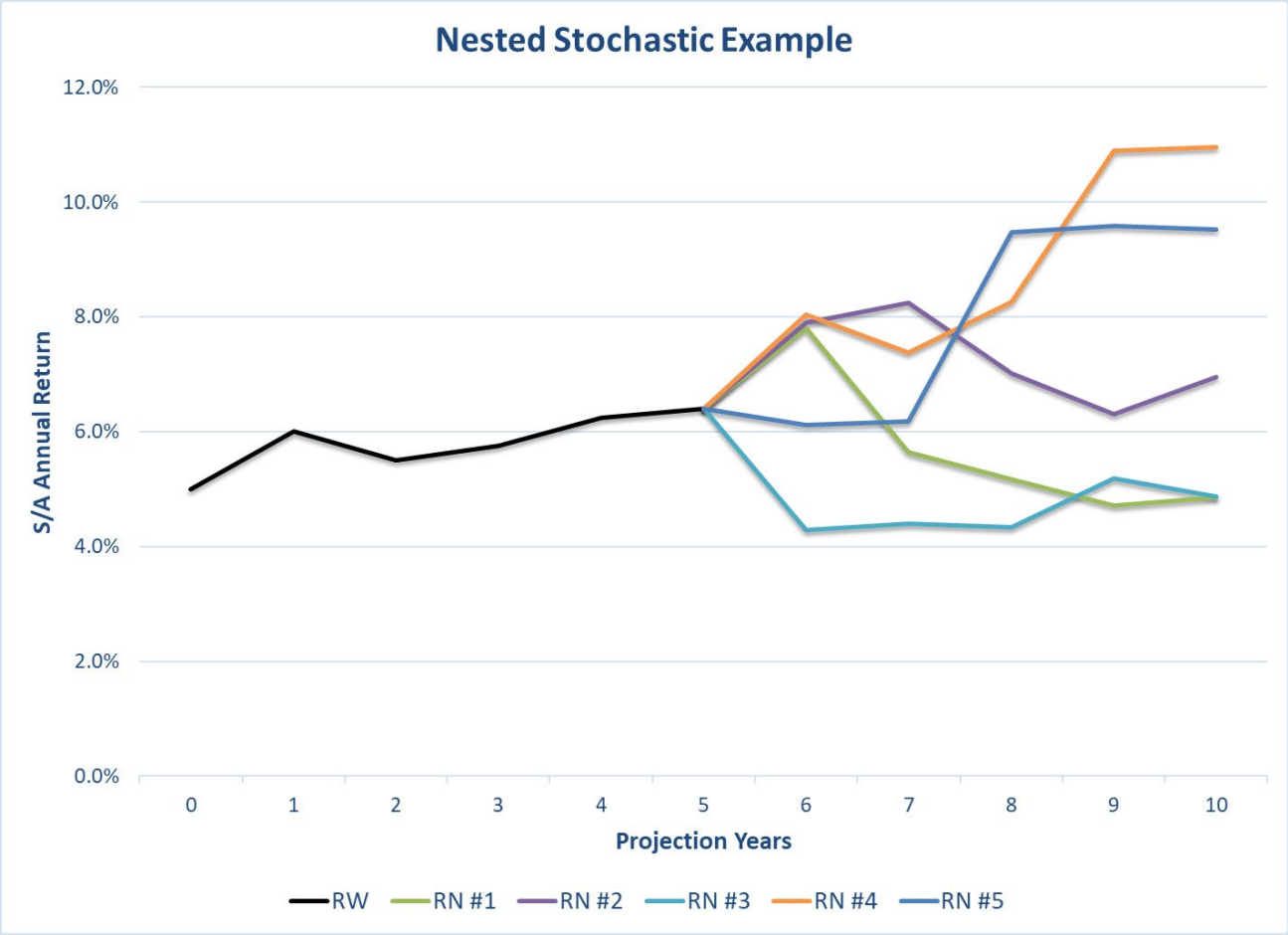
Correlation & Diversification

- Amplified correlation in tail scenarios
- Correlation:
  - Among market risk factors
  - With “Insurance” risks
  - With other product lines

