MOODY'S ANALYTICS

Stochastic Modelling for Insurance

Economic Scenario Generator

Jonathan Lau, FIA, Solutions Specialist
Jonathan.Lau@Moodys.com

5 June 2014

Moody's Analytics Overview – beyond credit ratings

Moody's

Moody's Analytics

Moody's Investors Service

2002	2005	2008	2011
K·M·V	Economy·com	Fermat	barrie+hibbert A Moody's Analytics Company
Quantitative Credit Analysis	Economic Analysis	ERM Software	Insurance Specialist

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 Captial 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

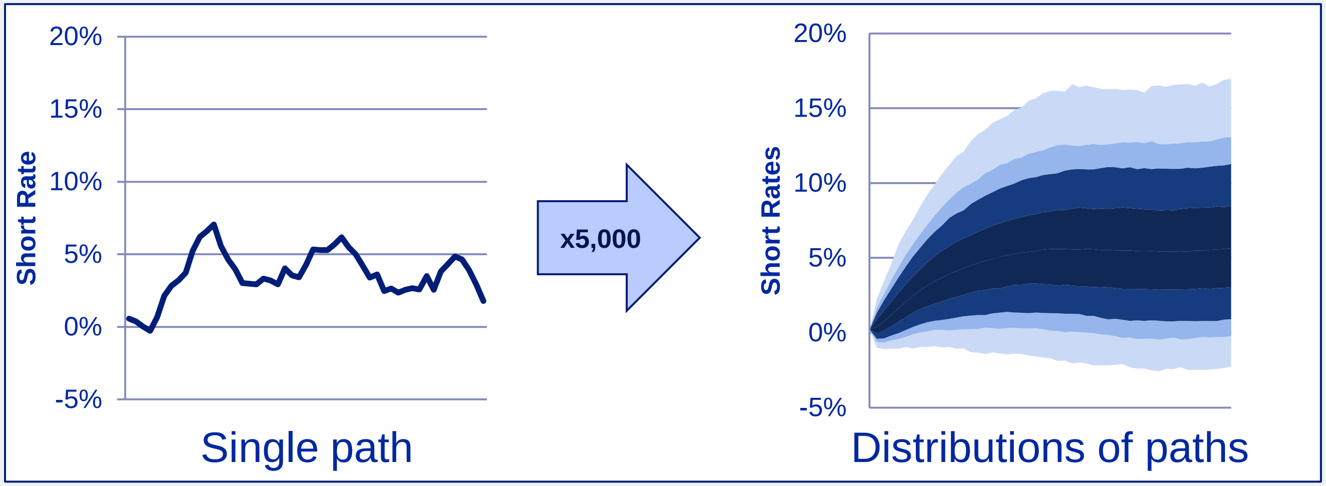
Objectives

- 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

1 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

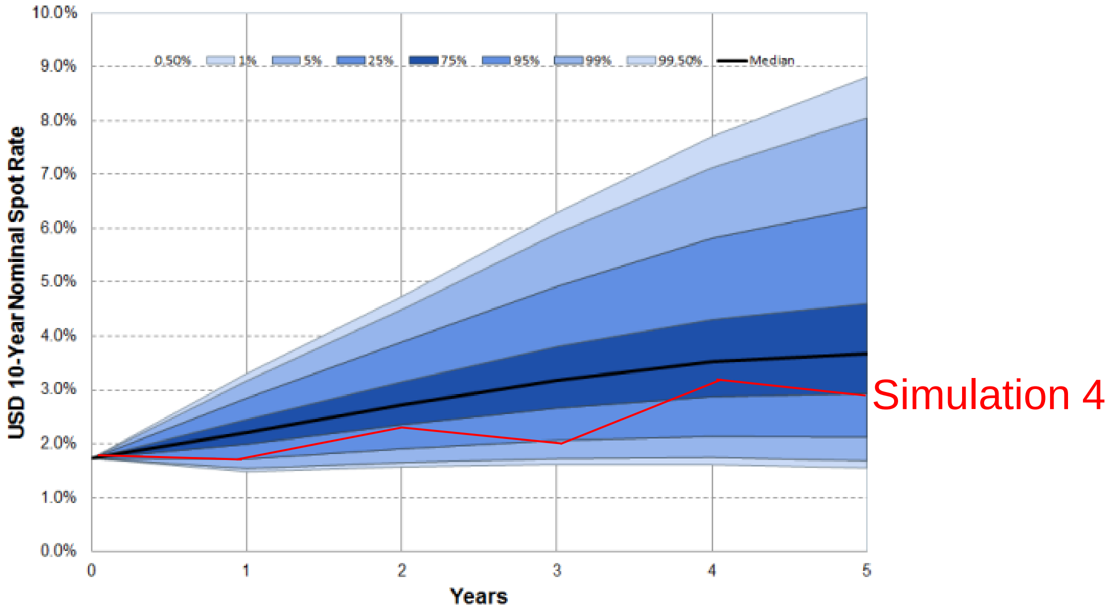


Economic Scenario Generator

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



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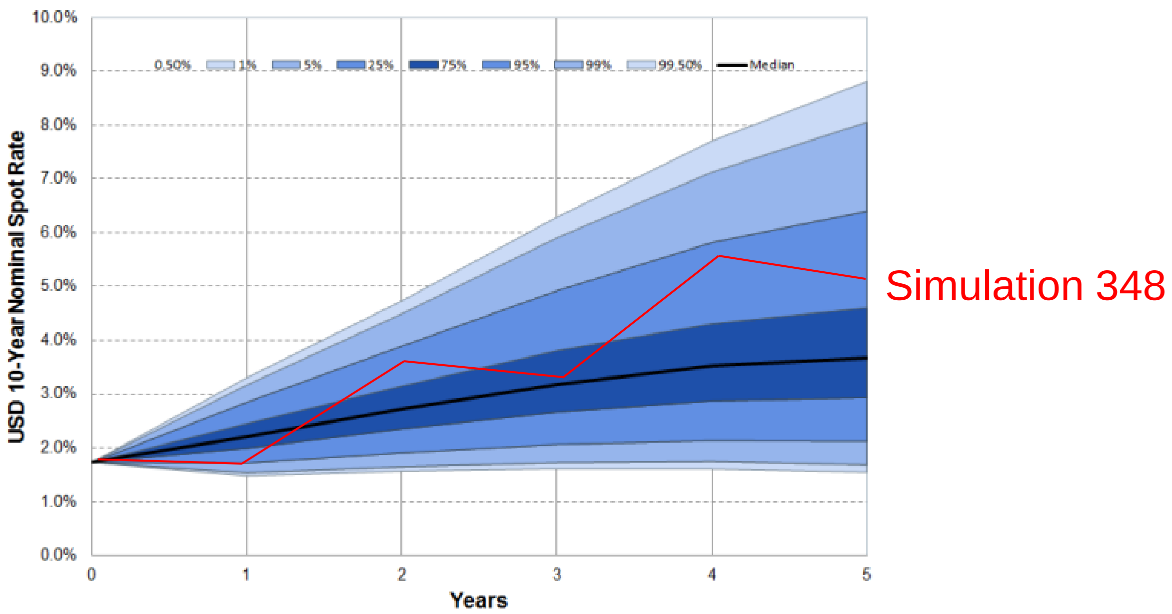

