LLOYD'S

SOLVENCY II MODEL VALIDATION WORKSHOP 1

15 & 16 March 2011

Agenda

- Introduction and overview of workstream

- Model Validation

- Assumptions & Expert Judgment

  Short break

- Dependencies

- Validation Tools

 *Table discussions and play back*

- Next Steps

# INTRODUCTION & OVERVIEW OF WORKSTREAM

Introduction

- A reminder of where we got to in 2010

- Recap on workstream objectives and deliverables for 2011

- Provide examples of what we will be looking for in our reviews

  o continue with syndicate 999

- You asked for more technical detail and here it is!

- Answer questions where possible

  o take away any we can't answer today and publish in FAQs

- And audience participation to keep you alert and interested!

Where did we end 2010 …
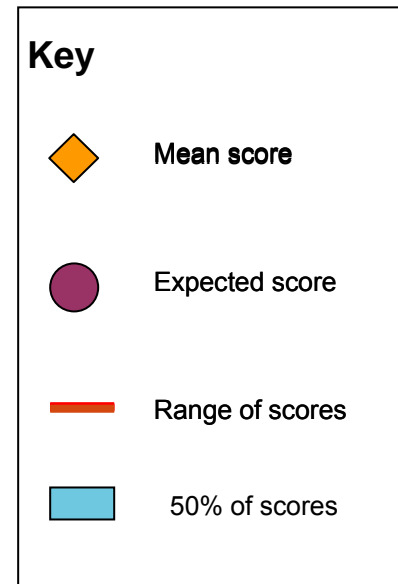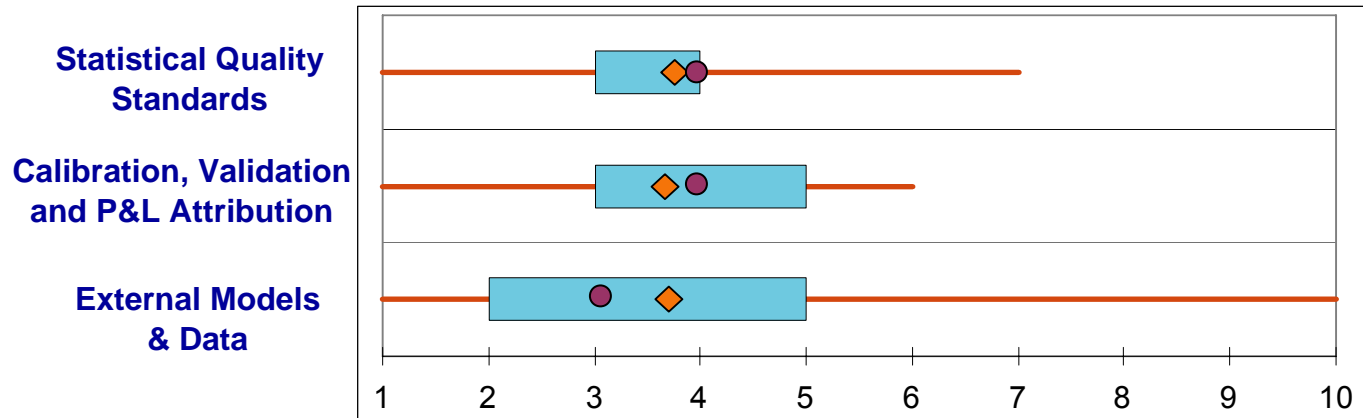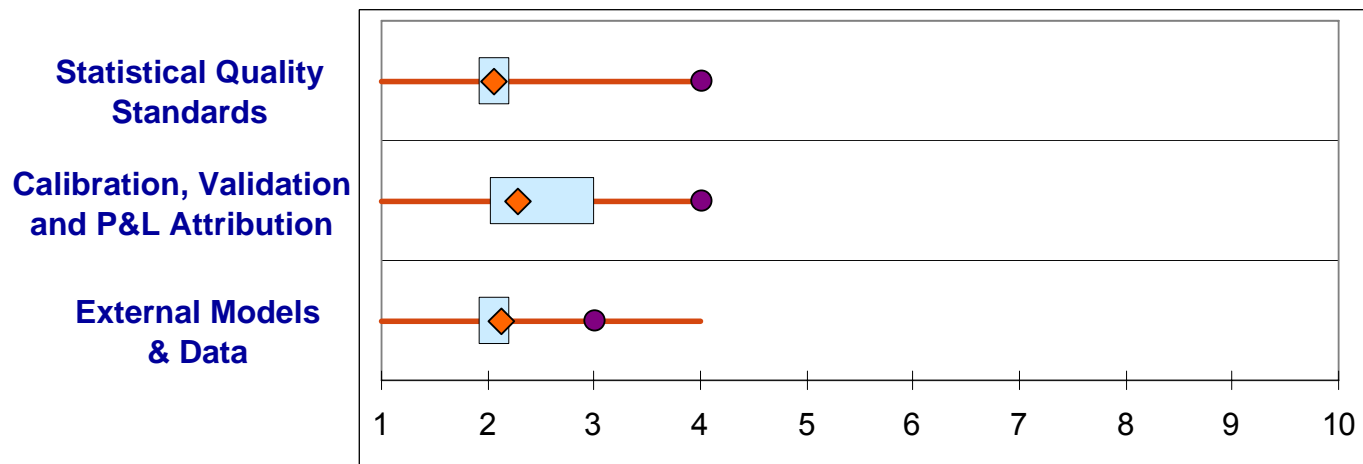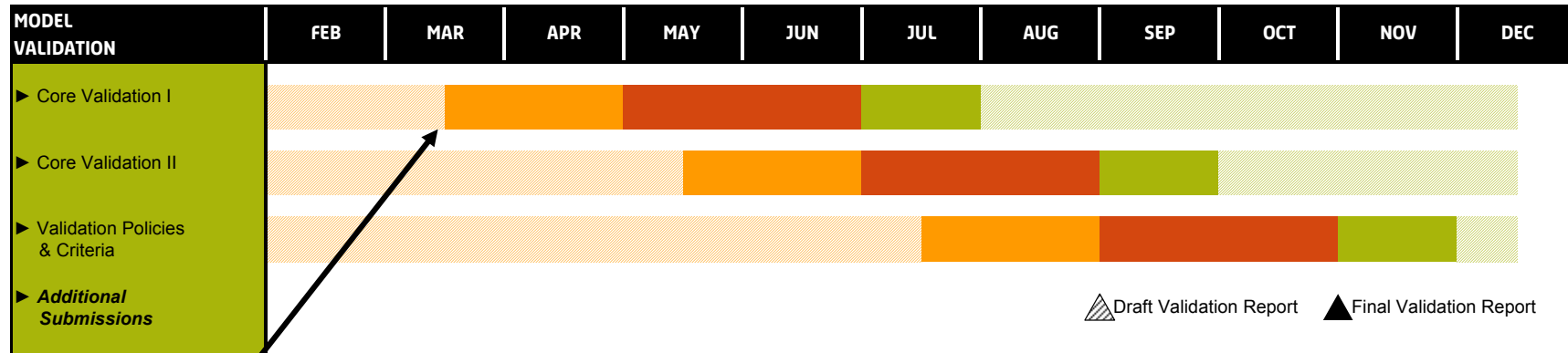
… and what is needed to improve scores?

The good news

- We believe that many agents have made progress on SQS and CVP that was not captured in their documentation

What was missing

- In many cases agents have not provided practical detail on how their validation process will work – theoretical vs practical

    o Examples include specifics on how the tools will be applied and criteria for reasonable test results

- These findings are similar to those in the FSA's **Solvency II: Internal Model Approval Process Thematic review findings** (February 2011) http://www.fsa.gov.uk/pubs/international/imap_final.pdf
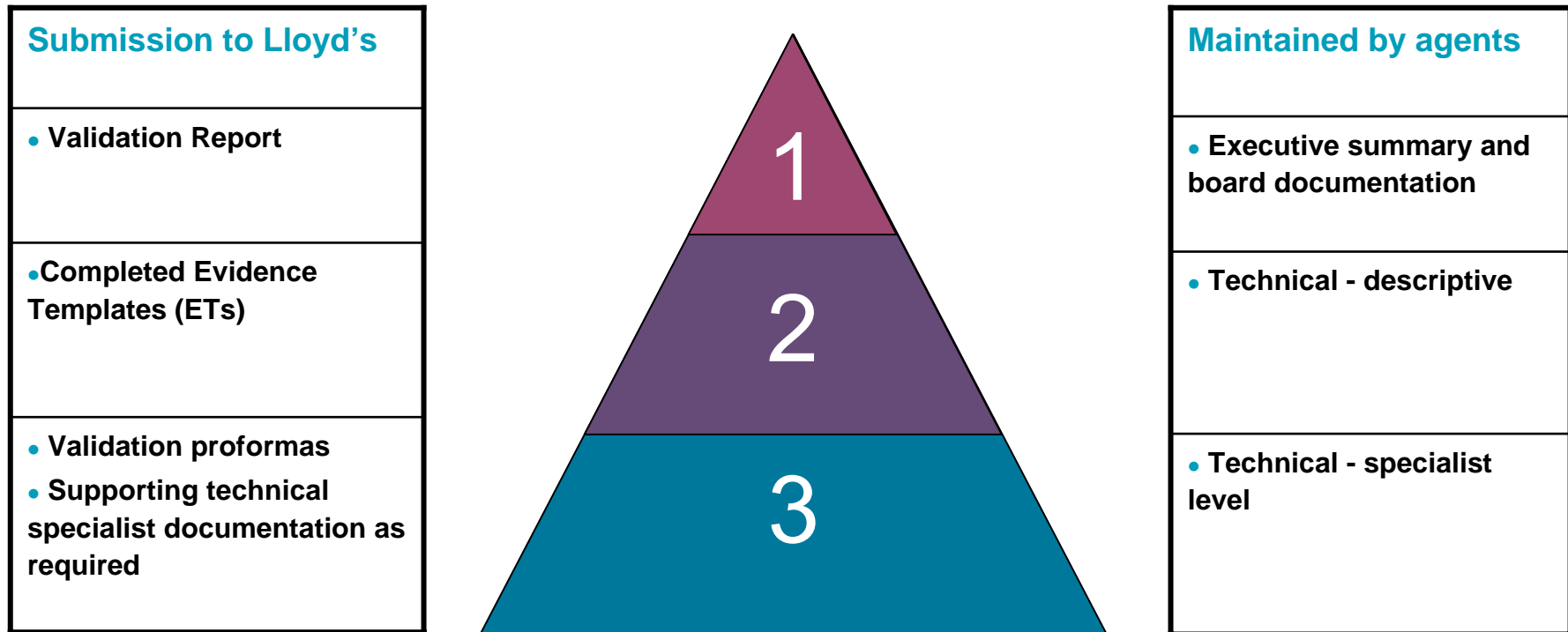
Workstream plan: Overview

