TOWERS PERRIN
TILLINGHAST

Stochastic Modeling Concerns and RBC C3 Phase 2 Issues

ACSW Fall Meeting
San Antonio

Jason Kehrberg, FSA, MAAA

Friday, November 12, 2004
10:00 - 10:50 AM

Outline

- Stochastic modeling concerns
- Background, scope, and general approach for RBC C-3 Phase II
- Other considerations when calculating RBC C-3 Phase II
- Our model
- Results
- Updates and conclusion

What do we mean by stochastic modeling?

- "Modeling of outcomes under a large number of randomly-generated future experience scenarios."
  - Eliminates the chance that the deterministic approach omits a significant scenario
- Derives the statistical distribution of possible outcomes
  - Facilitates the quantification of risk/return trade-off
- Variables modeled stochastically can be limited to one (e.g., interest rates), or several (e.g., interest rates, equity returns and mortality)
- A stochastic model is one that recognizes the random nature of the input components

Deterministic models

- A model that does not contain any random component is deterministic in nature.
- The output is determined once the set of inputs and the relationships between them have been defined.
- A deterministic model is really just a simplified stochastic model
- Deterministic modeling derives outcomes under a finite set of fully-defined scenarios
  - e.g., “New York Seven” interest rate scenarios
  - scenarios and outcomes don’t have associated probability weightings

Stochastic vs. Deterministic models

- Depends on whether one is interested in the results of a single scenario or in the distribution of results of possible scenarios
- The results for a deterministic model can often be obtained by direct calculation, but sometimes it is necessary to use numerical approximations
- If a stochastic model is sufficiently tractable, it may be possible to derive results by analytical methods
  - Usually Monte Carlo simulation is used

Sample stochastic path

A number of factors are leading to an increasing level of interest in stochastic modeling . . .

- Management information demands
  - desire to understand distribution of possible results, not just expected results
  - stochastic techniques are an integral part of many risk management programs
- Equity market falls / variable annuity guarantees
- Low interest rates / spread compression
- Technology
  - stochastic modeling is computation-intensive
  - improvements in processing speed are making stochastic modeling more feasible

A number of factors are leading to an increasing level of interest in stochastic modeling . . .

- Regulatory
  - RBC C3 Phase I — in effect, but only applies to a relatively small number of companies; requires use of stochastic interest rate scenarios to determine C3 component of RBC
  - RBC C3 Phase 2 — applies to variable annuities and life contracts with GMDBs; probably in effect for year-end 2004
  - AG39 — requires stochastic testing to assess adequacy of reserves for variable annuity guaranteed living benefits
  - International Accounting Standards may necessitate the use of stochastic techniques to value options and guarantees
  - Rating agencies have been willing to consider lowering capital requirements based on results of stochastic testing.

Stochastic modeling is evolving from just interest and equity returns to include other kinds of uncertain elements, such as mortality

- Mortality assumptions have been traditionally modeled as a deterministic process, represented by a table of mortality rates
- However, stochastic mortality analysis may be more effective in certain circumstances:
  - The analysis has a limited number of lives at risk
  - The economic consequences of death have a high severity but low probability of occurrence, such as the case of stop loss reinsurance
- Policyholder behavior
  - Changes in economic conditions can alter policyholder behavior

Risk-neutral (pricing) vs. Real-world (risk analysis)

"A stochastic interest rate generator is a valuable actuarial tool. The parameters that specify a stochastic model of interest rates can be adjusted to make the model arbitrage-free, or they can be adjusted to accommodate an individual investor's subjective views. The arbitrage-free settings of the parameters must be used when pricing streams of interest-rate-contingent cash flows, for example, when establishing the risk-neutral position for asset-liability management. The real-world settings of the parameters should be used when evaluating the risk-reward tradeoffs inherent in deviating from the risk-neutral position." [1]

Life insurers generally assume risk, which requires real-world scenarios to measure. They need risk-neutral scenarios to help price and manage the risk.