Computational Considerations

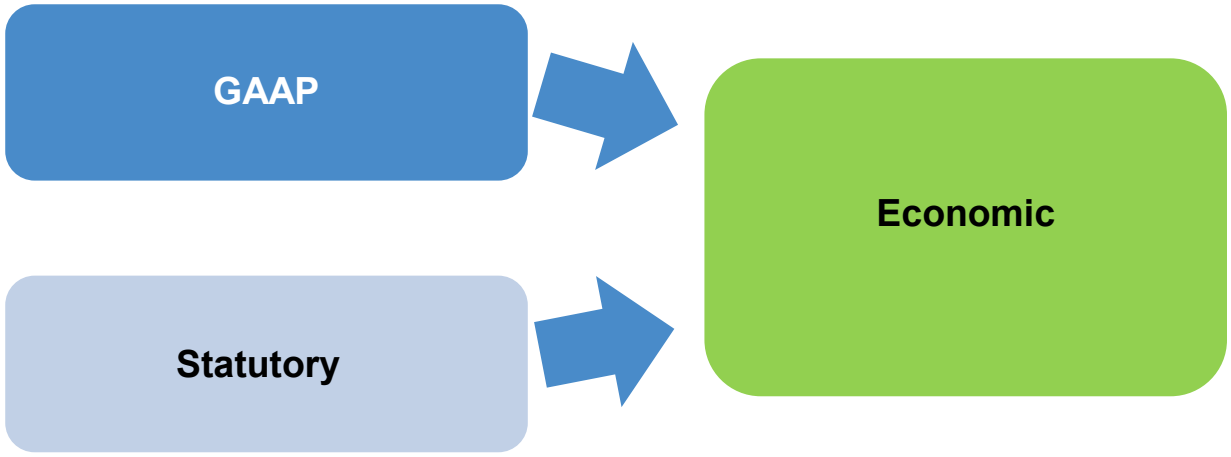
Technological advancements (GPUs and cloud computing) allow for a more robust quantification of the risk associated with Variable Annuity riders

- **A 30-year monthly projection comprised of 1,000 real world outer-loop scenarios with 1,000 risk neutral inner-loops at each timestep would require 360 million projections**



Highlights of Potential Impacts from Regulatory Changes

- **Three balance sheets converging towards an Economic based ALM**
- **GAAP and Stat will be more sensitive to market movements**
- **Benefits of hedging can be more easily reflected, and this will increase hedge targets**
- **Increased transparency and standardization, ultimately reducing the need for adjustments**



SAMPLE VA ERM PROCESS: ECONOMIC CAPITAL

VA ERM Process: Economic Capital

- Project assets and liability inforce along the outer-loop to reflect insurance assumptions and capital market changes
- **Scenarios calibrated to the company's unique business risk are preferred**

- At each time step along the outer loop, risk neutral inner loops are used to calculate liability Greeks
- **Liability Greeks drive the rebalance of the asset portfolio to match the hedge target**

- **Present value of terminal deficiency represents the mismatch between assets and liabilities**
- Tail of the terminal deficiencies drives capital: CTE 70 for the reserve and CTE 98 for TAR

- **Considerations must be made for risk components that are not fully captured in the nested stochastic framework:** policyholder behavior, additional hedge breakage, transfer algorithms, etc.

- **The decision of what to hedge is vital**
- **Sensitivity tests to determine strategy**

