Why Asset Liability Analysis is important

- Interest rate risks are embedded into many insurance company products and also investments
  - General account annuities
    - Minimum guarantees
    - Book value surrenders
  - Universal life secondary guarantees
  - Long term care
  - Callable assets
- Important to recognize the costs and risks of the options insurance companies are writing
- We only get one scenario
ALM Tools

- Cash flow analysis
- Financial statistics
  - Duration
  - Convexity
- Valuing embedded liability options
- Asset liability efficient frontier analysis
- Benchmark Portfolios
- Replicating Portfolios

Sample ALM Model

- Liabilities
  - Single premium deferred annuities
  - $454 million reserve
  - $415 cash surrender value
  - $454 fund value
  - Issued over last 8 years
  - Guaranteed credited rates either 3% or 4%
  - 7% initial surrender charge grading to zero over 7 years
- Assets
  - $216 million corporate bonds
  - $64 million mortgage passthroughs
  - $174 million CMOs (Sequentialss and PACs)
Behavior Assumptions

- Assets – bonds calls and mortgage prepayments
  - Callable Bonds
    - Firms make irrational decisions
      - Delay calling in-the-money bonds
      - Call out-of-the-money bonds
  - Residential mortgage pre-payments
    - Outside models (ADCO, BondEdge)
    - Single factor assumptions
    - Impact of economic environment
  - Commercial mortgages
    - Yield maintenance or make-whole provisions

Behavior Assumptions

- Liability - “Excess Lapse” formulas
  - Typically Exponential Formulas
    - Mult * (Comp – Cred - Threshold)^exponent
      - Surrender charge adjustment
      - Lower exponent, higher multiple
  - Considerations in setting parameters
    - Product
    - Distribution System
    - Market
  - Considerations in setting Competitor Rate
Excess Lapse Function

Mult = 2.0  
Exp = 2.5

Mult = 5.0  
Exp = 1.5

Cash Flow Analysis

- Comparing expected cash flows from assets and liabilities
- Should include all cash flows
  - Assets
    - Coupon
    - Calls/Prepayments
    - Adjusted for defaults
  - Liabilities
    - Premium
    - Benefits
    - Expenses
    - Taxes
    - Shareholder dividends?
Cash Flow Projections – Pop Down Scenario

Net Cash Flows – Stochastic Scenarios
Maximum, Minimum, 25 and 75 Percentiles
Duration and Convexity

- **Duration**
  - Negative of the first derivative of the price function with respect to interest rates

  \[
  \text{Effective Duration} = \frac{(P_\text{-} - P_\text{+})}{2P_0 \Delta y}
  \]

  Where
  - \(P_0\) = Bond price.
  - \(P_-\) = Bond price when interest rate is incremented
  - \(P_+\) = Bond price when interest rate is decremented
  - \(\Delta y\) = change in interest rate in decimal form

- **Convexity**
  - Second derivative of the price function with respect to interest

  \[
  \text{Effective Convexity} = \frac{(P_\text{-} + P_\text{+} - 2P_0)}{2P_0 (\Delta y)^2}
  \]

  Where
  - \(P_0\) = Bond price.
  - \(P_-\) = Bond price when interest rate is incremented
  - \(P_+\) = Bond price when interest rate is decremented
  - \(\Delta y\) = change in interest rate in decimal form
Calculating Duration and Convexity

- **Liabilities**
  - Project liability cash flows over arbitrage free stochastic scenarios
  - Use either spot rates or spot rates plus asset OAS to discount cash flows
  - Calculated \( P_- \) and \( P_+ \) by increasing and decreasing starting yield curve

**Issues:**
- Future premiums (especially on flexible premium products) can lead to unusual results

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**Price Function for Assets and Liabilities**

![Price Function Graph](image)

- **Market Value (\$ millions)**
  - Assets: Red Line
  - Liabilities: Yellow Line

- **Interest Rate Change (bp)**
  - Range from -150 to 150
## Asset Duration and Convexity

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Market Value ($ millions)</th>
<th>Duration</th>
<th>Convexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plus 100 bp</td>
<td>144.3</td>
<td>5.7</td>
<td>3.9</td>
</tr>
<tr>
<td>Plus 50 bp</td>
<td>148.5</td>
<td>5.4</td>
<td>-58.2</td>
</tr>
<tr>
<td>Base Line</td>
<td>152.4</td>
<td>5.0</td>
<td>-65.9</td>
</tr>
<tr>
<td>Minus 50 bp</td>
<td>156.1</td>
<td>4.2</td>
<td>-198.9</td>
</tr>
<tr>
<td>Minus 100 bp</td>
<td>159.0</td>
<td>3.4</td>
<td>-95.4</td>
</tr>
</tbody>
</table>

