MOODY'S | Better decisions

Moody's Analytics

The University of Edinburgh

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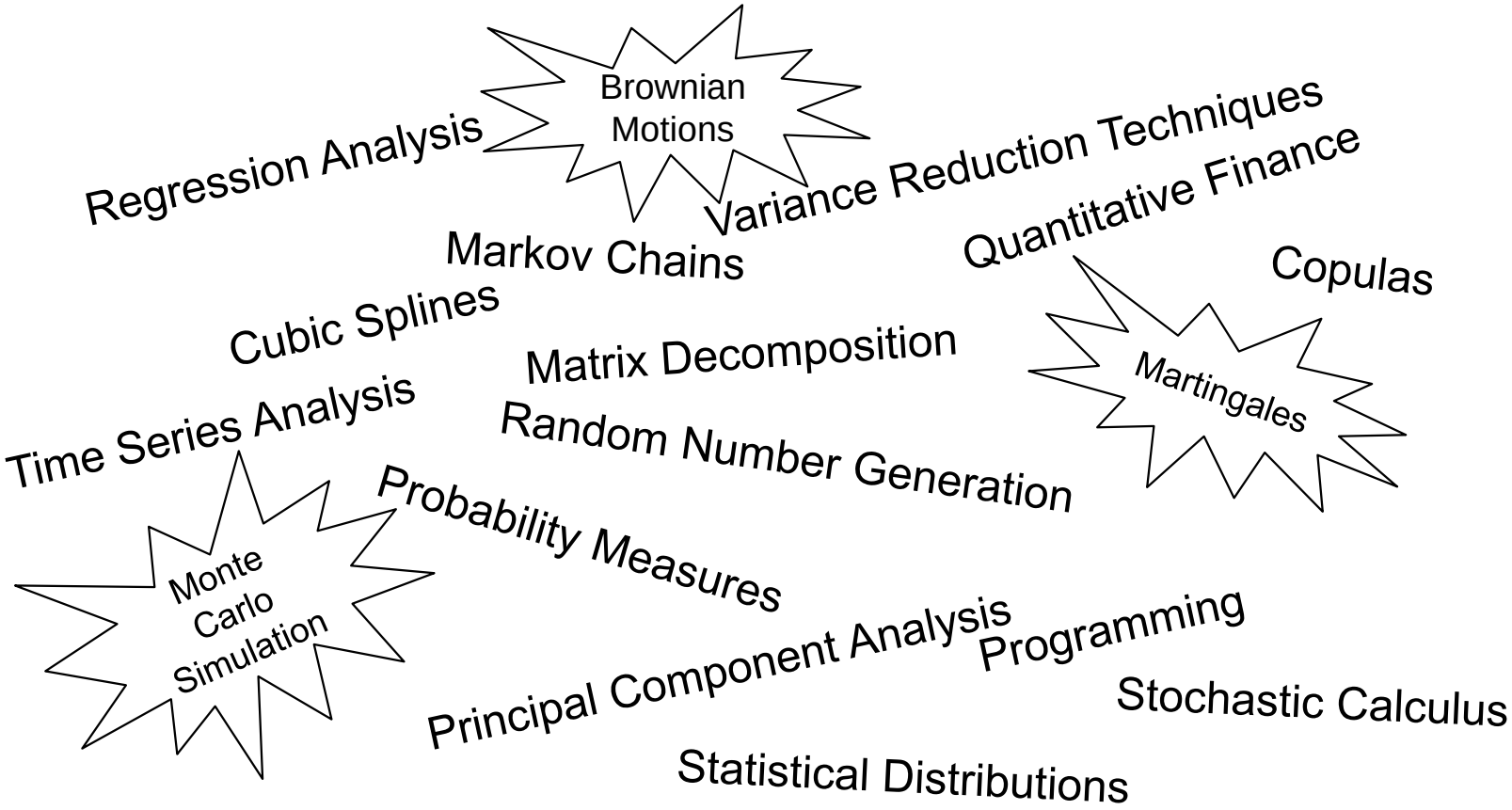
Modelling & Calibration Services

November 2021

Do you want to apply your knowledge and skills to solve challenging problems in the real world?

Moody's day to day work requires the use of a wide range of expertise and knowledge directly related to technical learnings at Edinburgh University



Agenda

1. About Moody’s
2. Insurance ERS
3. SG Models & Case Study
4. Working at Moody’s Analytics
5. Moody’s Analytics Graduate Programme
6. Q+A

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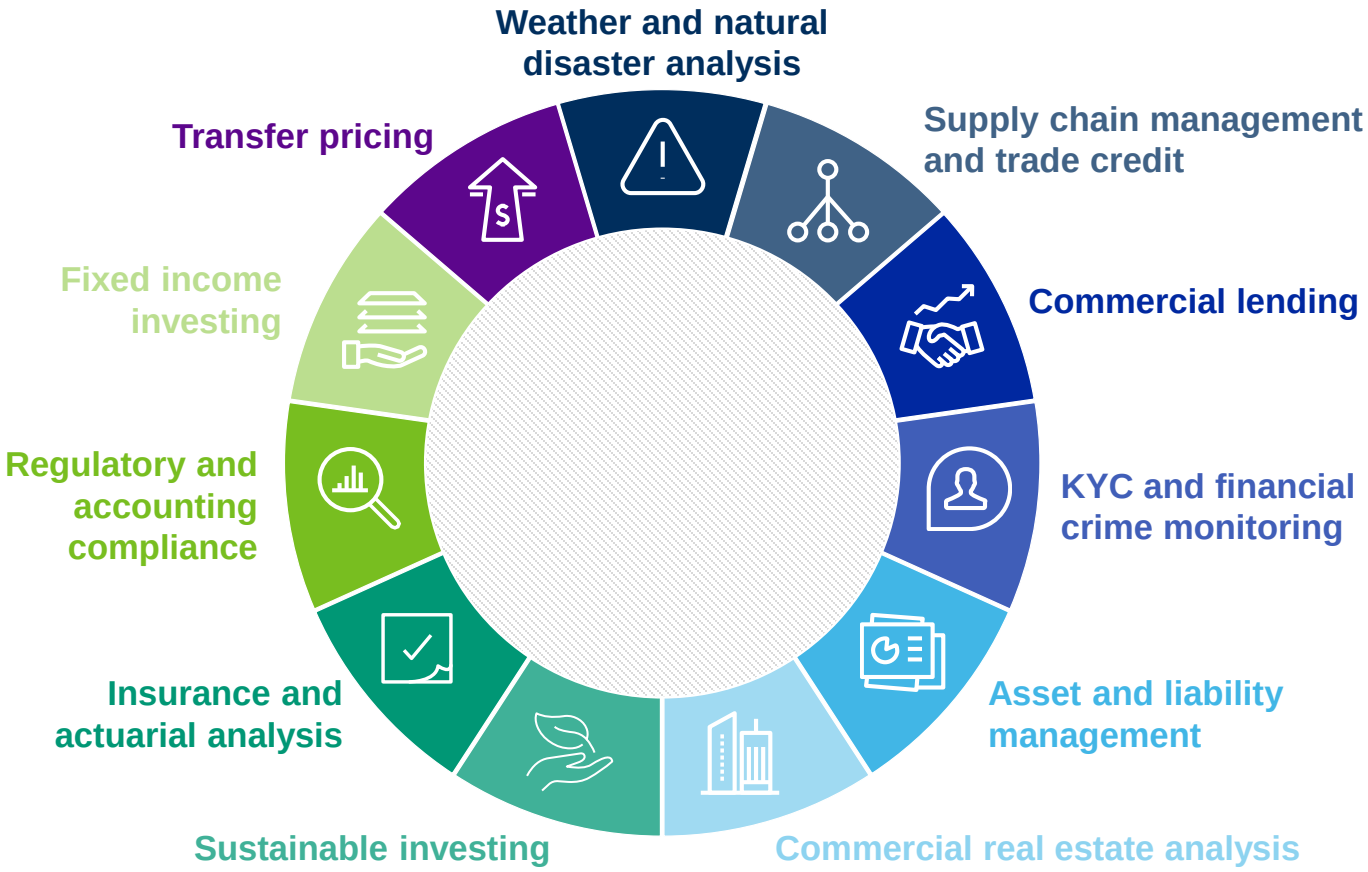
About Moody’s

Moody's as an Integrated Risk Assessment Business



$40B+

Total Addressable Market*

Helping customers make **BETTER DECISIONS**

CURATED DATA

ENTITIES
~400 million
public & private entities

SECURITIES
$70+ trillion
rated debt

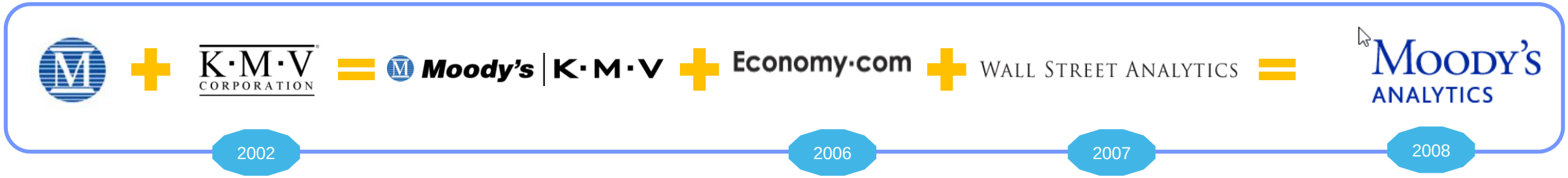
ECONOMIES
500+ million
economic, financial and demographic time series

PROPERTIES
20+ million
commercial real estate properties

PEOPLE
13+ million
risk profiles

*Including RMS.