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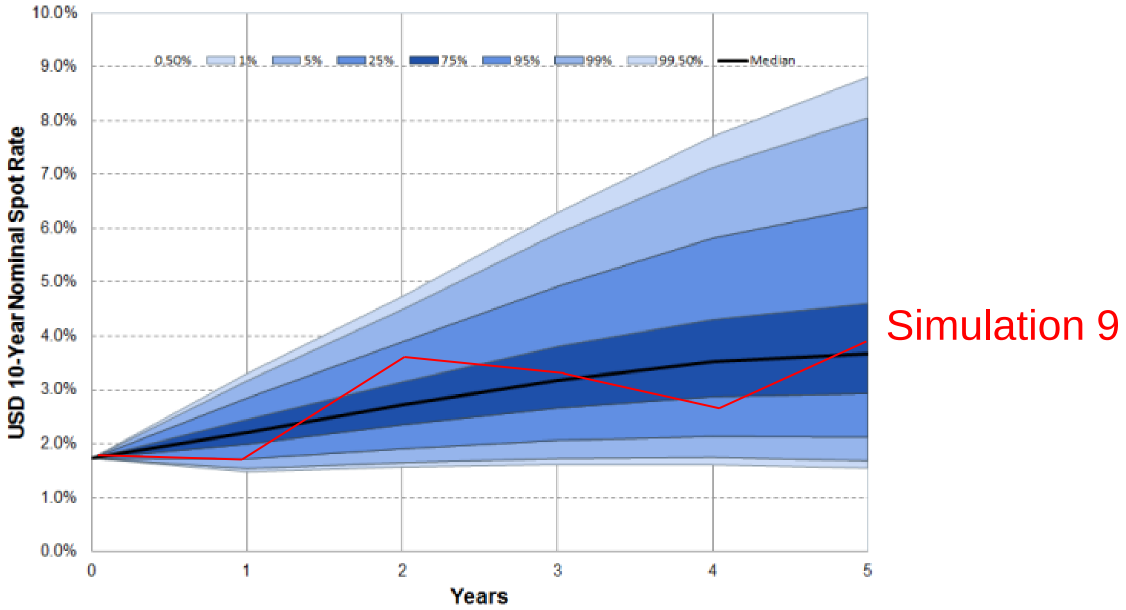
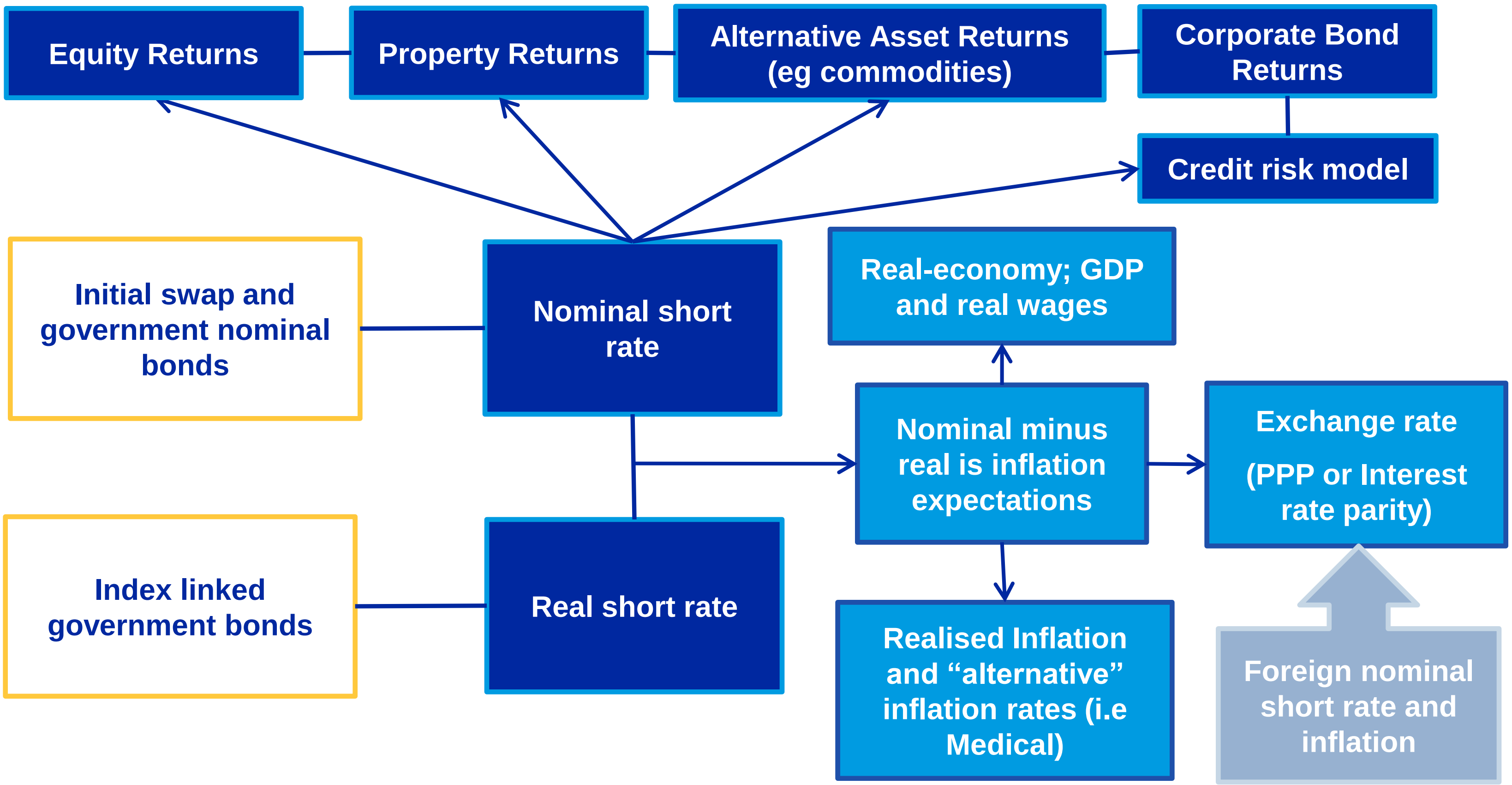


