Deloitte.

# ESGs

## Testing and validating scenarios

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# Agenda

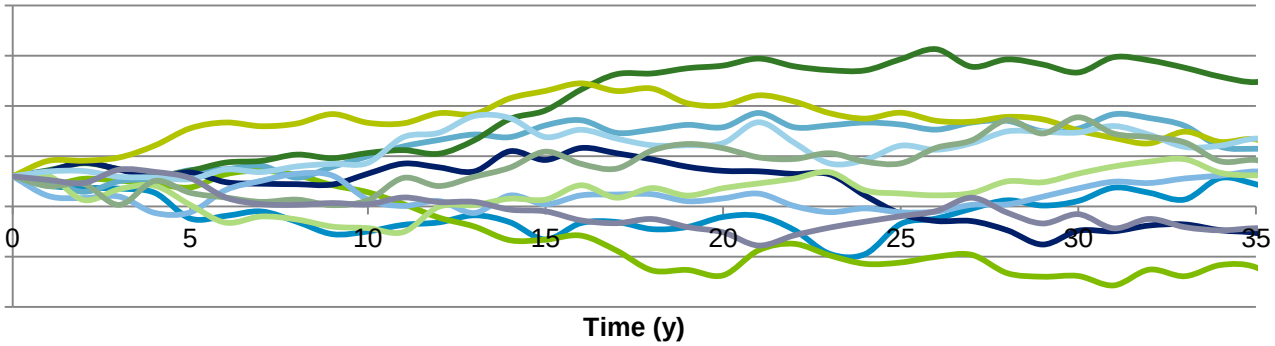
- Using ESGs
  - Purpose
  - Process (providers, groups and business units)
  - Solvency II requirements
- Formulating calibration assumptions
  - Required assumptions
  - Data challenges
  - Potential solutions
- Validating scenario sets
  - Aims
  - Analyses
- Future challenges

# Using ESGs

# Using ESGs

## What do ESGs do?

- Generate many scenarios for future economic variables




- Asset classes:
  - Nominal rates
  - Real rates
  - Inflation
  - Equities
  - Property
  - Credit spreads / default probabilities
  - Alternatives
  - Exchange rates

# Using ESGs
## Purposes

- Two key types of ESG model:

| | |
|---|---|
| Risk neutral | • Market-consistent valuation (for reporting)<br>• Hedging |
| Real world | • Risk/return quantification<br>  • Regulatory/economic capital calculation<br>  • Investment strategy setting<br>  • Pricing |

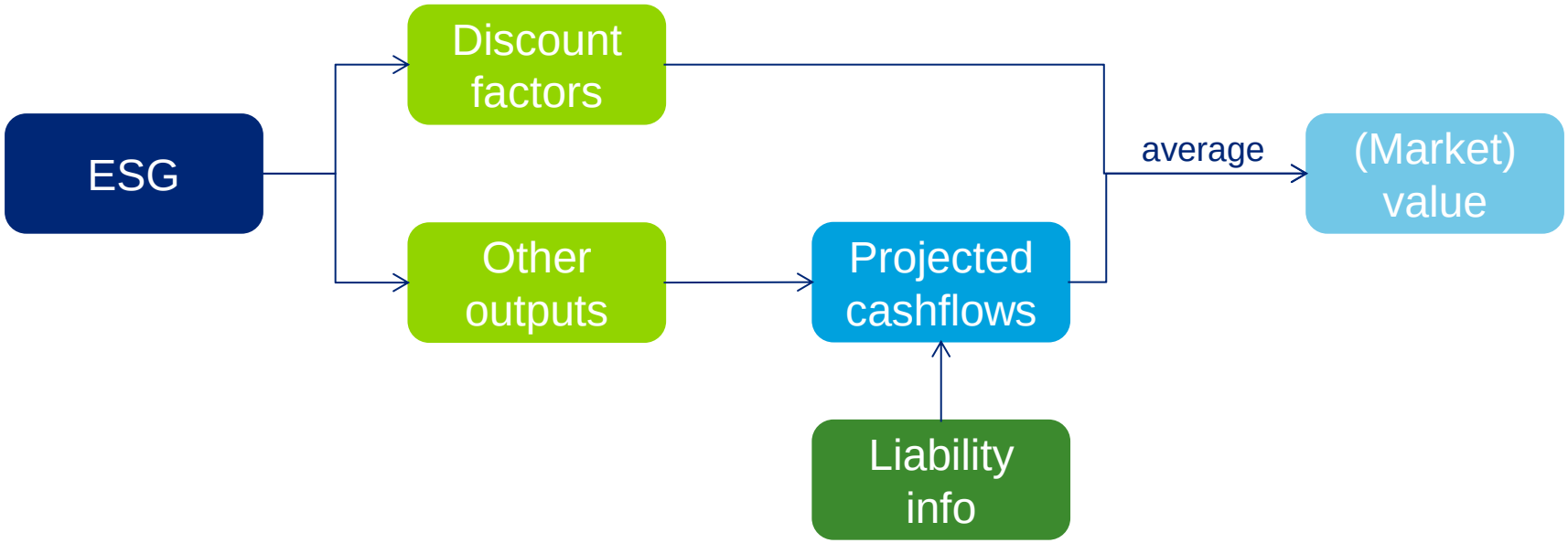
(Deflator-based models incorporate features of both types of model)

- Application: Monte Carlo approach especially useful for valuation when liabilities involve non-linear cashflows:
  - Options/guarantees
  - Path-dependence
  - Management actions

# Using ESGs

## Stochastic modelling for valuation

Liability values found as expected value of discounted projected cashflows:

