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Select Issues of Insurance Liabilities: Stochastic Modeling of Equity Guarantees

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Introduction to Equity-Linked Guarantees

- Equity-linked variable insurance with guarantees:
  - Separate account product with assets held at market value
    - "segregated funds" in Canada
    - "variable annuities" in the U.S.
    - "unit-linked" in the UK
  - Can also contain general account "fixed interest" option
  - Policyholder is assessed a spread-based fees that covers:
    - Investment management, administrative expenses, overhead
    - Benefits, cost-of-capital and profit
- In addition to the investment potential, products offer:
  - Wide variety of guaranteed benefits
  - Tax advantages & security features not found with mutual funds

Introduction to Investment Guarantees

- Guarantees are key elements of the product:
  - Often, mandated minimums to qualify as insurance
  - Source of competitive differentiation
  - May be integrated into the policy design, or added as riders
- Investment guarantees:
  - Can apply at death (GMDB), maturity (GMMB), annuitization (GMIB) or withdrawal (GMWB). Many variations exist:
    - Minimum return on invested principal (e.g., 0 – 5%)
    - Automatic or elective ratchet (reset guarantee to current market)
    - Income guarantees
  - Can operate across all investments ("family-of-funds") or "fund-by-fund", by deposit, etc.

Introduction to the Marketplace

- Extremely popular alternative to mutual funds due to guarantees & other insurance attributes:
  - Canada ≈ CAD $50 billion in assets under management (AUM)
  - U.S. ≈ USD $700+ billion
- One of the largest sources of new premium income
- Market convergence:
  - Reinforces image as full-service “financial institutions”, not “insurance companies”
- Insurance wrappers:
  - Many funds are externally managed by brand-name mutual fund companies

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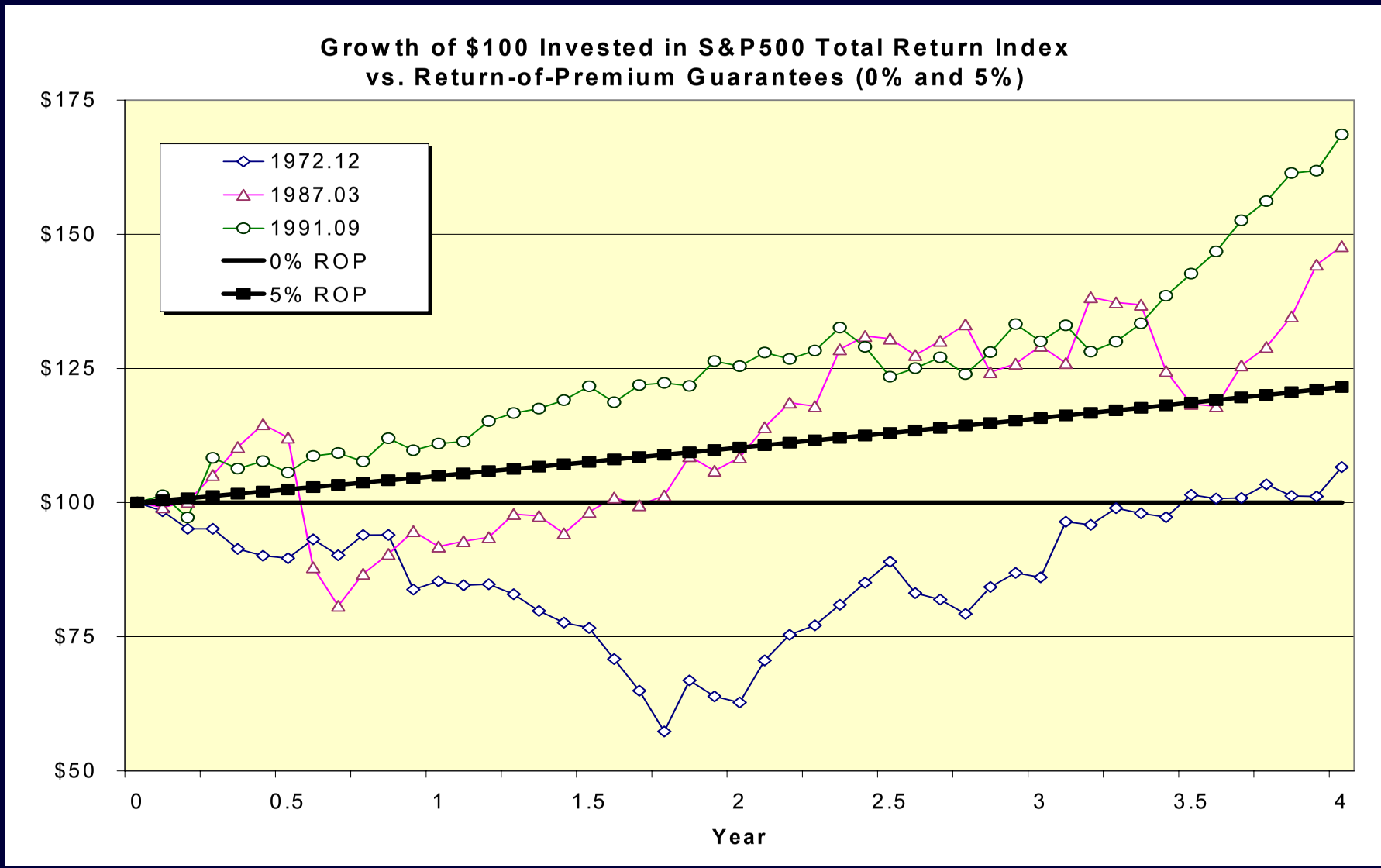
The Cost of Equity Guarantees