MODEL VALIDATION	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
► Core Validation I											
► Core Validation II											
► Validation Policies & Criteria											
► *Additional Submissions*											

△ Draft Validation Report ▲ Final Validation Report

You are here

Core Validation I

- Assumptions & Expert Judgment
- Dependencies
- Model robustness
- Stress & Scenario testing
- Backtesting

Core Validation II

- Calibration
- Probability distribution forecast
- P&L attribution
- External models

Policies & Criteria

- Methodologies
- Validation policy
- Data directory & policy
- Risk mitigation
- Mgmnt actions
- Guarantees etc

Model Demonstrations

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Independent validation is required to ensure objective challenge in an agent's validation process

Objectives for agents	Demonstrate that you meet the Statistical quality, Calibration, P&L attribution, Validation, and External Models and data tests and standards for internal model approval. (CEIOPS 48/09: chapters 5-8 and 10)
What areas of validation are covered?	Data, assumptions, methods and expert judgement. (CEIOPS 48/09: 8.18. - Documentation, systems/IT, model governance and the Use test will be covered under other workstreams but will need to be in validation report.)
Deliverables	• Evidence template updates – 28 April, 30 June, 26 Aug & 16 Dec • Draft Validation report 26 Aug & Final validation report 31 Oct
Lloyd's review approach	On site model reviews, evidence template reviews and supporting documentation on sample basis, standardised tests
Feedback	Agent specific feedback and market de-briefs via workshops

Differing levels of documentation

Submission to Lloyd's

- **Validation Report**

- **Completed Evidence Templates (ETs)**

- **Validation proformas**
- **Supporting technical specialist documentation as required**

1

2

3

Maintained by agents

- **Executive summary and board documentation**

- **Technical - descriptive**

- **Technical - specialist level**

# At what stage would you describe your internal model validation policy?

A. Fully defined and embedded.

B. Pretty much well defined, but still
    needs finalisation and approval.

C. Drafted, but still subject to
    significant debate.

D. Not well defined and a lot of work
    is still to be completed.

E. None of the above!

Does it match submitted scores and what progress has been made?
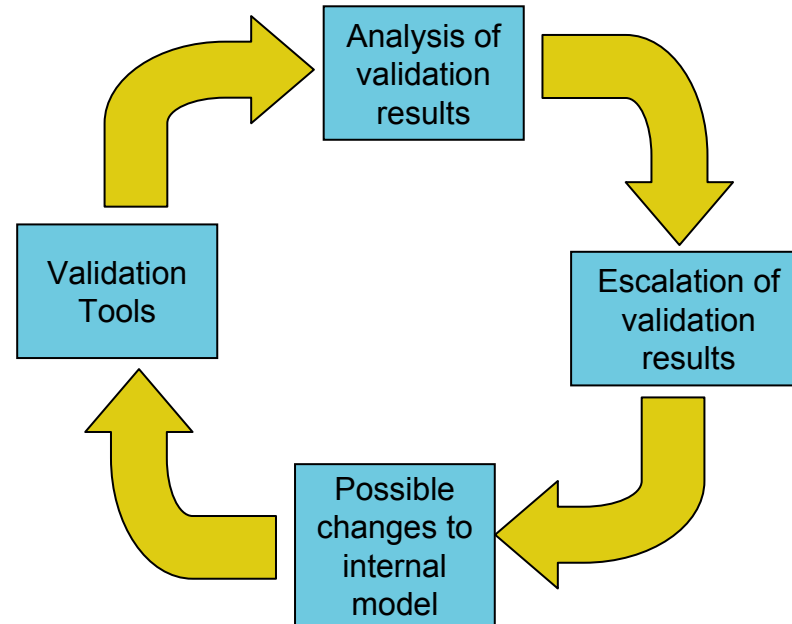
Agent self assessment (August 2010)
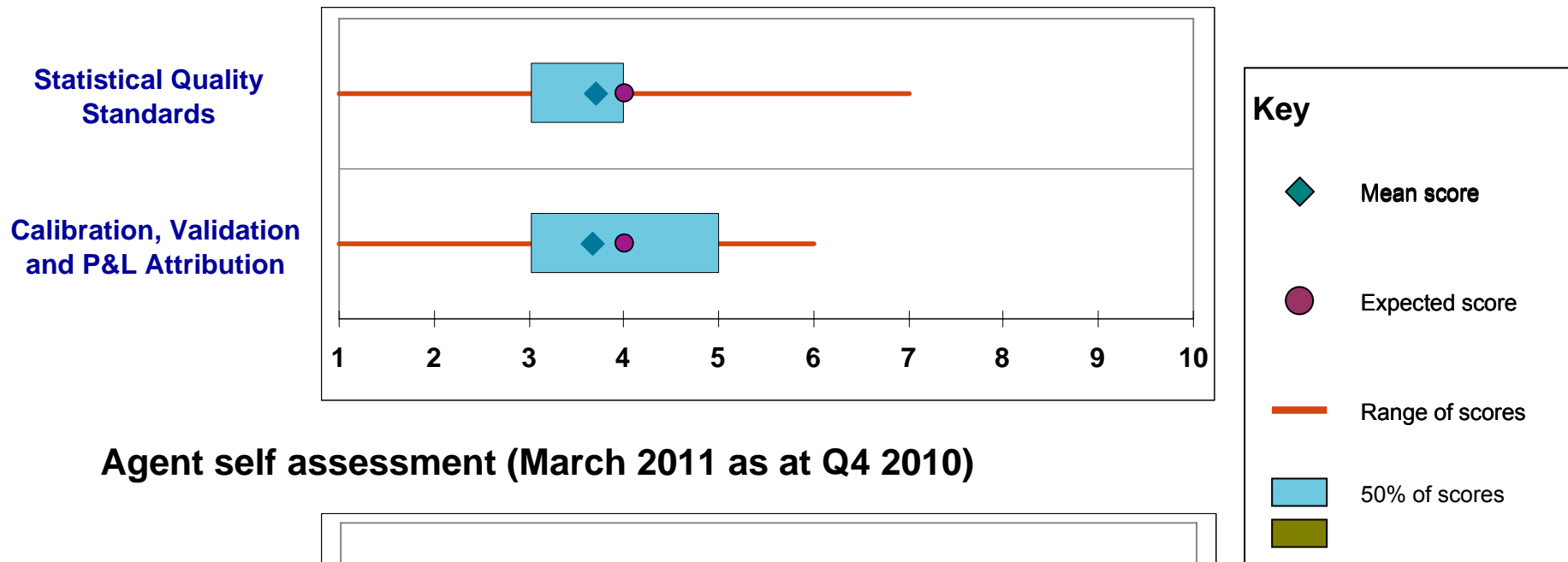
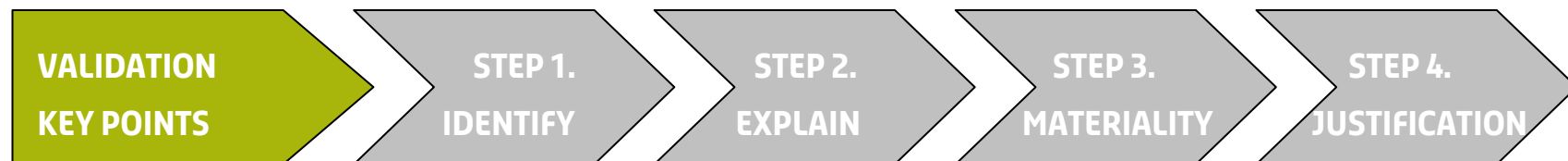**Agent self assessment (March 2011 as at Q4 2010)**

Key

- ◆ Mean score
- ● Expected score
- — Range of scores
- � 50% of scores

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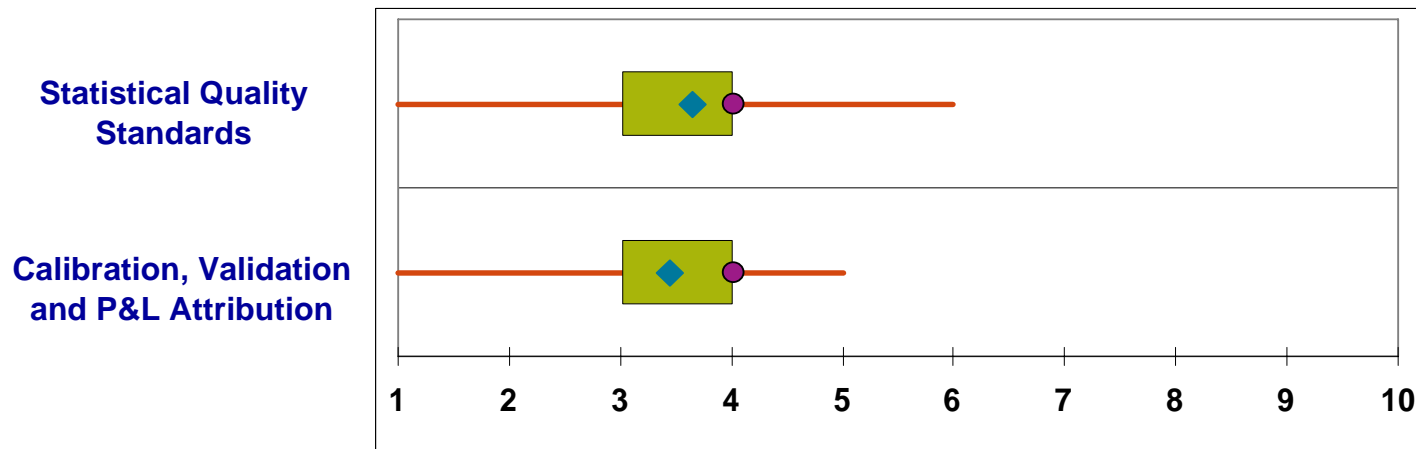
MODEL VALIDATION

Validation is a process – not a test

```
        ┌──────────────┐
        │  Analysis of │
   ⤴    │  validation  │   ⤵
        │   results    │
        └──────────────┘
┌──────────────┐          ┌──────────────┐
│  Validation  │          │ Escalation of│
│    Tools     │          │  validation  │
│              │          │   results    │
└──────────────┘          └──────────────┘
   ⤴    ┌──────────────┐   ⤵
        │   Possible   │
        │  changes to  │
        │   internal   │
        │    model     │
        └──────────────┘
```

CEIOPS 48/09 (8.20)

- It's not enough to just apply the tools.