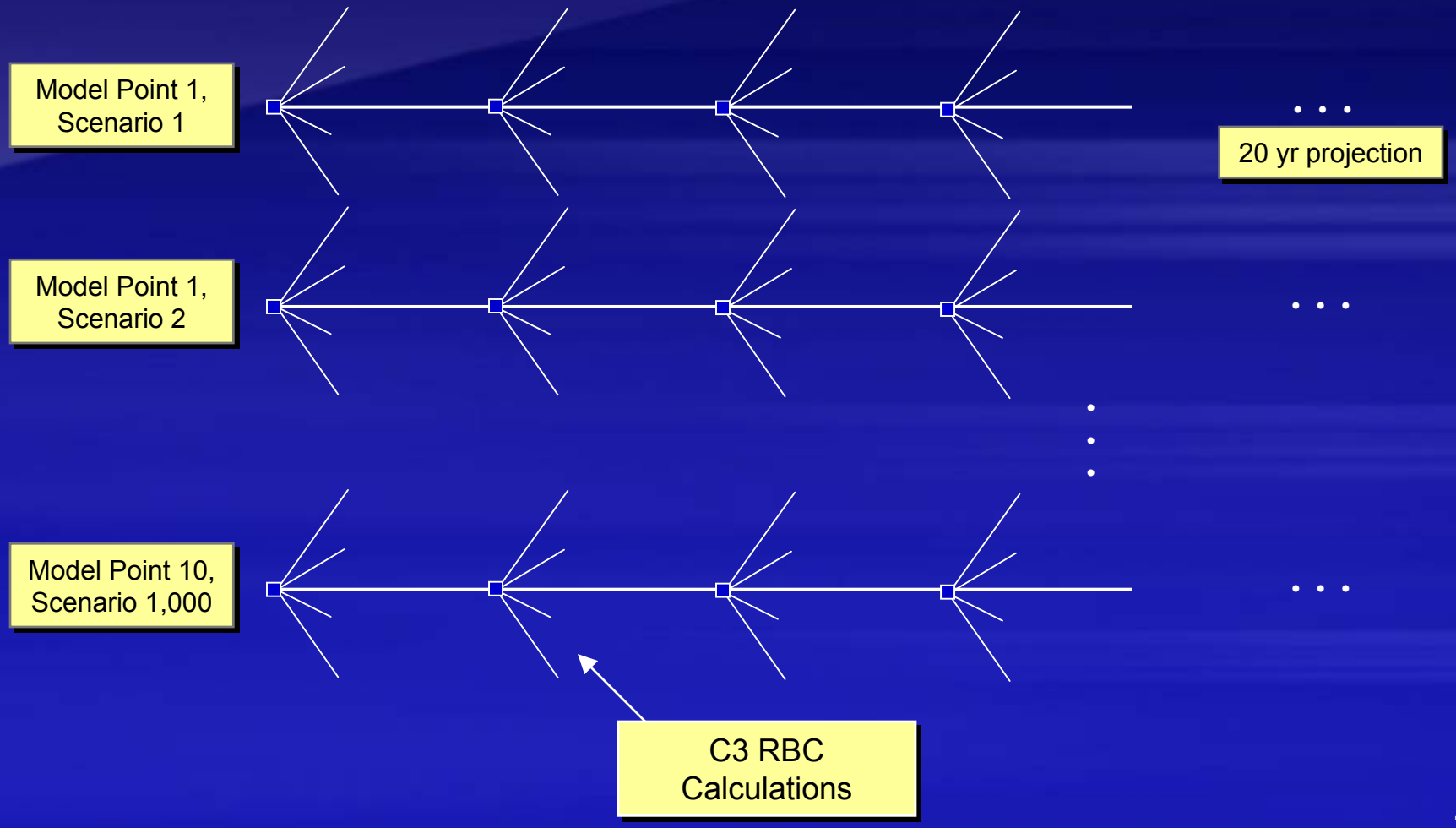
[1] Introduction to "An Actuarial Layman's Guide to Building Stochastic Interest Rate Generators" by James A. Tilley, *Transactions*, Volume XLIV

How many scenarios are enough?

- There are practical limitations on run time
  - PC catastrophe models use 10,000+ scenarios
  - Life models typically do 100+
- We frequently use 100-1,000 scenarios, based on run time limits, and knowledge that accuracy also depends on assumptions
  - 1,000 seems to be a rule of thumb ideal minimum

What is stochastic on stochastic?

- Essentially adding a fourth dimension to an existing stochastic projection



Outline

- Background, scope, and general approach for RBC C-3 Phase II
- Other considerations when calculating RBC C-3 Phase II
- Our model
- Results
- Updates and conclusion

Background

- Move to scenario modeling started in early 1990s when asset adequacy analysis became part of the life insurance company reserve opinion
- RBC requirements introduced shortly thereafter were factor-based
- Regulators wanted RBC to better reflect the degree of asset/liability mismatch risk
- NAIC implemented phase I Dec. 31, 2000
  - Addressed interest rate risk for annuities and single premium life
  - Introduced scenario testing to RBC
- NAIC on target to implement phase II Dec. 31, 2005
  - Addresses both equity risk and interest rate risk

Scope

- Includes
  - Variable annuities
  - Group annuities containing VAGLBs or GMDBs for their equity funds
  - Life insurance contracts with GMDBs for equity fund performance
- Excludes
  - Equity indexed products
  - Separate account products that guarantee an index are covered in another recommendation from AAA
  - Variable life insurance

General approach

- Aggregate results of running stochastic scenarios through a cash flow testing model
  - Include cash flows from any fixed account options
  - Use prudent best estimate assumptions
  - Must use “calibrated” scenarios to ensure “fat tails”
- Grouping (of funds and of contracts), sampling, number of scenarios and simplification methods are up to the actuary, but subject to ASOPs, documentation and justification
- Use same models as for cash flow testing

General approach (continued)

- Determine the Additional Asset Requirement (AAR) for each scenario
  - AAR = - Minimum[S(t) × pv(t)], t = 0, 1, 2, …
    - S(t) = statutory surplus at end of year t
    - pv(t) = accumulated discount factor for t years
    - Starting assets = statutory reserves held
    - Modeled statutory reserve = cash surrender value
- Total Asset Requirement (TAR) = AAR + starting assets
- Unlike the 95th percentile standard in Phase I, Phase II uses a Conditional Tail Expectation (CTE) measure

General approach (continued)

- The TARs are sorted, and the average of the highest 10% (i.e. TAR CTE90) is taken
- C3P2 RBC = TAR CTE90 - statutory reserves held
  - Combined with $C1_{CS}$ for covariance purposes
- A confidential actuarial memorandum/certification containing supporting documentation and justification must be prepared and made available to regulators upon request
  - Appropriate sensitivity tests should be included