Risk Factors generated by the ESG

- 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

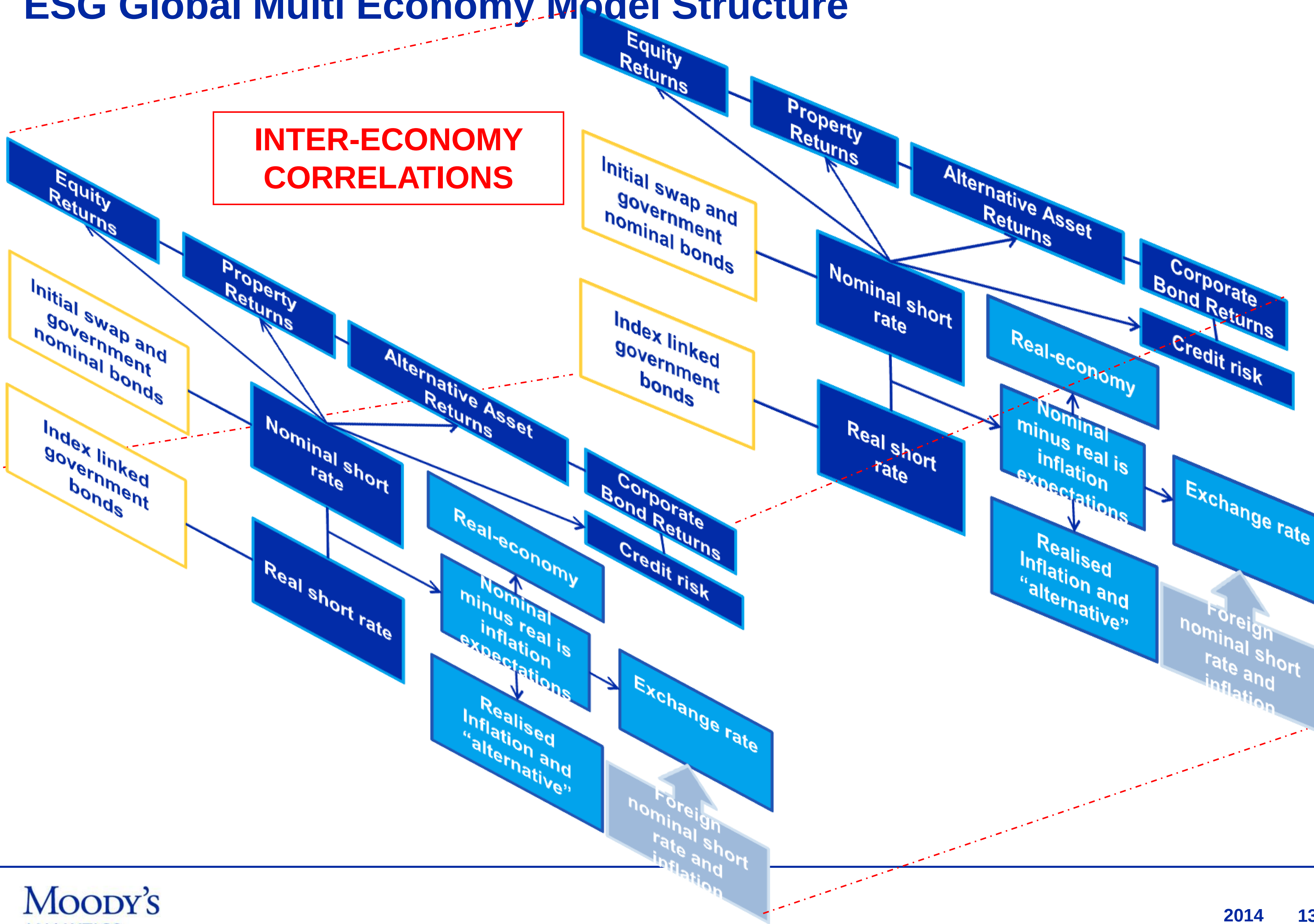


Joint distribution

» Correlation relationships between shocks driving each model

» Economically rational structure

ESG Global Multi Economy Model Structure



Use of the ESG in the insurance sector

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

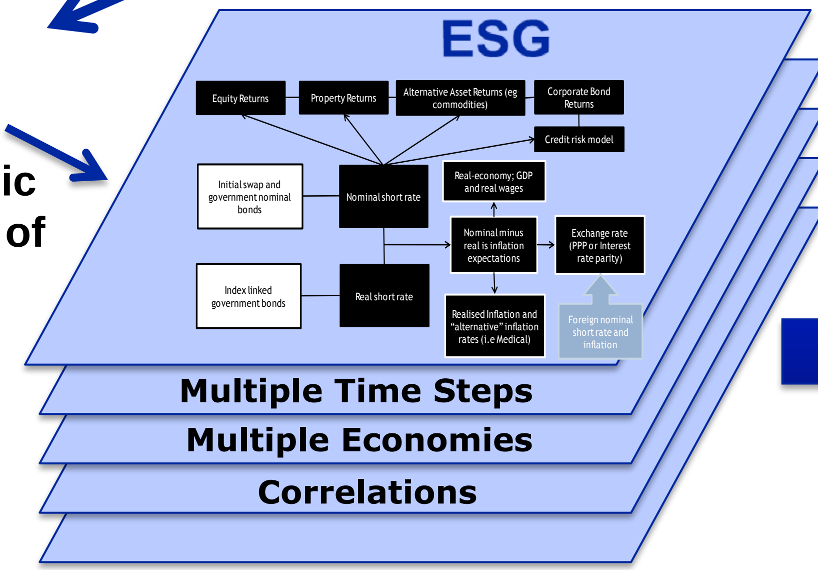
Stochastic Economic Scenario Generator

Historic Analysis & Expert Judgement

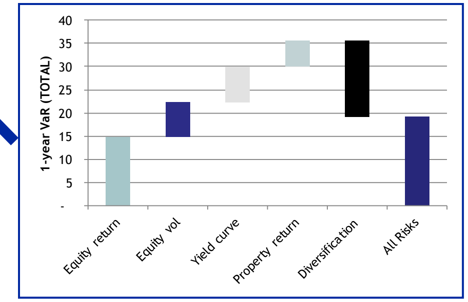
Establish economic targets for factors of Interest:
- Interest rates
- Equity
- Credit
- Correlations
- Alternatives

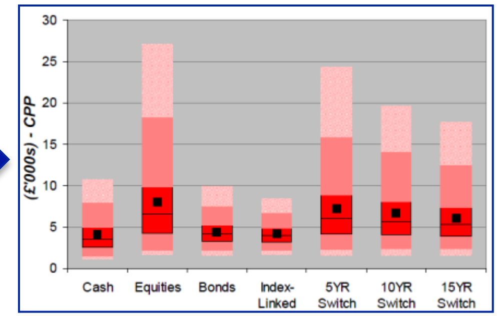
Stochastic Models

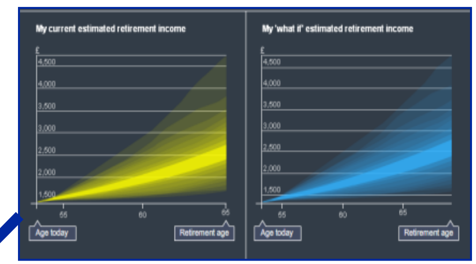
Choose models that will best represent the risk factors and the specific modelling problem.



Calibrate – Establish model parameters to meet targets







Visualise Output Validation Communication

Market Consistent ESG – Example

Article 77(2), DIRECTIVE 2009/138/EC *25 November 2009*

Example from Solvency II

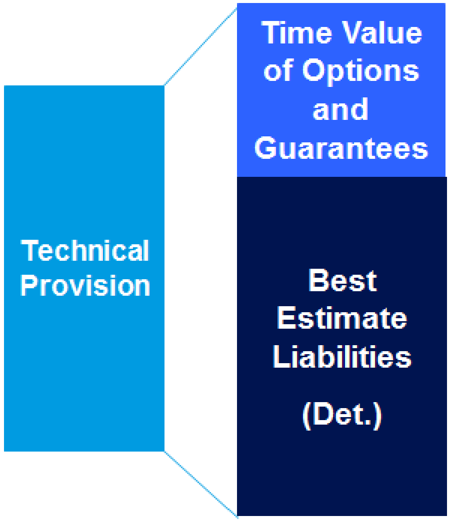
The best estimate shall correspond to the probability-weighted average of future cash-flows, taking account of the **time value of money** (expected present value of future cash-flows), using the relevant **risk-free interest rate term structure**.

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.

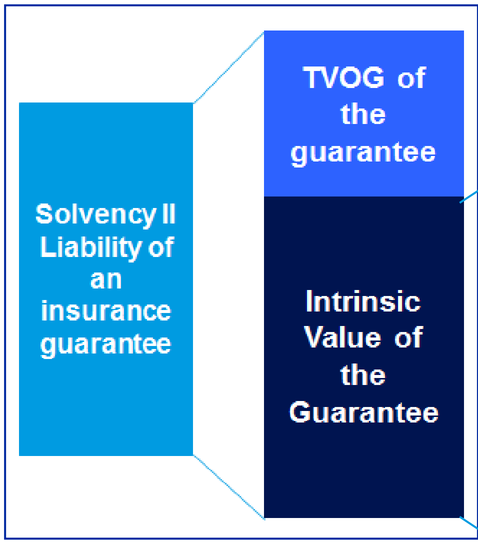
EIOPA Technical Specification 30/04/2014

TP.2.102. The best estimate of contractual options and financial guarantees should reflect both the intrinsic value and the time value.



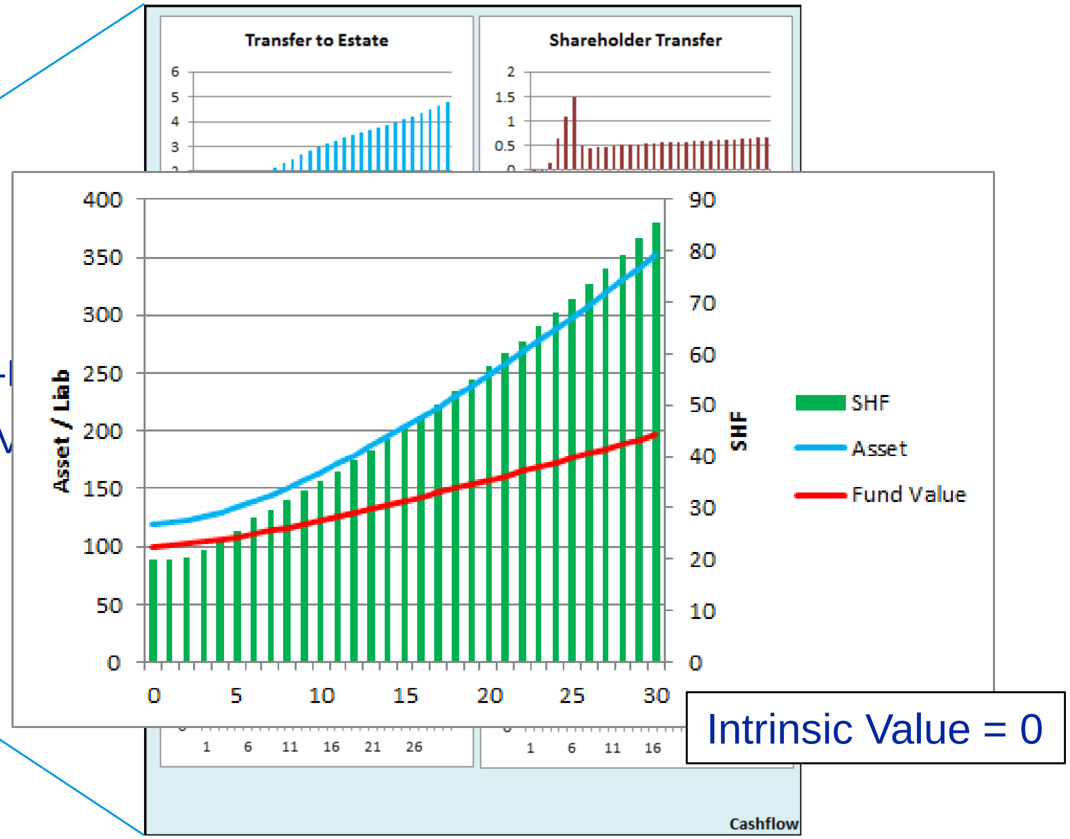
Valuation of Path Dependent Insurance Liability