- Stock returns are unpredictable:
  - Expected returns give no insight into potential exposure
  - Longer periods of relative stability interspersed with shorter periods of moderate to extreme volatility
- Investment guarantees are effectively put options sold by the insurance company to the policyholder:
  - No payout unless guarantee is “in-the-money” at “exercise date”
  - Potential cost is characterized as “low probability, high severity”
  - Guarantee has little to no cost under an “average” stock return
- History is only a guide to future experience:
  - Stochastic methods are needed to price and value the risks appropriately!

Growth of $100 Invested at Specific Dates



A Pricing Example

- An insurer offers a guaranteed return-of-premium after 10 years and charges an "all-in" fee of 250 bps per year.
  - What is the embedded cost of the maturity guarantee at issue?
  - Determine the annual cost (revenue, in bps) so that the present value exactly offsets the expected payout under the guarantee
  - Using deterministic "single scenario" pricing:
    - Cost is zero if expected gross equity return exceeds +2.5% p.a.
    - Cost is 118 bps per year if gross equity return is zero
    - Cost is 250 bps (the entire fund charge) if gross equity return is –3%
  - These approaches are not helpful, because they ignore the uncertainty (variability) in equity returns:
    - This uncertainty has a very significant impact of the cost of the guarantee!

Stochastic Modeling: What is It?

- Integrate a stochastic process for equity returns into a forecast:
  - Pick a probability distribution for equity returns
  - Randomly generate thousands of paths for future experience (plausible “scenarios”)
  - Make assumptions about mortality, expenses, the behaviour of policyholders, management strategy, etc.
  - For each scenario, calculate revenue and expenses
  - Discount cashflows to the current date (time value of money)
- This provides a *distribution* of possible results – a value for each of the stochastic scenarios:
  - Use statistical techniques to make inferences about the relative frequency and severity of results (e.g., the median, 90th percentile, conditional tail expectation)