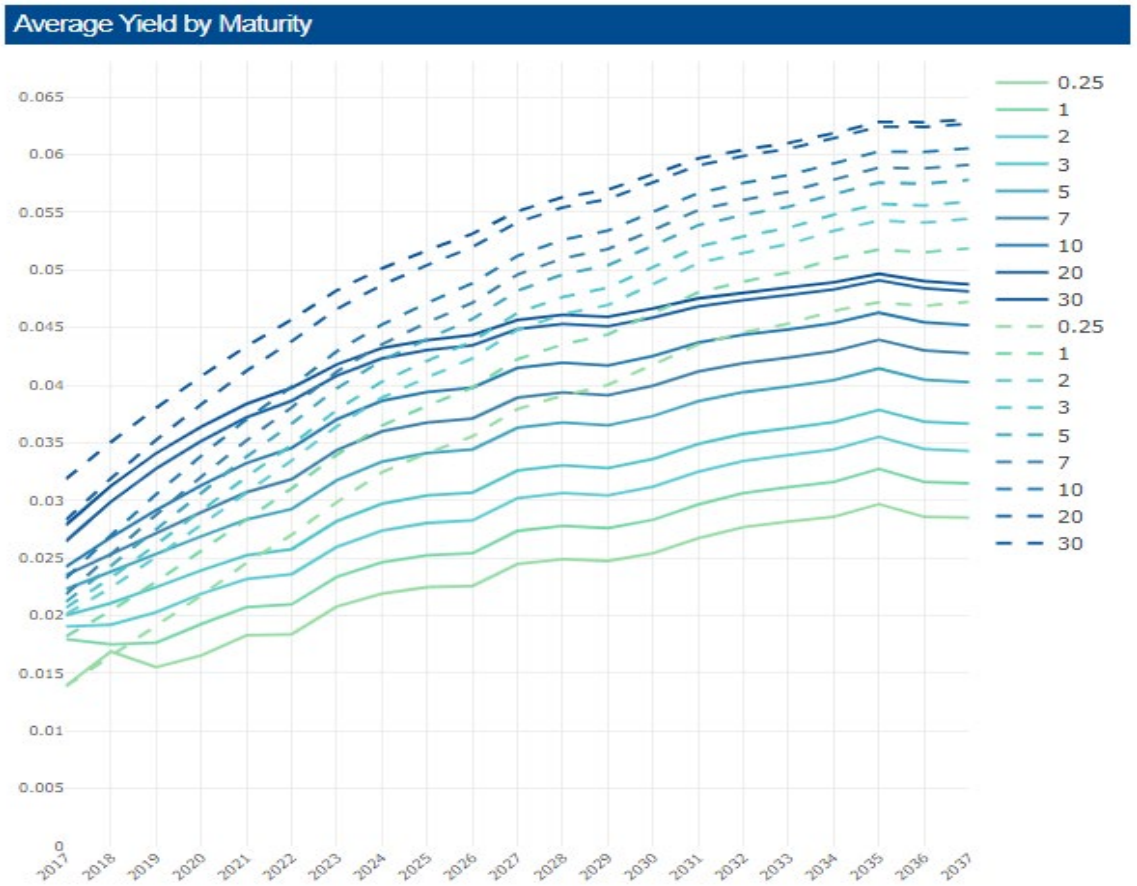
Real World Outer Loop Scenarios: Rising Yields

VA ERM Process

- Real World Scenarios
- Risk Neutral Scenarios
- ALM and Capital
- Modeling Considerations
- Hedging Benefit

❖ **Real World Outer Loop scenarios are retrospective, and generally calibrated to historical data; *however, actuarial judgement should be used to reflect the company's views of the future state of economic and financial market variables***

I-to-H vs. I-to-N Calibration: Treasury Yields



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Real World Outer Loop Scenarios: Returns

VA ERM Process

- Real World Scenarios
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- **Calibrating purely to historical rates results in negative returns for longer duration treasury asset classes, particularly in the early years of the projection**
- **Economic capital market assumptions should be both consistent with historical observations, and also reflect a forward-looking view of market expectations and uncertainties**

Treasury 1 Year I-to-N vs. I-to-H Calibration

Initial-to-Normative

Asset Class	Average Annual Return
US Cash	1.62%
US Treas 1 to 3	2.16%
US Treas 3 to 5	2.30%
US Treas 5 to 7	2.14%
US Treas 7 to 10	1.64%
US Treas 10 to 20	0.58%
US Treas 20 plus	-1.57%

Initial-to-Historical

Asset Class	Average Annual Return
US Cash	1.37%
US Treas 1 to 3	1.87%
US Treas 3 to 5	1.30%
US Treas 5 to 7	0.73%
US Treas 7 to 10	0.12%
US Treas 10 to 20	-0.61%
US Treas 20 plus	-1.89%