- "*Poor practice was also shown when firms could not articulate the criteria used to validate parts of the internal model.*" (FSA, Thematic review findings, February 2011)

| VALIDATION KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |

There is a common theme in validation

- **1. Identification** – specification of the data/ assumption/ method/ EJ to be validated

- **2. Explanation** – how it is used in the model

- **3. Materiality** – how significant it is

- **4. Justification** and limitations – why it is or is not appropriate

- Also remember **proportionality** – more validation effort on the more material risks

| VALIDATION KEY POINTS	STEP 1. IDENTIFY	STEP 2. EXPLAIN	STEP 3. MATERIALITY	STEP 4. JUSTIFICATION
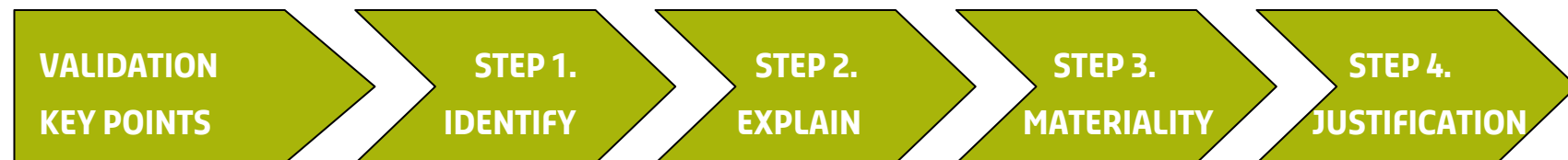
Materiality is more important than definitions

- Some common (frustrating) dilemmas:

  - In or out of scope?

  - Assumption or expert judgement?

  - External model/data or not?

- The level of validation required depends on the materiality of the data/ assumption/ method/ EJ – **not** on how you label it

| VALIDATION KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |
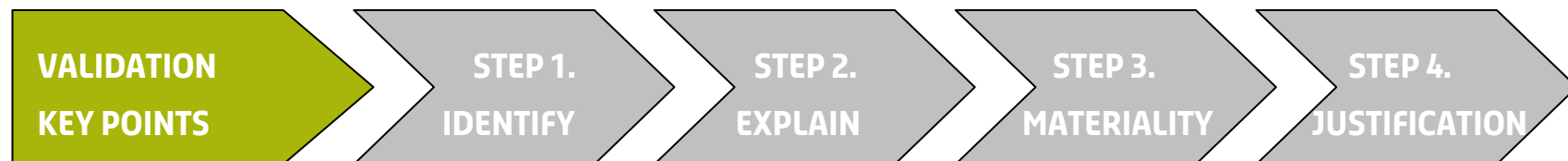
Methods must be validated

- No method is mandated or pre-approved – including how the SCR is calculated or whether you use a stochastic model (Article 121-4).

- **Exception**: all undertakings need to use the validation tools listed in CEIOPS 48/09 (8.3.3)
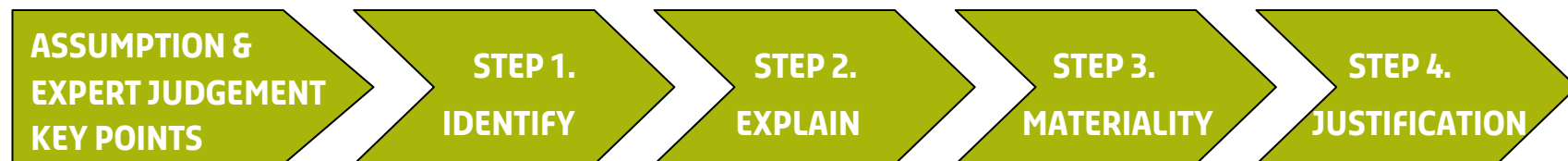
- Lloyd's takes the same position
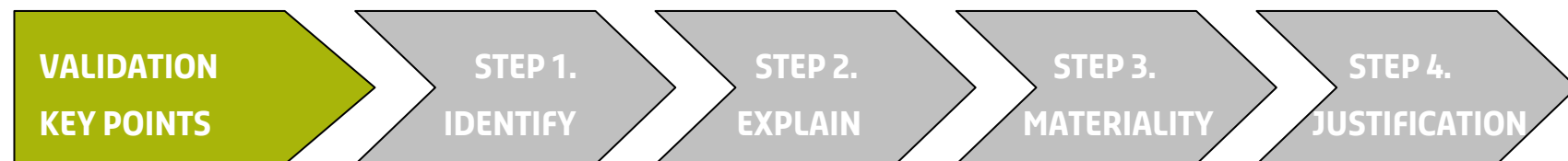
VALIDATION KEY POINTS > STEP 1. IDENTIFY > STEP 2. EXPLAIN > STEP 3. MATERIALITY > STEP 4. JUSTIFICATION

Which element of validation is currently causing most issues?

A. Knowing what tests to apply

B. Producing evidence that guidance is met

C. Resource constraints

D. Independence and objective challenge

E. Other

ASSUMPTIONS & EXPERT JUDGEMENT

Four key themes to touch on

1. Transparent **identification** and clear **documentation** of assumptions is required

   o *"The undertaking shall identify all assumptions inherent to the internal model" (5.115)* and "*Undertakings shall document all internal model assumptions and the corresponding procedures*" *(5.118)*

2. You must be able to **provide a rationale** with supporting evidence for the judgments and assumptions you have made

   o "….*At any time the undertaking shall be able to explain and justify [these] assumptions to the supervisory authority*" *(5.116)* and "*[expert judgment] is admissible only if its deviation and usage follows a scientific method.*" (5.185)

3. Understand the **materiality** of the assumptions in your model and reflect this in your validation efforts

   o "*…the undertaking shall take into account as a minimum: 1) Significance [of the assumption]…*" *(5.116)*

4. Develop transparent **criteria** for validating assumptions, and demonstrate these criteria are applied

   o Undertakings should be able to "*specify what an unreasonable output would be.*" (FSA, Thematic review findings, February 2011)

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION
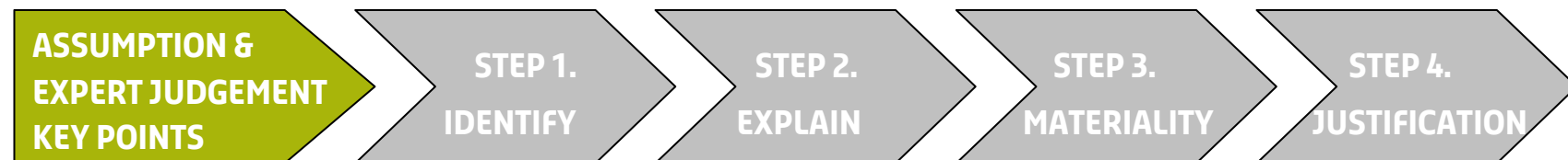
What is an assumption ?

- Consider a frequency / severity model based on historical data

- Which of the following are assumptions?

  1. Adjustments made to data for parameterisation (e.g. inflation)

  2. Choice of poisson distribution for frequency and lognormal for severity

Vote:

   A. Neither

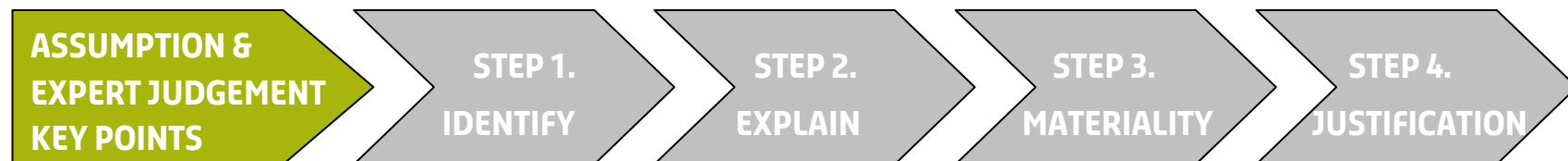   B. 1 Only

   C. 2 Only

   D. Both

The answer is it really doesn't matter!

- All modelling decisions need to be justified and validated - the appropriate approach will vary according to:

  o The level of materiality

  o The range of potential alternatives

  o The sensitivity of the result to the decision

  o The tools that are appropriate for the particular decision

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS ▸ **STEP 1. IDENTIFY** ▸ **STEP 2. EXPLAIN** ▸ **STEP 3. MATERIALITY** ▸ **STEP 4. JUSTIFICATION**
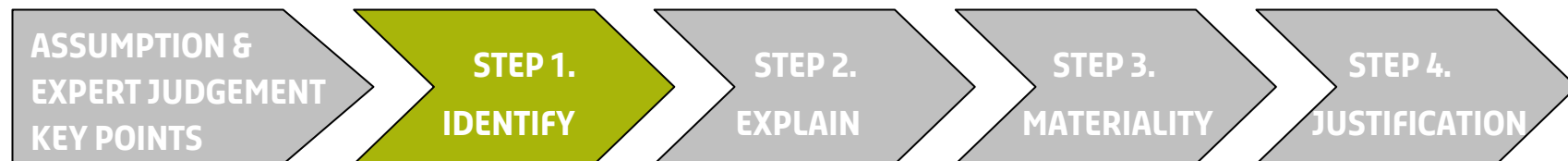
Syndicate 999 example - Assumptions

- We will use our example Syndicate 999 to illustrate a possible approach to providing evidence for assumptions

- Syndicate 999 uses a frequency / severity model for premium risk

- This is **<u>not</u>** an example of how the methodology works

- Consider a typical review question:

  - *How have you validated the assumptions underlying the model of premium risk for your most material line of business?*

| ASSUMPTION & EXPERT JUDGEMENT KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |

Syndicate 999 example - Assumptions

- **Step 1: Identify** the most material risk category, and then the assumptions that have been made during the modelling of premium risk

- Syndicate 999 has created schematic diagrams to help demonstrate modelling process and to support validation work

- The next slides show examples of these diagrams and the outcome of the identification process