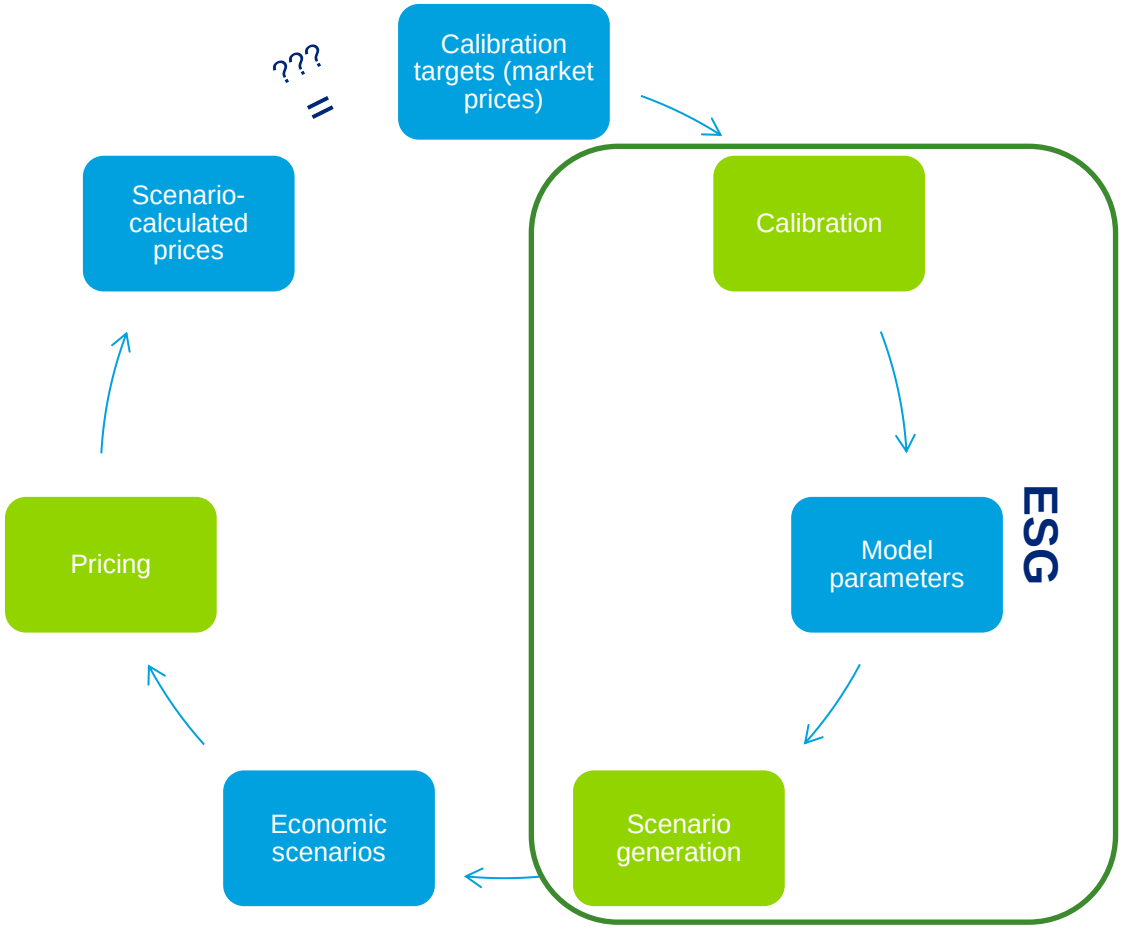



- Risk-neutral means no arbitrage opportunities:
  - Expected PV of any investment strategy is equal to amount invested today
  - In contrast to real-world simulation, where risk premiums may be used

# Using ESGs

## Market consistency

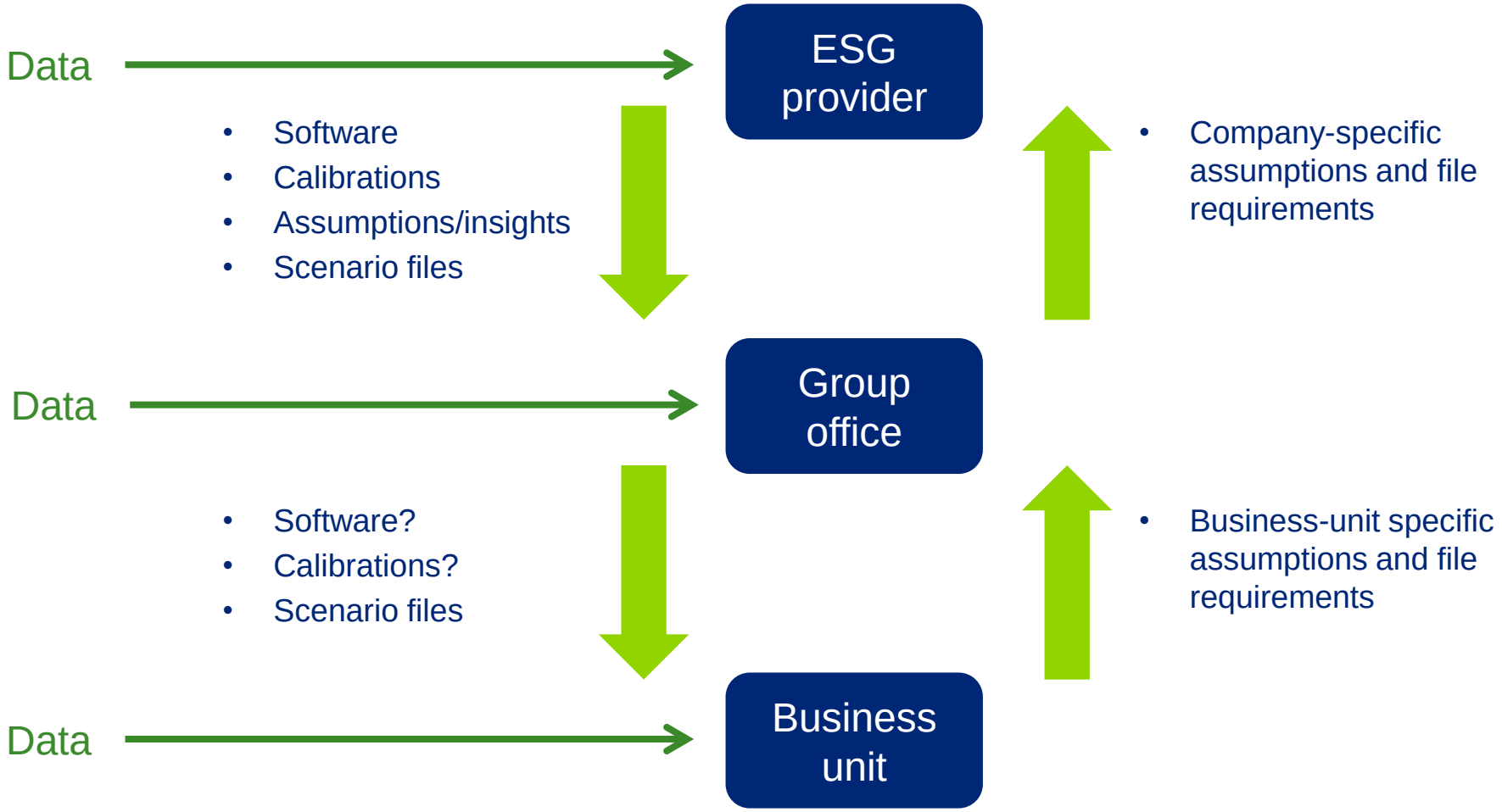
- Risk-neutral ESG models are calibrated to market data




- Calculated values of liabilities (which are complex financial contracts) can be thought of as being a “market price”

# Using ESGs

## Provision of scenarios: a typical process



# Using ESGs

## Provision of scenarios - challenges

- For example:
  - Ownership of assumptions
  - Adequate validation/challenge of assumptions
  - Meeting ad-hoc requirements

- Often Business Units do not have access to software / provider contact themselves, perhaps due to:
  - Cost
  - Resource/expertise requirements

- We are seeing reliance on third party providers and/or group centralisation *increasing* over time
  - For software and resources… but not assumptions!

- For CEE calibrations (e.g. Czech Koruna), lack of market data can make calibration difficult

# Using ESGs

## Solvency II

***Article 126***

*"The use of a model or data obtained from a third-party shall not be considered to be a justification for exemption from any of the requirements for the internal model set out in Articles 120 to 125."*

- Use test
- Statistical quality standards
- Calibration standards
- Profit & loss attribution
- Validation
- Documentation

As an ESG provider, we find we get many more questions and challenges now than we used to – this is good!

# Formulating calibration assumptions

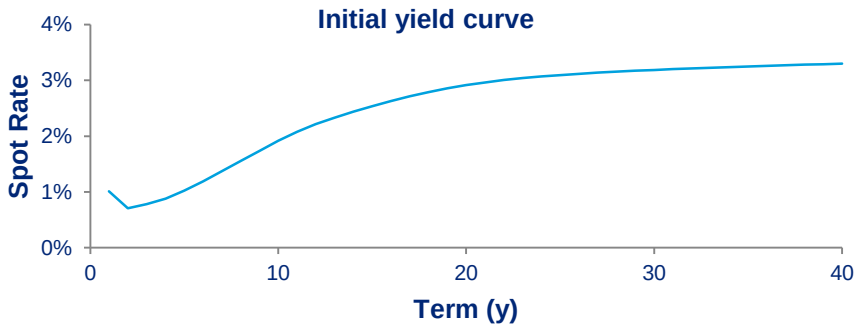
# Formulating calibration assumptions

## Required assumptions

- Aim wherever possible to calibrate to today's **market price data**
- Projected behaviour based upon these prices:

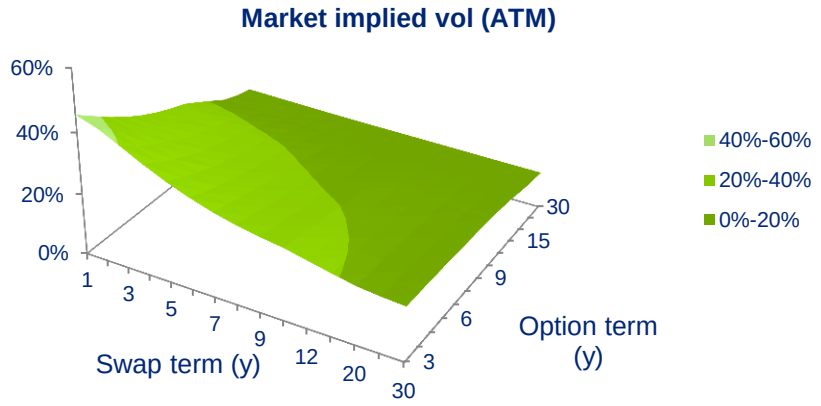
### Drift

- Linear payoffs – bonds, forward contracts




### Volatility, skew, autocorrelation etc.

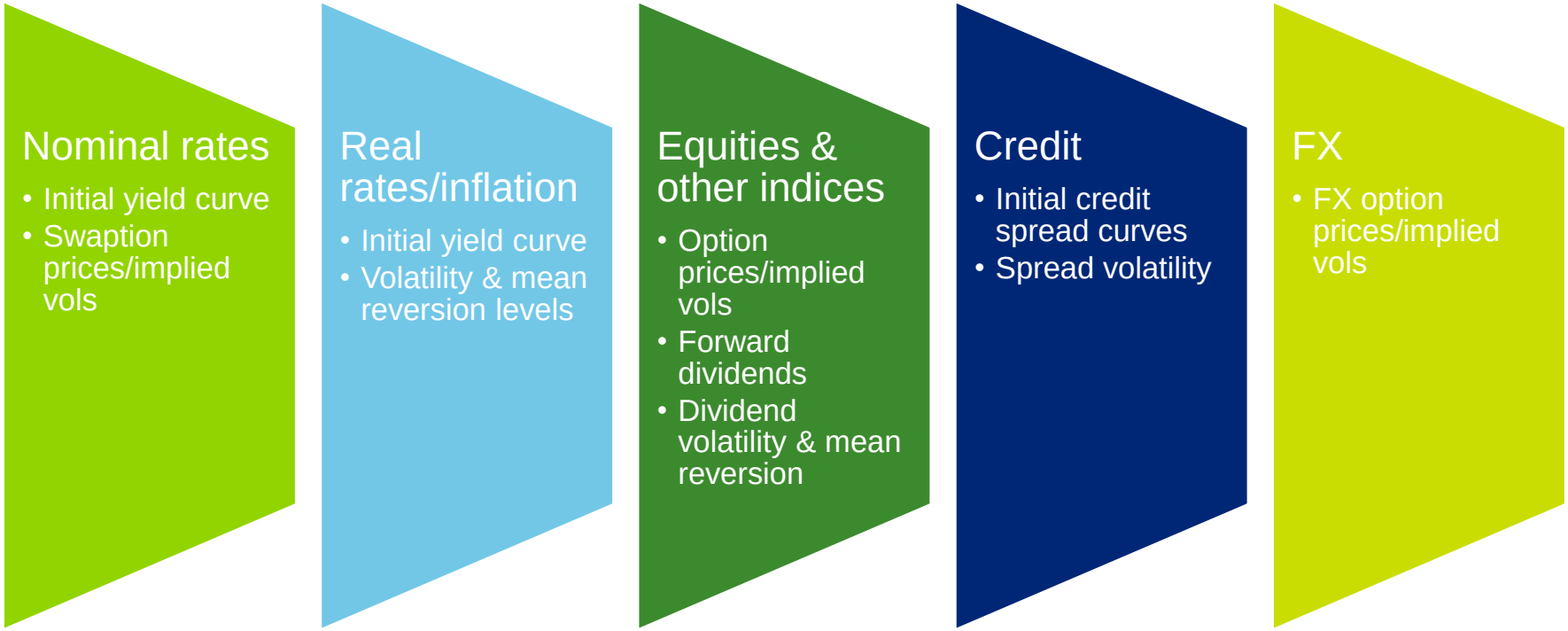
- Non-linear payoffs - options + other derivatives



# Formulating calibration assumptions

## Required assumptions

- Ideally:




+ inter-asset class correlation assumptions!

# Formulating calibration assumptions

## Data challenges

Ideally, we would calibrate using targets solely sourced from market prices. In practice, many reasons why not possible:

| | |
|---|---|
| Nominal rates | • Swaption prices based on swap rates – inconsistency if using government curve |
| Real rates | • Few economies issue inflation-linked bonds<br>• Derivatives on these bonds are even rarer |
| Equities & other indices | • Insurers generally interested in **long term** implied volatilities – very scarce data<br>• For property etc., no liquid derivative markets |
| Credit | • Data very fragmented as multiple issuers – some indices do exist for major economies<br>• Few derivatives |
| Correlations | • Few liquid cross-asset class derivatives |

# Formulating calibration assumptions

## Important features of an assumption-setting approach

The issues described have long existed and **many workarounds can be used**. In a Solvency II world, these must be well-justified!

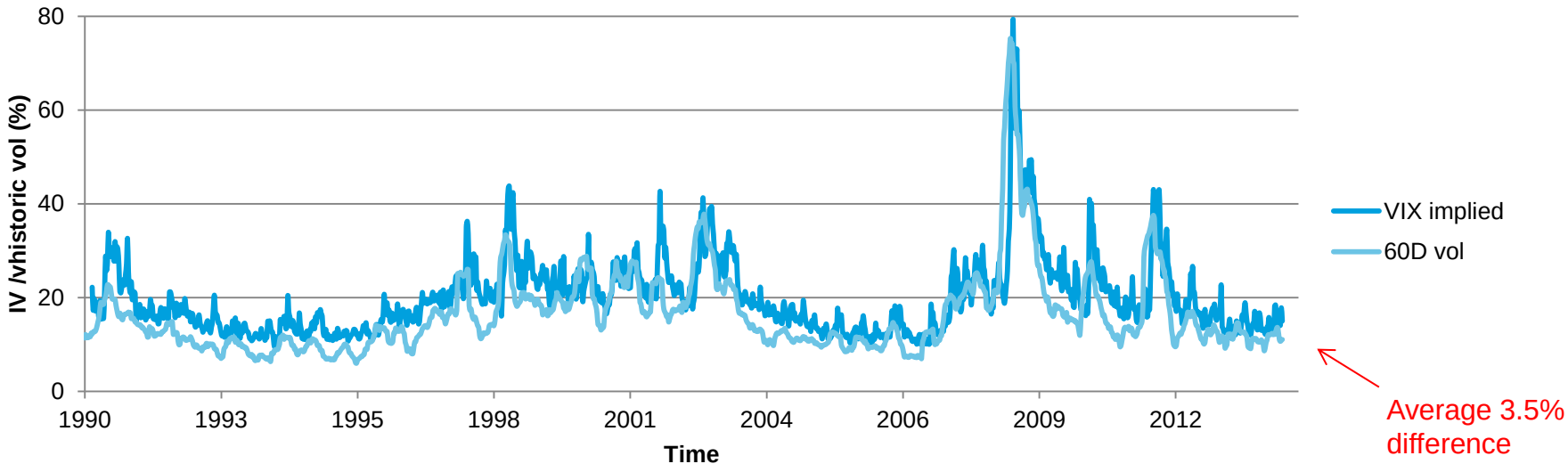
- Informed by relevant data
- Limited and well-validated use of expert judgement
- Stability over time

# Formulating calibration assumptions

## Solutions

### 1 – Use of historic data

- Common approach for several targets
  - Volatility – property, inflation, credit…
  - Correlations
- Note  implied volatility ≠ volatility
  - Bias
  - Observed volatility says nothing about forward-looking term structure, skew