Real World Outer Loop Scenarios: Calibration

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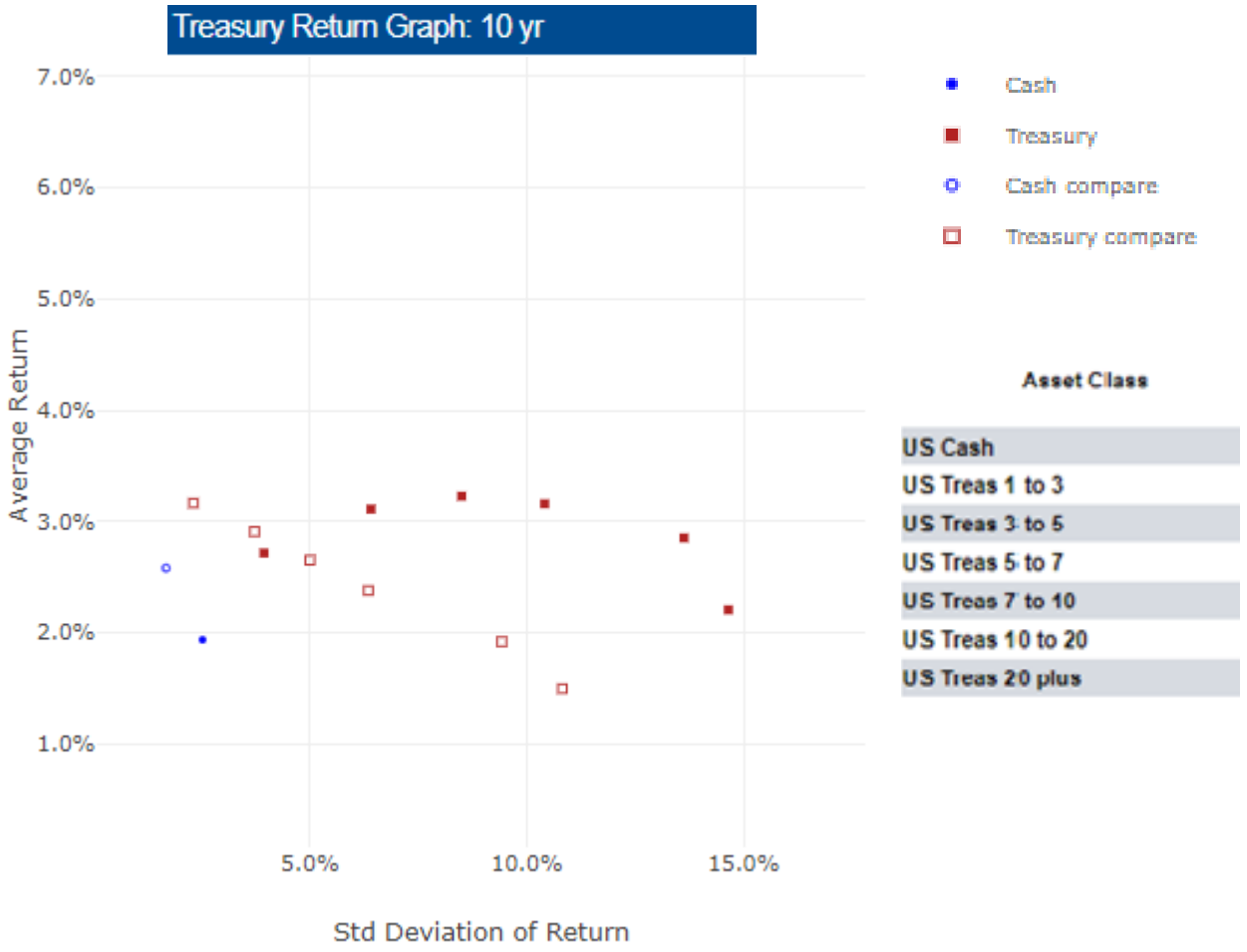

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Real World Outer Loop Scenarios: Regulatory Changes