Outline

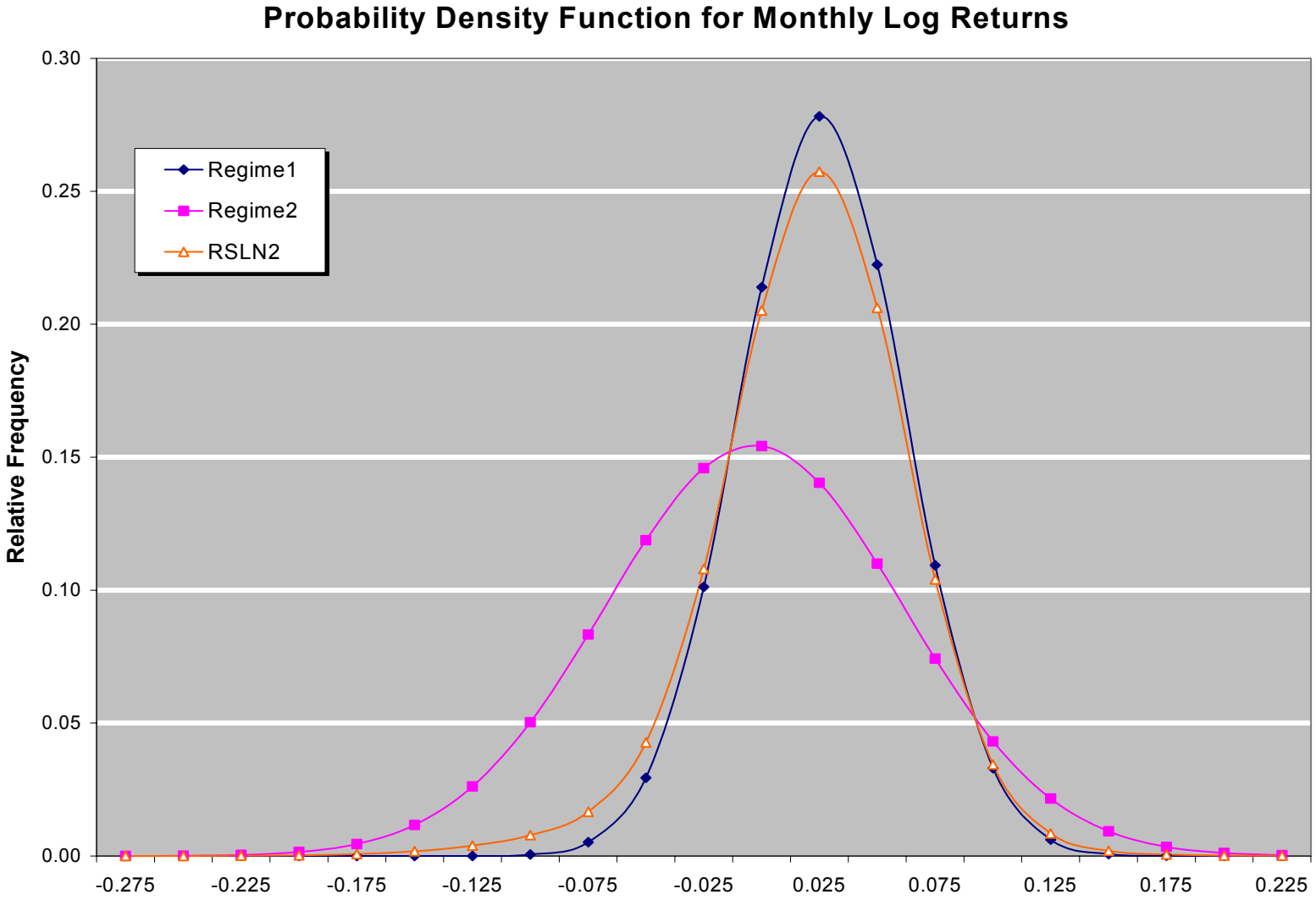
- Background, scope, and general approach for RBC C-3 Phase II
- Other considerations when calculating RBC C-3 Phase II
- Our model
- Results
- Updates and conclusion

Equity scenario requirements

- Must meet specified distribution percentiles
  - Based on RSLN2 model & historical S&P 500 returns
  - Don't need to satisfy all calibration points, but you should be satisfied differences won't materially impact capital requirements
- Models that use mean-reversion or path-dependency must be well documented and supported by research

Calibration Point	One Year	Five Year	Ten Year
0.5%	0.65	0.58	0.67
2.5%	0.70	0.66	0.79
2.5%	0.77	0.78	1.00
5.0%	0.84	0.91	1.21
10.0%	0.91	1.07	1.51
90.0%	1.35	2.73	5.79
95.0%	1.42	3.07	6.86
97.5%	1.48	3.39	7.94
99.0%	1.55	3.79	9.37
99.5%	1.60	4.10	10.48

Example of RSLN2



Realistic expected equity returns

- Expected equity returns are a matter of much debate
- Dick Wendt's article in *Risk and Rewards* (Investment Section newsletter, February 2002) argued for an equity return of 3.0 - 3.5% in excess of long-term initial Treasury returns
- Towers Perrin's asset consultants have "standard" scenarios that assume 3% over the "normalized" government bond yield, e.g., 3.0% plus 5.3%, or 8.3% total compound return

Interest rates

- Interest rates are used for:
  - Discounting future surplus needs,
  - Earnings on projected general account investments
  - GMIB purchase rate margins

- Stochastic
  - One-year treasury rates from an integrated scenario generator are allowed
  - Independent stochastic interest rates can be used if the actuary deems them appropriate

- Deterministic
  - Implied current forward rates from current swap yield curve
  - GMIB results need to reflect the impact of the uncertainty in interest rates

Pre-packaged scenarios are available

- A supplement to the proposal provides 10,000 scenarios for the common asset classes typically needed in the stochastic cashflow projections of variable annuities
- The supplement documents the models and parameters used to develop the scenarios and provides guidance on using them