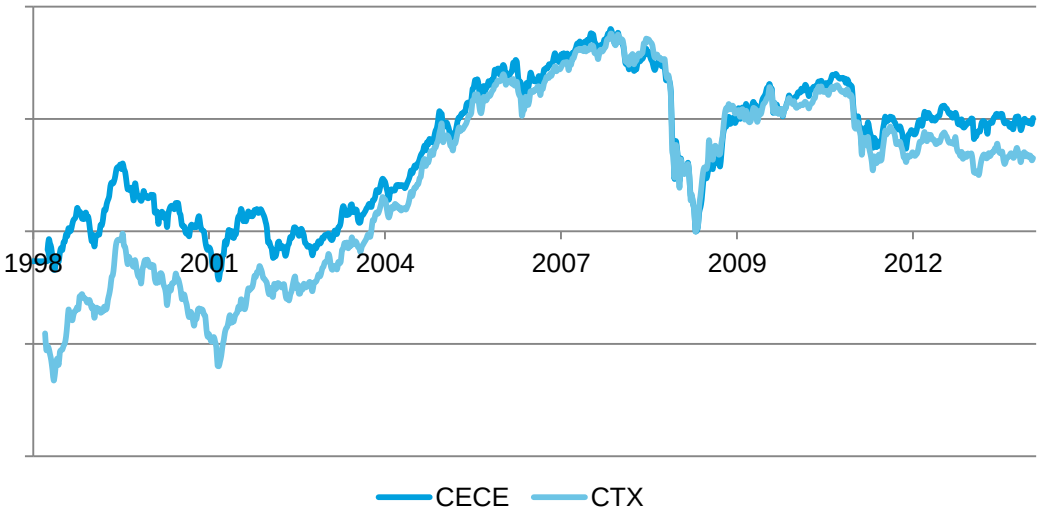


# Formulating calibration assumptions

Solutions

## 2 – Use of proxy data series

- Asset class may be approximated by a related, more established class for which data exists
- Substitute assumption should be well-validated:
  - Statistically
  - Analysis of underlying drivers




- May seek to make appropriate adjustments to proxy data

# Formulating calibration assumptions

Solutions

## 3 – Third party guidance

- Calibration assumptions are, ultimately, prices of simple financial contracts
  - Request quotes from banks – they are the market makers!
  - Seek assistance from data provider
  - Inspect regulatory returns
- With Solvency II, insurer still required to take ownership of assumptions

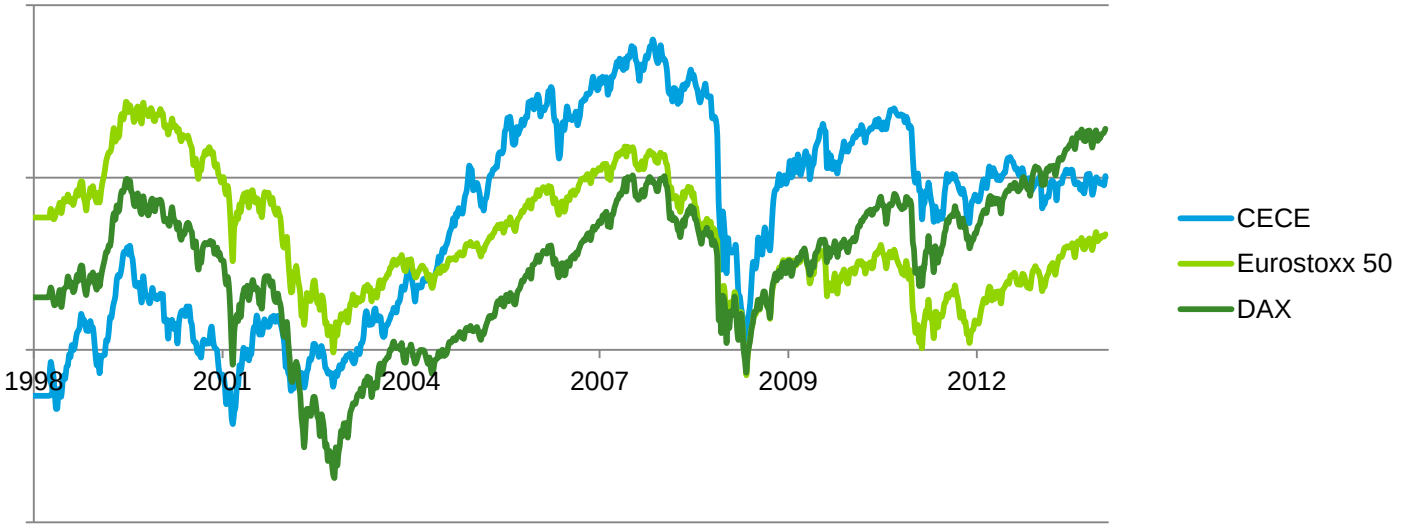
# Formulating calibration assumptions

## Example – Czech/CEE equity

- Only short-term options traded for CECE
  - Would like a full surface

- Could we use a major EUR index like the Eurostoxx or DAX as a proxy?