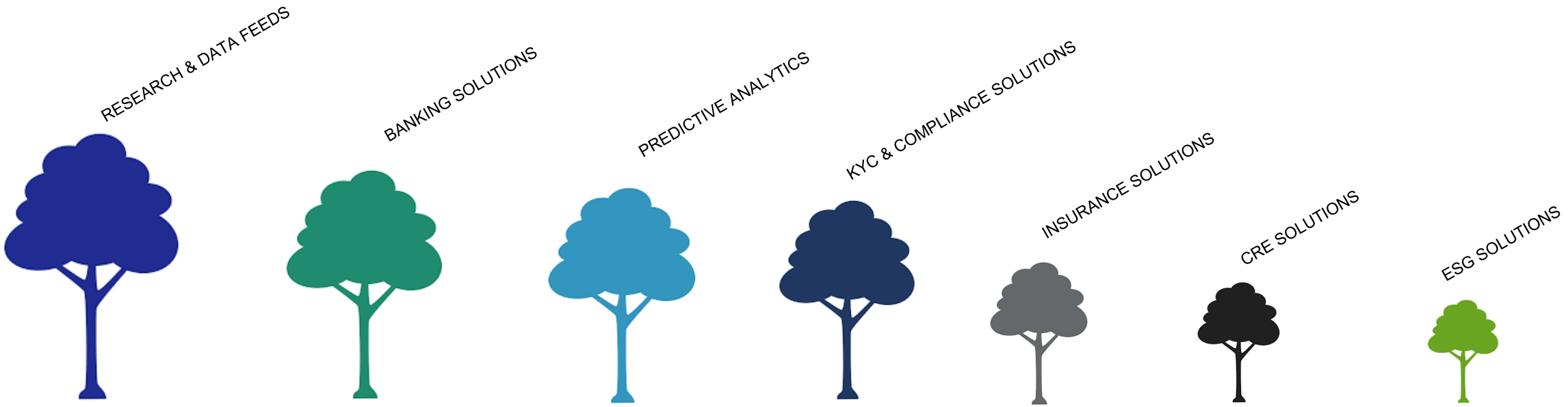
Moody's Analytics companies



Some of our later acquisitions

MA brands

Diverse Product Base Enables Growth Across Sectors



Moody's CreditView
orbis
AXIS
CreditLens
grid
Economic Data & Forecasts

MA – By the Numbers

2021 FINANCIAL PROFILE

FORECAST *

Moody's Analytics **

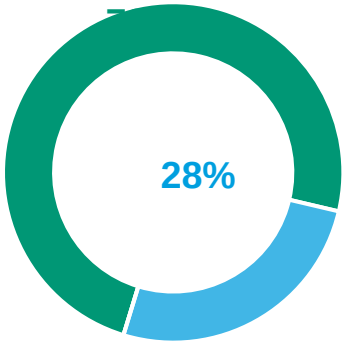
- Revenue: $2,423m
- Recurring revenue: 93%
- Retention rate: 94%
- Margin: ~29%

Research, Data & Analytics

- Revenue: $1,748M

Enterprise Risk Solutions

- Revenue: $675M



** Including RMS*
*** MIS revenue: $3.3bn*

CUSTOMERS

1,500+ Asset Managers

2,900+ Commercial Banks

3,100+ Corporations

300+ Real Estate Entities

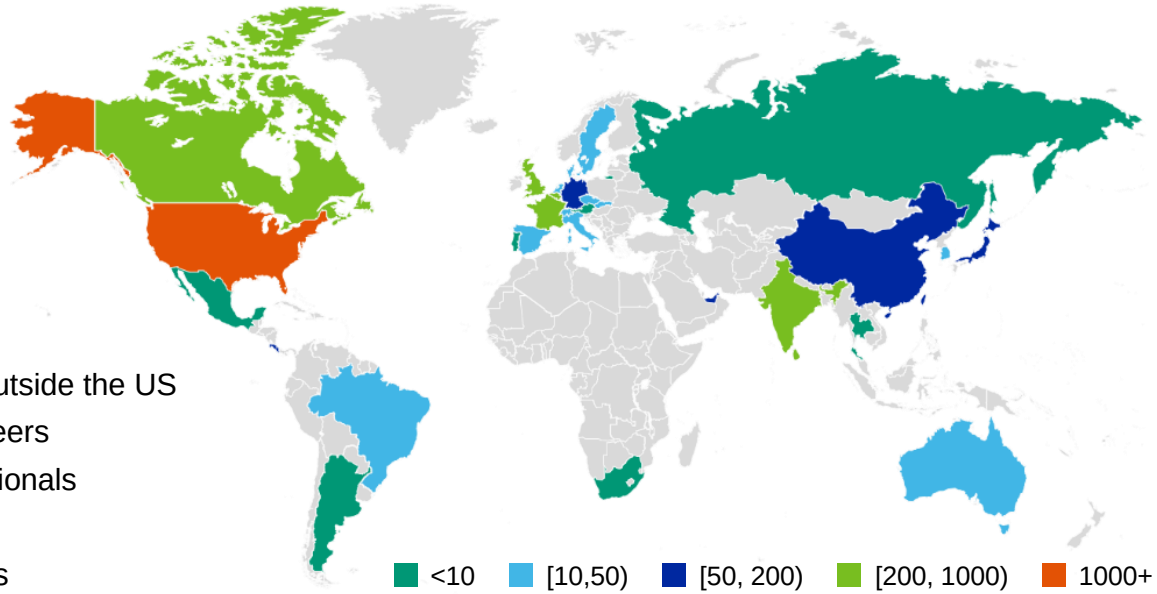
225+ Securities Dealers and Investment Banks

1,000+ * Insurance Companies

4,000+ Governments & Other Entities

PEOPLE *

- 63 cities
- 6,500 FTE worldwide
- 60% of FTE based outside the US
- ~700 software engineers
- ~1,000 sales professionals
- ~ 400 quants
- ~ 570 data specialists



Our Culture and Values

We play an important role in this world

Purpose

WHY WE EXIST

To bring clarity, knowledge and fairness to an interconnected world

Mission

WHAT WE DO

To provide trusted insights and standards that help decision makers act with confidence

Vision

OUR ASPIRATION

To promote progress through better decisions

Business Resource Groups

Moody's BRGs drive networking and professional development opportunities for diverse populations at Moody's.

Diversity & Inclusion at Moody's has been largely defined and acknowledged through BRGs

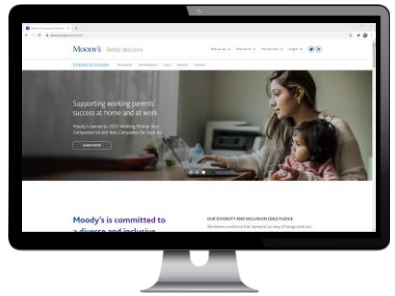
- MOODY'S ENABLE BRG
- MOODY'S GENERATIONAL BRG
- MOODY'S MINDS BRG
- MOODY'S MULTICULTURAL BRG
- MOODY'S PRIDE BRG
- MOODY'S VETERANS BRG
- MOODY'S WOMEN'S BRG

We've been recognized for how we value our team members, whether they're LGBTQA+, working parents, or veterans etc..

We provide Business Resource Groups (BRGs) to support team members who find their diversity in gender, sexual orientation, multi-culturalism, generational divides, military duty, accessibility & disability and mental health.

We are consistently recognized as a Top Employer

Visit the Diversity, Equity & Inclusion Microsite at www.moodys.com/diversity



MOODY'S

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ERS Insurance

ERS Insurance

ERS Insurance teams are located in:

- Edinburgh
- London
- Paris
- Grenoble
- New York
- Hong Kong
- Tokyo

There are around 150 people involved in the development, implementation and support of our products, including

- Quantitative PhDs
- Software & Quality Assurance Engineers
- Economists, Actuaries, CFAs and FRMs
- Product Managers, Project Managers and Business Analysts
- Data & Operations Specialists

What we do

Insurance ERM

Description

Award winning capital and regulatory reporting solutions.

Advanced internal model solutions using cutting-edge proxy modelling techniques.

Products

- Proxy Generator
- RiskIntegrity™
- Capital Aggregator

Scenario Generation

Description

Market leading scenario generation products using advanced stochastic modelling for market risks.

Used for liability valuation, real-world projection and risk aggregation.

Products

- Scenario Generator (SG)
- Risk Scenario Generator (RSG)

Wealth & Pensions

Description

Asset Liability Modelling for pension funds.