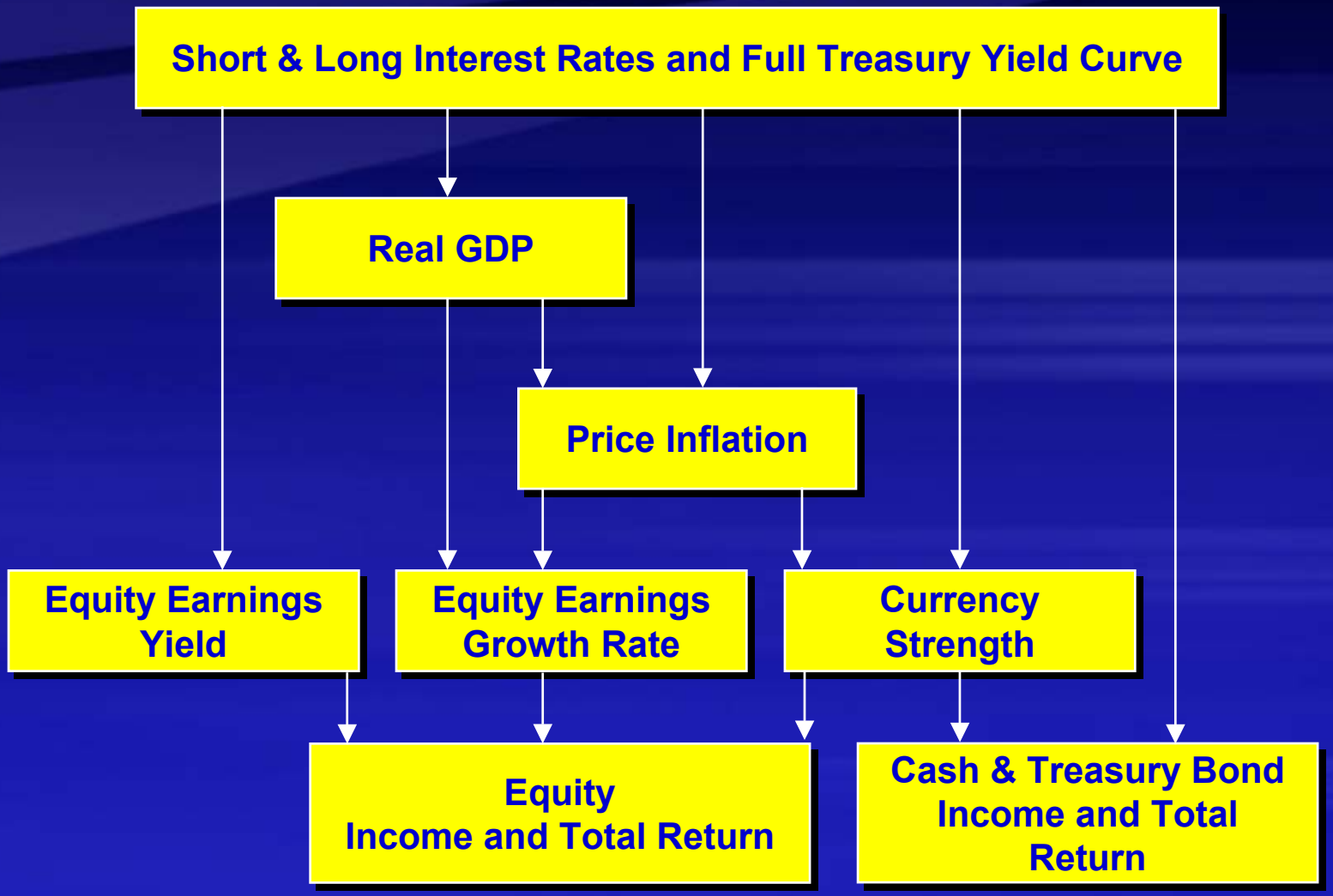
- U.S. Treasury yields
  - 3-month
  - 7-year
  - 10-year
- Money market
- U.S. bonds
  - Intermediate-term gov't
  - Long-term corporate

- Diversified
  - Fixed income
  - Balanced
  - U.S. equity
  - International equity
- Equity
  - Intermediate risk
  - Aggressive or specialized

Global CAP:Link is Towers Perrin's comprehensive real-world scenario generator

- Most of the calibrations are fixed; however, the user can determine certain key parameters such as expected average long-term interest rates and equity returns
- A comparison of CAP:Link results to the AAA calibration parameters shows that CAP:Link is not as adverse at low probabilities in later durations
  - the AAA model assumes independence of equity movements, whereas CAP:Link has long-term mean reversion
  - we believe mean reversion is appropriate
  - however, we have developed different parameters that come close to the AAA model