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS

STEP 1. IDENTIFY

STEP 2. EXPLAIN

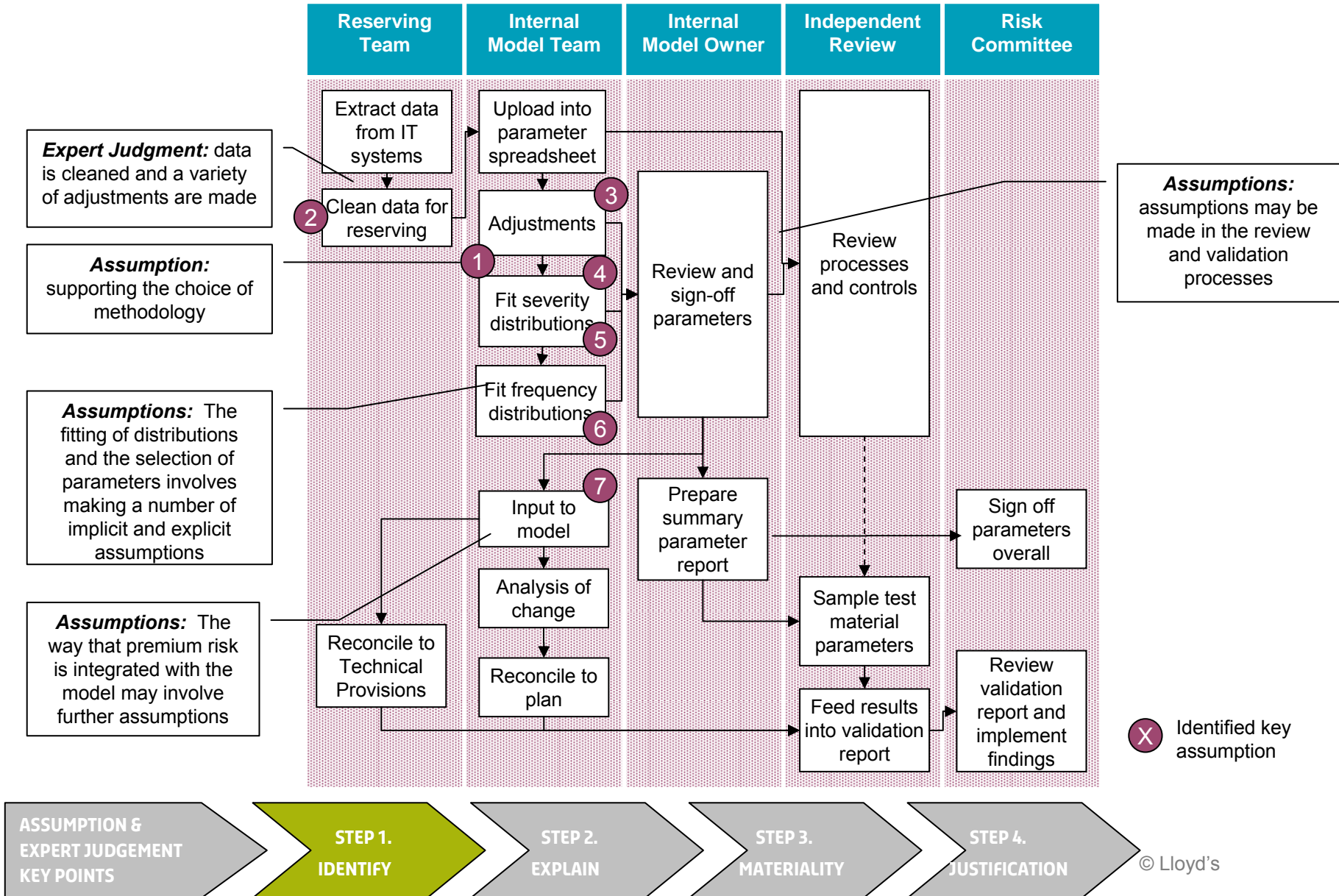STEP 3. MATERIALITY

STEP 4. JUSTIFICATION

Syndicate 999 example - Assumptions

- The diagram illustrates the structure of the SCR calculation - this is only an example, and it is intentionally simplified
- It is intended to show how clear identification of model components can support validation
- For syndicate 999, this process has identified Property Treaty Premium risk as a material driver of results
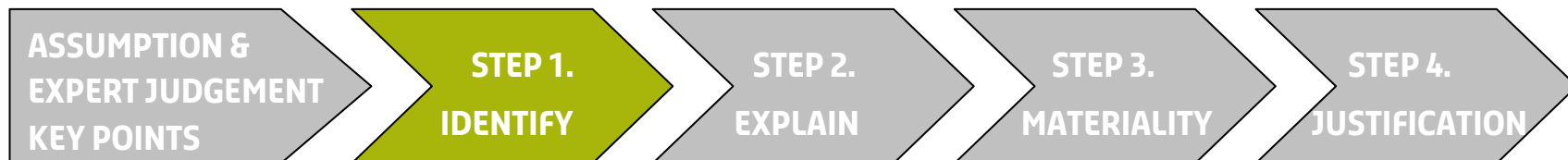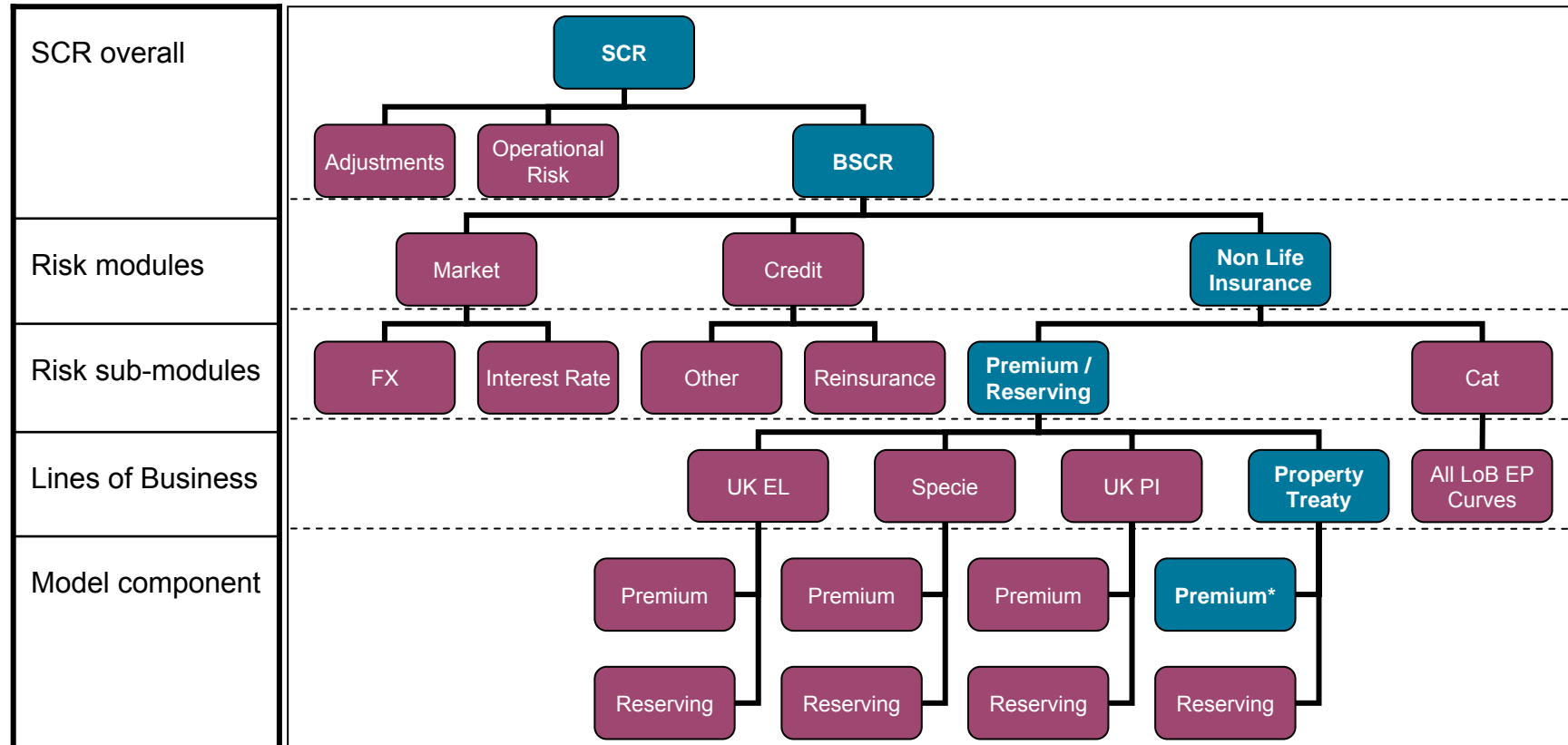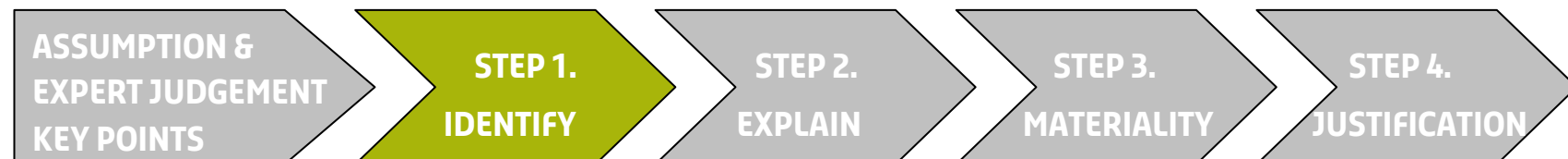
Syndicate 999 example - Assumptions

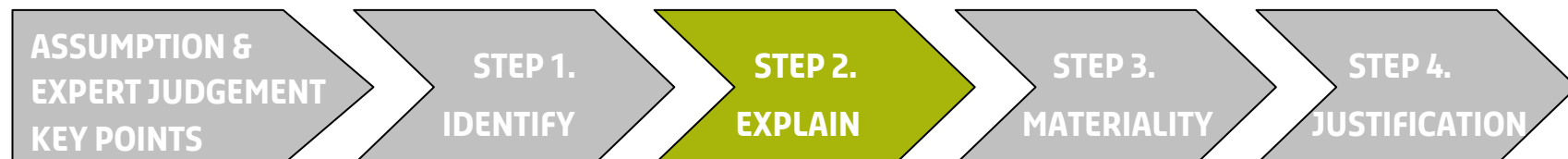- The diagram shows the process Syndicate 999 uses to parameterise premium risk for Property

Reserving Team	Internal Model Team	Internal Model Owner	Independent Review	Risk Committee

Expert Judgment: data is cleaned and a variety of adjustments are made

Assumption: supporting the choice of methodology

Assumptions: The fitting of distributions and the selection of parameters involves making a number of implicit and explicit assumptions

Assumptions: The way that premium risk is integrated with the model may involve further assumptions

Assumptions: assumptions may be made in the review and validation processes

Extract data from IT systems

Clean data for reserving (2)

Upload into parameter spreadsheet

Adjustments (3)

(1) (4)

Fit severity distributions (5)

Fit frequency distributions (6)

Review and sign-off parameters

Review processes and controls

(7)
Input to model

Analysis of change

Reconcile to Technical Provisions

Reconcile to plan

Prepare summary parameter report

Sign off parameters overall

Sample test material parameters

Feed results into validation report

Review validation report and implement findings

(X) Identified key assumption

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS

STEP 1. IDENTIFY

STEP 2. EXPLAIN

STEP 3. MATERIALITY

STEP 4. JUSTIFICATION

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Syndicate 999 example - Assumptions