Deterministic Market-Consistent Roll Forward Using Risk-Free Rates



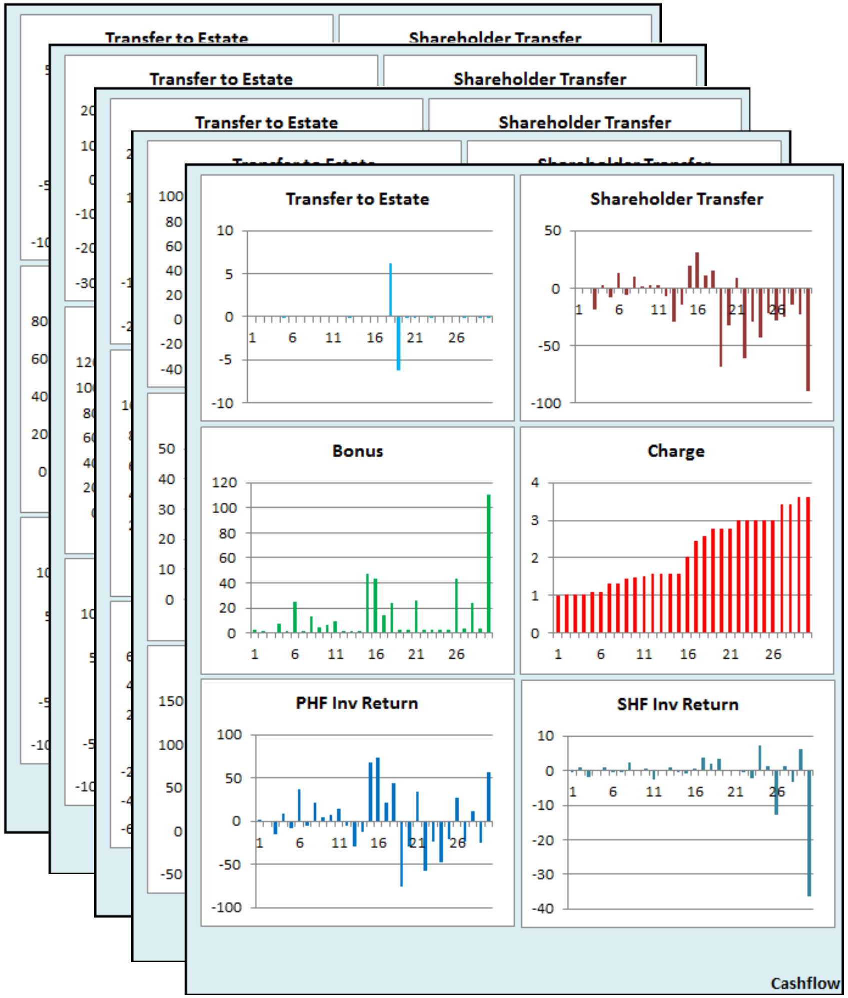
Risk-free Roll-I

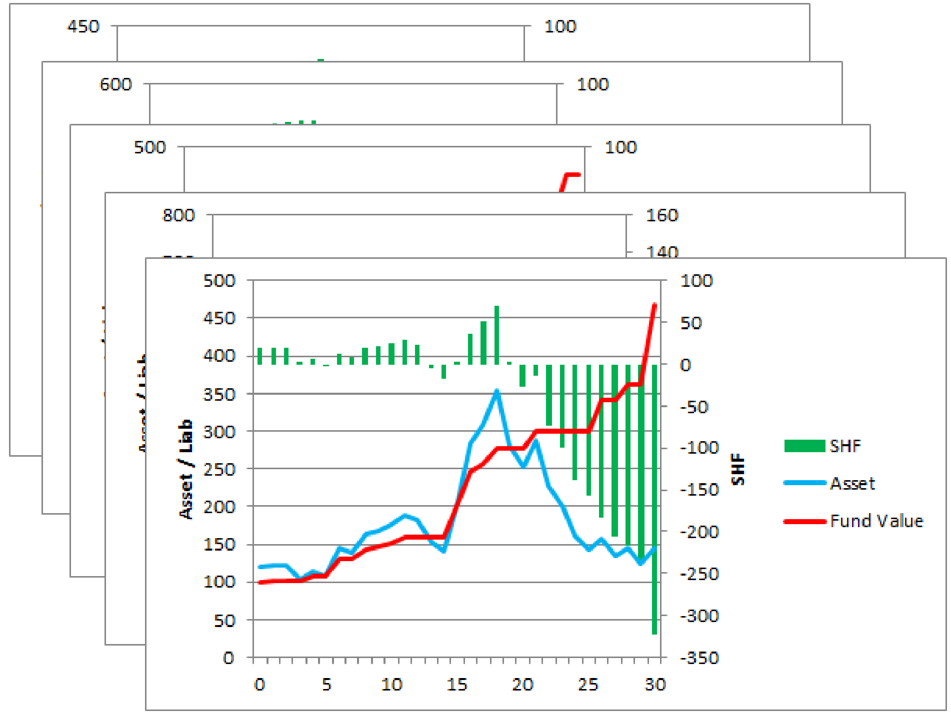
Deterministic V



Valuation of Path Dependent Insurance Liability

Run ALM Many Times Using Stochastic Market-Consistent Scenarios





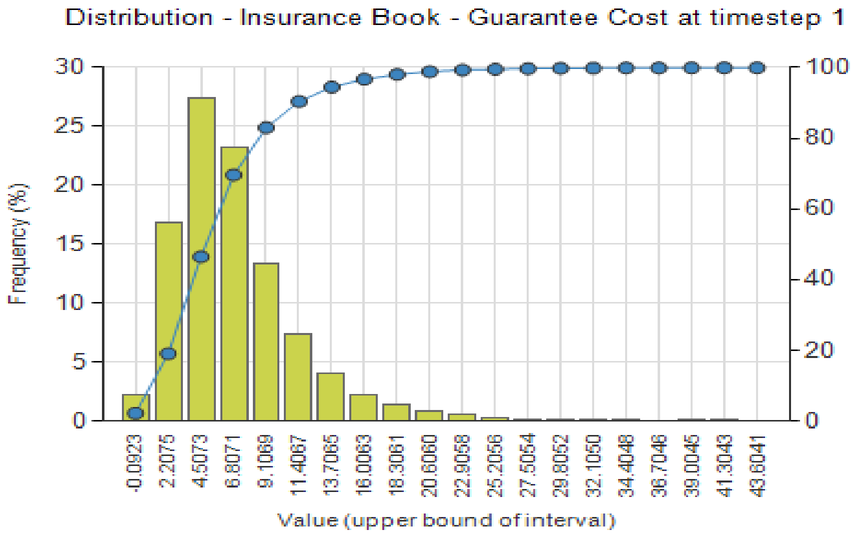
» **Average value** represents stochastic value