STATUTORY CHANGE: AAA Academy Generator should be used for interest rate and equity (separate account) scenarios

- Proprietary scenarios should only be used if they do not yield a "materially lower TAR"
- ***RESULT: AAA scenarios should be used to satisfy regulatory needs, but custom calibrated scenarios should be used to capture the company's economic view, and the unique risk of the business***

STATUTORY CHANGE: General Account asset projections will follow VM-20 guidance as well

- ***RESULT: Increased transparency and standardization with an immaterial impact on results given the small percentage of account value in the G/A***

STATUTORY CHANGE: Replace existing standard scenario with a more benign valuation that is meant to serve as a true floor in the Stat reserve calculation

- ***RESULT: Mitigates the remaining non-pbr components of the Stat reserve, and amplifies the importance of the stochastic reserve calculation***

Real Neutral Inner Loop Scenarios

Risk neutral scenarios are used to calculate liability and asset market values and Greeks at each node along the outer loop

Regulation does not mandate the use of nested stochastic scenarios in the valuation of variable annuities

- **Several changes do indirectly increase the need for these risk neutral inner loops**

STATUTORY CHANGE: Reduction in the minimal allowable hedge effectiveness error factor

- ***RESULT: Increased need for adopting a VA risk management framework that incorporates a robust dynamic hedging program (nested stochastics)***

STATUTORY CHANGE: C3 Capital is calculated as the difference between the TAR (CTE 98) and Statutory Reserve (CTE 70) along the same distribution

- ***RESULT:***
  - ***Amplifies the importance of the extreme tail of the distribution***
  - ***Dynamic replication hedging should be used to mitigate the large losses in the tail***

ALM and Capital: VM-21

VA ERM Process

- Real World Scenarios
- Risk Neutral Scenarios
- **ALM and Capital**
- Modeling Considerations
- Hedging Benefit

Current State of AG-43 under VM-21: CTE Amount

- CTE amount is derived from the analysis of asset and liability cash flows produced by the application of a stochastic model of interest rates and equity returns
- For each scenario, greatest present value of accumulated deficiencies at the end of each projection year is calculated
- **Accumulated deficiency is the difference in assets and liabilities at the end of the year in each scenario where the liability is equal to the "working reserve"**
- **Reserve is set at the CTE 70 level: the average of the worst 30% of deficiencies**

STATUTORY CHANGE Removal of Working Reserve from GPVAD calculation

- ***RESULT: Better alignment with Economic view***

Statutory View Assuming Hedging:

$$CTE\ Amount = HE \times CTE\ Amount_{with\ hedging} + (1 - HE) \times CTE\ Amount_{without\ hedging}$$

ALM and Capital: Economic

VA ERM Process

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Economic View:

Deficiency or TAR = PV(unhedged cash flows) + Initial Hedge Target + PV(hedge breakage)

- **Unhedged CF's**
  - Base contract cash flows: M&E fees, surrenders, GMDBs, etc.
- **Initial Hedge Target = Expected Cost of Hedging**
  - Reflects the present value of the guarantees being hedged as well as any associated fees that are also hedged
- **Hedge Breakage**
  - **Breakage captured explicitly in the model due to changes in rates, equity, credit and volatility**
    - Frictional costs associated with replication hedging, including: KRD mismatches and mismatches driven by embedded transfer algorithms

Modeling Considerations

Additional breakage must be considered that is not captured in the model:

- Fund Basis/ Fund Mapping Risk
- Liquidity
- Inconsistency between projection intervals and rebalancing frequency

Additional Key Assumptions:

- **Longevity/Mortality**
- **Policyholder behavior:**
  - Rider utilization efficiency
  - Dynamic Lapses
  - Shock Lapses
  - Policyholder behavior becomes increasing unpredictable in an economic shock

Modeling Considerations: Correlation

- **Correlation and quantifying diversification are vital across all phases of the model**
- **Tail correlation among assets and risk factors**