Risk Measure: Conditional Tail Expectation

- Also called "expected shortfall" or "Tail-VaR"
- $CTE^{+}(x)$ = right-tail conditional expectation
  = weighted-average of highest $(100 - x)\%$ losses
  $\approx$ ½$(100+x)^{th}$ percentile
- Most appropriate risk measure for setting the total balance sheet provision (reserves + required capital) under a realistic valuation:
  - more robust than "percentiles" or "mean + deviation" measures (less sampling error $\rightarrow$ higher accuracy for given # of scenarios)
  - less sensitive to small changes in initial conditions (MV÷GV)
  - always reflects downside risk (tail events)
  - easy to calculate and readily interpretable

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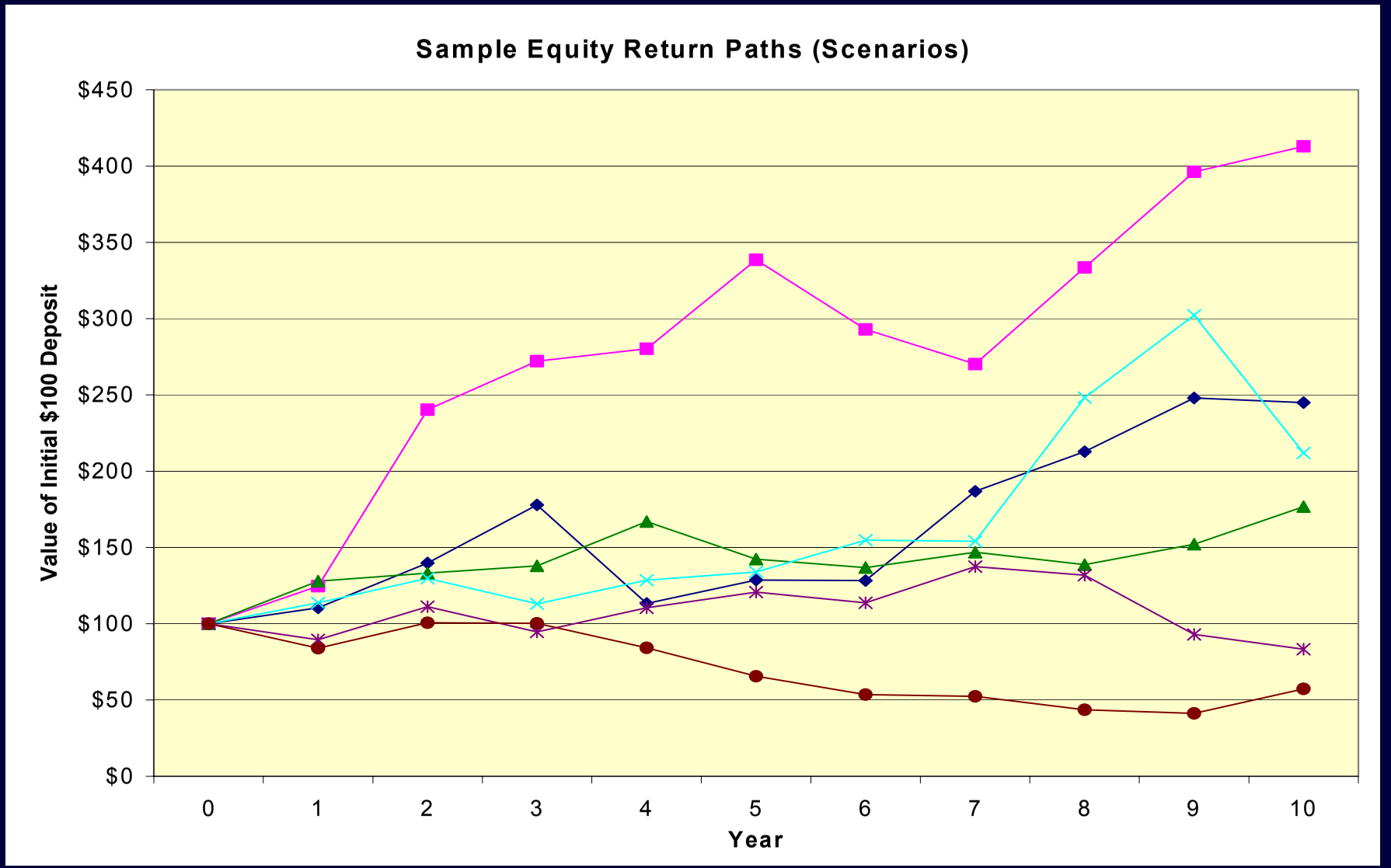