Helping product providers understand their products and communicating risk profile to retail customers.

Products

- DBALM
- Pensions Risk Analytics
- Investment Governance
- Wealth Scenario Generator (WSG)

Moody’s Analytics Scenario Generator (SG)

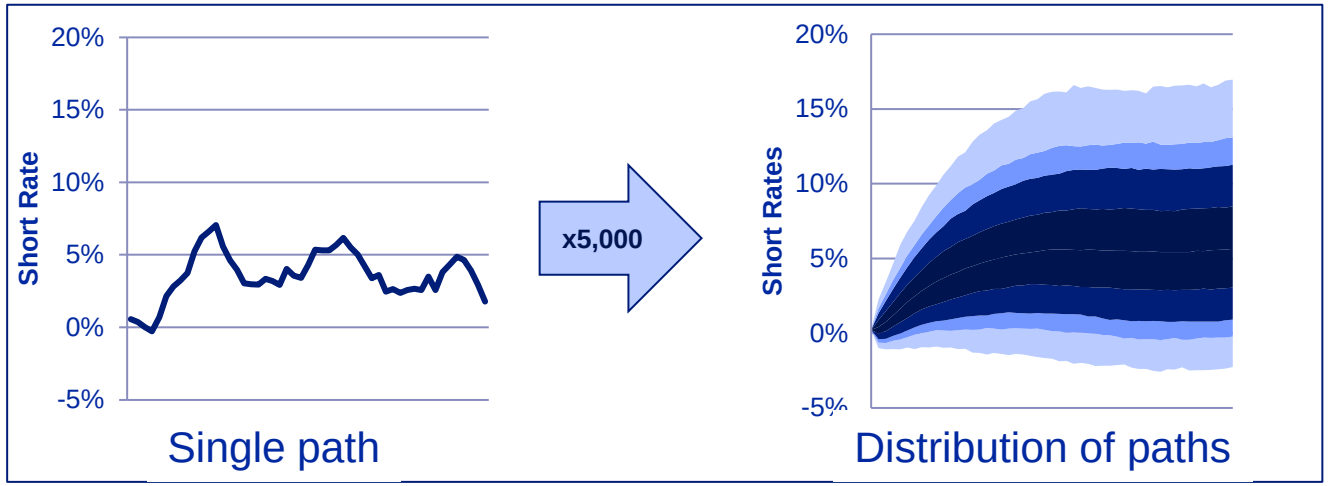
Moody’s Analytics Scenario Generator

ESG Trusted by Regulators

Over 90% of Approved Internal Model firms in Europe use our ESG

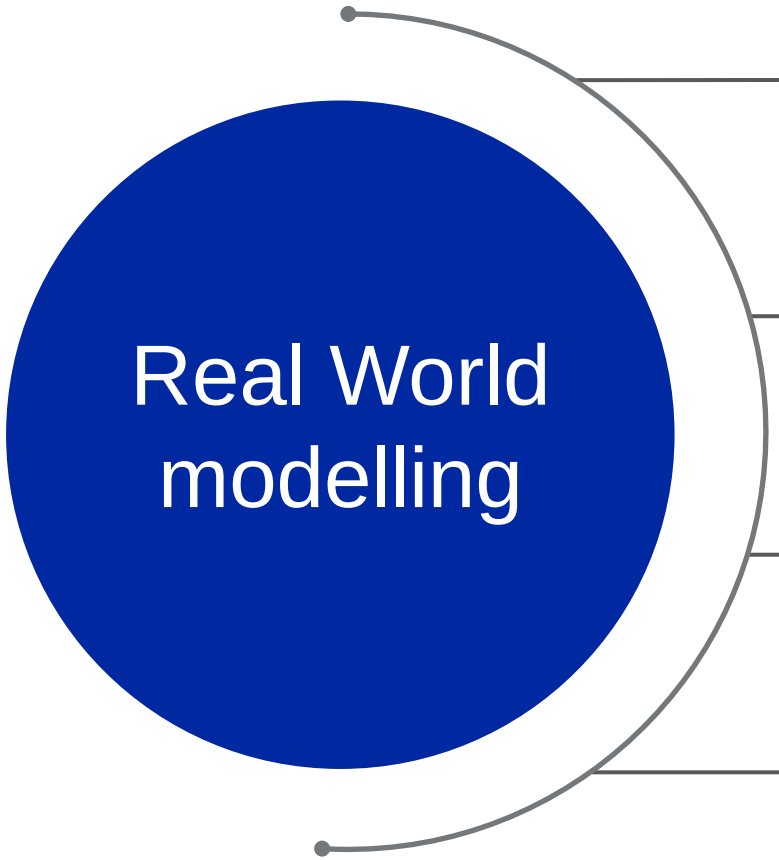
What is an Economic Scenario Generator?

- Generates scenarios for various economic variables and asset returns using Monte Carlo simulation
  - A simulation is a collection of many paths (trials)
  - Generate 1000s of different paths of an economy by stochastically modelling many different risk drivers
  - Interest rates, equity returns, corporate bond returns
- Two main uses:
  - Real-world projections for risk management
  - Market-consistent valuation for pricing



Real World Modelling

What our clients use it for?



Capital calculation

Predominately used by clients for projection of credit, default, market and other risks over a 1 year or a similar short term horizon for Value at Risk calculation as part of Regulatory or Economic Capital framework..

SAA and Investments

Our asset and portfolio capabilities help our clients assess the performance of their investment strategies under a range of conditions.

Product design/pricing

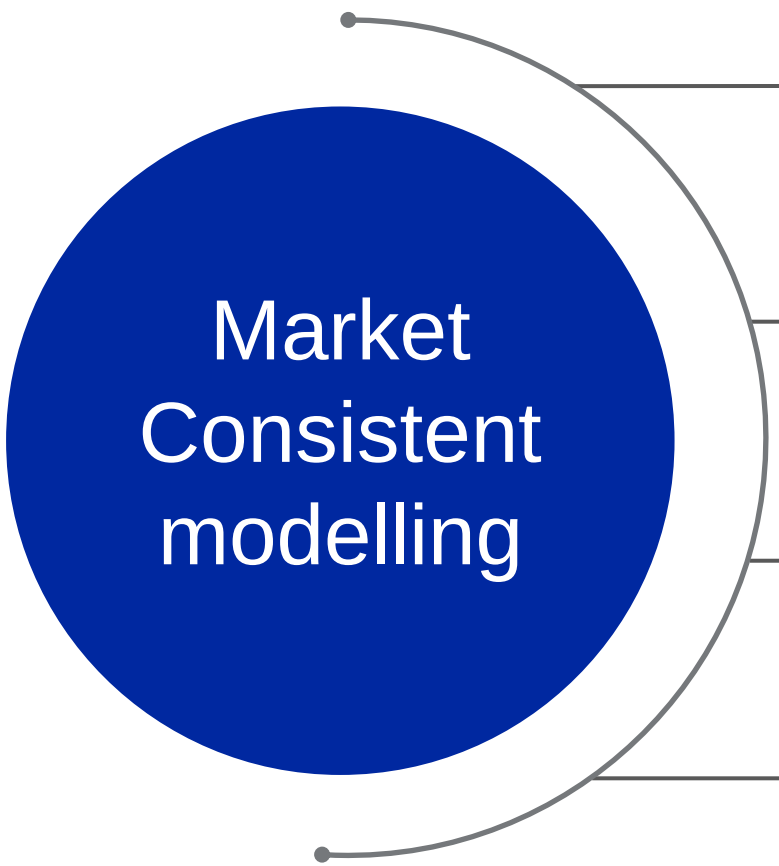
Many insurance contracts are dependent on the level of interest rates or asset returns. That's why our clients use our models to produce realistic distributions.

Scenario Testing

What will happen to my business under a "hard Brexit" scenario?
How will my investments perform under a "stagflation" scenario?
Narrative real world projections provide our clients with that insight.

Market Consistent Modelling

What our clients use it for?



Liability Valuation

Many of our clients need to calculate the value of their liabilities as part of Market Consistent Embedded Value (MCEV) reporting. Where the value of the liabilities needs to represent their market value.

Stress Testing

In many cases our users want to understand the sensitivity of their liabilities to different risk factors. For that purpose they produce different stress scenarios.

