Stochastic Modelling for Insurance

Economic Scenario Generator
Moody’s Analytics Overview – beyond credit ratings

Research-Led Risk Management Solutions for Financial Institutions
Strong & Growing Presence in the Global Insurance Market

» 200 Insurance Relationships
» 70% of Insurers in Global Fortune 500 clients
» Combine B&H & Moody’s expertise to extend what we offer to the insurance sector
» Focus on supporting the Capital modeling & ERM activities of insurers
» Leveraging both the research expertise and enterprise infrastructure.
Agenda – Stochastic Modelling for Insurance Companies

» Stochastic Modelling for Insurance and Asset Management
  • ESG (Economic Scenario Generator) Overview
  • Different Uses of ESGs

» ESG Model Selection and Calibration

» Stochastic Modelling for Turkish Insurers and Key Challenges

» Update on Solvency II and global regulations
Objectives

» Explain the use of ESG by insurance companies
  – **Market Consistent ESG** for calculating Time Value of insurance options and guarantees
  – **Real World ESG** for internal solvency capital calculation and other applications

» Explain the approach to validating ESGs for insurance companies
  – Choosing the appropriate asset model
    • ESG is NOT a black-box
    • Validation and documentation
  – The challenges for insurance companies (compared to banks)
  – The challenges facing developing markets
  – Answering the challenges for Turkish Insurers

» Update on Solvency II and Global Insurance ERS requirements
Overview – Stochastic Modelling
What are Stochastic Simulations?

» Future is *unknown*

» We may have *expectations* about the future but we are never *certain* about it

» Simulate *many* future scenarios based on mathematical stochastic models

» Use scenarios in *Monte Carlo* simulations by ALM systems

» *Average* of the *Monte Carlo* simulations converge to our expectation
Stochastic Economic Scenario Generator

The ESG uses Monte Carlo Simulation to generate thousands of simulations of risk factors across multiple time periods.

Example: 10-year Spot RateProjected over 5 years
Stochastic Economic Scenario Generator

The ESG uses Monte Carlo Simulation to generate thousands of simulations of risk factors across multiple time periods.

Example: 10-year Spot Rate Projected over 5 years

![Graph showing projected USD 10-Year Nominal Spot Rate with shaded regions and a red line indicating Simulation 348.](image)
Stochastic Economic Scenario Generator

The ESG uses Monte Carlo Simulation to generate thousands of simulations of risk factors across multiple time periods.

Example: 10-year Spot Rate Projected over 5 years
Risk Factors generated by the ESG

» The ESG generates Monte Carlo simulations for the joint behaviour of multiple risk factors:
  - Nominal Interest Rates
  - Real Interest Rates
  - Inflations Indices
  - Equity and dividend returns
  - Property and rental returns
  - Credit Spreads, rating transitions, risky bonds returns
  - Alternative asset returns
  - Interest rate implied volatility and equity implied volatility
  - Exchange rates
  - Macroeconomic indicators such as GDP, wage indices
  - Non market risk such as mortality and lapse rates

» Coherent modelling in Real World and Market Consistent environment
B&H Economy Model Structure

Joint distribution

» Correlation relationships between shocks driving each model

» Economically rational structure
ESG Global Multi Economy Model Structure

INTER-ECONOMY CORRELATIONS

- Equity Returns
- Property Returns
- Alternative Asset Returns
- Corporate Bond Returns
- Real-economy
- Exchange rate

Initial swap and government nominal bonds
Index linked government bonds
Nominal short rate
Real short rate
Realisation and "alternative"

Nominal minus real is inflation expectations
Realised inflation and "alternative"
Foreign nominal short rate and inflation

Credit risk
2014 13
Use of the ESG in the insurance sector

- Calculation of cost of options and guarantees (EV, Fair Value, Best Estimate Reserves)
- Economic Capital calculation
- ALM, Asset Allocation, Business Planning
- Hedging
- Pricing and product development
- Retail advisory
- Technical Provision (Time Value)
- Internal models, ORSA
- Use Test
Stochastic Economic Scenario Generator

Historic Analysis & Expert Judgement

Establish economic targets for factors of interest:
- Interest rates
- Equity
- Credit
- Correlations
- Alternatives

Stochastic Models

Choose models that will best represent the risk factors and the specific modelling problem.

Calibrate – Establish model parameters to meet targets

Multiple Time Steps

Multiple Economies

Correlations

Visualise Output

Validation

Communication
Market Consistent ESG – Example
The best estimate shall correspond to the probability-weighted average of future cash-flows, taking account of the **time value of money** (expected present value of future cash-flows), using the relevant **risk-free interest rate term structure**.