VA ERM Process

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- **Modeling Considerations**
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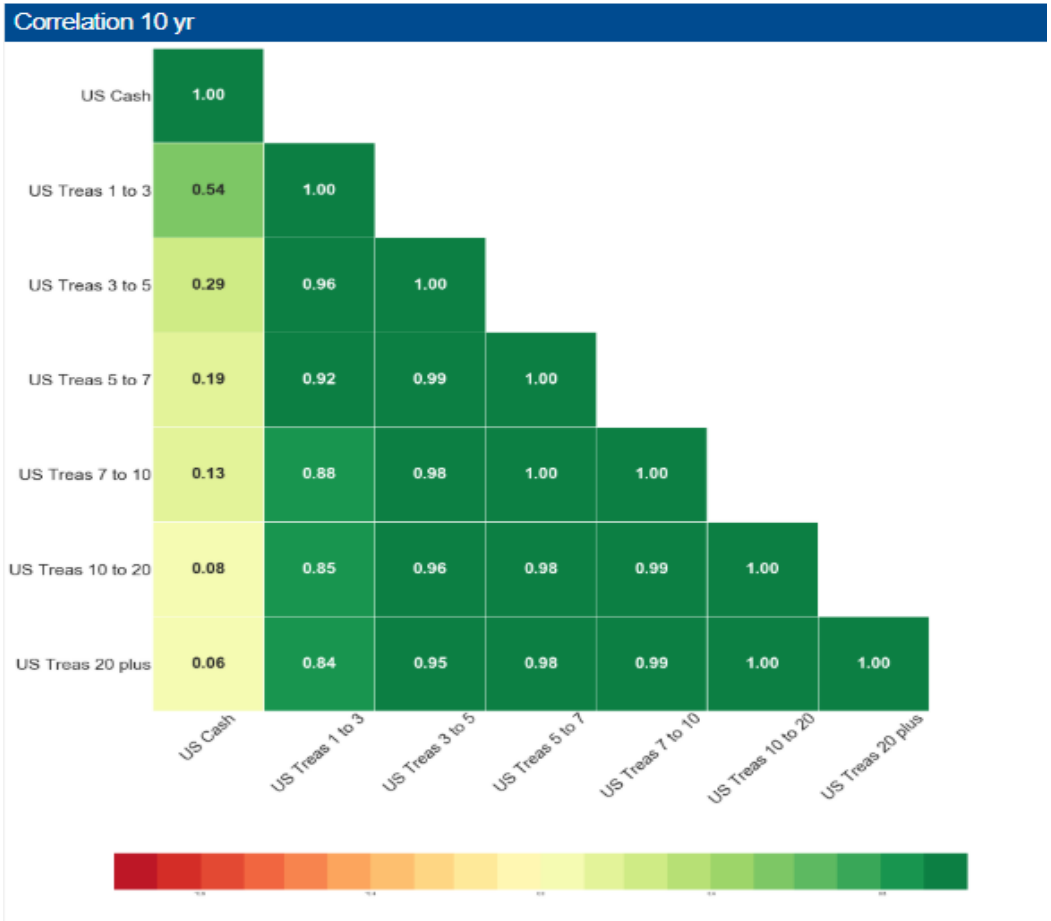

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Modeling Considerations: Vol Target Funds

Vol Target and Vol Transfer Funds:

- **Many large VA writers have introduced managed volatility funds**
  - When volatility rises funds are transferred out of equities and into cash or fixed income
  - Designed to limit equity exposure when market volatility increases
- **Rebalancing Algorithms introduce added complexity to the valuation of VAs**
  - Increased complexity in modeling fund returns
  - How effective are these funds at delivering stable volatility?
  - How does this impact the cost of the guarantees from Insurer's perspective?
  - Cost of guarantees is extremely sensitive to choice of equity model and volatility convention
  - Tail equity scenarios result in reduced liability delta but increased exposure to rates and credit