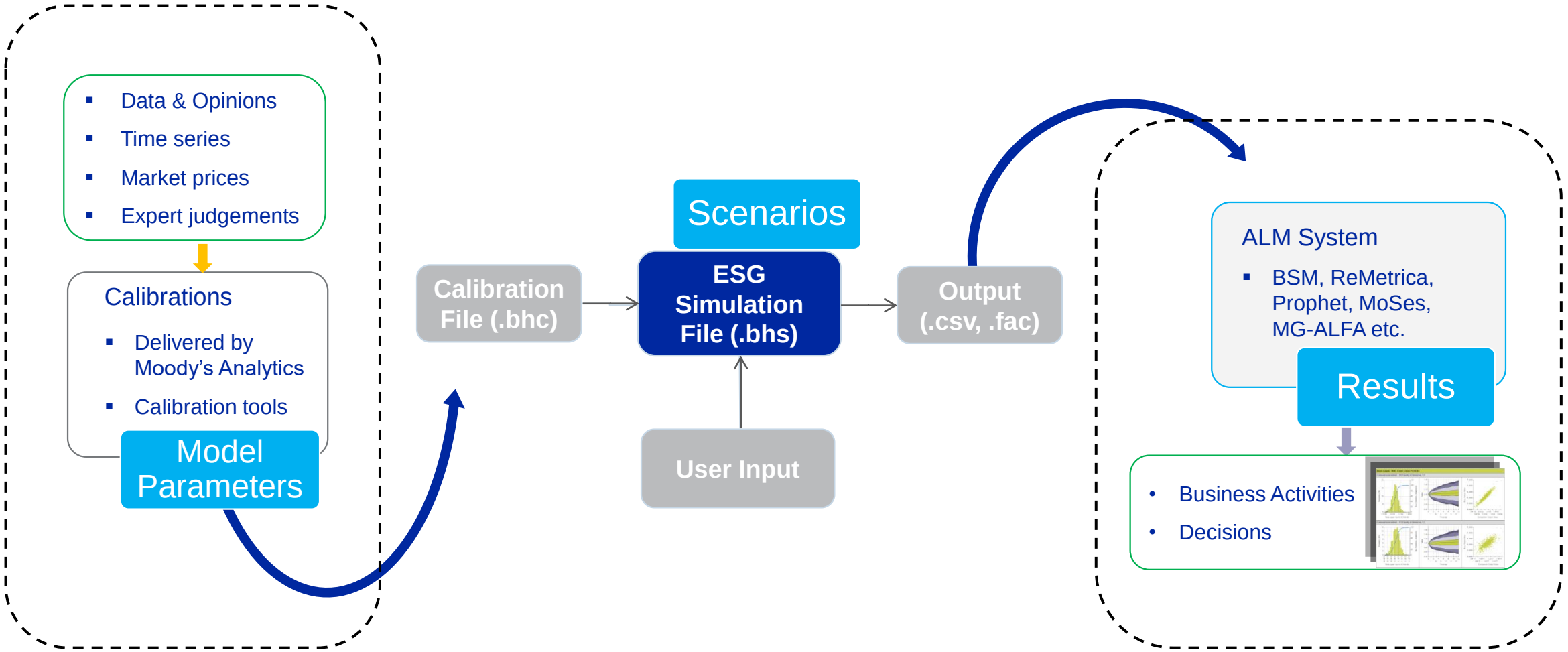
Proxy Functions

Valuing insurance liabilities with guarantees is a deeply nested stochastic process requiring both Market Consistent and Real World Scenarios. LSMC methods that utilize MC modelling make it much easier problem.

Hedging

Market Consistent modelling can also be used for valuing derivatives and hence hedge values and their sensitivities (Greeks).

SG Production Process



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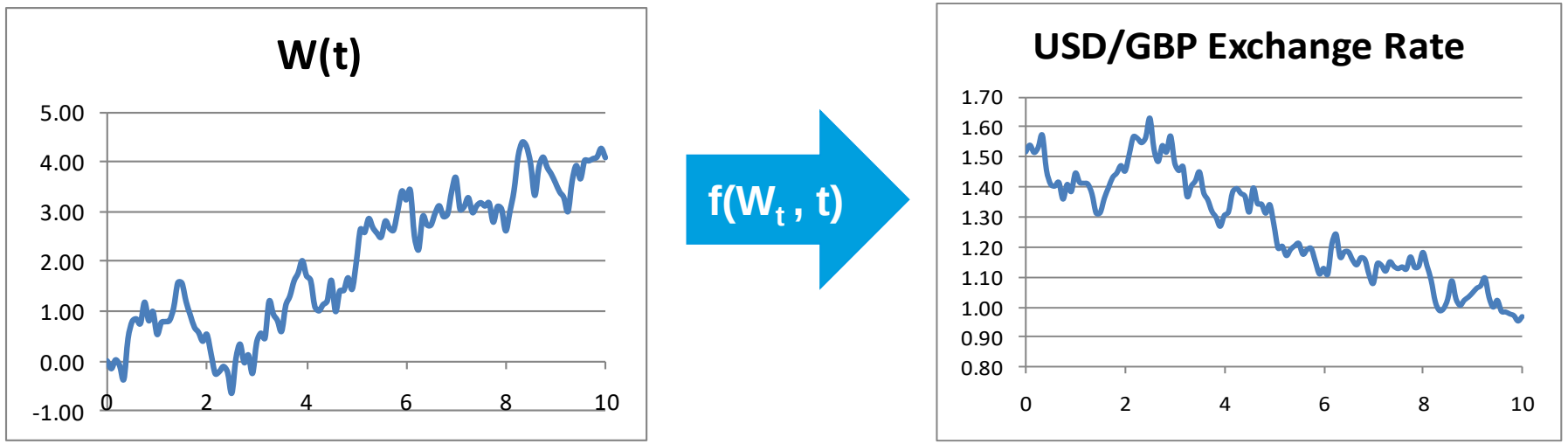
SG Models & Case Study

Randomness in our Models

- A Brownian motion $W(t)$ is a process for describing the evolution of a normally distributed random variable.
- $dW(t)$ represents the normally distributed increments of a Brownian motion (aka “Shocks”)
- Brownian motions in our stochastic equations result in the stochastic evolution of our economic variables, e.g. equity returns, interest rates and exchange rates.
- We need to sample from a normal distribution to obtain our Brownian Motion shocks
  - We do this using pseudo random numbers



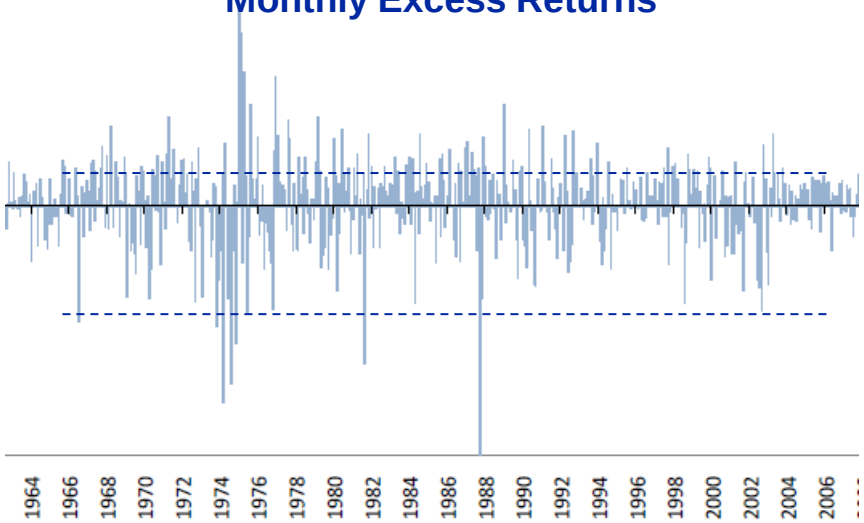
Example:
SVJD Equity Model

SVJD Model Motivation

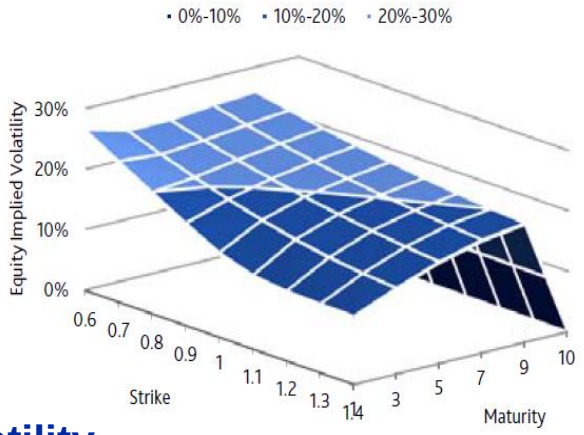
Equity Returns

- Large asset returns are more likely to be negative
- Returns are correlated across economies – Tail Correlations
- Negative skew in equity return distributions