**Historic behaviour:**



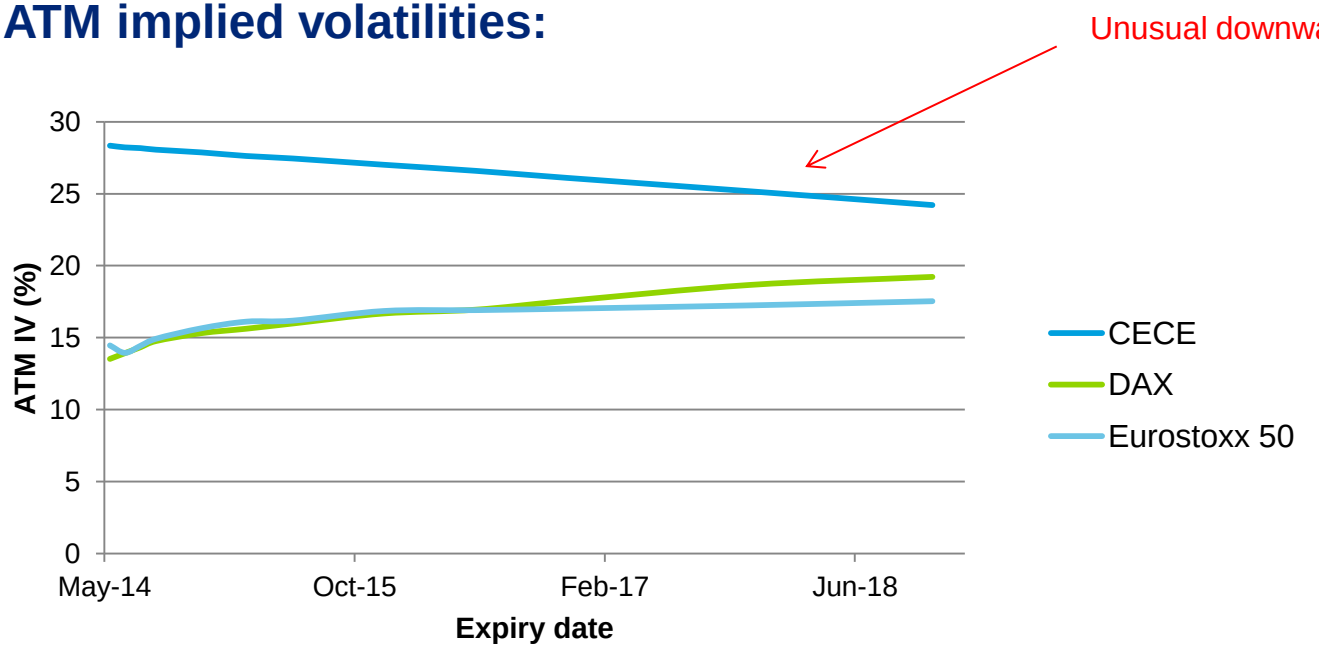
# Formulating calibration assumptions

## Example – Czech/CEE equity

### Historic volatility:

| CECE | Eurostoxx 50 | DAX |
|---|---|---|
| 27.2% | 23.1% | 24.44% |

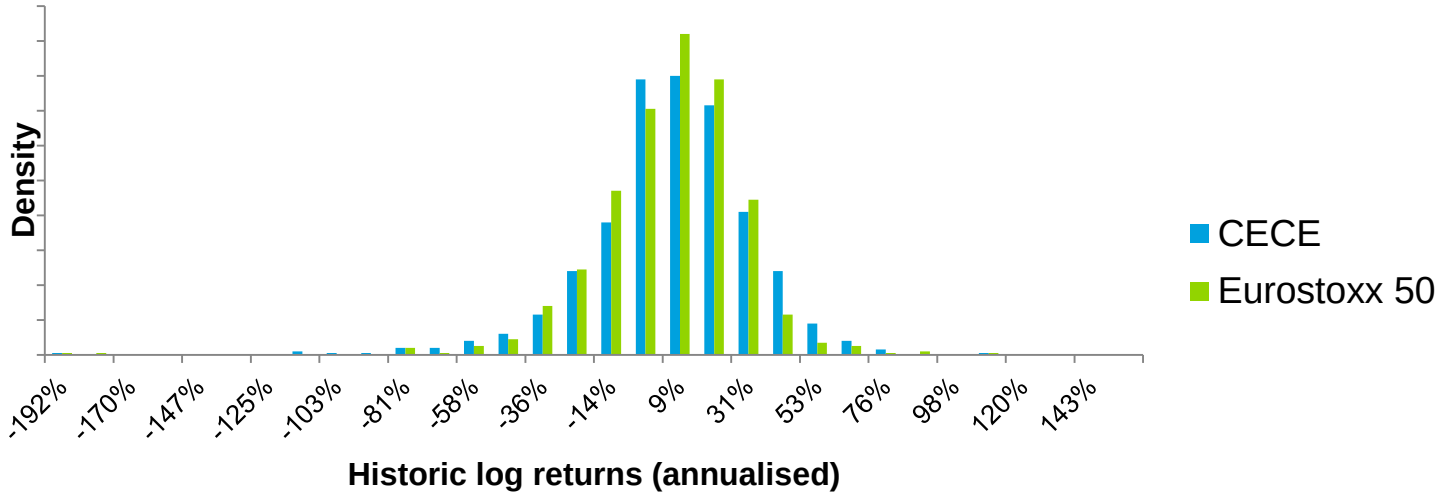
### Short term ATM implied volatilities:



# Formulating calibration assumptions

## Example – Czech/CEE equity

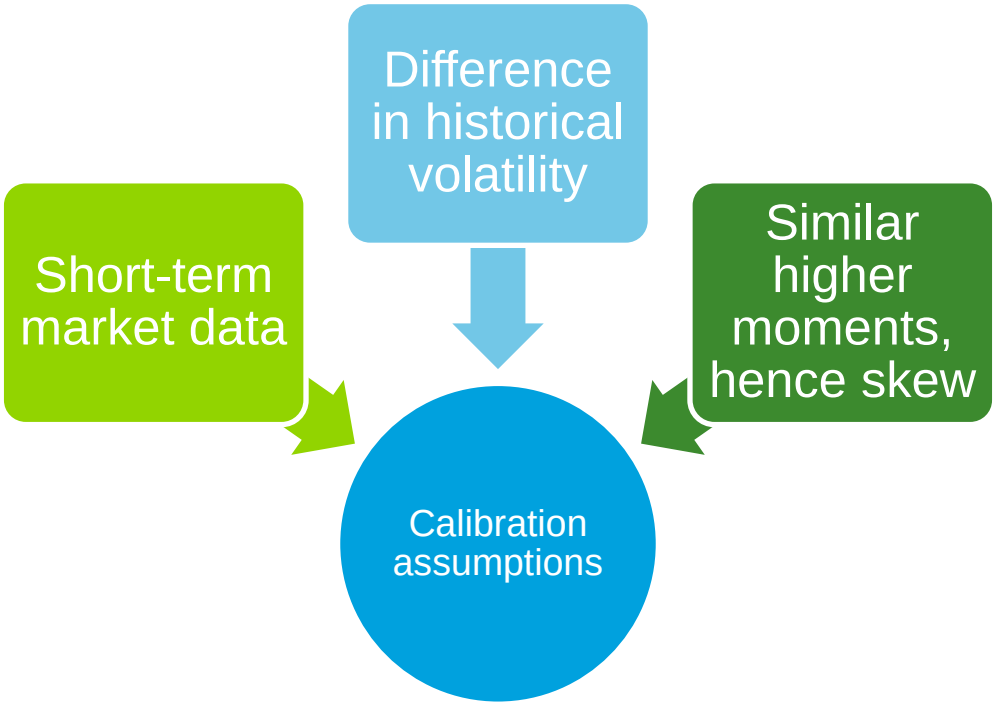
### Higher moments:




| | CECE | Eurostoxx 50 |
|---|---|---|
| Skewness | -0.7 | -0.8 |
| Kurtosis | 6.2 | 5.9 |

# Formulating calibration assumptions

## Example – Czech/CEE equity




- Lot of choice as to how incorporate these observations into assumptions
  - But this analysis provides us with evidence to back-up approach
- Approach should be robust – i.e. stable over time

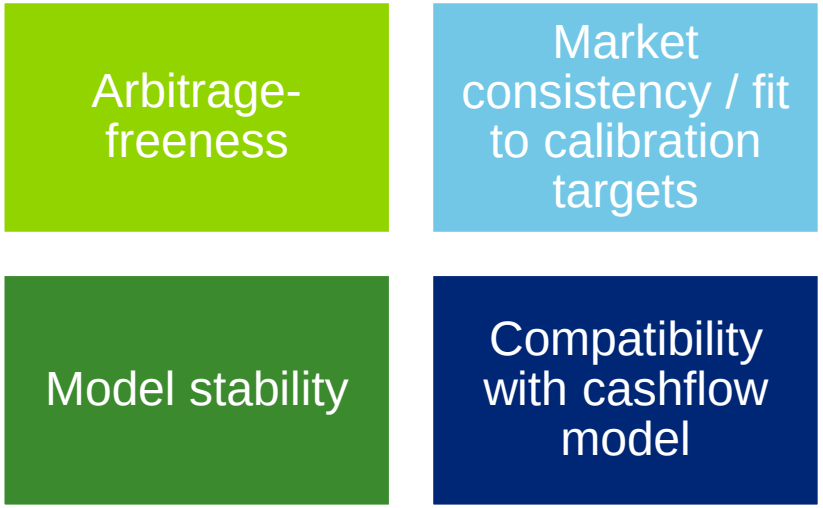
# Validating scenario sets

# Validating scenario sets

## Aims

- Having made a set of scenarios, must adequately validate them

- Seek to verify:

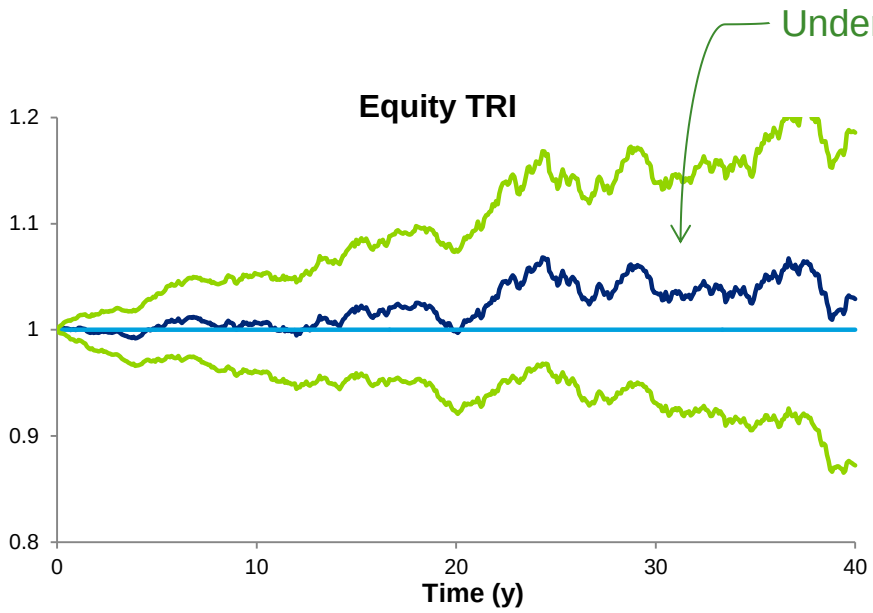


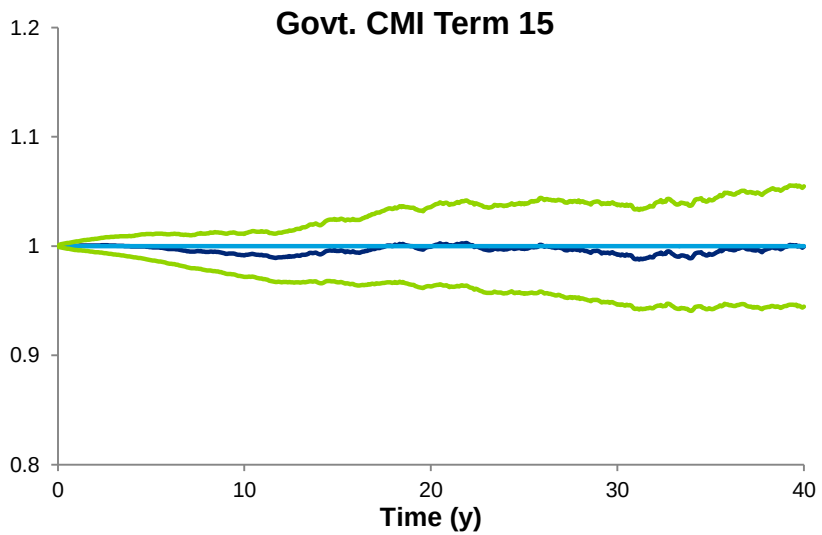

- Ideally in as automated and judgement-free way as possible

# Validating scenario sets

## Analyses – no arbitrage/leakage

Test both raw outputs and more complex (dynamic?) strategies:



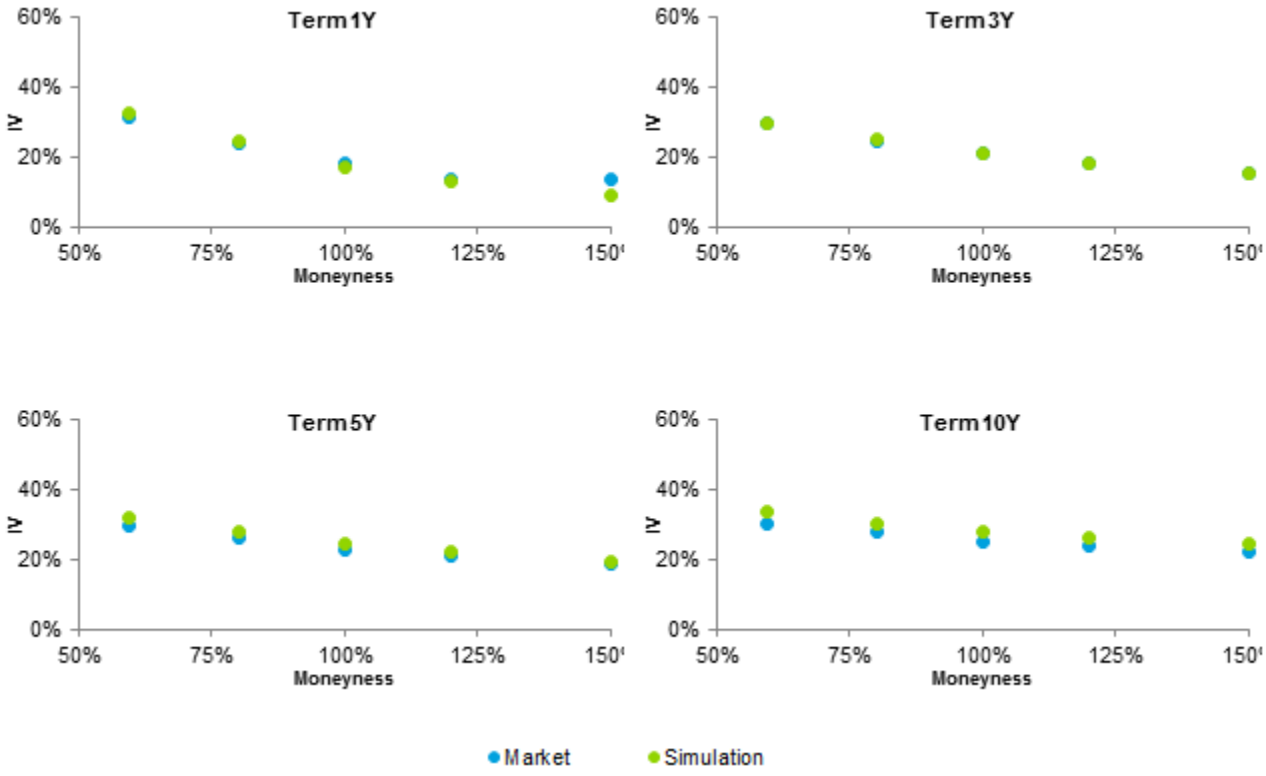




- Means of quantifying error:
  - Maximal error
  - Confidence intervals
  - Terminal leakage

# Validating scenario sets

## Analyses – market consistency

Compare market prices against those found through pricing using scenarios:



# Validating scenario sets

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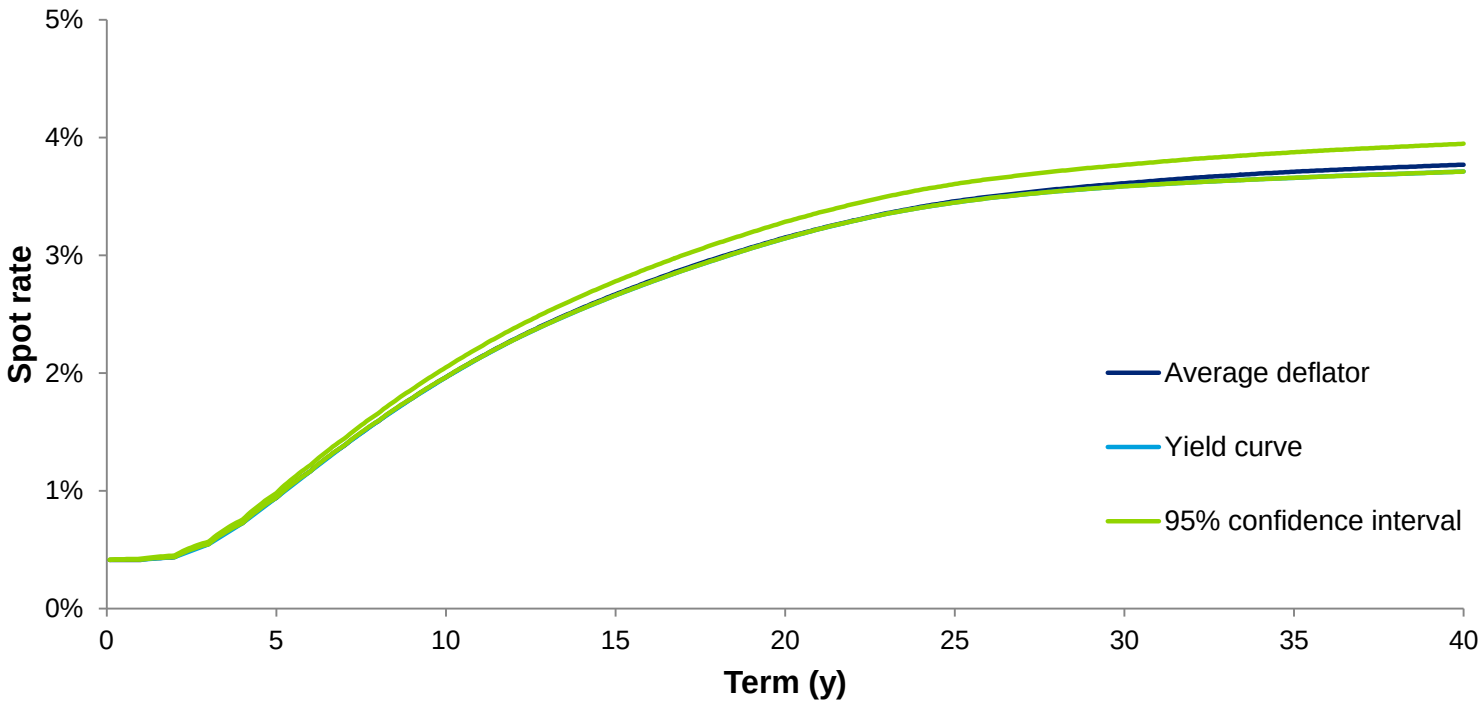