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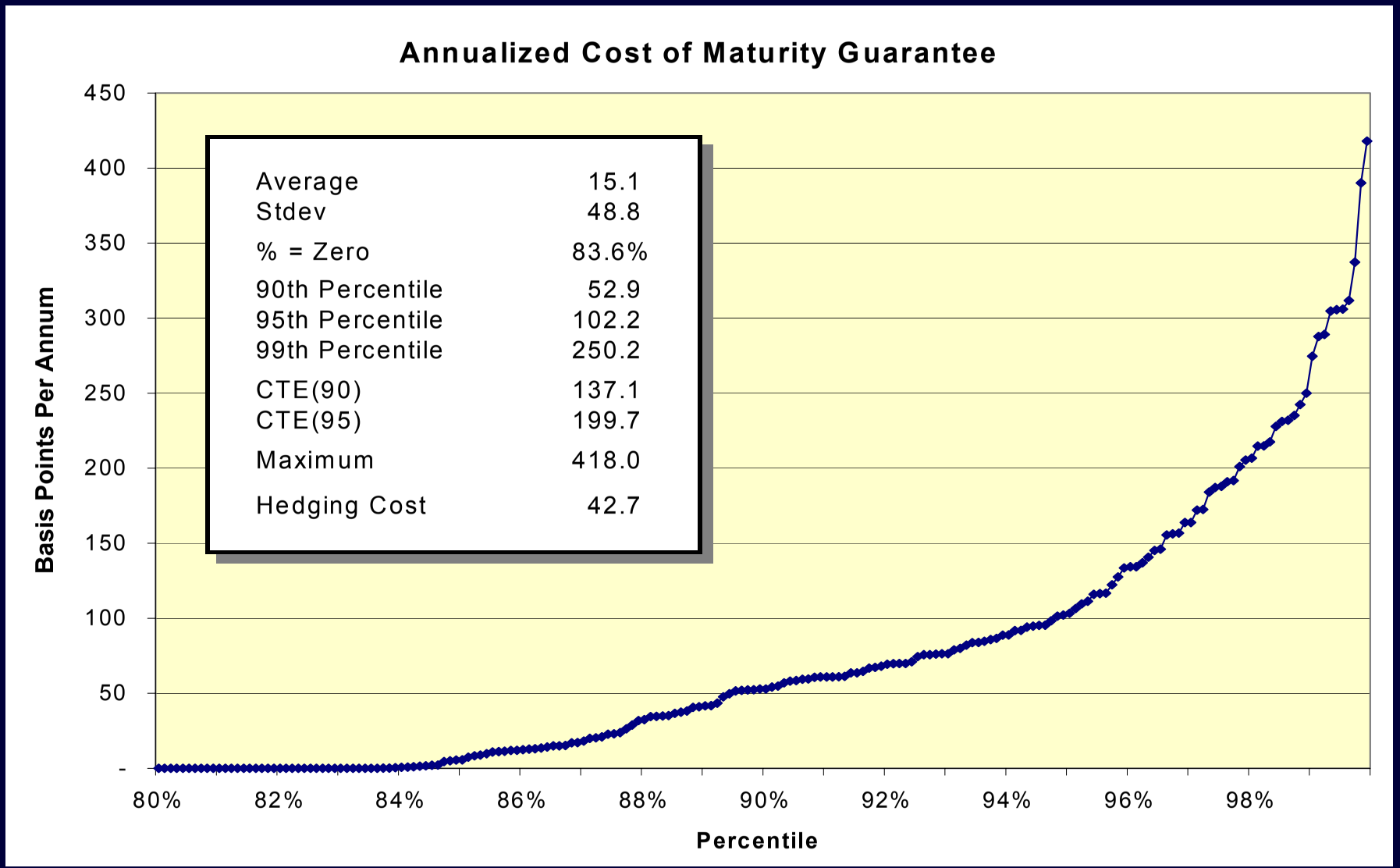