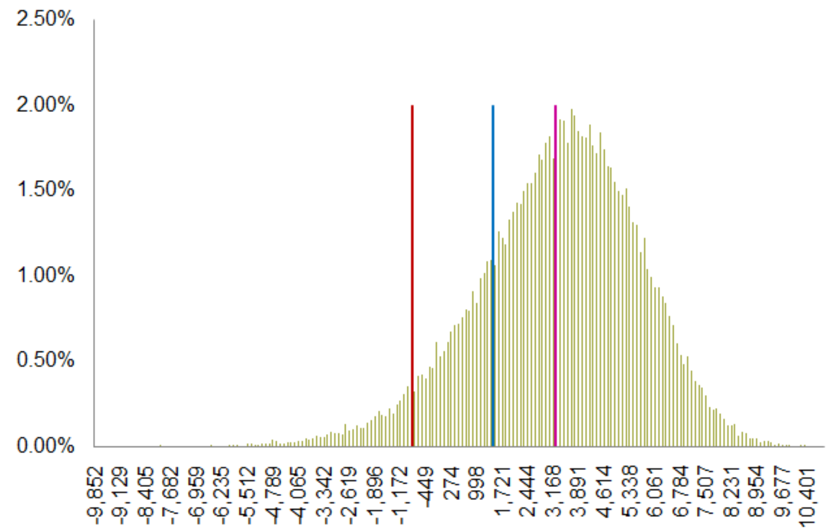
» The **difference** between the stochastic value and the intrinsic value is the **time value**

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

Interest Rate	Equity/Property	Credit	Other Markets
Shift	Level	Spread Level	FX
Twist	Volatility	Transitions	
Curvature			
Volatility			

Non Market Risks		
Catastrophe	Longevity	Lapse
	Mortality	Expense
	Morbidity	

V@R

IR	Eq	Credit	Misc
22,515,826	74,565,212	5,123	0
54,486,312	58,321,588	551,314	
484			
224,182			

V@R

UW - NL	UW - Life	Lapse	Expense
1,561,516	546,546	5,465,412	4,462,132
2,651,684	9,851,951	-5,568	
93,232			
961,323			
88,896			

Capital Aggregation Correlation Matrix*

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

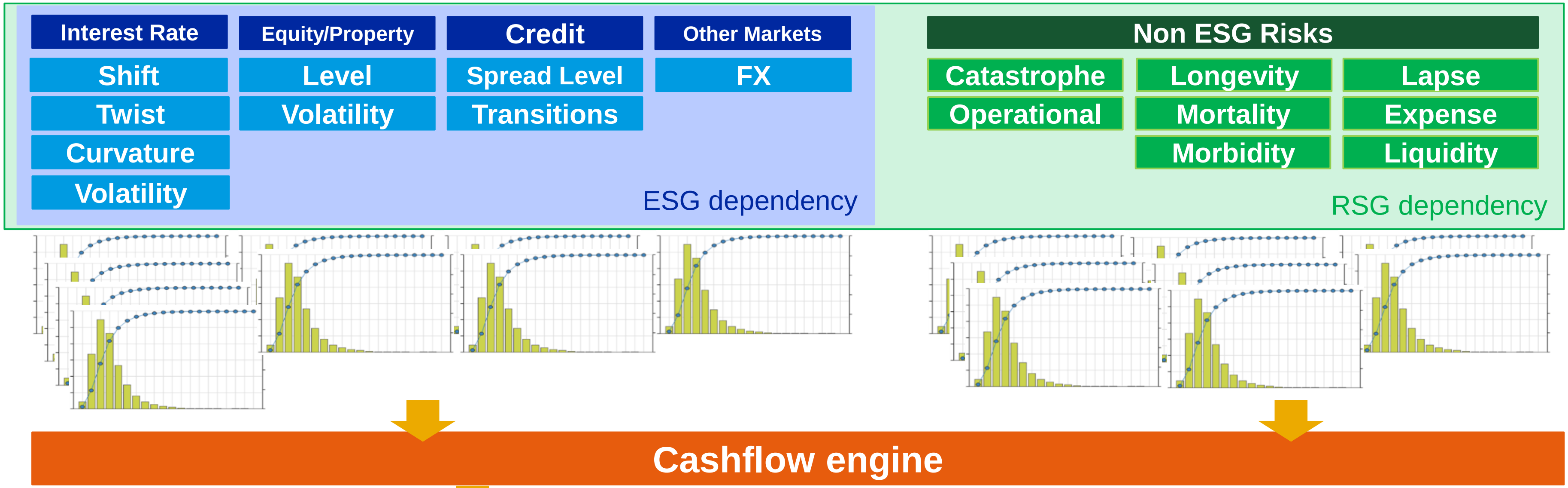
Risk Capital

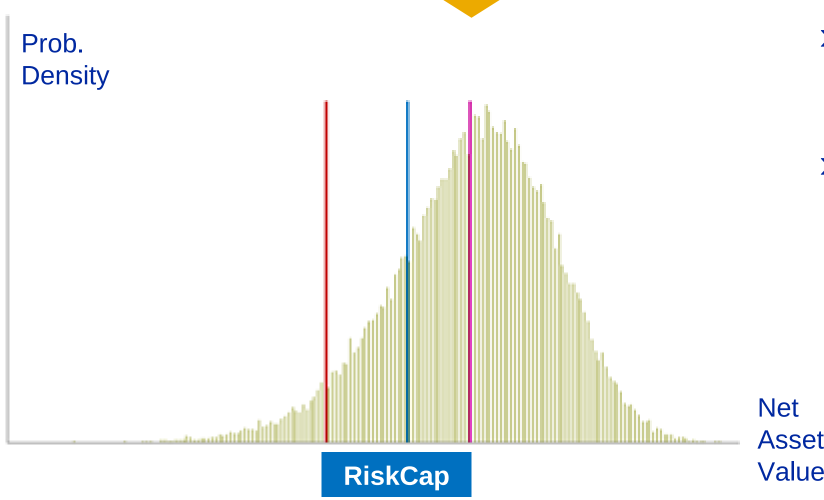
Problems:

» 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



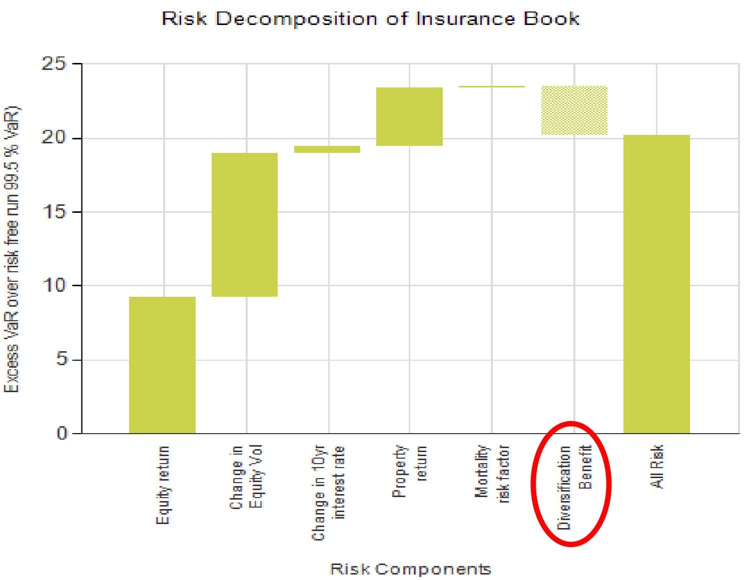


» Risk Capital reflect company specific risk profile

» Contains useful metrics beyond Stress and Correlate approach

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

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

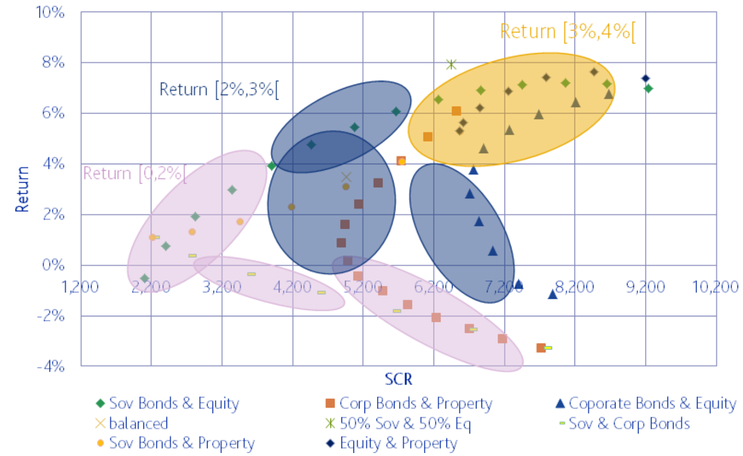
Other uses of Real World ESG

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



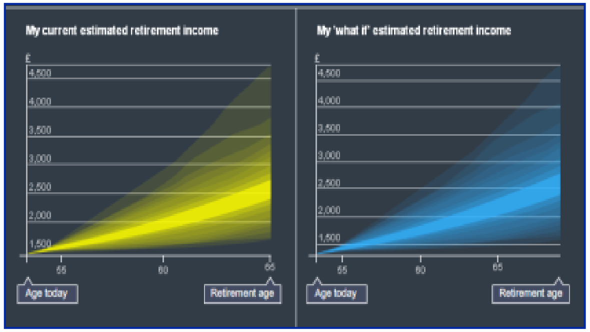
ALM Hedging

» 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



2 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

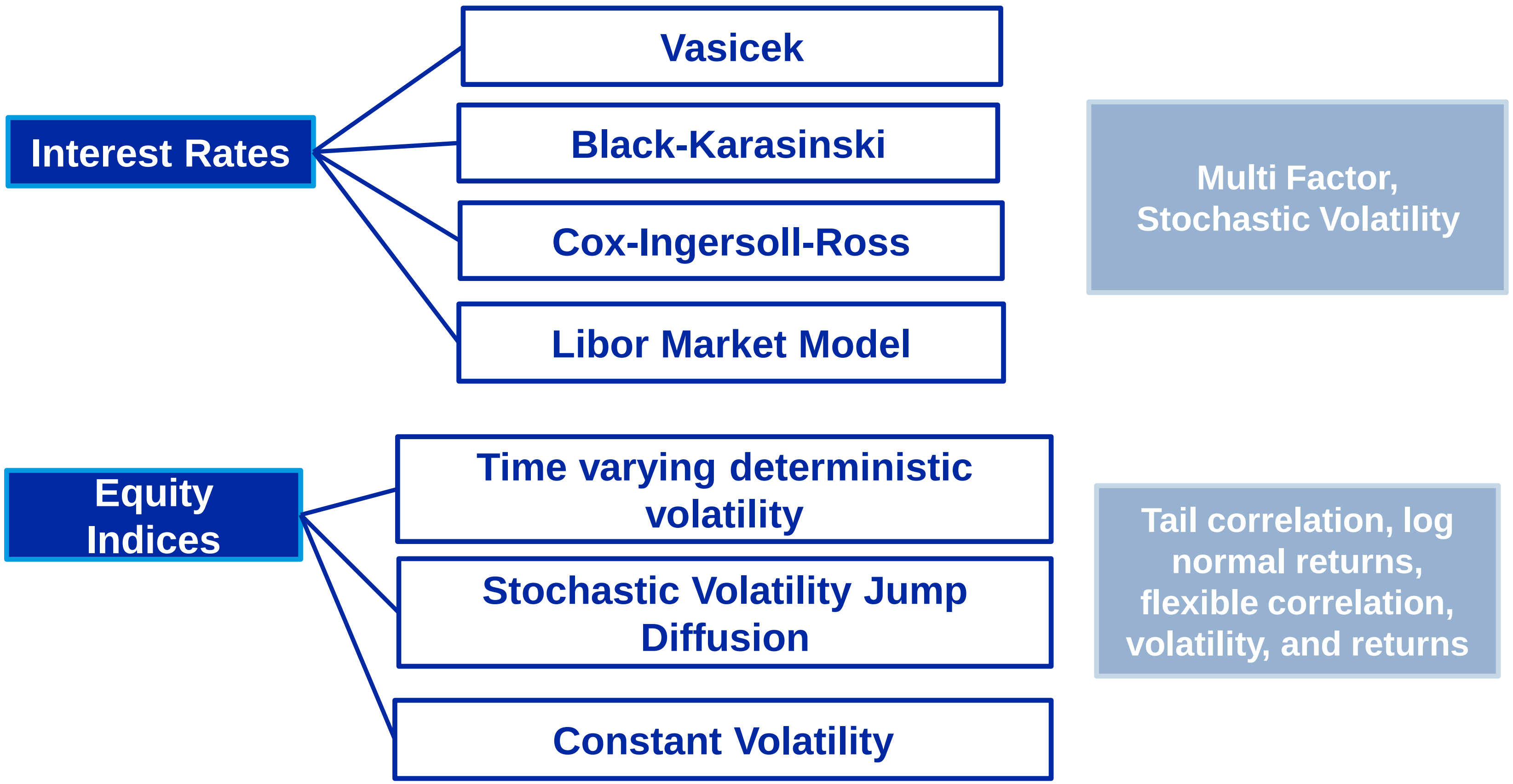
- Subjectivity in: data sources, data policies, weighting, judgement

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



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)

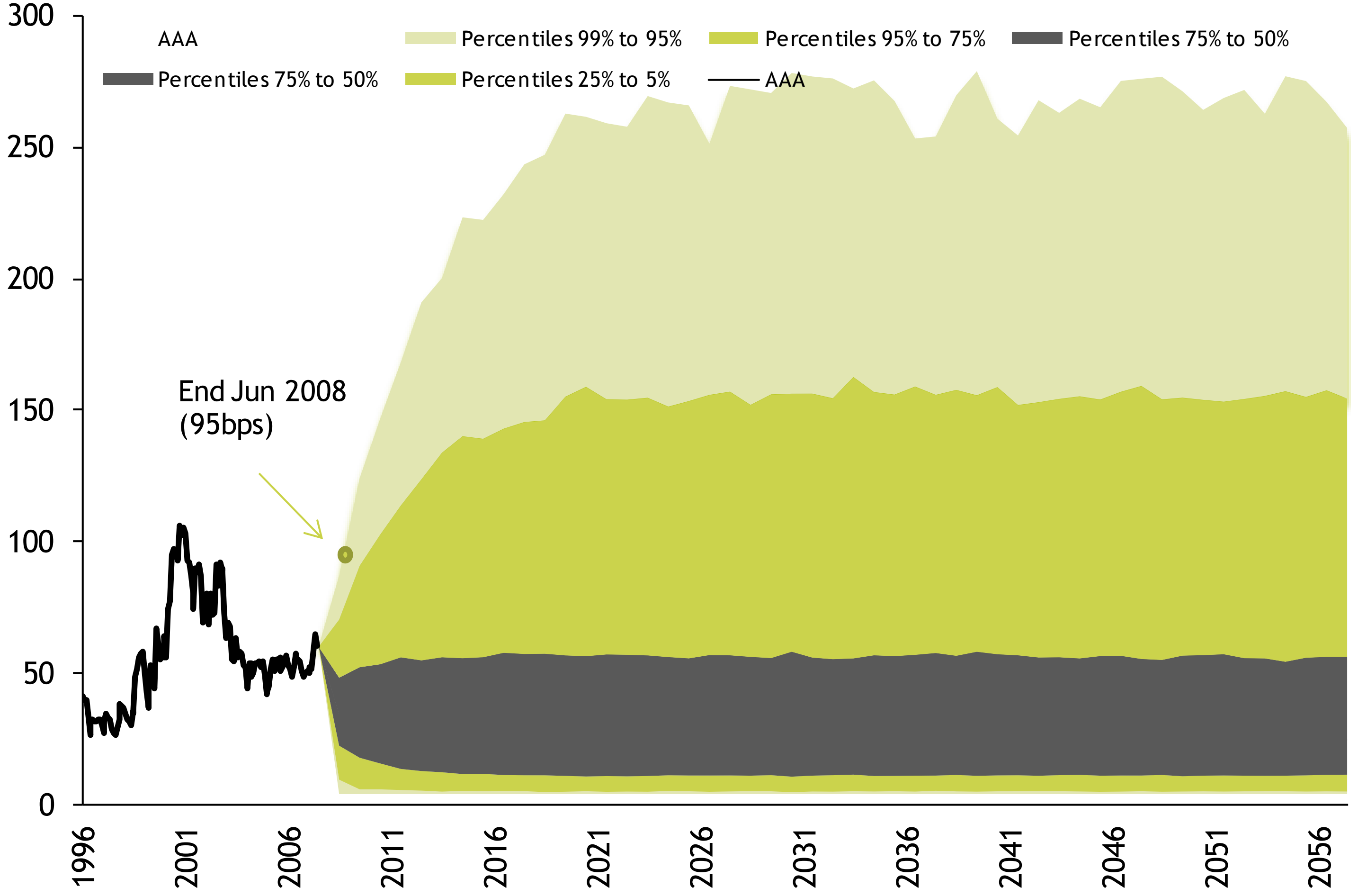
- Advanced Market Consistent models
  - Lognormal (time varying volatility)
  - Stochastic Volatility with jump diffusions (SVJD)

- 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, …)