# Validating scenario sets

## Analyses – market consistency

- Monte Carlo prices are an average

  → can use similar pass/fail criteria used for no-arbitrage tests

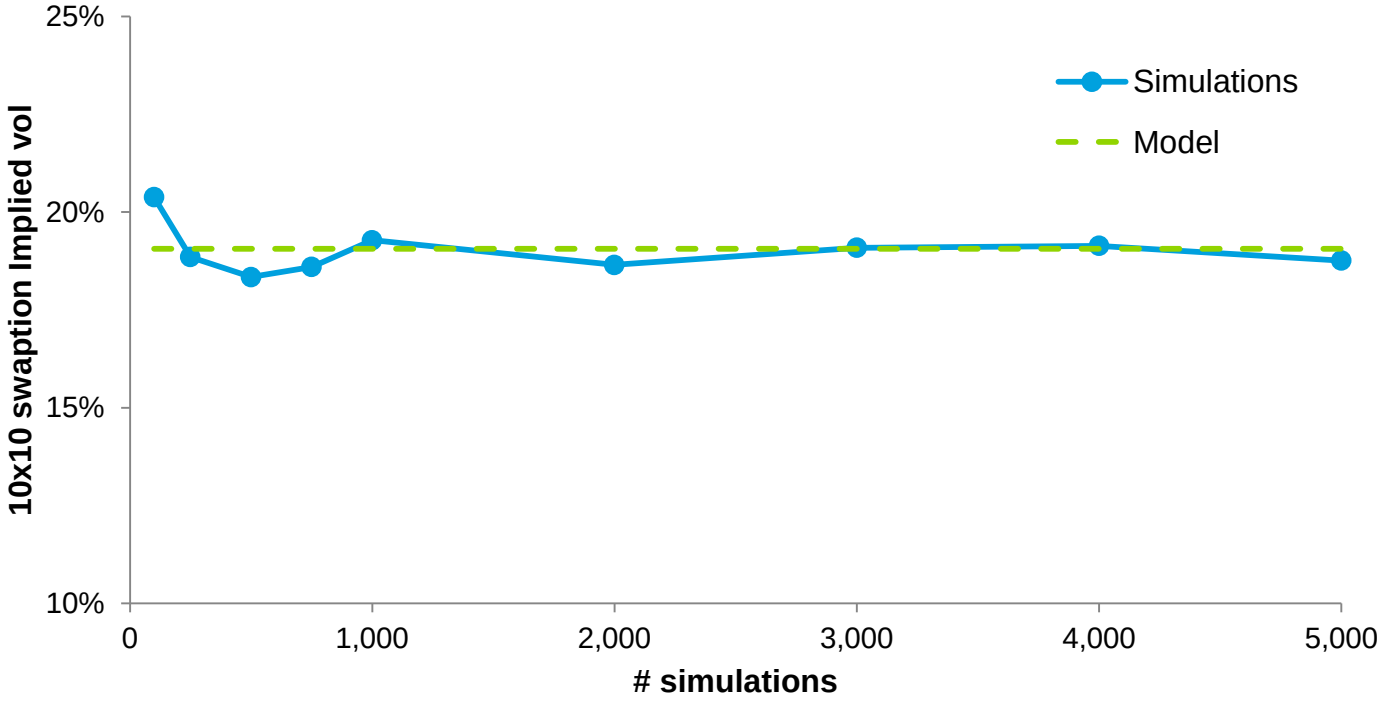
- Can break down error into two parts:


- Significance of sampling error best quantified through comparing prices, not vols etc.

# Validating scenario sets

## Analyses – convergence

- Are we convinced enough simulations have been used?




- In more volatile environments, more scenarios required

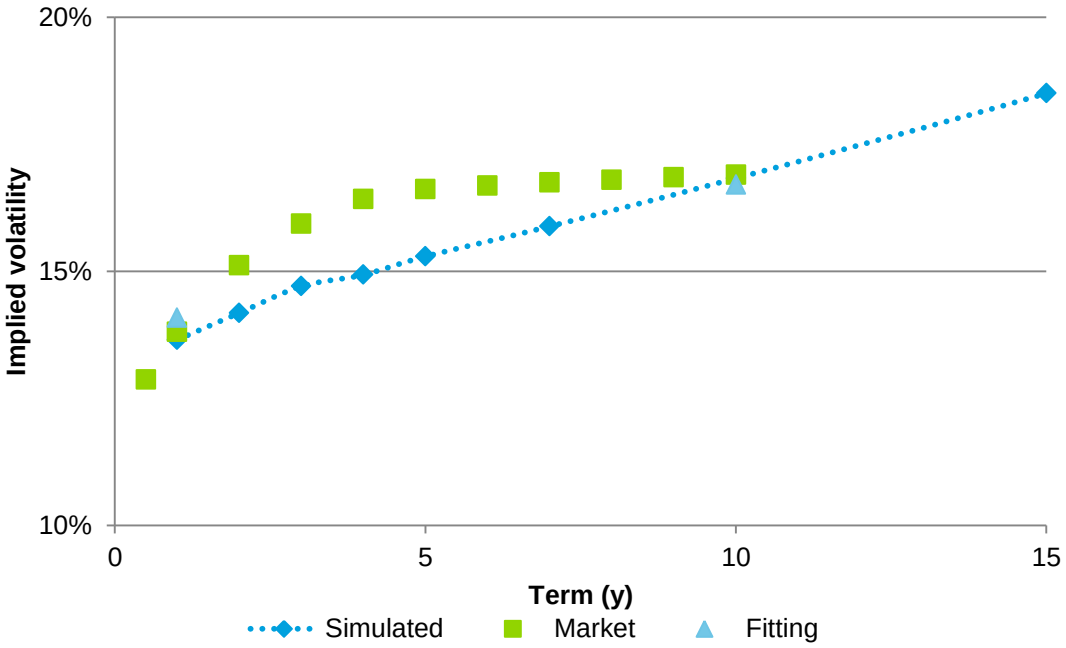
# Validating scenario sets

## Analyses – out of sample testing

- Wish to verify model is not over-fitted, but instead has some predictive power
  - If it doesn't, ESG is pointless!

Do not always have excess data available, but sometimes we do!