## Liability Duration and Convexity

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Market Value ($ millions)</th>
<th>Duration</th>
<th>Convexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plus 100 bp</td>
<td>143.8</td>
<td>2.2</td>
<td>-66.9</td>
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<tr>
<td>Plus 50 bp</td>
<td>145.3</td>
<td>1.8</td>
<td>-93.7</td>
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<tr>
<td>Base Line</td>
<td>146.5</td>
<td>1.3</td>
<td>-117.8</td>
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<tr>
<td>Minus 50 bp</td>
<td>147.2</td>
<td>0.9</td>
<td>-12.7</td>
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<tr>
<td>Minus 100 bp</td>
<td>147.8</td>
<td>1.0</td>
<td>33.0</td>
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</tbody>
</table>
Valuing Embedded Liability Options

- Example – Partial Free Withdrawals
  - Project average distributable profits with partial free withdrawals over stochastic scenarios (base line)
  - Remove partial withdrawals and adjust credited rate until average distributable profits equal base line
  - Difference in credited rate is the "value" of partial withdrawal benefit
  - Analysis can be extended to any embedded liability option

Asset Liability Efficient Frontier Analysis

- Extension of the efficient frontier from the capital asset pricing model (CAPM)
  - CAPM uses the rates of return on assets and the volatility of those returns to determine "optimal" portfolios
  - Asset liability efficient frontier analysis extends this concept to test various ALM strategies
Methodology

- Define Risk and Return
  - Anything that can be calculated from the projection output  
    - Risk
      - Volatility
      - Number of scenarios with negative present values
      - Number of periods where surplus is negative
    - Return
      - Average present value of distributable profits
      - Number of scenarios where assets under management exceed x dollars

Methodology

- Develop a robust set of strategies
  - Investment
  - Crediting
  - Product design
- Run stochastic projections for each strategy
- Plot risk and return statistics
- Determine efficient strategies
- Decide on acceptable levels of risk and return
Sample

- Define 9 different reinvestment strategies
  - 50/50 5 year A and 5 year BBB corporate bonds
  - High quality (AAA) corporate short
  - High quality (AAA) corporate long
  - BBB corporate short
  - BBB corporate long
  - 100% PAC CMOs
  - 100% Passthroughs
  - 50% PAC CMOs, 50% A corporate long
  - 50% AAA corporate short, 50% BBB corporate long

Sample

- Risk and return statistics
  - Return
    - Average present value of distributable profits at 12%
  - Risk
    - Percentage of quarters with negative statutory profits
Advantages of ALEF Methodology

- Measure the impact of different strategies on key financial metrics
- Definition of risk and return consistent with company objectives
  - Not limited to standard definitions
- Allows for stochastic processes for any assumption
Benchmark Portfolios

- Used to evaluate investment performance
- Historical have been based on broad, market wide indices
  - Lehman (now Barclays) Aggregate index for bonds
  - S&P 500 index for equities
- More recently, companies have been developing customized benchmarks

Developing Customized Benchmark Portfolios

- Quality target
- Sector allocation
  - Option risk
  - Liquidity
  - Regulatory constraints
  - Duration targets
Sample Indices – Barclays Family of Indices

<table>
<thead>
<tr>
<th>Index</th>
<th>Duration</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Treasury</td>
<td>5.32</td>
<td>2.01</td>
</tr>
<tr>
<td>Short Treasury</td>
<td>0.41</td>
<td>0.15</td>
</tr>
<tr>
<td>U.S. Treasury: U.S. TIPS</td>
<td>4.23</td>
<td>3.02</td>
</tr>
<tr>
<td>U.S. Credit</td>
<td>6.32</td>
<td>4.29</td>
</tr>
<tr>
<td>1-3 Yr Credit</td>
<td>2.03</td>
<td>2.28</td>
</tr>
<tr>
<td>U.S. Intermediate Credit</td>
<td>4.38</td>
<td>3.70</td>
</tr>
<tr>
<td>U.S. Long Credit A</td>
<td>12.5</td>
<td>6.01</td>
</tr>
<tr>
<td>U.S. Mortgage Backed Securities</td>
<td>2.92</td>
<td>3.49</td>
</tr>
<tr>
<td>U.S. Corporate High Yield</td>
<td>4.44</td>
<td>9.48</td>
</tr>
<tr>
<td>Municipal Bond</td>
<td>8.24</td>
<td>3.48</td>
</tr>
</tbody>
</table>

Benchmarks by Line of Business

- Linear combination of appropriate benchmarks
- Criteria is desired quality, duration and asset mix
- Can be aggregated across company or used on an LOB basis
Replicating Portfolios

- Definition
  - Portfolio of marketable securities developed to replicate the characteristics of a group of liabilities