The calculation of the best estimate shall be based upon up-to-date and credible information and realistic assumptions and be performed using adequate, applicable and relevant actuarial and statistical methods.

The cash-flow projection used in the calculation of the best estimate shall take account of all the cash in- and out-flows required to settle the insurance and reinsurance obligations over the lifetime thereof.

**EIOPA Technical Specification 30/04/2014**

**TP.2.102.** The best estimate of contractual options and financial guarantees should reflect both the intrinsic value and the time value.
Valuation of Path Dependent Insurance Liability
Deterministic Market-Consistent Roll Forward Using Risk-Free Rates

Solvency II Liability of an Insurance guarantee

TVOG of the guarantee

Intrinsic Value of the Guarantee

Risk-free Roll-Forward Deterministic Value

Intrinsic Value = 0
Valuation of Path Dependent Insurance Liability
Run ALM Many Times Using Stochastic Market-Consistent Scenarios

- Average value represents stochastic value
- The difference between the stochastic value and the intrinsic value is the time value
Real World ESG – Example
Example Use – Determine the tail for SCR

- Real World ESG models are calibrated to realistic distributional targets
- Probability distribution of risk factors (equity, interest rates, etc) translated into probability distribution of the Net Asset Value

- Holistic approach captures dependency between risk factors
- Internal model approach also contains Use Test information such as risk exposure decomposition and reverse stress test material.
**Approach (1): Stress and Correlate**

**Capital Aggregation Correlation Matrix**

*Capital Aggregation Matrix does not reflect actual correlations between risk factors*

**Risk Capital**

**Problems:**

» Does not capture dependency effects that are firm specific

» Capital aggregation matrix requires subjective input and does not reflect actual correlations between risk factors
Approach (2): Holistic Balance Sheet

- **Interest Rate**
  - Shift
  - Twist
- **Equity/Property**
  - Level
  - Volatility
- **Credit**
  - Spread Level
  - Transitions
- **Other Markets**
  - FX
- **Non ESG Risks**
  - Catastrophe
  - Operational
  - Longevity
  - Mortality
  - Lapse
  - Expense
  - Morbidity
  - Liquidity

**ESG dependency**

**RSG dependency**

**Cashflow engine**

» Risk Capital reflect company specific risk profile

» Contains useful metrics beyond Stress and Correlate approach

- Probability of insolvency
- Upside potential statistics
- Conditional tail expectation

Risk Cap
Solvency Capital / Economic Capital

» Capital allocation
  • By risk factors
  • By line of businesses/products

» Capital efficiency through optimising
  • Investment strategy
  • Management action
  • New business strategy
  • M&A strategy

» Risk framework that are specific to the insurance company
  • Specific to risk profile and cashflow of the company
  • Provide financial confidence internally and externally
Other uses of Real World ESG

Experience from B&H

Strategic Asset Allocation and Portfolio Optimisation

» Maximises investment returns
  • Minimises volatility
  • Minimises VaR
  • Minimises risk capital

» Used by insurance companies (life and non-life), pensions funds and asset managers

ALM Hedging

» Matching investment strategies to liability profile

Retail Advisory

» Spectrum charts instead of simplistic “high-medium-low” numbers

» Welcomed by regulators and policyholders for increased transparency
Choosing Stochastic Models
### Stylised Facts & Data

Goal is to produce **realistic** and **justifiable** projections of financial and macroeconomic variables.

Use all credible historical **data**, market expectations via **options** and expert **judgement**.

Our approach involves 3 main activities:

1) Developing and documenting a set of stylized facts and beliefs.
2) Use these to select/build/structure, calibrate and validate models.
3) Look at real world markets to validate and review the stylized facts and models.

These are all ongoing activities:

» Frequent calibration

» Regular Real World Target updates and methodology reviews
Weighting Schemes & Data

Calibration is an art

- Subjectivity in: data sources, data policies, weighting, judgement

Goal is to produce realistic and justifiable projections of financial and macroeconomic variables.

Use all credible data available:

- Combine with market data of expectations: e.g. option implied volatility, consensus data
- Filter and clean data: liquidity of instruments, depth of market
- Exponentially-weighted moving average ensures more weight is placed on recent observations
- Consistency across asset classes
Models & Calibrations

- **Interest Rates**
  - Vasicek
  - Black-Karasinski
  - Cox-Ingersoll-Ross
  - Libor Market Model

- **Equity Indices**
  - Time varying deterministic volatility
  - Stochastic Volatility Jump Diffusion
  - Constant Volatility

And others for credit, inflation, exchange rates, MBS, derivatives etc.