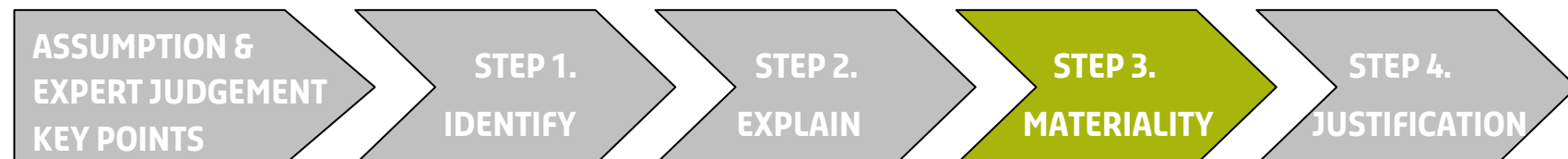|	Assumption	Materiality	Rationale
1	Selection of frequency / severity methodology		
2	Cleaning of data		
3	Adjustment of data for inflation and changes in terms		
4	No IBNER for claim size data		
5	Poisson / Lognormal selected for Frequency / Severity		
6	Choice of parameters for fitted distributions		
7	Using fitted EU distributions to model FE portfolio		

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION

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Syndicate 999 example - Assumptions

- **Step 2**: **Explain** how the identified assumptions fit into the model

- This links the identification to the structure of the model overall, and should provide the reviewer with the background to determine why an assumption is necessary

- For example, Syndicate 999 has identified the choice of a log-normal distribution for claims severity as an assumption. The explanation step is relatively straightforward and does not need to provide much detail:

  - …Insurance losses are modelled for material class of business using a frequency / severity approach. Individual gross losses are simulated within the model

  - Reinsurance recoveries are modelled directly, based on the planned reinsurance programme, and losses are netted down – this also links to the credit risk module, where reinsurer defaults are simulated…….
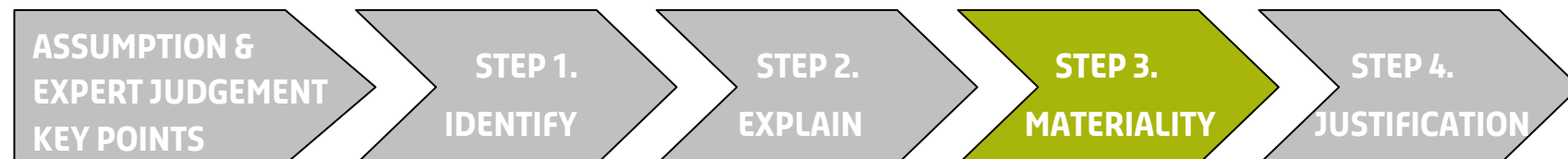
ASSUMPTION & EXPERT JUDGEMENT KEY POINTS ➤ STEP 1. IDENTIFY ➤ STEP 2. EXPLAIN ➤ STEP 3. MATERIALITY ➤ STEP 4. JUSTIFICATION

Syndicate 999 example - Assumptions

	Assumption	Materiality	Rationale
1	Selection of frequency / severity methodology	*Addressed under 'methodological adequacy' – similar principles apply*	
2	Cleaning of data	Low	Few changes are made
3	Adjustment of data for inflation and changes in terms	Medium	Deductibles have changed markedly in last 2 years, and an adjustment (up to c. 10%) is made to older claims data to reflect this
4	No IBNER for claim size data	Low	Reserving analysis suggests IBNER accounts for <2%
5	Poisson / Lognormal selected for Frequency / Severity	High	Sensitivity analysis suggests ~25% change in loss distribution tail between top 3 best-fit
6	Choice of parameters for fitted distributions	High	Changes to frequency and severity parameters change the result materially
7	Using fitted EU distributions to model FE portfolio	Medium	FE portfolio is small relative to EU (<20%)

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION

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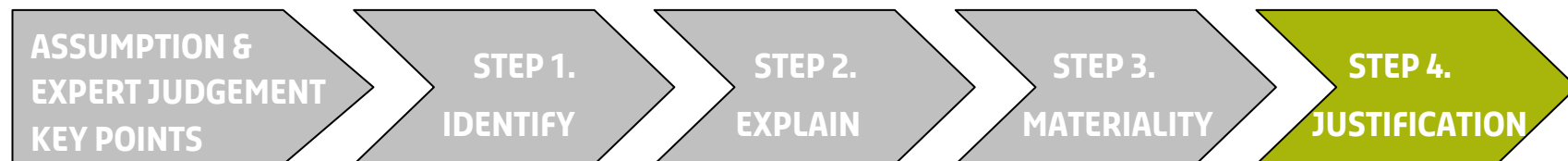
Syndicate 999 example - Assumptions

- Syndicate 999 has investigated other potential assumptions for the choice of severity distribution

- Note that there are limited data points, particularly in the tail

  - Assumptions need to be applied in the processing of this data

- 3 best fit have been investigated, and the following table shows a comparison at various percentiles

- The different options have very different tails, making this is a material assumption

- The investigation should consider other criteria as appropriate

£m	Lognormal (selected)	Normal	Pareto
99.9%	9.9	6.3	12.5
99.5%	**9.0**	**6.1**	**11.3**
99%	8.1	5.9	9.9
95%	7.2	5.4	7.4
75%	4.5	4.3	4.6

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION

Syndicate 999 example - Assumptions

- **Step 4: justification/limitations** of the selected approach compared to alternatives

  - The selection of the assumptions used in the model should have a reasonable and transparent justification

  - Agents should consider alternative assumptions, and understand the implications of those alternatives on their model

  - Agents should use appropriate validation tools to support their choice of assumptions

  - In this example, Syndicate 999 would be expected to be able to show that alternative distributions had been considered, and to provide a rationale for the distribution that was selected

  - Syndicate 999 would also be expected to understand the limitations of the selected assumptions, and the potential implications for the model overall

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION

Syndicate 999 example - Assumptions

Excerpt from Syndicate 999 model parameterisation report

- The statistical analysis for the distribution fitting is stored in **h:\model\parameterisation\fitting**

- The following table summarises the results of this analysis and comments on the selection:

Distribution	Chi-Sq	MSE	Selected	Comment
Normal	135	575	N	Fit is poor in the tail – this would make distribution unsuitable
Log-normal	45	255	Y	Selected as the best fit. Q-Q plot also shows a good fit to the available data. Weight of the tail has been discussed at the IM steering group, and is believed to be appropriate.
Pareto	51	250	N	Good fit for the data points. Does not give materially different results to LN centrally, but shows a heavier tail. The fit has been discussed with underwriters and at the IM steering group, and it was believed that this overstates the tail. This is supported by benchmark data, and some scenario testing of the class loss ratio
Weibull	75	325	N	Fit results are poor

| ASSUMPTION & EXPERT JUDGEMENT KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |
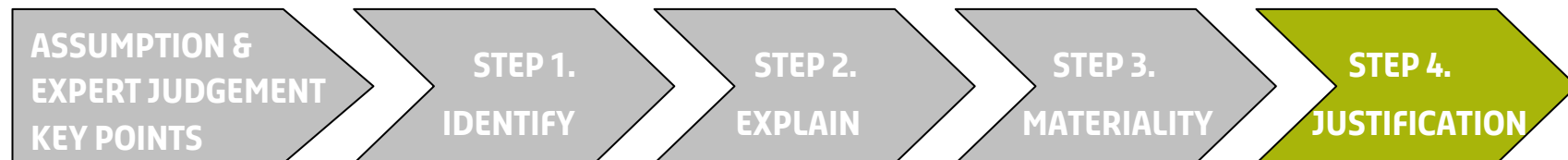
Syndicate 999 example - Assumptions

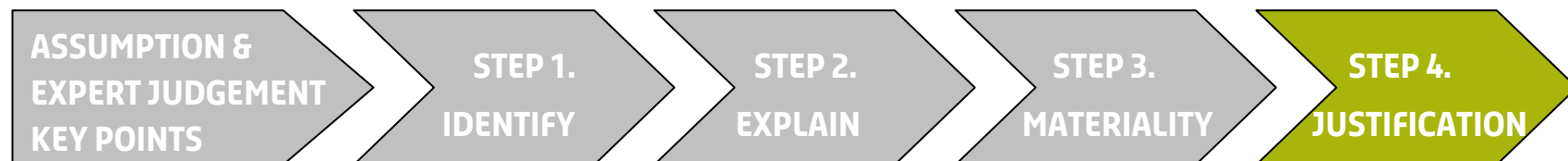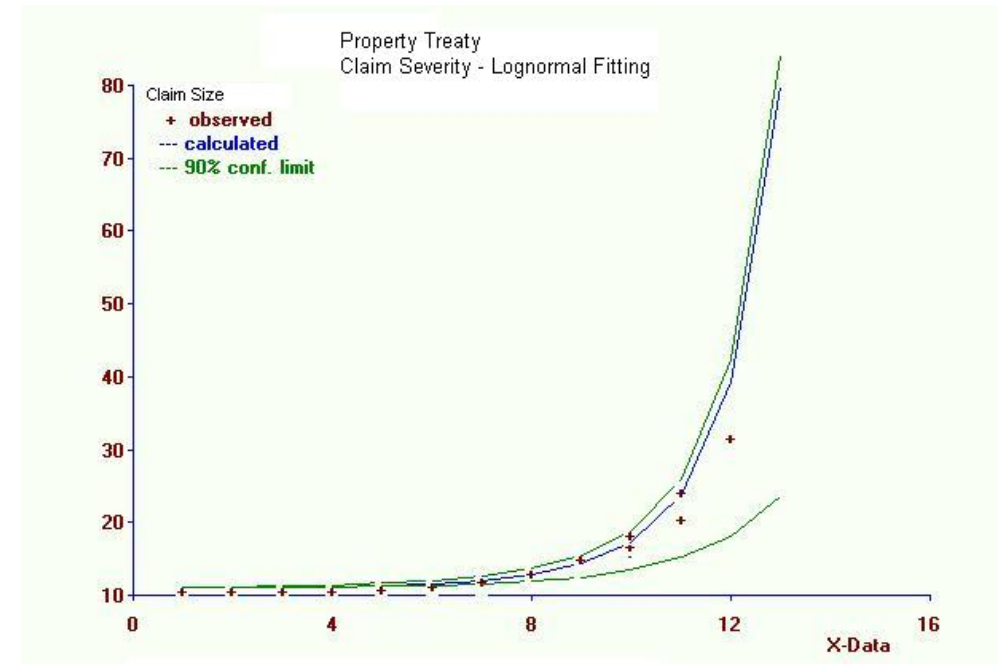- **Step 4: Justification** of the selected approach, and discussion of alternatives

Excerpt from modelling methodology:

….Once the data adjustments have been made, the adjusted data is fed into the fitting spreadsheets (**h:\model\parameters\property**).

A number of standard fitting methodologies are used to fit statistical distributions to the adjusted data. This process is conducted based on all data, but an additional run excluding outliers is performed as a sense-check at the centre. Specific attention is paid to the fit in the tail.