Monthly Excess Returns



Market Implied Volatility Surface

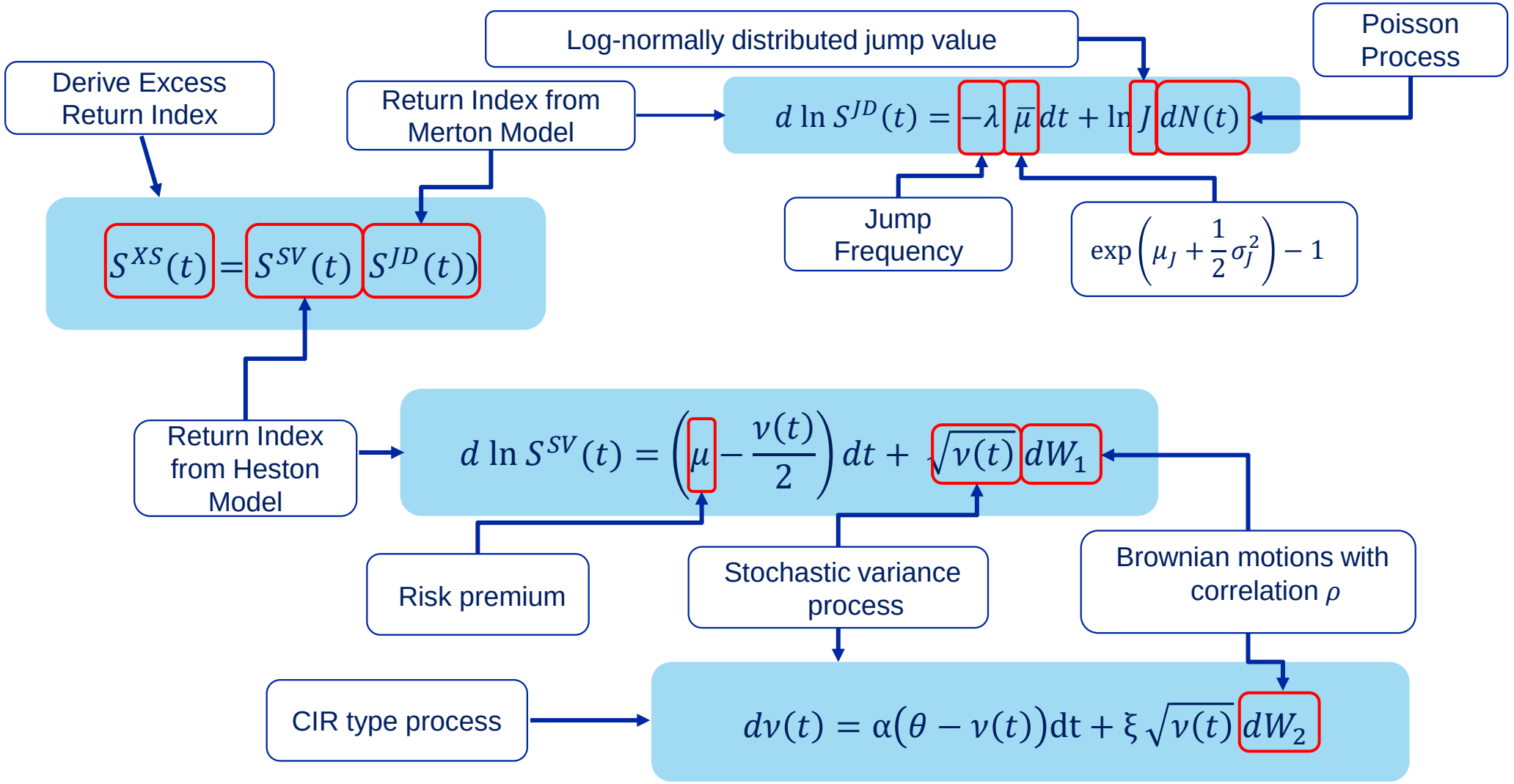


Volatility

- Asset returns do not display constant volatility
- Large asset returns tend to be associated with large volatility
- Volatility tends to be mean reverting
- Asset returns exhibit volatility clustering
- Implied volatilities can vary by option term and strike (Volatility smile)

SVJD Model Structure

» A model of “excess” return, being the additional return over the risk free (i.e. cash) return



SVJD Implementation

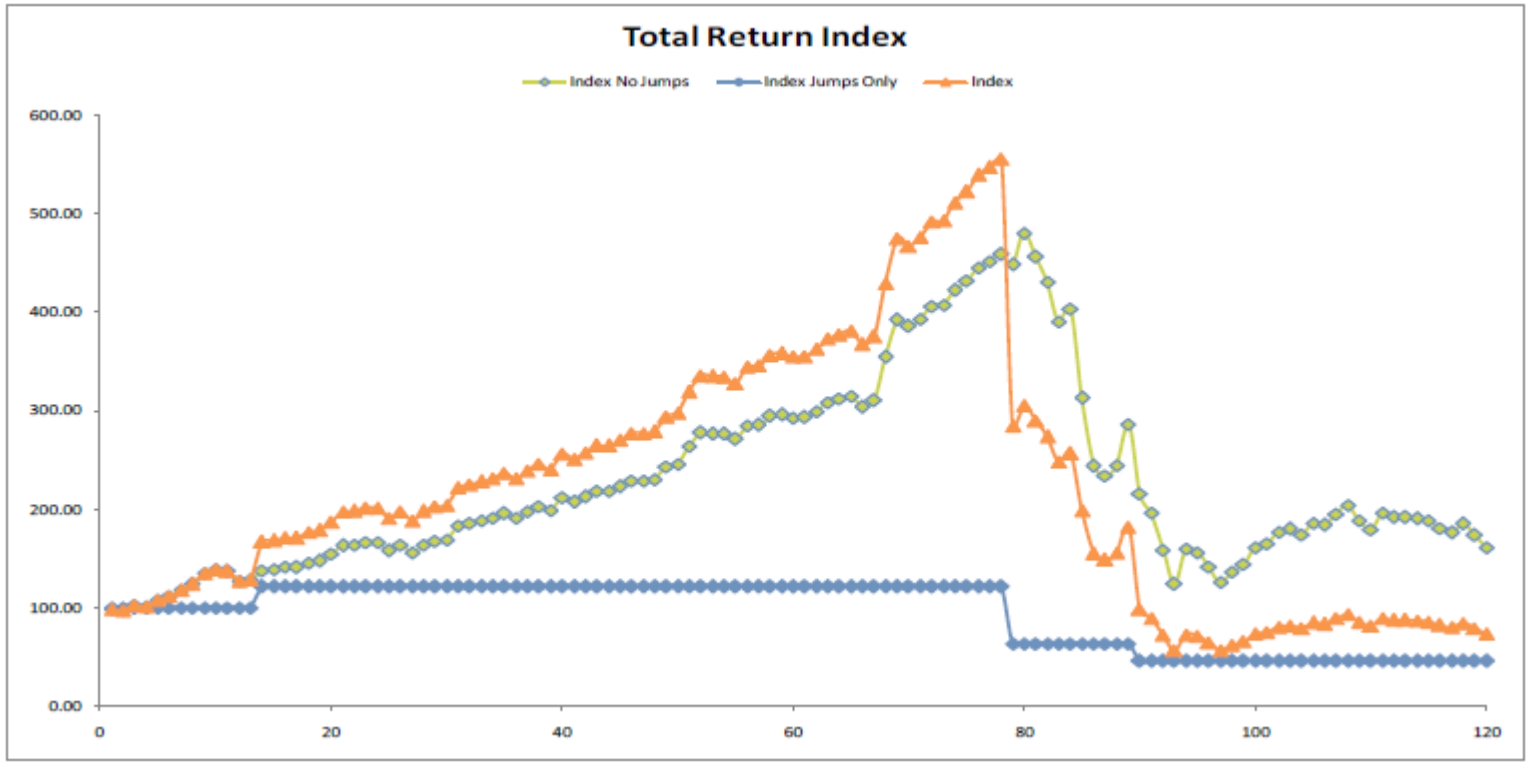
» Stochastic volatility part is implemented using a biased Euler scheme:

$$S_{t+\Delta t}^{SV} = S_t^{SV} \exp\left\{\left(\mu - \frac{(v_t)_+}{2}\right)\Delta t + \sqrt{(v_t)_+}\sqrt{\Delta t}Z^{(1)}\right\}$$
$$v_{t+\Delta t} = v_t + \alpha(\theta - (v_t)_+)\Delta t + \varepsilon\sqrt{(v_t)_+}\sqrt{\Delta t}Z^{(2)}$$

» The jump diffusion part is implemented as:

$$S_{t+\Delta t}^{JD} = S_t^{JD} \exp\{-\lambda\bar{\mu}\Delta t\} \prod_u^{N(\Delta t)} J_u$$
$$N(\Delta t) \sim \text{Poisson}(\lambda\Delta t)$$
$$J_u \sim \text{LogNormal}\left(\mu_J, \sigma_J^2\right)$$