All models documented in academic literature and MA research papers
Interest rates: Model Choices

» Black-Karasinski
  - Short rate model – describes the short rates from which the entire yield curve is derived (+ term premium)
  - Based on a simple and plausible short rate dynamic but limited capacity to fit simultaneously to a large number of market prices
  - Understanding/Communication relatively simple

» Libor Market Model (LMM)
  - “Heath-Jarrow-Morton” family of model – direct modelling of the forward rate curve
  - Extremely flexible – able to fit to a very large number of market prices
  - More complex than Black-Karasinski
  - Recommended for Market-Consistent valuations

» LMM+
  - Extension of LMM model
  - Stochastic Volatility
  - Integrate a displacement parameter to reach any distribution between normal and log-normal
  - Can model the entire implied volatility cube of interest rates
Equity model choices

» Modelling of *excess returns* of equities

» Basic model
  – Lognormal (constant volatility)

» Advanced Market Consistent models
  – Lognormal (time varying volatility)
  – Stochastic Volatility with jump diffusions (SVJD)

» Advanced Real World modelling
  – Heavy tails / skewness
  – Stochastic Volatility with jump diffusions (SVJD)
Credit modelling in the ESG

» Reduced form model – extended Jarrow Lando Turnbull (JLT)
  – Econometric model
  – Default probabilities, spreads, transitions, bond pricing
  – Ratings based with transition matrix and stochastic process

» Credit transitions / defaults linked to equity market returns

» Stochastic behaviour of spreads

» Flexible modelling framework – wide range of credit risky asset classes:
  – Municipal bonds (together with Green’s model to allow for tax effects)
  – Credit risky sovereign debt (→ Eurozone)
  – Option adjusted spread modelling for ABS (e.g. CMBS, RMBS, …)
Stochastic projection of spreads - example

AAA
Percentiles 99% to 95%
Percentiles 95% to 75%
Percentiles 75% to 50%
Percentiles 75% to 50%
Percentiles 25% to 5%
AAA
End Jun 2008
(95bps)
Knowledge transfer

» MA/B&H ESG is NOT a black box.
  - Transparency is a core value to the B&H services

» Knowledge transfer is provided through
  - ESG trainings
  - Bespoke trainings/workshops
  - Detailed model documentations
  - Calibration reports (economic analysis + validation reports)
  - ESG Users group meetings (current topics and presentation of new models)
  - Access to online research library
  - Access to technical support
Knowledge Database

Knowledge Base

Browse by...

Search Knowledge Base

Barrie & Hibbert Knowledge Base

Through our work with clients on specific issues, we frequently uncover revealing insights about some of the major challenges facing whole sectors.

Wherever possible we share our research with our clients and more widely to stimulate debate and discussion. This type of dialogue is not just about providing thought leadership, it’s also an important way to refine our research and models while continually enhancing the value of our work for all our clients.

We store all our research in the Barrie & Hibbert Knowledge Base. Anyone can view the Knowledge Base and its document.

» Models methodologies, Economic research,

» Calibration documentation and Technical Advisory Panel
2.2 Calibration method

Using the fact that spread is an increasing function of $\tau$ value (with all other parameters fixed), we can write the cumulative distribution function of spread in terms of the cumulative distribution function of $\pi$ as follows:

$$Pr[S < s] = Pr[S(\tau) < s] = Pr[\pi < \pi^{-1}(s)] = F(\pi^{-1}(s))$$

where $F$ is the cumulative distribution function of the non-central chi-squared distribution and $\pi^{-1}(s)$ is the $\pi$ value corresponding to the spread level $s$, obtained by numerical inversion of the relationships above (spread=default probability-> $\pi$).

Similarly, any desired percentile of the spread distribution can be found by computing the corresponding percentile of the $\pi$ distribution and converting that it value to a spread.

Since our calibration targets are expressed in terms of moments of the spread distribution (i.e., average and standard deviation), we use the following expression for the $p^{th}$ moment:

$$E[S^p] = \int_0^\infty xe^{x} Pr[S > x] \, dx$$
The ESG proposition of B&H

» **Software**
  - Professional software, Intuitive User interface
  - Compatible with many operating systems and ALM solutions
  - Includes an API
  - Grid computing

» **ESG modelling**
  - Joint stochastic modelling of multiple assets, multiple economies, multiple use
  - Bond portfolios and composite portfolios
  - MBS and derivatives (FRNs, swaps, swaptions, options…).