Global CAP:Link Cascade Structure — Core



Credit for hedges

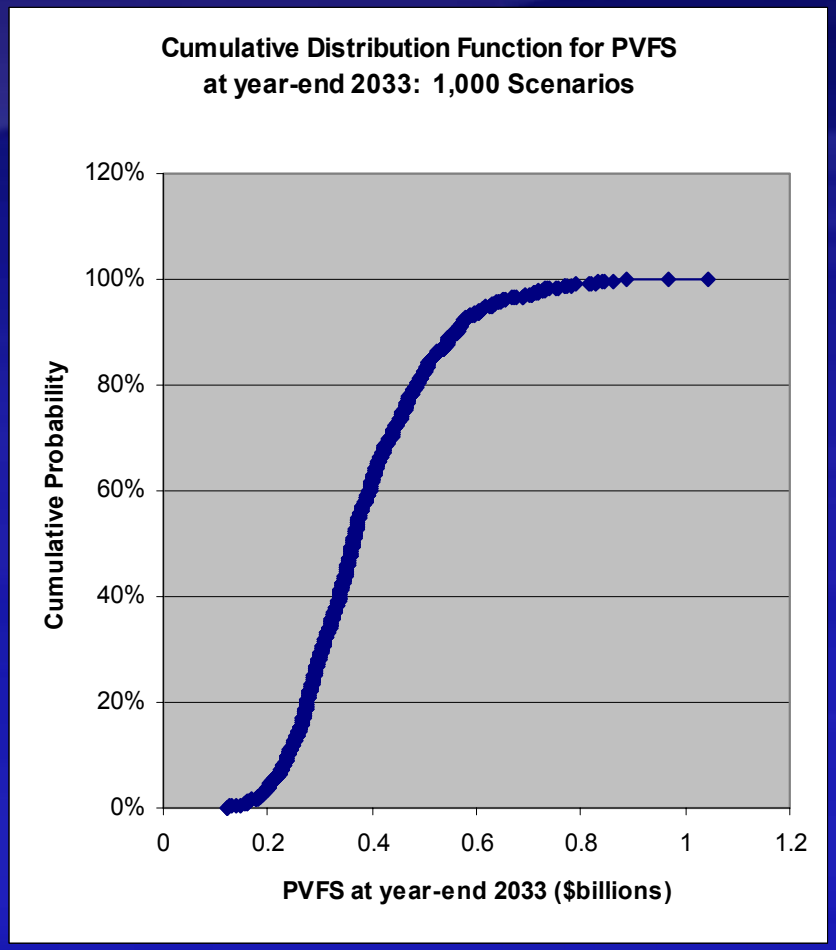
- Encourages prudent risk reduction strategies by recognizing:
  - Impact of hedge positions currently held
  - Costs and benefits of expected hedge positions held in the future under an approved hedging strategy
    - Approved hedging strategies must be clearly defined and approved by the board of directors or an authorized committee
  - Basis, gap, price, and assumption risk

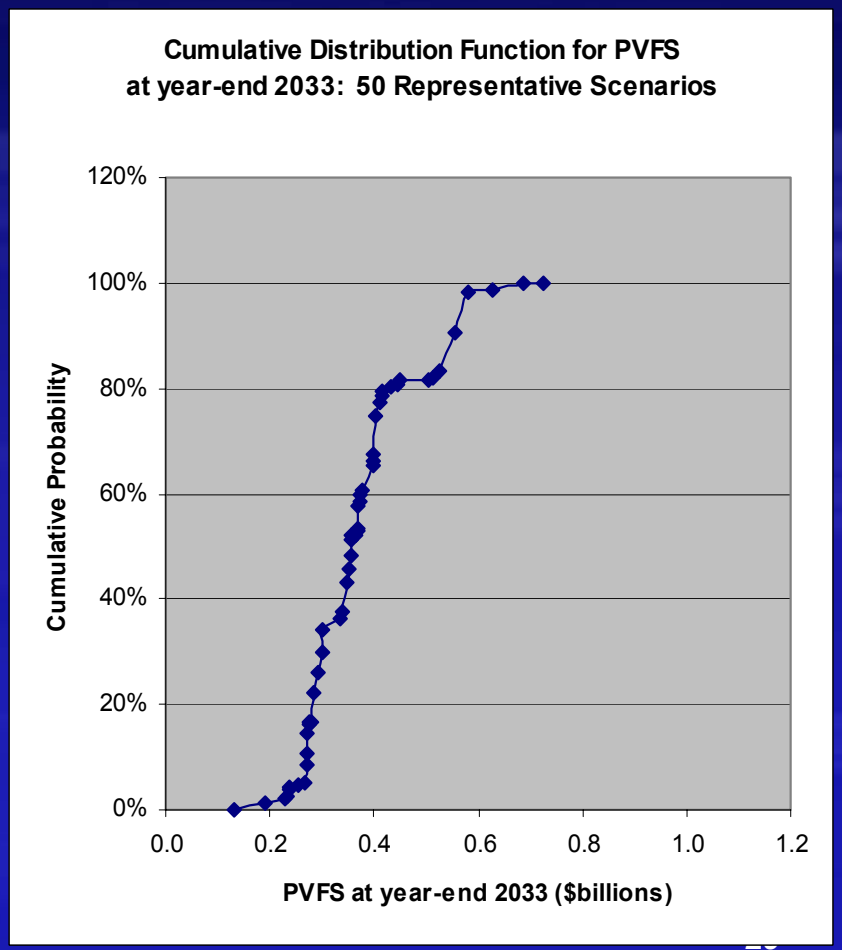
Other considerations

- Interest rate risk
  - Recommend that C-3 interest rate risk of the guaranteed fixed fund option be recognized for all VAs in calculating RBC according to methods outlined in the proposal
- Policyholder behavior
  - Absent empirical data, the actuary should set conservative behavior assumptions
  - Prudent best estimate with margin for error directly related to uncertainty in the underlying risk factor
- Aggregation
  - For multiple products, aggregate results within scenarios if possible, else calculate RBC by product and add up
- Representative scenarios