The log-normal distribution showed a good fit according to a chi-sq statistic, and visual analysis of the Q-Q plot supported this choice

The results of this fitting are saved within the spreadsheet for review by the internal model owner, who is responsible for signing off the choice of distribution and the associated parameters…….

Property Treaty
Claim Severity - Lognormal Fitting

Claim Size
+ observed
--- calculated
--- 90% conf. limit

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS

STEP 1. IDENTIFY

STEP 2. EXPLAIN

STEP 3. MATERIALITY

STEP 4. JUSTIFICATION

Syndicate 999 example - Assumptions
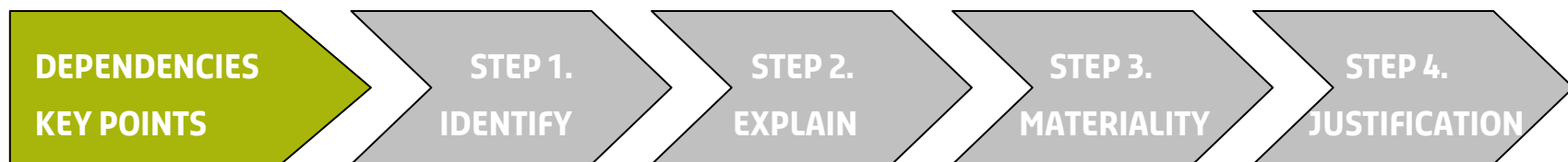# What evidence is required?

- Agent evidence should:

  o Link to the validation cycle

  o Make it easy to identify key assumptions and understand why they have been made

  o Summarise results, and reference technical details for drill-down

    - Details should include the full application of appropriate validation tools, with clear pass and fail criteria

  o Identifies less material assumptions and associated processes, albeit at a proportionately higher level

  o Maintains a track record, and compares emerging experience to model assumptions over time

- Agents should **not** produce a copy of the example!

ASSUMPTION & EXPERT JUDGEMENT KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION
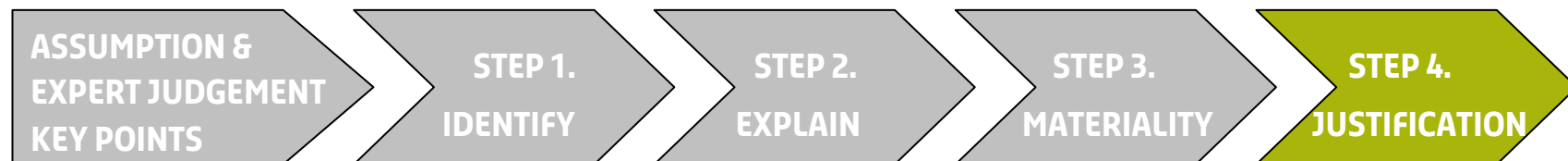
DEPENDENCIES

Key messages on dependencies

1. Validation must rely heavily on expert judgement and stress and sensitivity testing.

   - *"[T]here may be no conclusive evidence regarding the theoretically correct dependency or aggregation mechanism."* (5.233a)

2. Develop criteria for a reasonable dependency structure.

   - *"Poor practice was also shown when firms could not articulate the criteria used to validate parts of the internal model."* (FSA, Thematic review findings, February 2011)

3. Focus your validation efforts on the tail dependencies!

   - *"[T]he dependency structure in the tail is of particular importance."* (5.246)

DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION

Key messages on dependencies

4. There may be a difference of perspective between the supervisor and agents.

   ○ *"[S]upervisory authorities shall challenge the aggregation assumptions."* (5.235)

- The agent will often start from an assumption of independence between risks and add dependencies on an exceptions basis

- The supervisor will focus on justification for any diversification benefit; it may appear to be starting from an assumption of full dependence

- Disagreements are more likely to arise if the agent has not explicitly considered tail dependencies (E.g. "We chose a correlation of 50% based on judgement. Period.")

| DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |
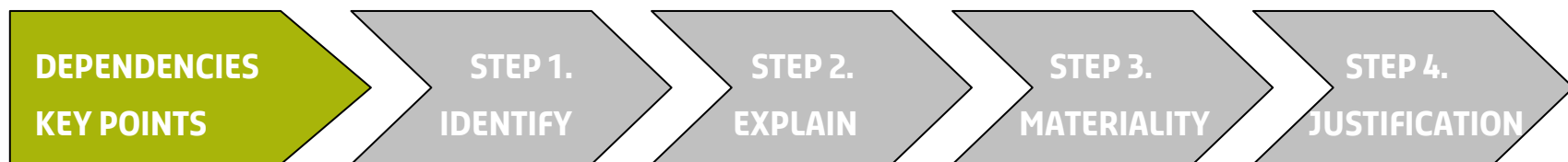
Syndicate 999 example - Dependencies

- We will again use our example Syndicate 999 to illustrate a possible approach to providing evidence for dependencies

- Consider a typical review question:

  - *How have you validated the diversification benefit between your two largest reserving risks?*
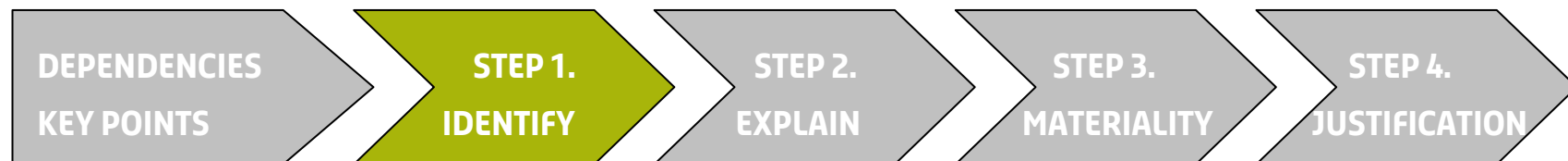
| DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |
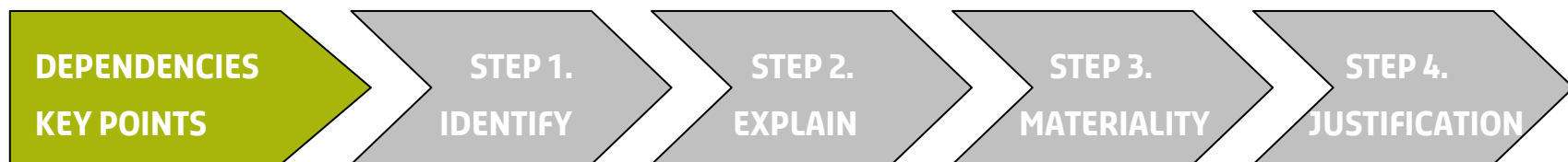
Syndicate 999 example - Dependencies

- EL and PI are the two largest reserving risks for Syndicate 999
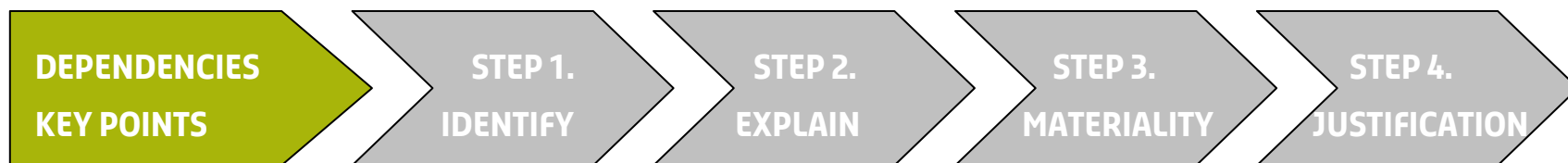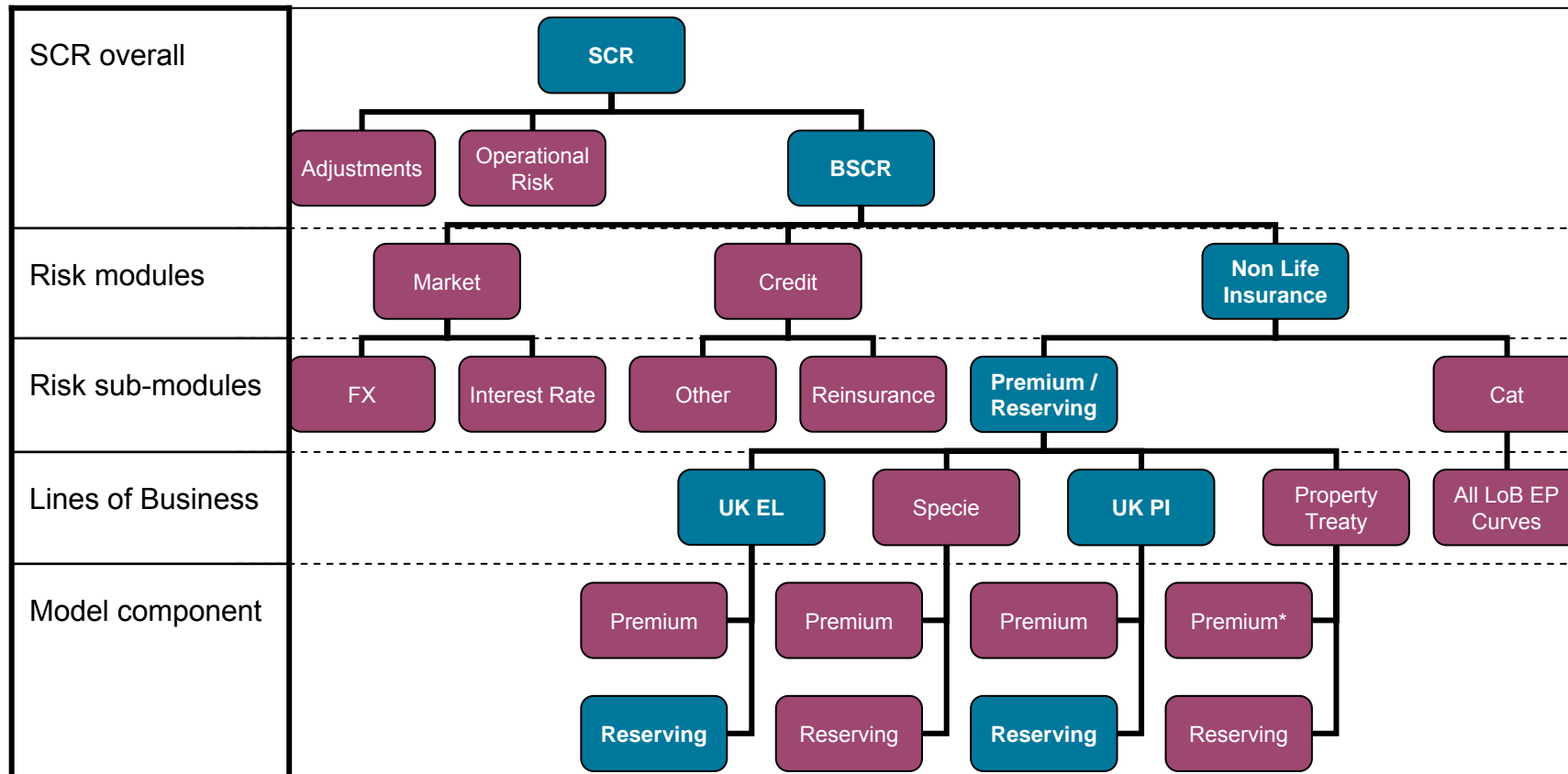
Syndicate 999 example - Dependencies

- **Step 1**: **Identify** what the diversification benefit is.