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1. Background:
   - Products
   - Markets
2. Why stochastic modeling?
   - The cost of investment guarantees
3. **Industry developments:**
   - Canada
   - United States
4. Implications for risk management

Recent Industry Developments

- In 2000, variable insurance & annuity products in Canada and the United States started to receive significant attention:
  - Huge market growth in 1990s
  - Subsequently, poor equity returns and continued volatility
  - More generous guarantees
  - Deterministic methods produced ‘inadequate’ or ‘excessive’ liabilities
  - Little to no capital requirements
  - Relatively unsophisticated modeling
  - Inappropriate or inadequate pricing
  - Little or no risk management
  - Tightening of reinsurance market (lack of supply)

Industry Developments

- Lack of standards eventually gave way to deterministic methods:
  - Simple “drop/recovery” scenarios to set floor liability
  - Stochastic modelling recommended to test adequacy
- Deterministic methods are inherently flawed:
  - Stochastic methods needed to value and price equity guarantee risks
- Primary workgroups:
  - Canadian Institute of Actuaries Task Force on Segregated Fund Investment Guarantees
  - American Academy of Actuaries Life Capital Adequacy Subcommittee (C3 Phase II RBC for Variable Annuities with Guarantees)
  - American Academy of Actuaries Variable Annuity Reserve Workgroup
- Reports available electronically on the Internet:
  - CIA: http://www.actuaries.ca AAA: http://www.actuary.org

CIA Task Force & AAA LCAS Reports

- Many similarities, including key principles:
  - Stochastic analysis is superior to other techniques
  - Consistency in practice & ease of implementation
  - Forecasting models are prospective and cashflow based
  - The company determines the appropriate assumptions (not mandated)
  - Scenario model for equity returns must pass calibration criteria
  - Policyholder behaviour is an important component
  - Integrated "total balance sheet" approach to general account:
    - Methodology determines "Total Asset Requirement" (liabilities + capital)
    - Aggregate, total portfolio calculations (reflects diversification)
  - Actuarial certification is required (not a solvency opinion)
  - Recognition that capital is only part of the solution:
    - First line of defense is a sound and structured "risk management culture"

Using Models to Determine Regulatory Capital

- A radical departure from the past!
  - Minimum required capital is usually based on formulas:
    - Prescribed factors applied to published balance sheet items
    - Risk diversification crudely recognized (if at all)
    - Intended to be broadly applicable; may not reflect company circumstances
- Regulators seem to be moving towards model-based capital:
  - Results better reflect true risk profile & impact of management action
    - Useful in product pricing, capital allocation and performance measurement
    - Company assumes responsibility for integrity of the models
    - However, greater need for skilled resources and sophisticated software
- Works best if “principles based”, not “rules based”:
  - Regulators need to rely on companies to “do the right thing”
  - May entail increased documentation, certification and peer review

Approaches to Total Asset Requirement (TAR)

- AAA C3 Phase II RBC Recommendation (Sep 2003):
  - Target implementation: Dec 2004 (subject to NAIC approval)
  - $CTE^{+}(90\%)$ of "lowest PV of accumulated surplus" (floor of zero)
  - "Always" sufficient to avoid the need for external funding
  - Modeling is expected, but "alternative factors" available for GMDBs
  - VARWG proposal: $CTE^{+}(65\%)$ for statutory liabilities
- Canadian Required Minimum Capital (MCCSR):
  - Effective Dec 2001 (transitional period ended Dec 2002)
  - $CTE^{+}(95\%)$ of "present value of net policy cashflows" (no floor)
  - Only "present value" sufficient (could have negative surplus in future)
  - Use published factors unless model approved by OSFI
  - Same method for statutory liabilities ~ range $CTE^{+}(60\%)$ – $CTE^{+}(80\%)$