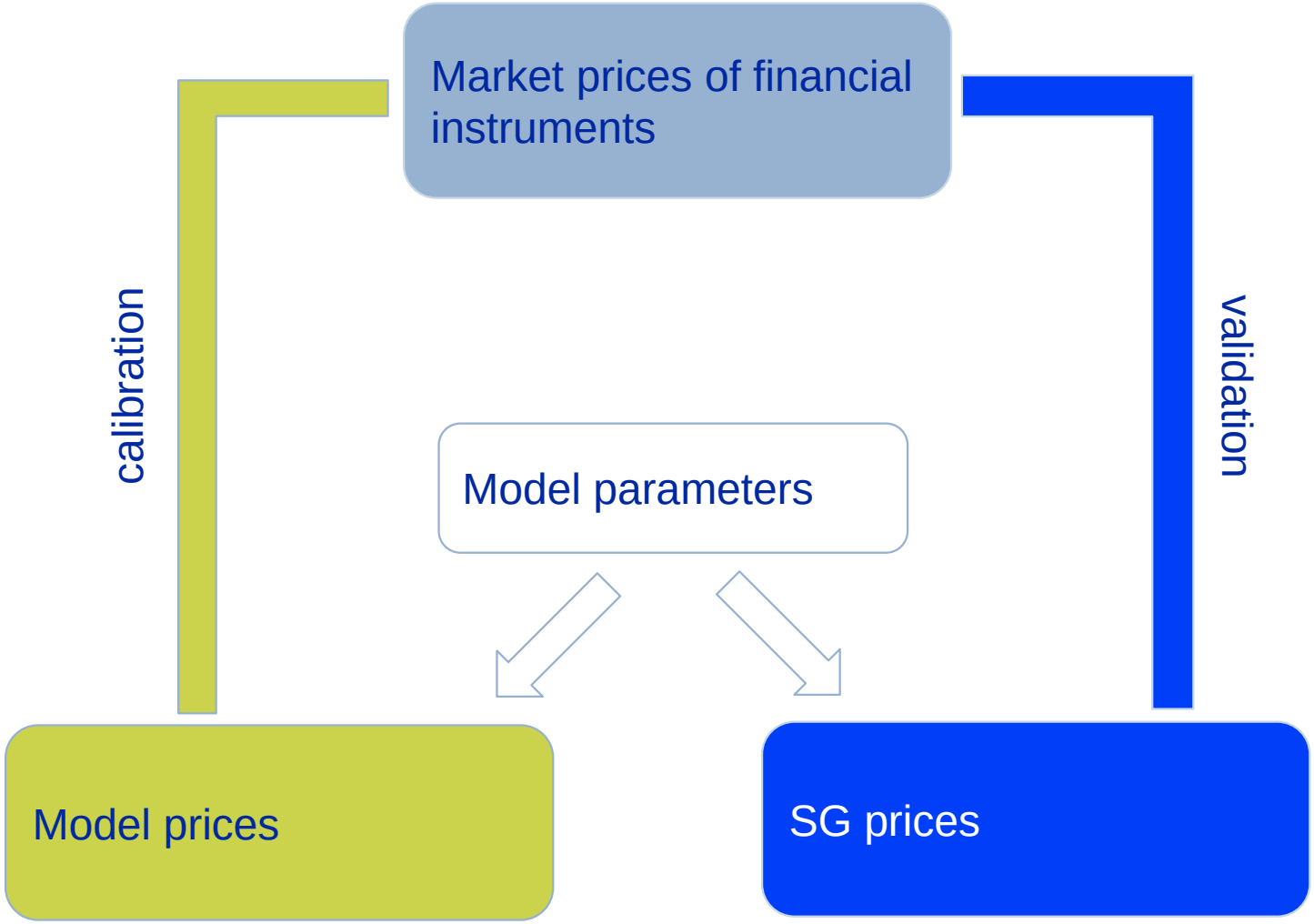
SVJD Model - Results



Desired properties captured:

- Large jumps are rare and most likely negative
- Volatility in returns is stochastic
- Volatility clustering

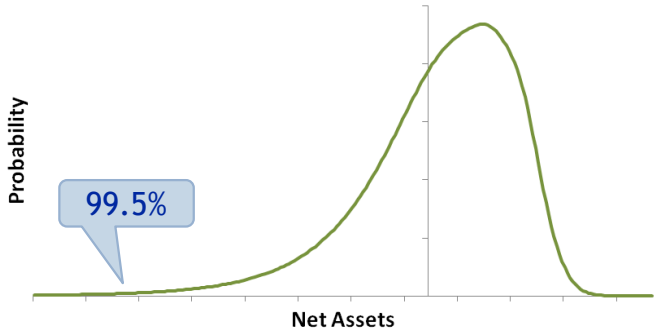
Market Consistent (MC) Calibration & Validation



Example:
Case Study

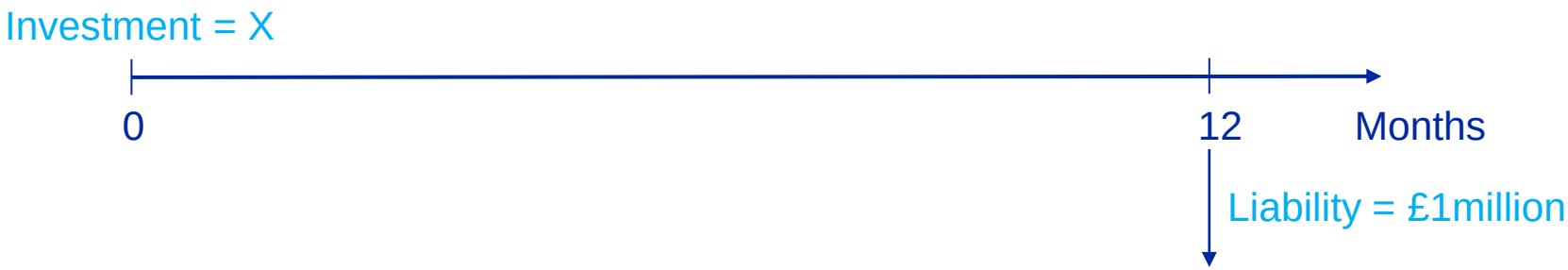
Objective (Solvency Risk)

- Insurers need to ensure that they have adequate capital resources.
  - *"How much capital does the insurance company need to hold today for there to be an X% probability that this capital will be sufficient to fund all liability cashflows?"*



- When calculating solvency an insurer must project asset and liability portfolios
  - SG must produce realistic distributions
- Value at Risk:
  - Insurer models behavior of the economy over 1 year and calculates value of assets and liabilities
  - Then evaluates whether the company has sufficient capital to survive a 1/200 year event in the next year e.g. asset values drop or many claims are made?

Example Capital requirement



- Calculate X such that there is a 99.5% probability of meeting your liability if
  - X is invested in UK Equities
  - X is invested in a 50:50 portfolio of cash and UK Equities
- We can use the SG:
  - Simulate E_GBP to estimate probability distribution of X at 12 months
  - Estimate the median
  - Estimate 0.5th percentile point

Implementation in SG (Real World Projection)

.BHS setup

- Build an initial simulation file with GBP economy and one equity asset
- Select appropriate models
- Select appropriate simulation setup options for Real World runs
- Select appropriate outputs
- Calibrate the sim file with our RW *calibration* file
- Run your simulation file to simulate the probability distribution of the investment returns with the ESG
- Choice of model, parameters, time-step, number of trials, etc. affect the distribution of returns

Project the Capital Requirement

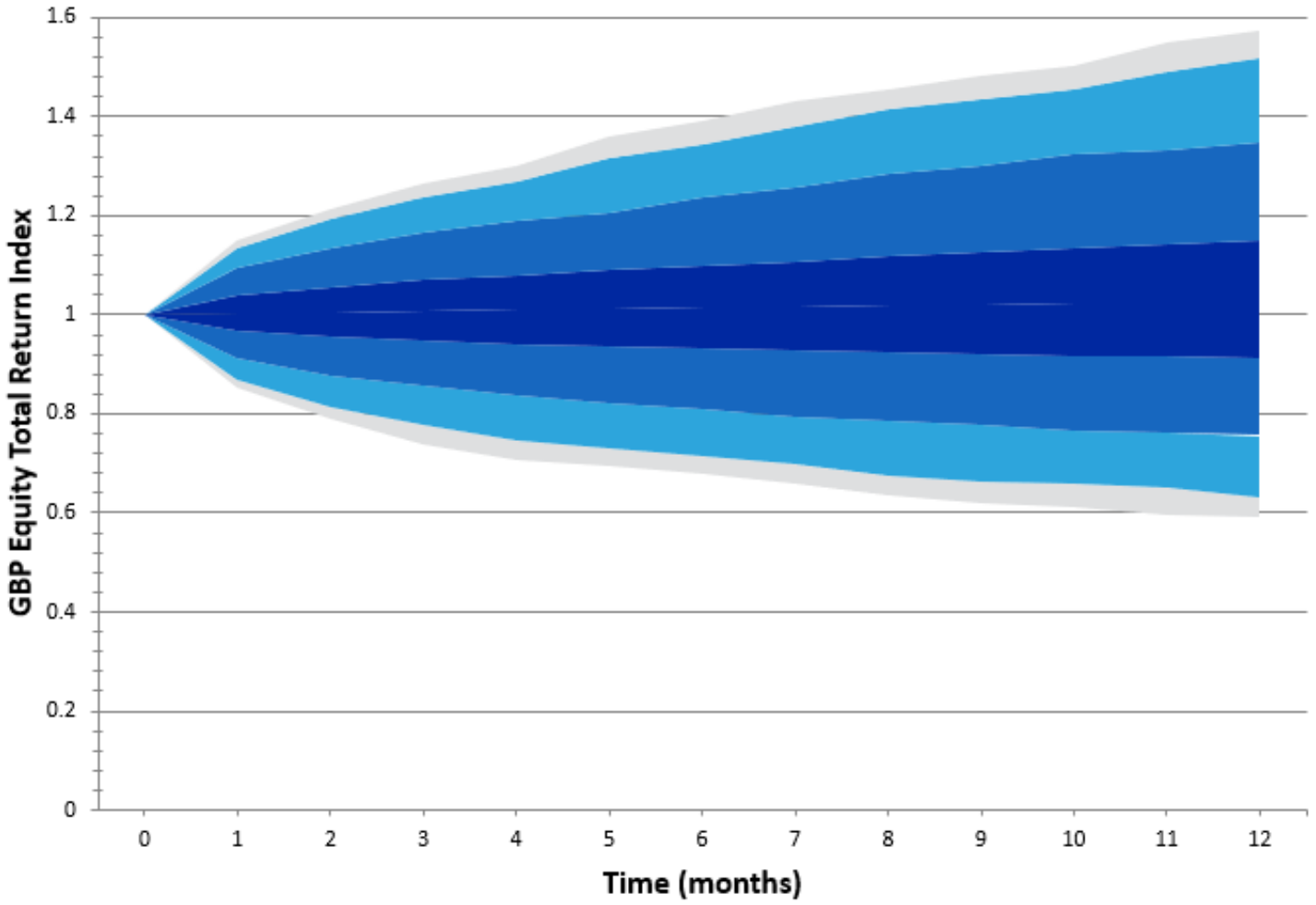
- Analyse the ESG outputs based on
  - X invested in Equities
  - X invested in the Portfolio of Cash and Equities