  - Possible response: use the simulation outputs to calculate the diversification benefit at key percentiles

Percentile	Combined Reserving Risk for EL and PI			Diversification benefit
	Independence	Selected Dependence	Full Dependence	
90th	154,280	161,198	164,186	1.8%
95th	211,041	232,223	253,968	8.6%
99.5th	475,189	597,662	687,358	13.0%

DEPENDENCIES KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION

Syndicate 999 example - Dependencies

**EL and PI reserve risk distributions
under alternative dependence structures**

DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION
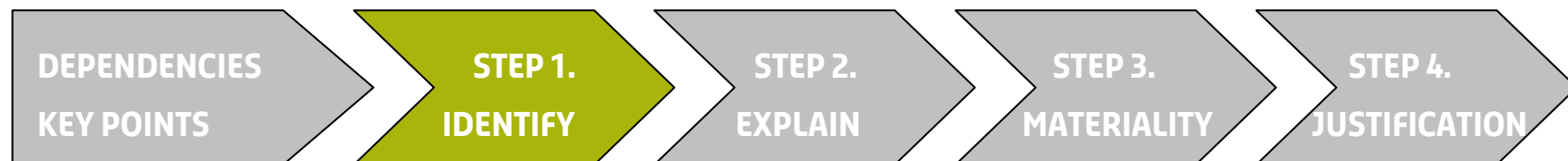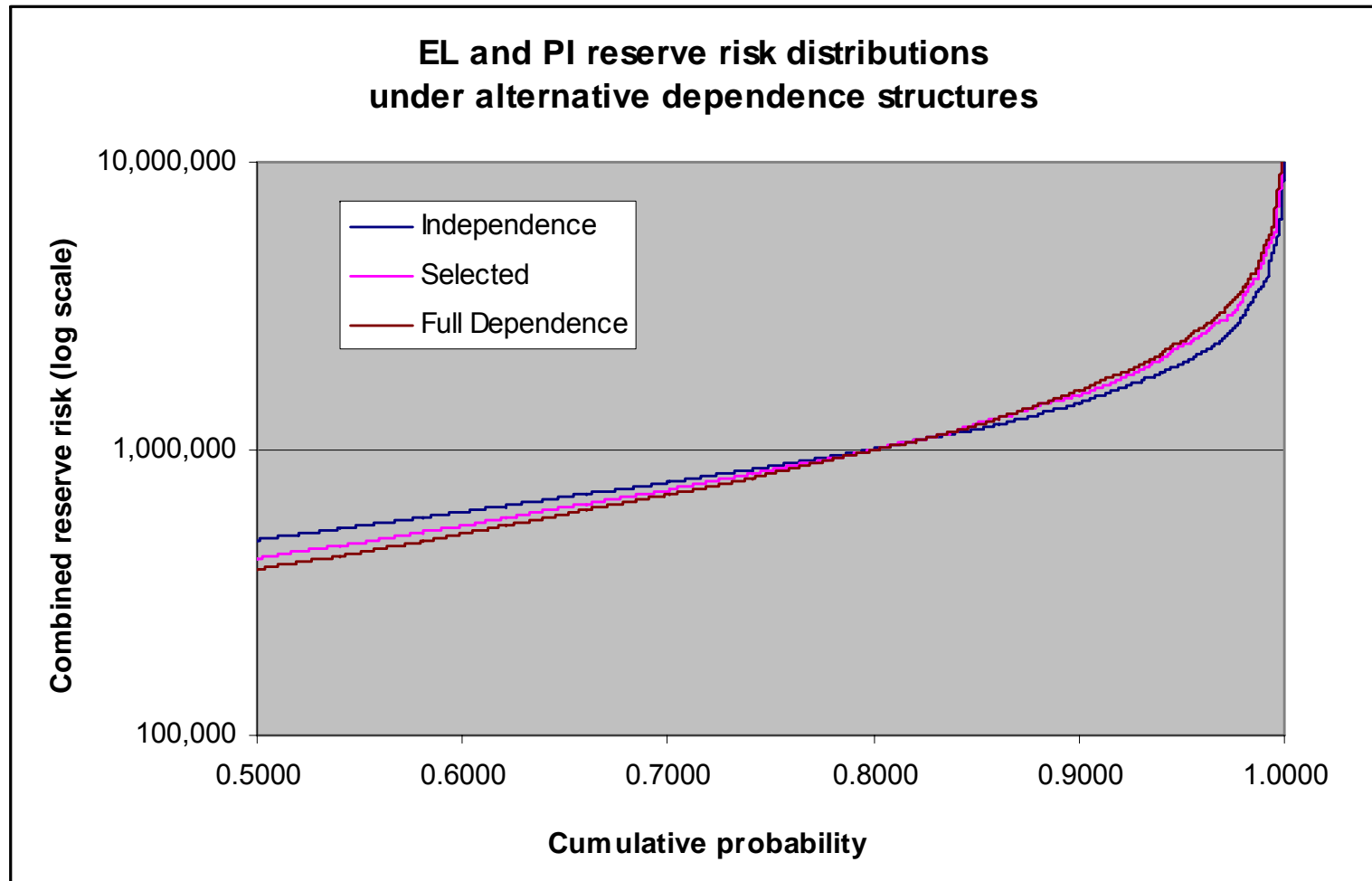
Syndicate 999 example - Dependencies

- **Step 2**: **Explain** the key drivers of the diversification benefit.

- There are in effect 3 steps to explaining the diversification benefit:

  - The explanation in terms of the **business drivers** of diversification

  - The explanation in terms of the **model variables** or properties

  - The explanation of why the model correctly reflects business drivers

- In this step we will focus on the model variables.

- The first and third explanations will be addressed under Step 4: **justification/ limitations.**

- The explanation in terms of model properties will of course vary by model type.

| DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |
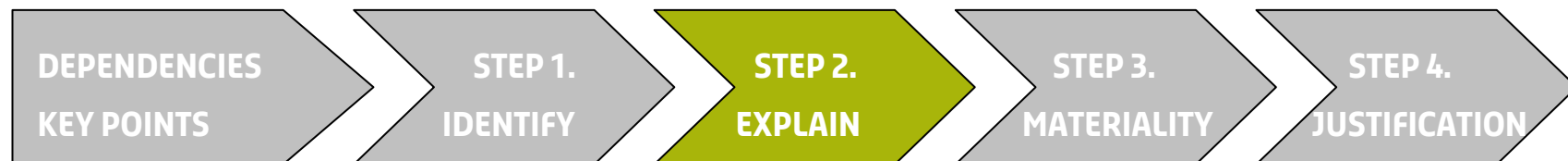
Syndicate 999 example - Dependencies

- CEIOPS 48/09 (5.230) summarises two broad approaches to aggregation.

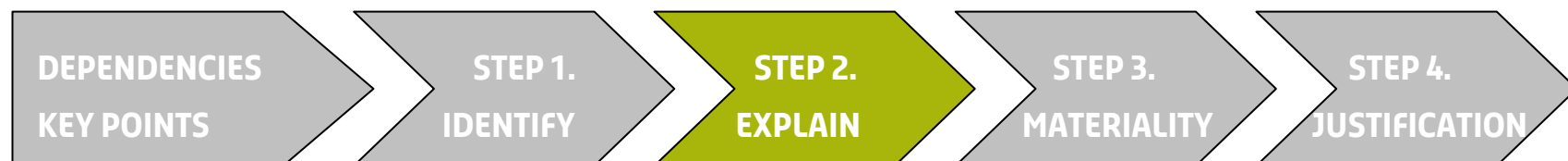| Internal model type	Number of aggregation steps	Example
Modular/ "Bottom-up"	Multi	Correlation matrix and copula
Integrated/ "Drivers based"	Single	Common drivers such as cat risk and inflation

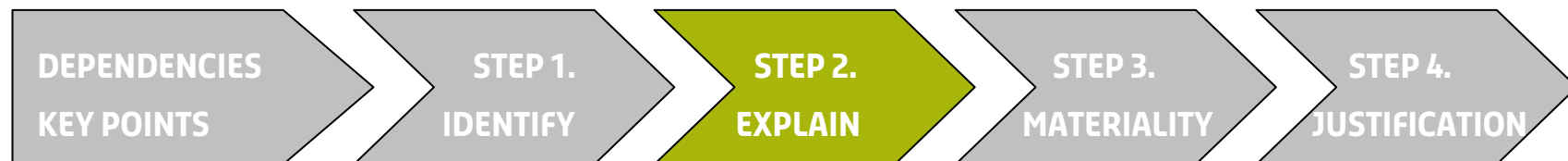- In practice, many models will contain both approaches.

| DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |
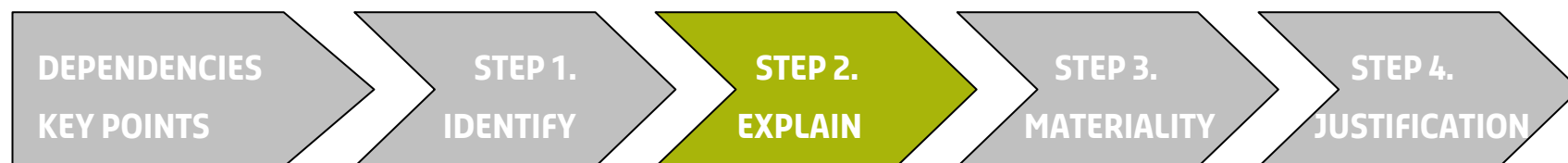
Syndicate 999 example - Dependencies

- **"Bottom up" type model**: explain in terms of the features of the dependency structure.