Calibration Criteria for Equity Return Models

- Equity return model must satisfy calibration table:
  - Focus on "Diversified Equity" ~ represented by TSX or S&P500
  - Narrow the range of practice, but not specifically exclude models
    - If necessary, satisfy calibration by adjusting model parameters
  - Table shows required "gross wealth ratios" at various quantiles over 1, 5 and 10 year holding periods: model must produce "fatter tails" (severity) for the given relative probabilities (frequency)
  - Both Canadian and U.S. tables based on stochastic models fit to monthly market data using statistical techniques
- Canadian Table (TSX 1956.01 – 1999.12):
  - Less prescriptive (fewer points); loosely based on a mixture of models
- U.S. Table (S&P500 1952.12 – 2002.12):
  - Left and right-tail points; based on specific model (RSLN2)

Equity Calibration Tables

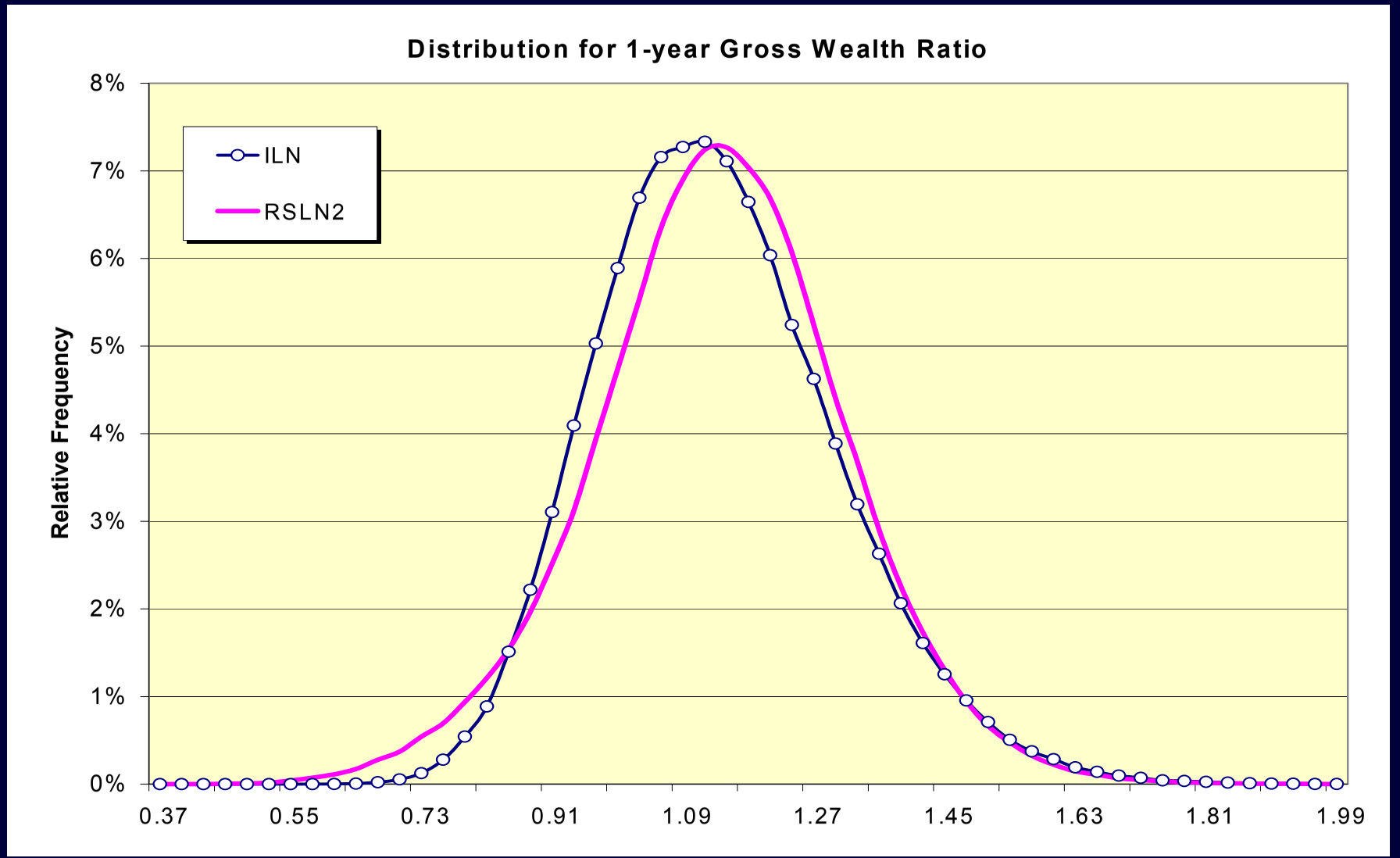
Equity Total Return "Gross Wealth Ratios" at the Calibration Points