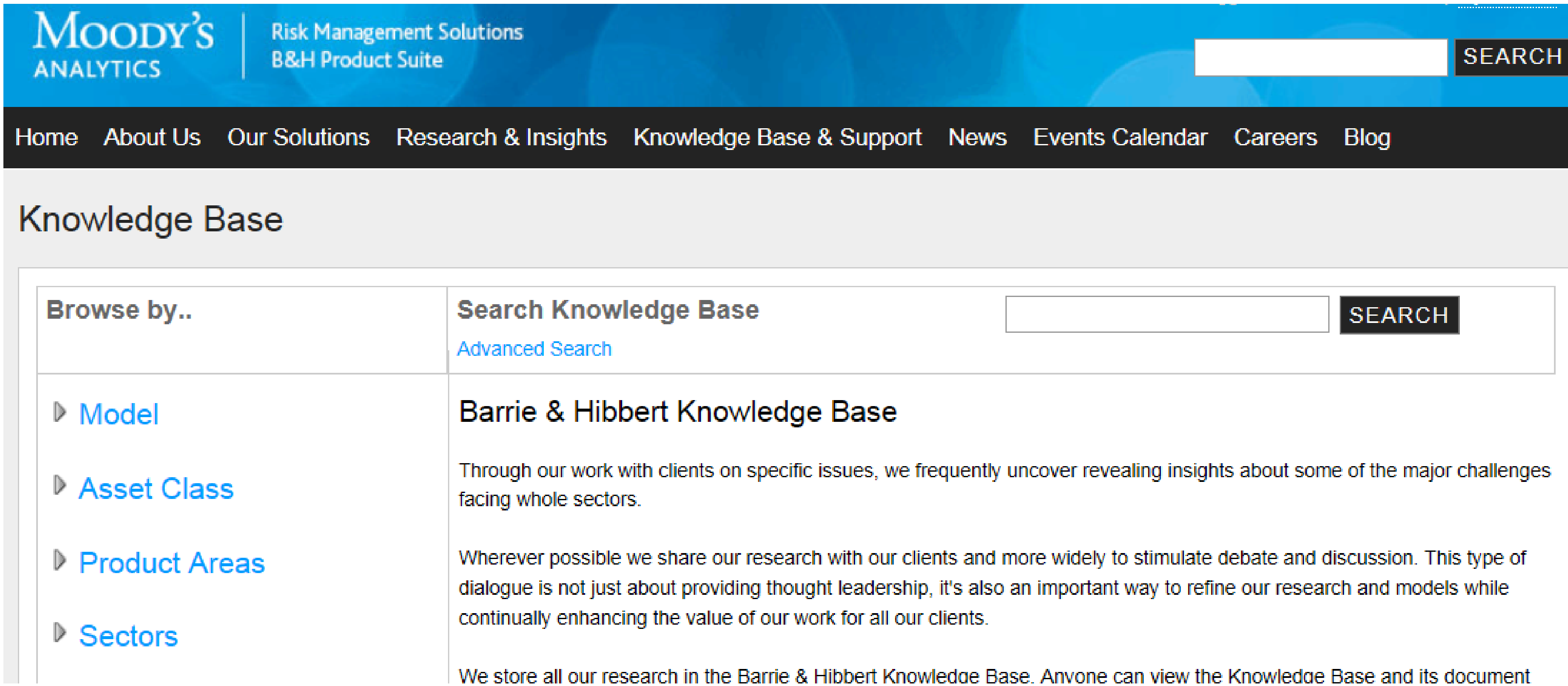
Stochastic projection of spreads - example



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

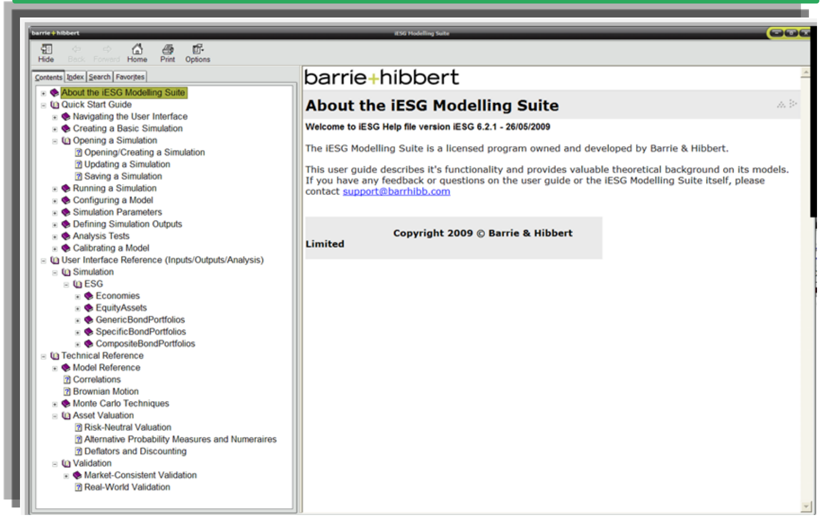


» Models methodologies, Economic research,

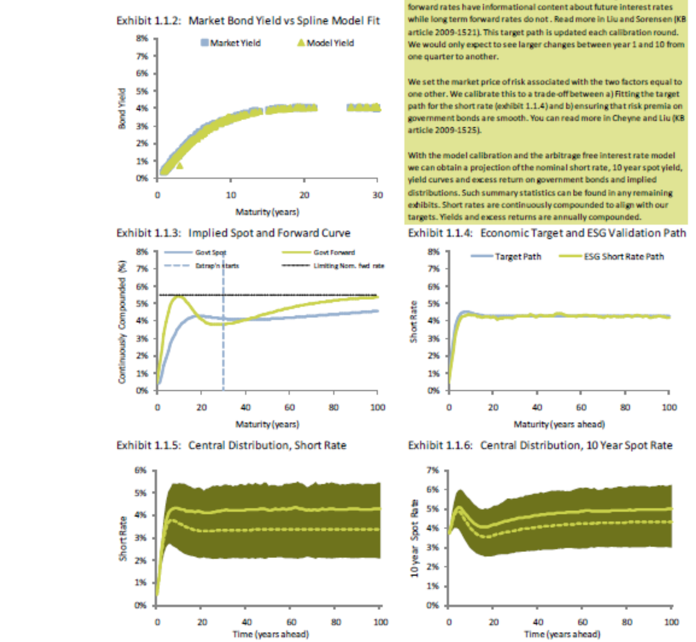
» Calibration documentation and Technical Advisory Panel

Documentation

Help menu in ESG



Calibration report



barrie+hibbert

1 Real-World Interest Rate Calibrations

1.1 Nominal Rates - Extended 2-factor Black-Karasinski - Time-Varying Term Premium

Exhibit 1.1.1: Parameters in Extended 2FBK

Calibration Information	
Model:	Extended 2-factor Black-Karasinski
Economy:	USD
Calibrated To:	Govt. Nominal Bond Yields
Term premium:	Time-varying

Parameter	30 Sep 2009	30 Jun 2009
α_1	0.3000	-
α_2	0.0750	-
σ_1	0.3000	-
σ_2	0.2500	-

Commentary

Parameters in the extended 2FBK (exhibit 1.1.1) model are calibrated to historical volatility of the short rate and 10 year spot yields. These are updated once per year (Q2).
The initial instantaneous nominal forward curve (exhibit 1.1.3 shows the initial curve and associated spot curve) is a direct input in the extended 2FBK model. The curve is derived by fitting regression splines to the market bond yields (exhibit 1.1.2) and extrapolating to a limiting forward rate. You can read more in Antonio and Roseburgh (KB article 2008-1165) and Sorensen (KB article 2008). See Li, Liu and Sorensen for latest targets (Knowledge Base article 2009-1538). The extrapolation targets are updated in Q3.

The target path for the short rate (exhibit 1.1.4) is economically sensible in that: a) We do not make frequent changes to our long term interest rate expectations. b) Interest rates are mean reverting and c) Short term forward rates have informational content about future interest rates while long term forward rates do not . Read more in Liu and Sorensen (KB article 2009-1521). This target path is updated each calibration round. We would only expect to see larger changes between year 1 and 10 from one quarter to another.

We set the market price of risk associated with the two factors equal to one other. We calibrate this to a trade-off between a) Fitting the target path for the short rate (exhibit 1.1.4) and b) ensuring that risk premia on government bonds are smooth. You can read more in Cheyne and Liu (KB article 2009-1525).