» **Calibration Services**
  - Standard calibrations for a variety of economies and variety of assets
  - Bespoke calibrations services
  - Access to calibrations tools
  - Economic research
  - Automation platform

» **Support, maintenance, training**
  - Support
  - Training
  - Documentation
  - Maintenance services
Key Challenges for Turkish Insurers
Challenges for Insurance Companies

Banking models as insurance ESGs?

» Insurance cashflows are **long term** compared to banks

» Insurance balance sheet much more stable than banking balance sheet in the short term but more **prone to long-term risks**
   
   • **1-year VaR** is a very popular metric for insurance companies

» Need to capture diversification benefit (dependencies are important)

» 1 day VaR cannot be extended into 1 year VaR by scaling
   
   • Asset returns are not Markov processes according to historical observations
     o **Volatility clustering**
     o **Mean reversion**

   • Daily statistics are not representative for annual statistics

   • Introduces error term by scaling 1-day VaR into 1-year VaR

**Answering the challenge:**

» Insurance specific asset models, designed for long term time horizons
More Challenges for Insurance Companies (Life)

More complexity for life insurance balance sheets

» **Asset and liability cannot be separated**
  - Interest rates affects both bond prices and market-consistent liability value
  - Investment return **guarantees** with life insurance business
  - Or policyholder options (e.g. partial lapse, conversion, fund switches)
  - These options and guarantees are **non-hedgable** using exchange-traded instruments
    - They are very long term in nature
    - Insurance guarantees are usually complex and cannot be replicated using market instruments
    - Over-the-counter instruments contain thick margins and the true market-value cannot be observed

» **Asset and Liability need to be stressed simultaneously**

**Answering the challenge:**

» Stochastic simulation captures dynamic behaviours (Asset-Asset, Asset-Liability)
» Stochastic models calibrated to market prices to maintain market-consistency
Challenges in Developing Markets

Mathematical assets need to be calibrated to market data (bond yields, equity prices, etc)

» Lack of good quality data
  • Data coverage is not consistent
  • Market data does not have long enough history
  • Lack of liquidity in certain parts of asset market
    o Affects frequency of data
    o Bid-Offer spread/transaction costs mask the underlying market values

» High volatility challenges the stability of results

Answering the challenge:

» MSCI Index across all economies for consistent and comparable data
» Adjust weighting scheme to reflect the shorter data history
» Set global targets to make economic sense of the stochastic scenarios instead of blindly calibrating to poor quality data. B&H provides model calibrations to 28+ economies.

Example: TRY Equity

<table>
<thead>
<tr>
<th>Index</th>
<th>MSCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data since</td>
<td>1988</td>
</tr>
<tr>
<td>EWMA Average</td>
<td></td>
</tr>
<tr>
<td>Data Age</td>
<td>12.5 years</td>
</tr>
<tr>
<td>End 2013 LT</td>
<td></td>
</tr>
<tr>
<td>Volatility Target</td>
<td>41%</td>
</tr>
</tbody>
</table>
Insurance capital should also cover non-market risks/insurance risks

» Non-market risks often only affect the Liability side of the balance sheet

» Quite often insurance companies model non-market risks and market risks independently

• But need to bear in mind potential dependencies. E.g. equity risks and lapse risks
Solvency II Update and Moody’s Analytics ERS Solutions
Evolving Common Global Standard For ERM

» SII in Europe (Expected Jan 2016)
» IAIS Common Principles
» Global ORSA standards NAIC, EIOPA, OSFI
» Many challenges
  » Data
  » Capital Measurement
  » Multi year projection
  » Reporting
» Multi year journey for both insurers and regulators
Overview of MA ERS Insurance Proposition

RiskIntegrity Suite

- Capital & Solvency Measurement
  - Regulatory Capital & Reporting
  - Internal Capital & Solvency Measurement
  - Limits Monitoring
  - Proxy Modelling
- Capital & Solvency Management
  - Multi year projection
  - Stress & Scenario Testing
  - Multi-timestep proxy modelling
  - What if and mgmt action
  - Hedging
- Portfolio Management
  - Linking capital with portfolio management
  - Portfolio Construction, Pre trade modeling
  - Post trade risk governance
- Pricing & Underwriting
  - Linking Capital with Pricing
  - Financial Option & Guarantee pricing
  - Capital adjusted risk based pricing

Modular Enterprise Risk Management Platform

Financial & Risk Datamart

Data, Research, Expert Content

Scenario Generation Solutions & ECCA

Economic Forecasting & data
Economic Scenarios & data

Application Research

Credit Models & Data
Question and Answer
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