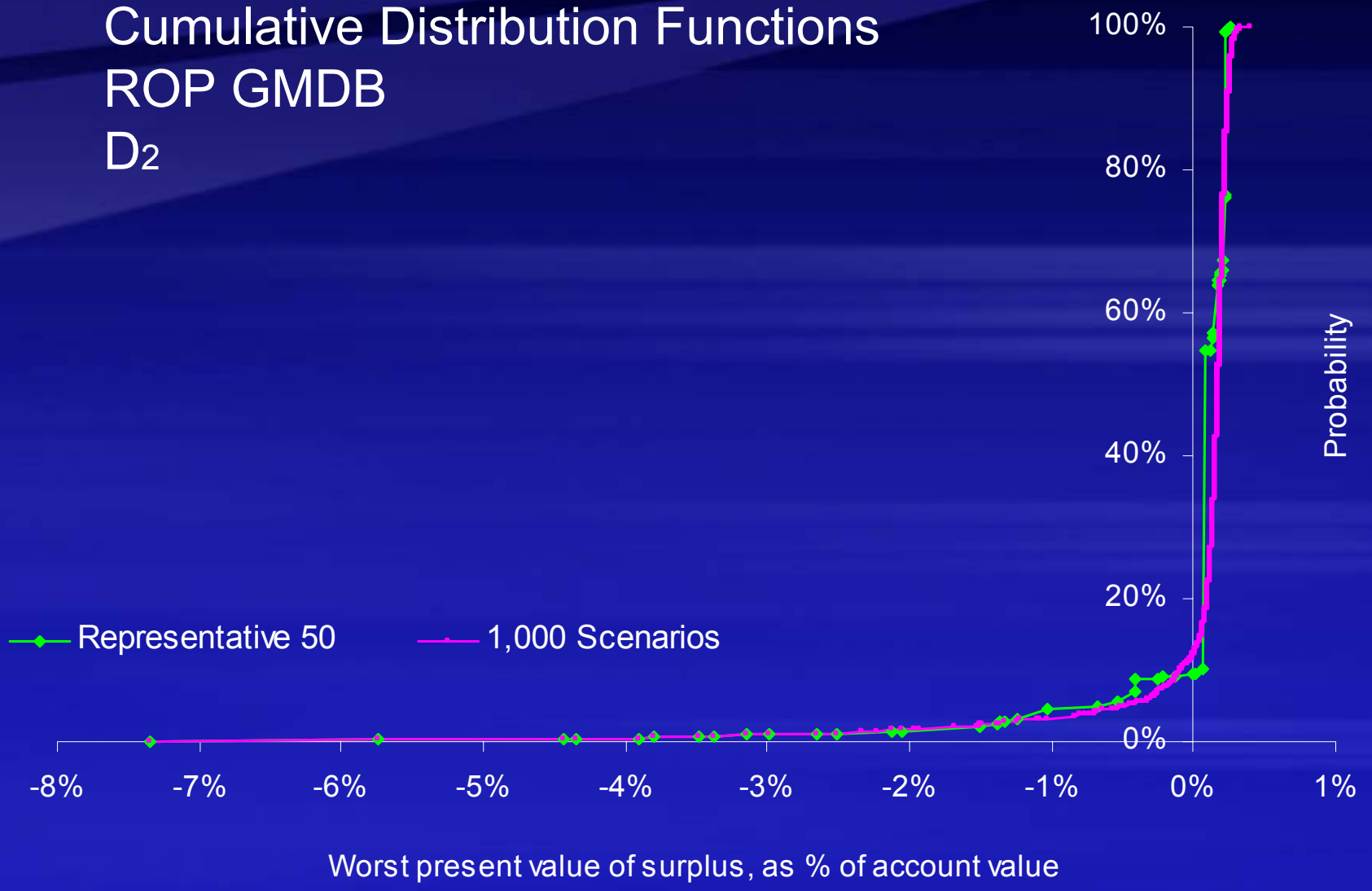
The scenario sampling algorithm uses distance (D) to ensure adequate tail representation

