Simulink for ALM Modeling

MATLAB Computational Finance Conference
April 2014
Introduction

- **Context – Dynamic Systems all the rage**
  - Interconnectivity matters

- **Scope of the Presentation**
  - 1 week re-build of a model built in 2002-2003
  - Skim-through rather than a deep-dive
  - Results discussed

- **Asset-Liability Modelling**
  - “Financial Circuitry”
  - Modeling workflow
  - Modularizing Modeling
The Asset Liability Problem for Pension Funds and Endowments

- Circa 2002, 2009
  - What ALM?
  - How is it addressed?
  - Why is it important?
  - Why is it difficult to do?
  - Who usually does the work?

- Why should an asset manager care?
  - Conversation leads to sales
  - Understanding the client need
  - Clients did not have the resources
  - Insight into other businesses
Why Simulink?

- Context
- Benefits
- Why do this?

```matlab
P = 100 * cumprod(1 + 0.10 + 0.20 * randn(10,1));
```

```matlab
function P = StockPriceSlow()
    T = 10;
    AUM = 100;
    Exprsk = 0.20;
    ExprRet = 0.10;
    P = zeros(T,1);
    for i = 1:T
        StockReturn = ExprRet + Exprsk * randn(1);
        if i == 1
            P(i) = AUM * (1 + StockReturn);
        else
            P(i) = P(i-1) * (1 + StockReturn);
        end
    end
end
```
The Model – High level Perspective

Wilkie Economic Environment

Portfolio of Assets

NPV Assets

Policy Subsystem

NPV Liabilities

Company Contribution

NPV Assets

Actuarial Employee and Pensioner Subsystem

NPV Total Liabilities

Market Environment

Yearly Employee Contribution

Employee Contributions

Market Environment

Return
Modelling the Market - Environment
Modelling the Market – Long-term Bonds
Modelling the Market – Real Yields
The Model – High level Perspective

Wilkie Economic Environment

Market Returns

Portfolio of Assets

Return

NPV Assets

Policy Subsystem

NPV Liabilities

Company Contribution

NPV Assets

Actuarial Employee and Pensioner Subsystem

NPV Total Liabilities

Market Environment

Yearly Employee Contribution

Employee Contributions

Market Environment
Modelling the Pension System

![Diagram of the Pension System Model]

- **Avg Pension Contribution:**
  - **0.02**
- **Salary Growth Rate:**
  - **0.02**
- **Termination Rate:**
  - **0.05**
- **Recruitment Rate:**
  - **0.03**
- **Retirement Rate:**
  - **0.80**
- **Avg Life Expectancy:**
  - **65**
- **Avg Age of Retirement:**
  - **65**
- **Average Salary:**
  - **In 1**
- **Total Employees:**
  - **In 2**
- **Total Pensioners:**
  - **In 3**
- **Percent of Salary Paid in Pension:**
  - **0.67**
- **Nominal Pensioner Liability:**
  - **In 4**
- **Percent of Salary Paid:**
  - **35**
- **Avg Employee Age:**
  - **In 5**
- **Nominal Employee Liability:**
  - **In 6**
- **Discount Rate (LT Bond Yield):**
  - **In 7**
- **Yearly Employee Contribution:**
- **Average Salary:**
- **Employee Contribution:**
- **Total Employees:**
- **Nominal Pensioner Liability:**
- **Nominal Employee Liability:**
- **NPV of Liabilities:**
- **NPV:**

**The Carlyle Group**
Modelling the Pension System – A Variety of Demographic Modeling

- Salary Growth Rate
- Average Salary
- In1
- Total Employees
- In2
- Employees Retired
- In3
- New Retirees
- In5
- Total Pensioners
- In6
- Average Age of Retirement
Modelling the Pension System – Simple Life Cycle Model

Initial Condition: Current Number of Pensioners

New Retirees

\[ \frac{K T_s}{z-1} \]

Product

Death Rate

Average Life Expectancy

Average Age of Retirement

Total Pensioners
Modelling the Pension System – Complex Actuarial Life Cycle Model
Modelling the Corporate Policy

NPV Assets

Surplus

Gain

Potential Contribution

NPV Liabilities

Funded Ratio

Funded Ratio

Upper Limit

0.8

1.2

Switch

Company Contribution

0

Do nothing

min

max

|u|

OR

NPV Total Liabilities

Support the current

High Cognitive Capability

Market Environment

Value Economic Environment

Portfolio of Assets

Return on Investment

Empirical Contributions

Use colors in preferred order for best results
What did I do with the model?

• Instead of focusing on asset mix studies, we focused on corporate policy to elevate the conversation from the investment team to the “corporate board”
  – Can we suggest an asset mix that minimizes the probability that the corporation will have to intervene in any way over the next 10 years?

• Monte Carlo simulation for long-term buy-and-rebalance strategy
  – Select a random fixed asset allocation, rebalanced yearly, from 1000 possibilities
  – In a 1000 simulations of the model using that allocation, count the instances of intervention
  – Which allocation coincided with the lowest probability of intervention?
  – What the work showed was that it was beneficial for pension funds and endowments to replace higher volatility assets with lower volatility higher Sharpe assets

• Monte Carlo simulation with performance driven feedback
  – For the corporation the asset mix should be counter-intuitively dynamic
    o move towards duration neutrality when the plan does well
    o move towards risk when the plan is under stress

• What happened to the model?
Other finance problems solved with Simulink?

• Structuring
  – Used Simulink to model the NAV of a number of Alpha overlay structures were built in Excel
  – Solved the self-referential issues and enabled Monte Carlo simulation of various covenants and triggers

• Trading
  – Used Simulink to construct a trading engine for single stocks with a technical signal and macro signal solved the forward looking bias
  – Used Simulink to construct a trading engine for a pairs-trade, extension of the last project
  – Was in the process of building a high-frequency trading engine with asynchronous price arrival, never completed

• Stateflow
  – Started looking into Stateflow to model the triggers
Benefits of working with Simulink in Finance

• Credibility
• Marketing
• Conversation
• Modularity
• Recyclability
Diversified Global Asset Management Corporation

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