With the model calibration and the arbitrage free interest rate model we can obtain a projection of the nominal short rate, 10 year spot yield, yield curves and excess return on government bonds and implied distributions. Such summary statistics can be found in any remaining exhibits. Short rates are continuously compounded to align with our targets. Yields and excess returns are annually compounded.

Exhibit 1.1.2: Market Bond Yield vs Spline Model Fit

Exhibit 1.1.3: Implied Spot and Forward Curve

Exhibit 1.1.4: Economic Target and ESG Validation Path

Exhibit 1.1.5: Central Distribution, Short Rate

Exhibit 1.1.6: Central Distribution, 10 Year Spot Rate

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Technical documentation

2.2 Calibration method

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

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

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

Similarly, any desired percentile of the spread distribution can be found by computing the corresponding percentile of the π distribution and converting that π 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:

$$E[S^p] = \int_0^\infty p s^{p-1} \Pr[S > s]\, ds$$

MOODY'S ANALYTICS

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

3 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
  - **Volatility clustering**
  - **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
    - Affects frequency of data
    - Bid-Offer spread/transaction costs mask the underlying market values
- » High **volatility** challenges the stability of results

Example: TRY Equity	
Index	MSCI
Data since	1988
EWMA Average Data Age	12.5 years
End2013 LT Volatility Target	41%

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.

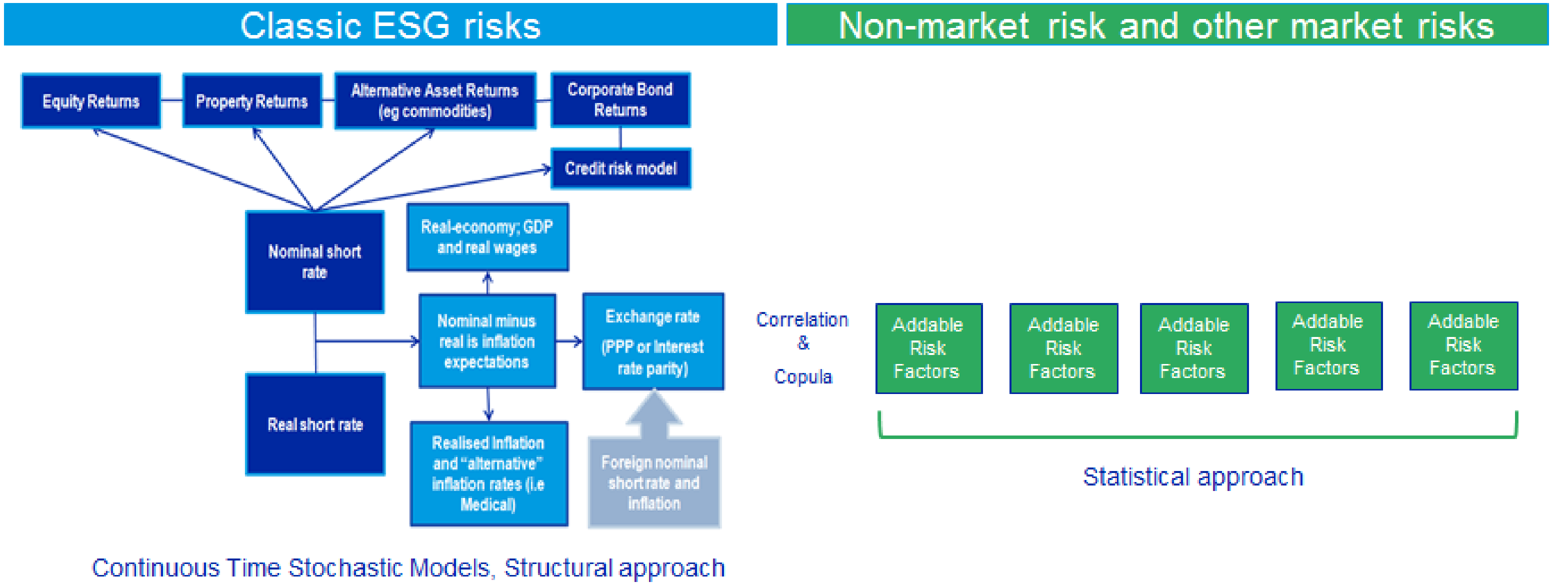
Beyond Market Risks

Insurance capital should also cover non-market risks/insurance risks

» Non-market risks often only affects 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



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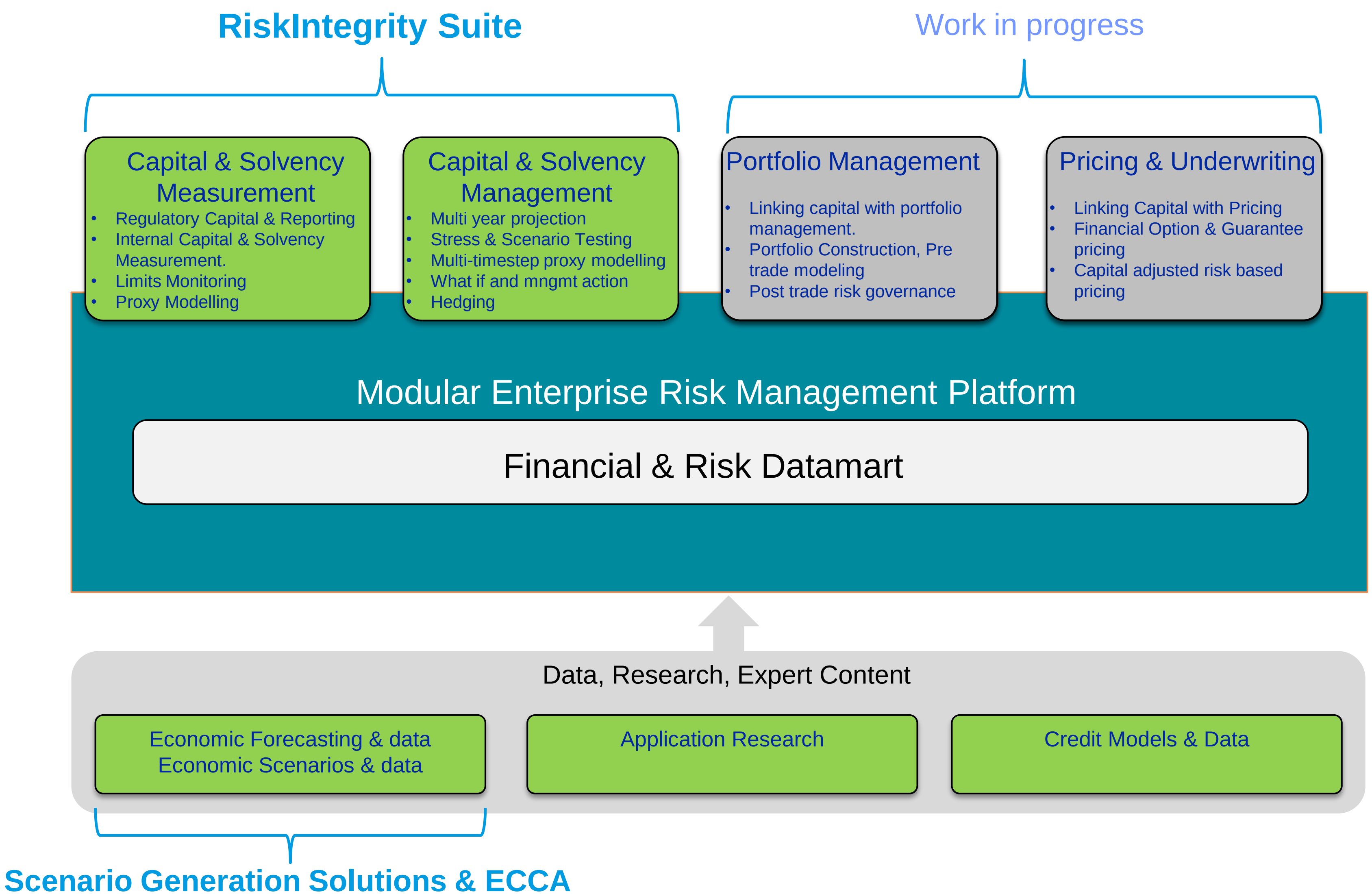
Solvency II Update and Moody's Analytics ERS Solutions

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



Question and Answer