Calibration Point (α)	1 Year		5 Years		10 Years	
	Canada	U.S.	Canada	U.S.	Canada	U.S.
0.5%	N/A	0.65	N/A	0.54	N/A	0.60
1.0%	N/A	0.69	N/A	0.62	N/A	0.72
2.5%	0.76	0.76	0.75	0.75	0.85	0.93
5.0%	0.82	0.83	0.85	0.87	1.05	1.13
10.0%	0.90	0.90	1.05	1.03	1.35	1.41
90.0%	N/A	1.34	N/A	2.67	N/A	5.55
95.0%	N/A	1.41	N/A	3.01	N/A	6.57
97.5%	N/A	1.47	N/A	3.31	N/A	7.55
99.0%	N/A	1.54	N/A	3.71	N/A	8.91
99.5%	N/A	1.59	N/A	4.00	N/A	10.00

Regime-Switching Lognormal Model (RSLN)

- Increasingly popular model for equity returns:
  - Well documented (see paper by M.R. Hardy, NAAJ April 2001)
  - Assumes the stock return process randomly switches between "regimes" at the start of each period according to fixed probabilities
  - Returns in each regime are lognormal
  - Two regimes (high & low volatility) sufficient for monthly models
- Tractable model with attractive properties:
  - Better fit to historic real world data than simple lognormal model
  - Negative skewness, fat tails, volatility clustering
- Some drawbacks:
  - Regimes are artificial and not particularly intuitive
  - Constant switching probabilities might be unrealistic
    - Are the equity markets "self correcting" over time?

Lognormal vs. RSLN2



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Balance Sheet Management

- Minimum required capital ("MRC") = TAR – LIABILITIES
- Actual B/S provision = LIABILITES + MRC × CAPITAL RATIO
- $1 provision in capital is much more "expensive" than a $1 of provision in the liabilities since:
  - Capital is "after-tax"
  - Operating "capital ratio" generally 150–200% (Canada), >250% (U.S.)
  - Strong motivation for companies to hold higher liabilities
- Stochastic methods required skilled resources & specialized tools:
  - Learning curve ↔ statistical techniques ↔ software development
  - Need to become comfortable working with probability distributions:
    - Financial results evaluated as realizations of plausible future experience
    - Decision-making will be based on relative probability measures

Risk Management

- Methodologies focus on the balance sheet (not income) using prospective simulations that start with actual market values:
  - Considerable earnings and capital volatility if liabilities are unhedged
- What has happened? What will happen next?
  - Reinsurance has largely disappeared; expensive
  - Rationalization; companies withdraw from market
  - Product re-design and retail price increases
  - Greater interest in active risk management (e.g., hedging)
  - Huge opportunities for well planned and executed business strategies
- Dynamic Capital Adequacy Testing / Dynamic Financial Analysis:
  - Regulators may use as a tool for evaluating models
  - Deterministic scenarios useful to understand exposure and management action in prolonged/adverse markets

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