- *What is the minimum capital we need to invest today in order to meet our future liability of £1million in 1 year?*
  - *With 99.5% probability*
  - *With 50% probability*

SG Demo

Discussion

Exercise 2: Equity TRI distribution



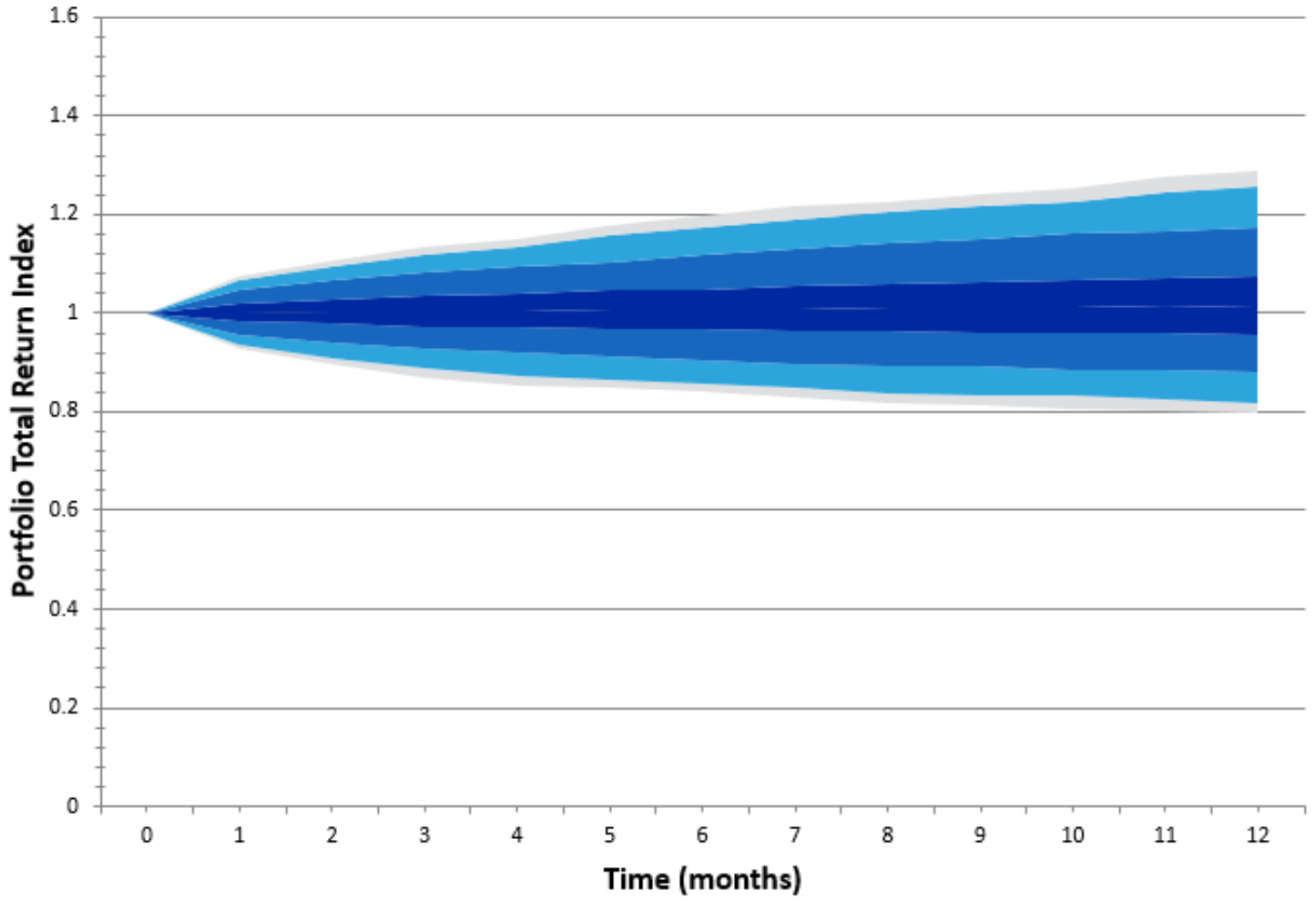
1.02

50% probability that £1m/1.02 = £0.98m will suffice

0.59

Probability of shortfall is less than 0.5% if X > £1m/0.66 = £1.69m

Exercise 2: Portfolio TRI distribution



1.01

50% probability that £1m/1.01 = £0.99m will suffice

0.80

Probability of shortfall is less than 0.5% if X > £1m/0.80 = £1.25m

» Less risk implies lower expected return

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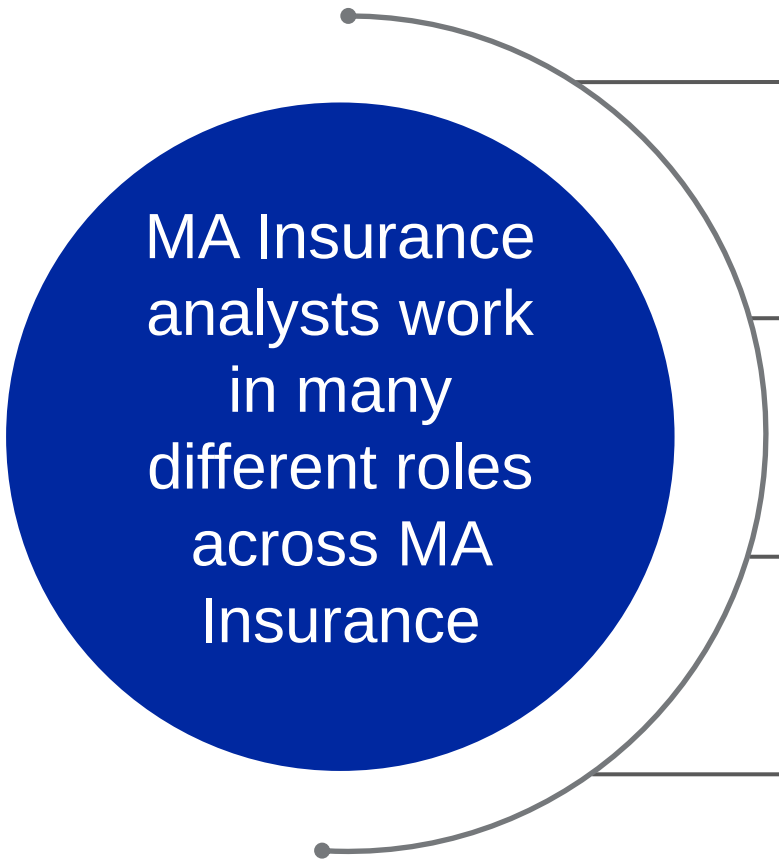
Working at Moody's Analytics ERS

Roles within MA Insurance



Calibration Services

Perform analysis on market and historical data to set targets for economic variables. Produce and validate calibrations to these targets. Apply expert judgment in review of results.

Research

Research and design solutions for emerging requirements/themes in the industry. Often driven by changes in regulatory requirements like SII or IFRS17.