Modeling Considerations: Vol Target Funds

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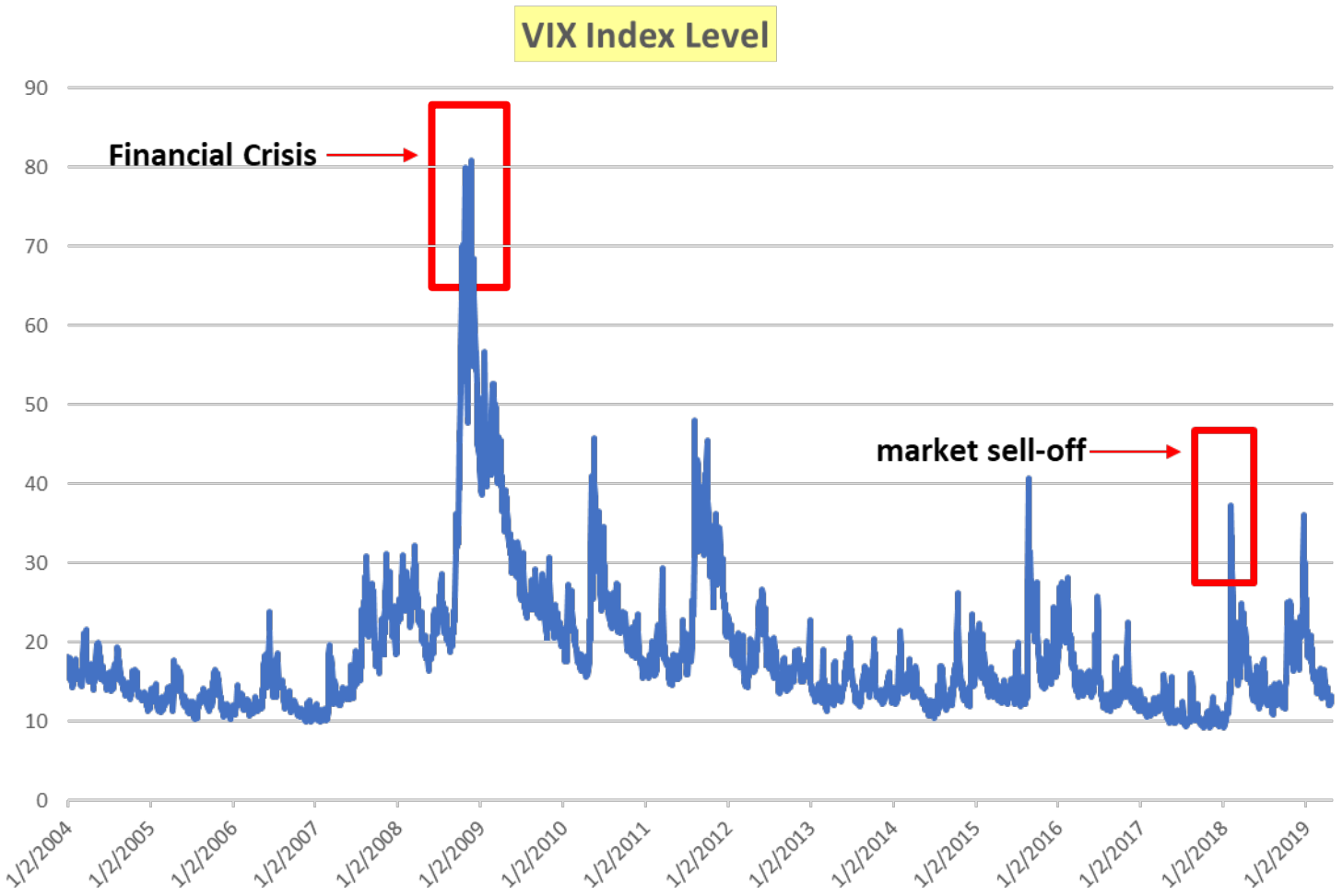

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Hedging Decisions

- **What to Hedge?**
  - KRDs, credit spreads, equity index levels
- **Sensitivity tests should be performed to decide on the specific liability components to hedge, and to analyze the costs and benefits of candidate hedging strategies:**
    - Fully hedge claims, Stop-loss (deductible), or first loss hedging
    - Do you hedge fees?
- **Do you supplement “core" hedge programs with macro hedges that would provide added protection in tail economic scenarios?**