Use of Replicating Portfolios

- Performance management
  - Investment strategy benchmarks
- Capital and value calculations
  - Solvency II
  - Economic Capital
- ALM and Risk Management
Process

- Analyze liability characteristics
  - Cash flows
  - Market value sensitivities
- Select securities for replicating portfolio
  - Zero coupon bonds
  - Credit default swaps (to add risk spread)
  - Call and put options (to capture optionally of liabilities)
- Use optimization techniques to select the “best fit” portfolio
  - More art than science

ALM Assumptions

- Asset Options
- Liability Options
Callable Bonds

- Finance theory has shown optimum time to call bond is when it is first in the money
- As usual, reality does not follow theory
  - Firms make irrational decisions
    - Delaying in-the-money calls
    - Calling an out-of-the-money bond
- Implications for asset projection models

Empirical Research

- King and Mauer (2000) examined factors affecting the timing of calls on non-convertible bonds
- Three groups:
  - Called immediately when bond went into the money
  - Called when bond was out of the money
  - Delayed call after bond went into the money
- Significant cost to delaying call
Factors Impacting In The Money Calls

- Opportunity cost of leaving bond outstanding (+)
- Amount of time bond has been in the money (+)
- Slope of the yield curve (+)

Implications For Setting Call Assumptions

- The more calls in are the money, the more likely the bond is to get called
- The longer a bond is in the money, the more likely it is to get called
- Out of the money bonds do get called
Policyholder Behavior Assumptions

- Flip side to call/prepayment assumption
  - Calls and prepayments are the exercise of a call options, usually in a down interest rate environment
  - Interest rate driven surrenders are the exercise of put options, usually in an up interest rate environment
- Usually vary by product type
- Should recognize impact of distribution on policyholder behavior

Types of Policyholder Behavior Assumptions

- Surrenders
- Partial withdrawals
- Flexible premium patterns
  - Higher or lower
- Other
**Typical Formulas**

- Usually compare credited rates with a defined competitor rate
- Competitor rates should reflect competition for funds in the market
  - Other insurance products
  - Money market accounts
  - CDs
- Include an adjustment for the impact of surrender charges
- Usually of the form:

  \[
  \text{Dynamic Lapse} = \text{Multiplier} \times 0.01 \\
  \quad \times [100 \times (\text{Credited Rate} - \text{Competitor Rate})]^{\text{Exp}} \\
  \quad \times (1 - \text{CSV/Fund Value})
  \]

**Excess Lapse Formulas - Parameters**

- Historically, for deferred annuities, multiplier and exponents of 2 and 2
- Recently, trend is towards higher multipliers and lower exponents
  - reducing the exponent reduces the steepness of the lapse curve
Excess Lapse Parameters

- Since the early 80’s, interest rates have exhibited a downward or level trend
  - Very few environments for evaluating excess lapse formulas
- Even with more experience, variety of product features and distribution systems will complicate assumption development process

Using mortgage prepayments to estimate deferred annuity excess lapses

- Extensive data on mortgage prepayments is available
- Although not perfectly analogous, prepayments and excess lapses should exhibit similar patterns
  - Surrender charges can be viewed as cost of refinancing
  - Savings on refinanced mortgage rate similar to increased yield on replacement annuity
Mortgage Refinance Decision - Simple

- Years to break even
  - Cost / monthly savings / 12
- Example:
  - 6% mortgage, $300,000 outstanding, 25 years remaining
    - Payment is $1,932
  - Refinance opportunity
    - 5%, 30 year, $1,610 monthly payment
    - Cost: $2,000
  - Breakeven is about 7 months
  - Ignores additional 5 years worth of payments

Mortgage Refinancing Decision - Actuarial Approach

- Calculate present values under both options
- Select option with lower present value
Mortgage Refinancing – Efficiency Ratio

- Apply this analysis to historical data
  - May have to go back to pre housing bubble for meaningful data
- Develop a function that relates likelihood of refinancing to based on “efficiency ratio”, i.e.

  \[
  \frac{\text{PV of costs after refinance}}{\text{PV of cost before refinance}}
  \]

Extension to Excess Lapse Assumption

- Use efficiency ratio function to develop excess lapse formula
- Differences between annuity surrenders and mortgage refinancing
  - Market conditions
  - Tax impacts
  - Surrender charges
Final Thoughts

- ALM analysis performed over multiple scenarios – actual results occur in one scenario
  - Averages are important, but so are distribution of results
  - Results in the tails can provide useful insights
- ALM is heavily dependent on assumptions
  - Policyholder behavior
  - Asset calls and prepayments
- Good data not always available
  - Use best estimate, but useful to sensitivity test
- The world is always changing – and we only have a rear view mirror

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