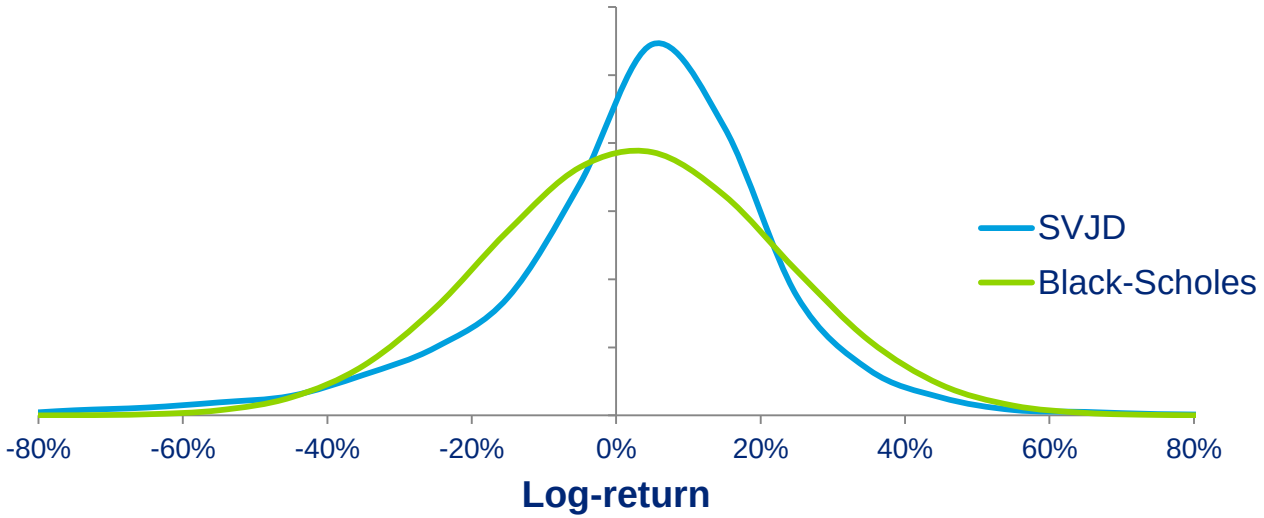
- Bond prices
- Swaption cube points
- Interest rate caps
- Intermediate points on implied vol term structure



# Validating scenario sets

## Analyses – distributional features

- Out-of-sample contracts most likely to be mispriced if output distributions are “not sensible”
- Extreme distributions may also impact ALM model compatibility




- Additionally, consider changes in distributional statistics over time – are these consistent with changes in calibration assumptions?

# Validating scenario sets

## Analyses – distributional features

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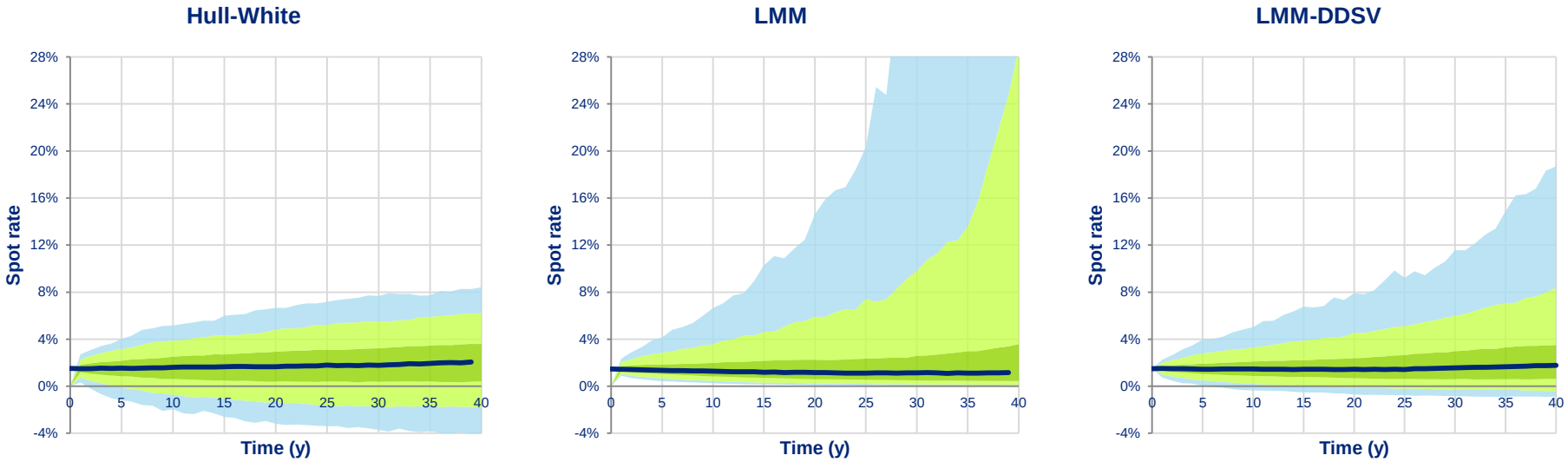


- Additionally, consider changes in distributional statistics over time – are these consistent with changes in calibration assumptions?
- Aside: have seen other European regulators asking firms to test multiple models

# Validating scenario sets

## Analyses – calibration stability

- For a given model, finding optimal parameter set is a hard problem

### 1) Test optimisation routine

– Generate targets *from* the model

– Fit to these targets – should be able to achieve **exact fit**, and ideally same parameters as used to generate targets

### 2) Test goodness-of-fit over time

– Fit to historic targets

– Asses fit in range of market conditions, and stability over time

### 3) Test parameter stability

– Make small adjustments to initial guess – should have small impact on outcome

# Validating scenario sets

## Doing all this analysis

- Some of this is one-off work (validating optimisation routine etc.)
- Model is not particularly firm-specific – provider may be best to validate
  - Firm need only demonstrate evidence and understanding
- If Business Unit is reliant on Group for scenarios, must seek to request sufficient information to calibrate
  - e.g. to accurately price swaption, many outputs required
- Much of regular validation process can be automated

# Future challenges

# Future challenges

## Immediate issues

- ESGs models have reached a mature stage where most calibration targets can be achieved:
  - Initial yield curves
  - Option surfaces
  - Volatility cubes
- Some advances can still be made with regards to credit modelling
- Automation an area of focus as volume of ESG file required increases
  - Quicker delivery
  - Sensitivities
  - Nested stochastic etc.

# Future challenges

## Longer term

- Emerging standards, including Solvency II and IFRS, continue to emphasize market consistency - generally a good thing.
- Insurance definition is based on classical option pricing theory (replicating portfolios); many assumptions:

### Forbidden

- Bid-ask spreads
- Market impact of trades
- Information asymmetries
- Taxes
- Solvency capital requirements and costs of holding these.
- Collateral posting requirements
- Risk of default on derivatives
- Illiquidity premiums or other non-cash-flow valuation effects

### Required

- Investment and unlimited borrowing at a single risk free rate.
- Unlimited and infinitely-divisible supply of underlying assets.
- Continuous-time trading (24/7)
- Buying and selling with no impact on the market price.
- Consensus on possible price moves in the underlying asset.

- Limitations highlighted post-2008!

# Future challenges

## Longer term

- Banks have adopted adjustments to counter weaknesses in theory:

| | |
|---|---|
| Credit valuation adjustment **CVA** | Allowance for possible default by derivative counterparties |
| Debit valuation adjustment **DVA** | Reduce stated liabilities with an allowance for own default. |
| Funding valuation adjustment **FVA** | Allowance for funding of derivative position (borrowing over the risk free rate, stock lending, collateral posting). |

- These innovations may hit insurers first via IFRS rather than Solvency II

# Future challenges

## Longer term

- Real-world modelling has itself advanced greatly in recent years due to Solvency II
  - *Diverged* from risk-neutral approach
- Incorporating these “real-world” features into market-consistent modelling will bring these two types of modelling closer together
- Working towards a Grand Unified Model!