GAAP CHANGE: Valuation of all guarantees moving to fair value

Hedging Decisions: Benefits and Costs

VA ERM Process

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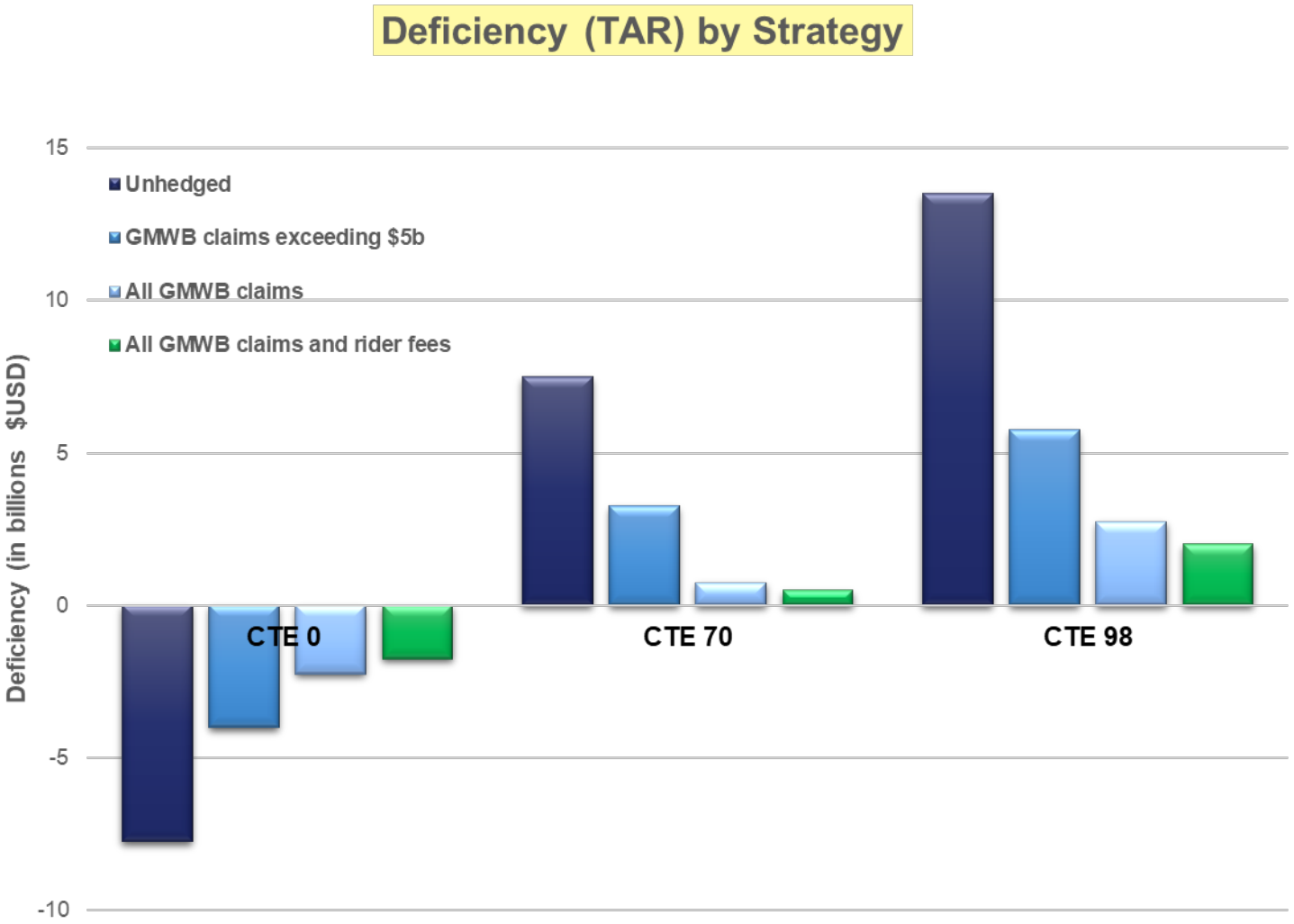

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