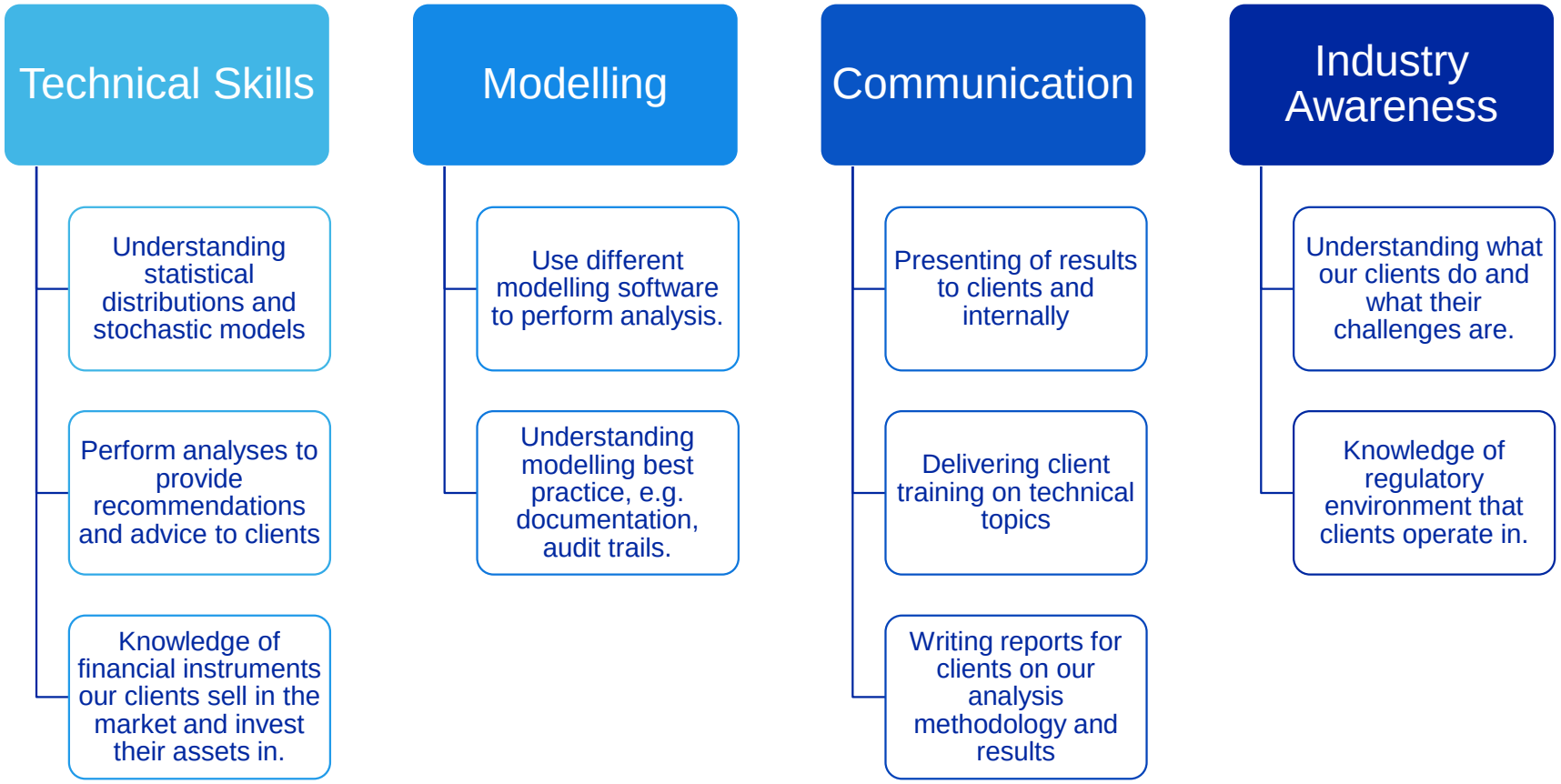
Product Management

Understand our clients' requirements and how they are using our solutions. Implement upgrades to our solutions to meet clients' needs.

Advisory Services

Work with clients to understand their objectives. Implement solutions to meet clients' objectives and provide technical expertise to solve clients' modelling problems.

How do mathematical skills help me do my job?



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Moody’s Analytics Graduate Programme

Moody's Analytics Graduate Programme – wider opportunities

- Current program is in its 10th year
- Graduates have been recruited and developed in the insurance business over the last ten years
- In this period we have recruited 20-25 graduates with all moving into permanent roles
- These graduates have developed and moved into a variety of roles in the organization:
  - Advisory Services Teams
  - Modelling and Calibration Services
  - Product Management
  - Research Teams
- Career progression is a focal points for us

Director – Advisory Service

Leading Advisory Team in Edinburgh Office

Associate Director - Modelling Operation

Leading client projects and engagements in US Office (WTC)

Assistant Director - Advisory Services

Product manager responsible for delivery of our ESG software in Edinburgh Office

Snapshot of Assignments

Partnered with a senior consultant on projects such as:

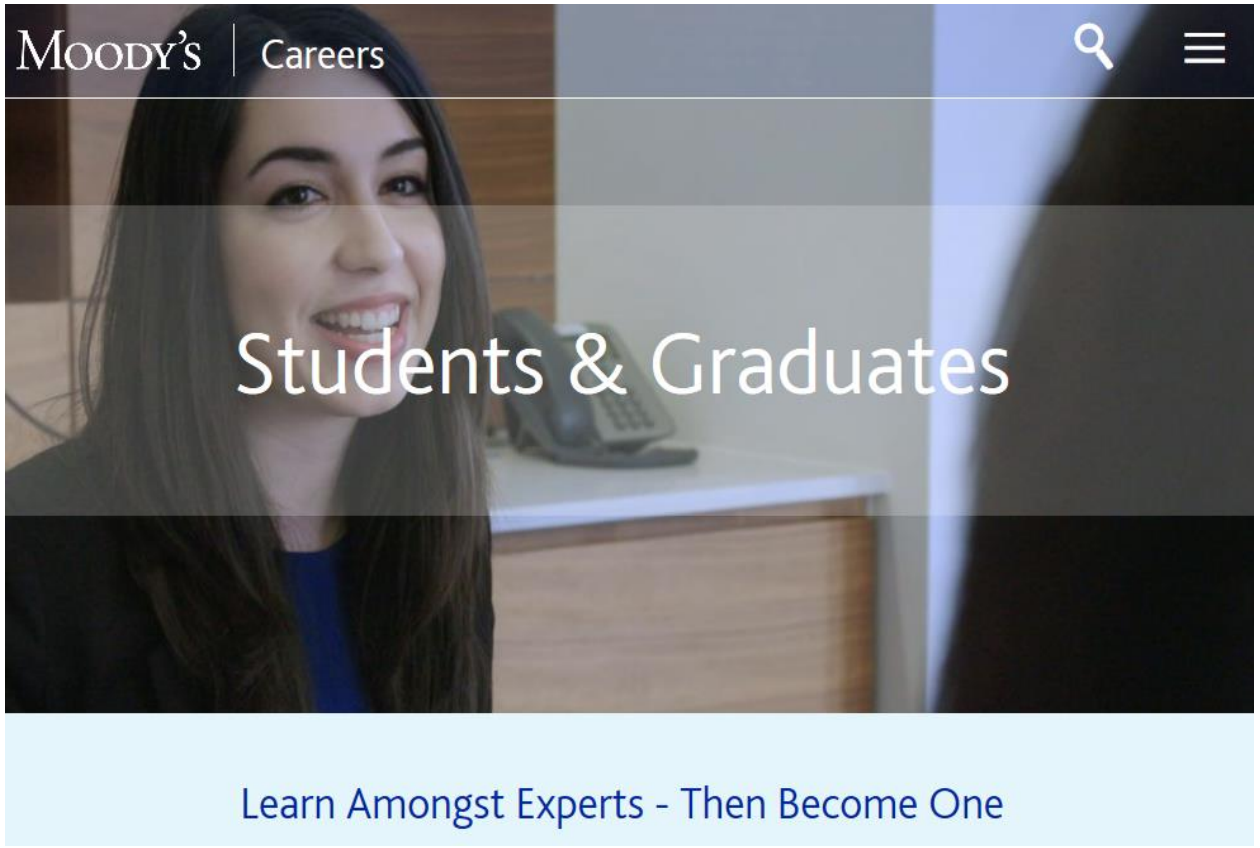
- Product Implementation – configuring the ESG software to produce scenario sets used in liability valuation, capital analysis, portfolio optimization and general risk management
- Product Customisation/Parameterisation
- Model and Calibration Method Development
- Business Analysis in Implementation projects related to the Solvency II
- Calibrating economic models to new data or market conditions
- Answering technical questions from customers to help them understand models or methods
- Implementing new services (such as economic scenario or model calibration services) to a customer's specific requirements
- Developing and implementing new methods, tools or infrastructure to enhance our propositions
- Providing training to internal teams and clients on the use of our software and the underlying quantitative models and techniques

What we are looking for

- Higher education within Finance, Actuarial, Maths or Physical Sciences
- Quantitative aptitude and proven analytical skills
- Good communication skills – both verbal and written
- Able to work to tight deadlines and manage own workflow/priorities
- Strong attention to detail
- Initiative and Result driven
- Fluency in English is essential
- Other European language is beneficial

The General Application Process

- Visit our career page: https://careers.moodys.com/students-and-graduates/ma-graduate-program/
- Select our Students and Graduates page to learn about working as a graduate at Moody's
- Or Select our search job function to look for roles globally
- Upon receiving your application, our recruitment team will review your CV, assessing your suitability for the programme alongside other applicants
- **Applications for the 2022 Graduate Programme will close 6th December**



Q+A

Submit questions to

Campus.Emea@moodys.com

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