- Note how the tail regions are oversampled

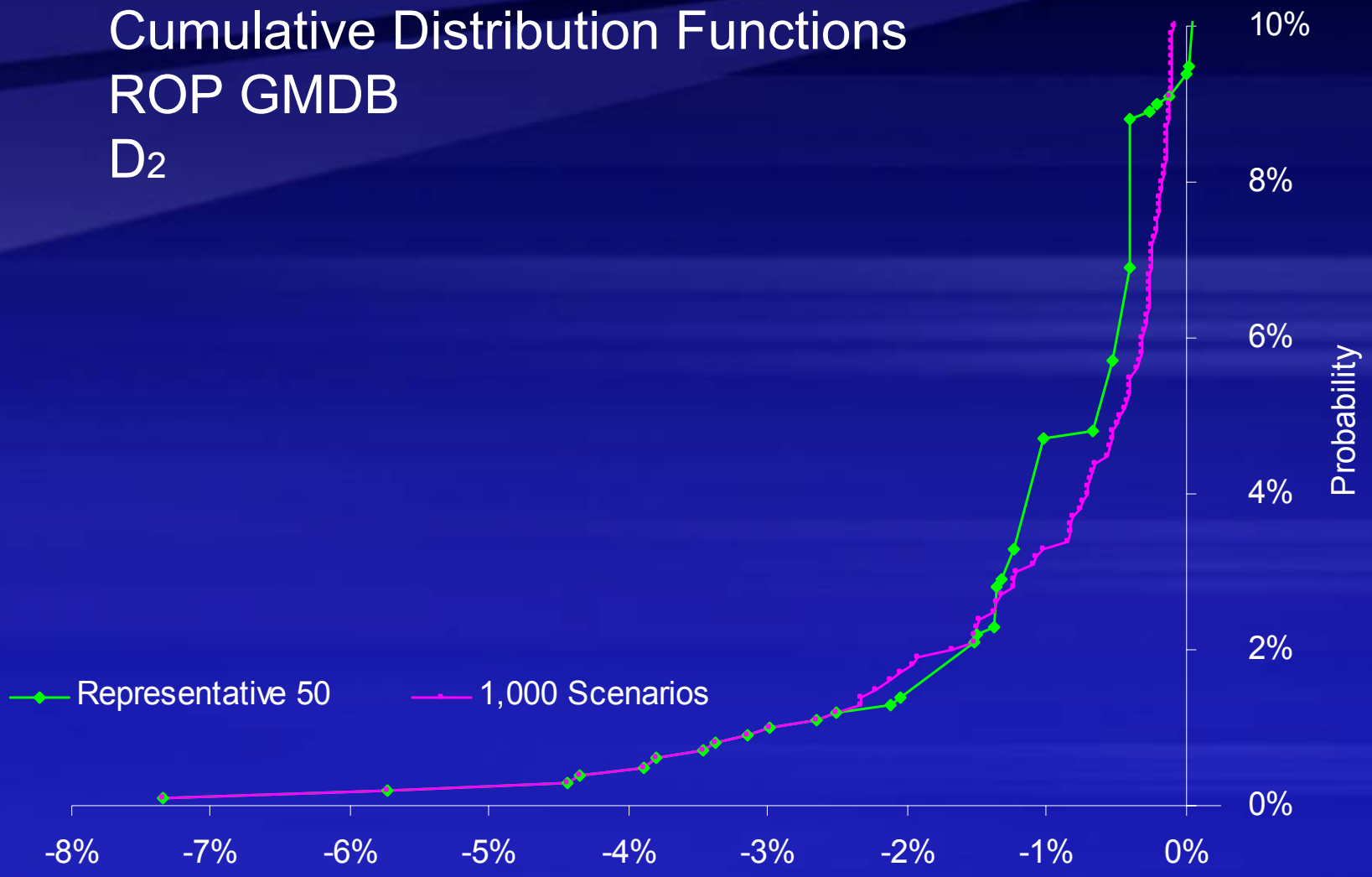




The relative present value method with distance measure D_2 gave the best results



Good fit in the tails is observed since D_2 forces representational scenarios into the tail



Alternative factors

- Life insurers offering only VAs with GMDBs may choose scenario testing or an alternative, factor-based approach
- GMDBs provided under group annuity contracts or insurance contracts, and all living benefit guarantees, must be evaluated by scenario testing
- Alternative factors allow an approximate sense of the impact for companies with known exposure data
- Factors will be developed using CTE 90
- Expected that Alternative Methodology will be applied on a seriatim basis
- Still not sure whether 65% or 100% of the MGDB 94 ALB table will be used

Outline

- Background, scope, and general approach for RBC C-3 Phase II
- Other considerations when calculating RBC C-3 Phase II
- Our model
- Results
- Updates and conclusion

Guarantees modeled

Type	Name	Description	Fees
GMDB	**ROP**	Return of Premium	5 bps
GMDB	**Rollup**	5% rollup, capped at 2.5x premium, frozen at age 80	20 bps
GMDB	**Ratchet** or **MAV**	Annual ratchet (maximum anniversary value), frozen at age 80	15 bps
GMDB	**Max** or **High**	Max (Rollup, Ratchet)	25 bps
GMDB	**EDB**	ROP + 40% enhanced death benefit (capped at 40% of deposit), incl. ROP	25 bps (20 EDB, 5 ROP)
GMIB	**Rollup**	5% rollup, capped at 2.5x premium, frozen at age 80, incl. Rollup GMDB	35 bps
GMIB	**Max** or **High**	Max (Rollup, Ratchet), both stop at age 75, incl. ROP GMDB	45 bps

Other key specifications and assumptions for the variable annuity model

- Single $50,000 policy issued to male, aged 65
- 100% invested in S&P 500 Total Return
- M&E risk charge = 1.5% fund value
- Advisory fee = 1.0% fund value
- Fund revenue share = 0.25% fund value
- Surplus earned (discount) rate = 5.77%, 3.75% after-tax
- Annual expenses = $85 per policy, 0.05% fund value
- Surrender charge = 7, 6, 5, 4, 3, 2, 1, & 0% of premium
- Lapse rates = 2, 4.5 , 5, 5.5, 6, 7, 8, 35, 20, & 12.5%
- No front end loads or annual fees

Outline

- Background, scope, and general approach for RBC C-3 Phase II
- Other considerations when calculating RBC C-3 Phase II
- Our model
- Results
- Updates and conclusion

Results – Duration 0

EXHIBIT 2
Baseline Results – Duration 0

	GMDB					GMIB	
ITM%	ROP	Rollup	Ratchet	Max	EDB	Max	Rollup
100%	1.0%	3.3%	1.1%	3.3%	0.7%	6.0%	7.7%

Results – Duration 3.5

EXHIBIT 3
Baseline Results – Duration 3.5

	GMDB					GMIB	
ITM%	ROP	Rollup	Ratchet	Max	EDB	Max	Rollup
60%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.3%
80%	0.0%	0.3%	0.1%	0.3%	0.0%	2.3%	2.1%
100%	0.3%	1.3%	0.2%	1.1%	0.2%	6.0%	7.9%
120%	1.5%	3.9%	0.8%	3.6%	1.1%	13.4%	16.1%
140%	3.0%	7.8%	2.1%	7.3%	2.6%	22.1%	24.6%

Results – Duration 6.5

EXHIBIT 4
Baseline Results – Duration 6.5

	GMDB					GMIB	
ITM%	ROP	Rollup	Ratchet	Max	EDB	Max	Rollup
60%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.2%
80%	0.0%	0.1%	0.0%	0.0%	0.0%	1.7%	1.3%
100%	0.0%	0.4%	0.0%	0.2%	0.0%	3.0%	5.9%
120%	0.3%	1.5%	0.1%	0.9%	0.2%	7.9%	14.1%
140%	1.0%	3.9%	0.5%	2.4%	0.8%	15.4%	23.5%

Results – Duration 9.5

EXHIBIT 5
Baseline Results – Duration 9.5

	GMDB					GMIB	
ITM%	ROP	Rollup	Ratchet	Max	EDB	Max	Rollup
60%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	0.3%
80%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%	1.8%
100%	0.0%	0.3%	0.0%	0.1%	0.0%	3.7%	7.4%
120%	0.2%	1.1%	0.1%	0.5%	0.2%	9.3%	16.5%
140%	0.6%	2.9%	0.4%	1.4%	0.5%	18.1%	26.1%

Current C-1 and C-3 RBC

EXHIBIT 6 Current C-1 and C-3 RBC (as a percentage of account value)		
Dur-ation	GMDB	GMIB
0	0.57%	1.57%
3.5	0.07% for ITM 60%, 80%, and 100% 0.32% for ITM 120% and 140%	1.07% for ITM 60%, 80%, and 100% 1.32% for ITM 120% 2.32% for ITM 140%
6.5	0.02% for ITM 60%, 80%, & 100% 0.08% for ITM 120% and 140%*	1.02% for ITM 60%, 80%, 100%, & 120% 2.05% for ITM 140%
9.5	0.00%	1.00% for ITM 60%, 80%, 100%, & 120% 2.00% for ITM 140%

* for duration 6.5, the MAV and HIGH GMDB products had factors of 0.02% for all ITM percentages

Sensitivity tests

EXHIBIT 7 – Results of Sensitivity Tests (duration 0)							
	GMDB					GMIB	
Sensitivity	ROP	Rollup	Ratchet	High	EDB	High	Rollup
Baseline	1.04%	3.27%	1.11%	3.25%	0.73%	5.99%	7.68%
No fees	1.13%	3.81%	1.44%	3.93%	1.44%	6.11%	7.98%
Reserve = fund value	0.04%	0.93%	0.07%	0.93%	0.04%	2.57%	3.73%
100% Female	0.57%	1.52%	0.53%	1.47%	0.36%	5.95%	7.25%
Issue age 55	0.32%	0.74%	0.26%	0.69%	0.18%	6.26%	7.02%
Issue age 75	2.90%	5.47%	3.71%	5.65%	2.57%	2.79%	4.58%
110% baseline mortality	1.16%	3.75%	1.28%	3.74%	0.83%	6.00%	7.79%
100% 2000 annuity table	1.00%	3.32%	1.08%	3.30%	0.73%	5.97%	7.67%
110% baseline lapses	1.01%	3.02%	1.06%	2.99%	0.71%	5.60%	7.29%
No dynamic lapses	0.88%	1.87%	0.84%	1.79%	0.59%	4.88%	5.39%
Flat purch int rate 3.68%	NA	NA	NA	NA	NA	8.79%	10.7%
10yr life certain annuity	NA	NA	NA	NA	NA	4.35%	5.88%
No dynamic annuitization	NA	NA	NA	NA	NA	1.78%	3.88%
Cap rollups at 2.0 x prem	NA	3.16%	NA	3.13%	NA	5.99%	7.68%
4% rollup percentage	NA	2.29%	NA	2.30%	NA	5.06%	5.80%

Outline

- Background, scope, and general approach for RBC C-3 Phase II
- Other considerations when calculating RBC C-3 Phase II
- Our model
- Results
- Updates and conclusion

The total asset requirement can be quite volatile

- C3P2 capital can vary substantially from period to period due to market movements
  - Excess asset requirements can change significantly as guarantees move from 20% ITM to 20% OTM
    - From a fraction of a percent to several percent for GMDBs
    - From one or two percent to the low or mid teens for GLBs
  - Views vary as to whether this volatility is desirable or not
- Potential methods to dampen volatility
  - Use a range for CTE(α), e.g. $0.85 \leq \alpha \leq 0.95$
    - Objectively defined, not subject to manipulation
  - Use a weighted average of capital standards over time
    - E.g. a weighted average of the current quarter result and the previous three quarters
  - Take advantage of "good" fluctuations to build a buffer that could then be gradually released

Variable annuity reserve working group

- Would revise the statutory reserve standards and methodology for variable annuities to make them consistent with the C-3 Phase II approach.
- The reserve methodology being developed, if adopted, could be applicable to all variable annuity products.
- Such a methodology could replace, where appropriate, the application of Actuarial Guideline XXXIII to variable annuity contracts and totally replace Actuarial Guidelines XXXIV and XXXIX.

The standard scenario alternative minimum

- In addition to stochastic scenario analysis, insurers would be required to perform a seriatim valuation using a "single standard scenario", which would have prescribed fund returns and liability (actuarial) assumptions.
  - There would be a single scenario "floor" for VA RBC and another single scenario "floor" for VA reserves.
  - The reserve scenario result could be a floor reserve, such that reserves would be the larger of the standard or the stochastic results.
- With regard to the equity scenario, the capital scenario has a 20% drop in year one, followed by annual returns equal to 10-year treasury plus 0.50%.
- Advantages
  - Easier for regulators to compare companies
  - The standard scenario could be used to get a "formula" reserve on a policy by policy basis.

Conclusions

- The AAA has put considerable effort into the proposal
  - Addresses the shortcomings of factor-based approaches to setting capital
- Adopting the proposal will require significant effort in order to avoid the likely higher capital requirements associated with the alternative method factors
  - Regardless, capital required under the proposal will likely be higher than that previously required
- Companies will be affected differently, depending on product design, asset mix and economic conditions
  - Companies with substantial enhanced VA guarantees could face significant RBC at today's equity market levels

Conclusions (continued)

- Companies are likely to much more closely examine and implement risk management strategies
  - Greater use will be made of asset allocation mixes and hedging, otherwise fees necessary to provide for the additional capital may become prohibitive
- Far from being just another regulatory requirement, this approach can provide companies with a far better understanding of their risk exposure
  - Enabling companies to price products appropriately and find the best risk mitigation strategies