- Example: the preceding table was produced using lognormal distributions for EL and PI and a t-copula

Model drivers of upper tail diversification benefit		
Increased variable	**Impact**	**Reason**
t copula tail dependence (*increased correlation or lower degrees of freedom*)	**–**	Model results move closer to full dependence
*S*kewness of EL and PI class distributions	**+**	The absolute value of the combined distribution in the tail increases but the spread between full dependence and the selected structure increases
Number of simulations	**+/-**	The diversification benefit stabilises as the number of simulations increases

DEPENDENCIES KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION
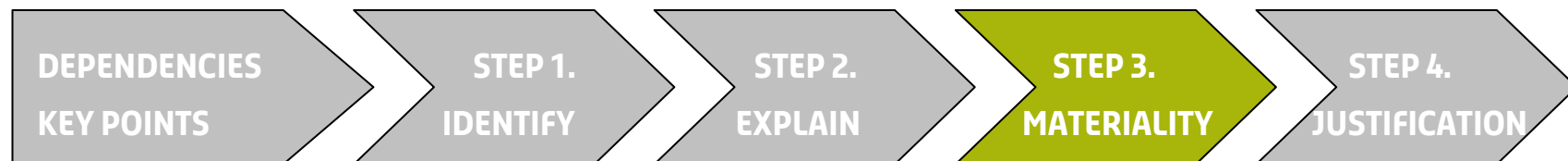
Syndicate 999 example - Dependencies

- **"Drivers based" model**: Explain the result in terms of shared (vs unique) drivers.

- Example: if inflation is a common driver then it will drive up claims costs in both classes

  - This effect is likely to be larger in the tail since large claims with longer payout periods will be more affected

  - Result: lower diversification benefit at higher percentiles (*the opposite of what is shown in the table*)

- Non-shared or unique drivers could have the opposite effect

  - Example: latent asbestos exposure affecting EL but not PI

DEPENDENCIES KEY POINTS → STEP 1. IDENTIFY → STEP 2. EXPLAIN → STEP 3. MATERIALITY → STEP 4. JUSTIFICATION

Syndicate 999 example - Dependencies

- **Step 3**: **Materiality** of the selected methods and assumptions

- Stress and sensitivity testing of key parameters

  - Common drivers such as cat risk, inflation, legislative risk, latent claims, foreign exchange rates, r/i failure

  - Parameters such as correlations or copula parameters

  - Note the link with Step 2: the above can help to explain the drivers of the diversification effect

- Impact of alternative dependence structures

  - Add in or remove dependencies between common drivers.

  - Example: a legal ruling and r/i failure affecting both EL and PI

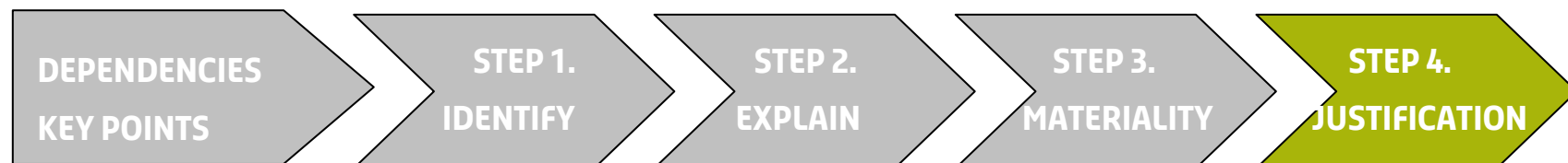 - Alternative copula with more/less tail dependence

DEPENDENCIES KEY POINTS	STEP 1. IDENTIFY	STEP 2. EXPLAIN	STEP 3. MATERIALITY	STEP 4. JUSTIFICATION

Syndicate 999 example - Dependencies

- **Step 4**: **Justification/limitations** of the selected approach vs. alternatives.

- CEIOPS 48/09 (5.245) cites two types of support for diversification benefits:

  - Empirical/statistical analyses

  - Expert judgement on causal relationships

- Statistical analysis example:

  - Measure correlations between residuals for fitted distributions for class reserving risk (e.g. if using a bootstrap approach)

  - Weak/low correlations provides some support for diversification benefit

DEPENDENCIES KEY POINTS	STEP 1. IDENTIFY	STEP 2. EXPLAIN	STEP 3. MATERIALITY	STEP 4. JUSTIFICATION
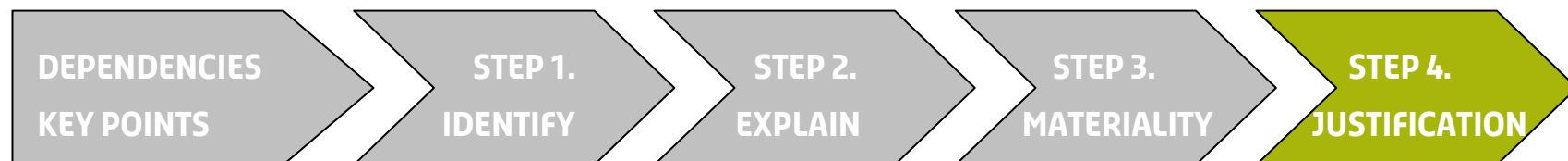
Syndicate 999 example - Dependencies

- Expert judgement on causal relationships examples:

  o Links back to **Step 2: Explanation** (especially for a drivers based approach)

  o Basic idea is to provide a comprehensive list of drivers and show that all key causal relationships driving dependencies have been appropriately modelled

  o Proportionality means emphasis on biggest drivers: e.g. inflation for reserving risk, cat risk for premium risk

- Pitfalls: lack of data, unadjusted trends in data such as UW cycle or CY inflation, zero correlation does not mean independence

- What about **criteria** for pass/fail of validation tests? We emphasised the importance of these earlier

| DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |

Syndicate 999 example - Dependencies

Example criteria 1: *comparison to min/max tail dependence*

- The selected tail dependence can be compared to the extremes of independence and full dependence

- Example: The table below shows that there is a 50% probability that PI reserves will exceed the 90th percentile when EL reserves exceed the 90th percentile

Tail dependencies for EL and PI reserving risk at 90th percentile			
	Independence	Full Dependence	Selected
Tail dependence	10%	100%	50%
Return period (years) for joint exceedance	100	10	20*

* Both EL and PI would exceed the 90th percentile once in 20 years under the selected dependency structure.
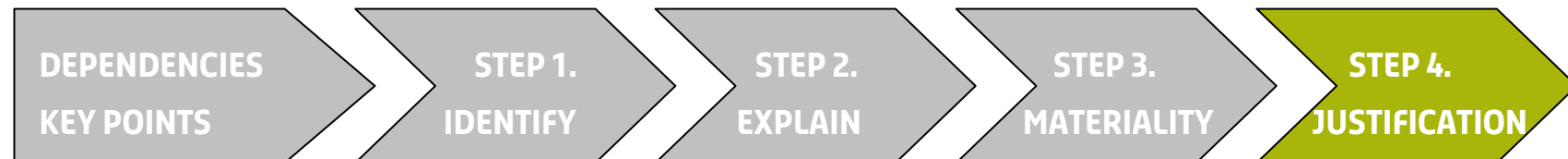
| DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |

Syndicate 999 example - Dependencies

Example criteria 1: comparison to min/max tail dependence (continued)
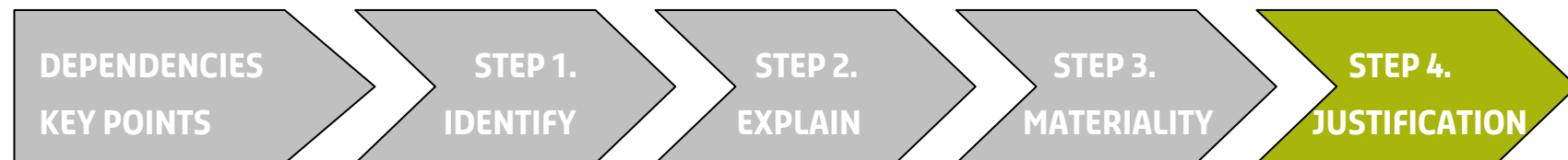
- The selected structure is closer to the independence assumption than the full dependence assumption on a percentile basis

- Alternatively, the selected structure implies that both EL and PI reserves will exceed their 90th percentile once in 20 years – closer to the full dependence assumption

- We haven't answered the obvious question:

  - What is the right place to be on the spectrum between independence and full dependence?

- You won't be able to answer this on purely objective criteria – subjective considerations will play a role

| DEPENDENCIES KEY POINTS | STEP 1. IDENTIFY | STEP 2. EXPLAIN | STEP 3. MATERIALITY | STEP 4. JUSTIFICATION |
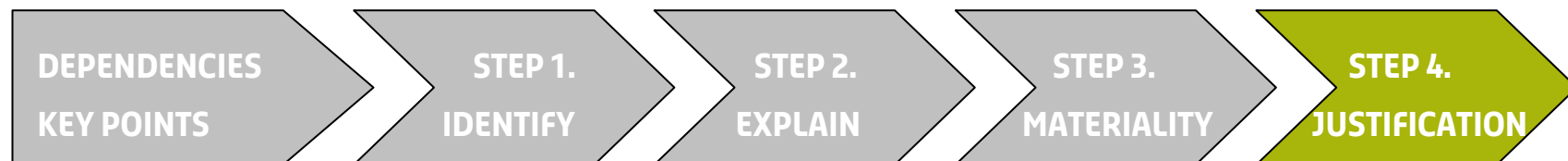
Syndicate 999 example - Dependencies

Example criteria 2*: comparison to alternatives*

- The FSA has highlighted the importance of understanding the alternatives before deciding whether the selected approach is reasonable

- These criteria can build on the work done in the **materiality** step (Refer back to the examples for **Step 3**)

- Example: comparison with the standard formula assumptions for premium and reserve risk aggregation

  - See p. 198 of the QIS 5 spec

  - Assumes a lognormal for the underlying risk

  - $\rho(\sigma) * V$ gives VaR 99.5th (σ calculated using correlation matrix)

  - Compare with model results

DEPENDENCIES KEY POINTS	STEP 1. IDENTIFY	STEP 2. EXPLAIN	STEP 3. MATERIALITY	STEP 4. JUSTIFICATION

Syndicate 999 example - Dependencies

Question:

- Are agents expected to do analyses similar to the preceding examples for all model dependencies?

Answer:

- No. The examples are for illustration only. Use the principle of proportionality when deciding how much effort is required.

- In case you didn't know:

    "*Dependencies are very hard to estimate and validate.*"

    CEIOPS 48/09 (5.233)

VALIDATION TOOLS

Validation tools: Testing against experience

Purpose	Assess the discrepancies between the model and actual realisations (8.56)	
Areas validated	Validates the probability distribution (a **method**) and the **assumptions** and **expert judgement** on which it is based	
Validation cycle		
	Overall tests	**Key events tests**
1) Tool application	• goodness-of-fit tests (χ^2 , MSE, Anderson-Darling, graphical tests, etc.)	• select a trigger event • identify the source portfolio
2) Analysis of results	compare results for alternatives	assess whether model accurately reflects likelihood of trigger event
3) Possible changes	Modify distribution with expert judgement or replace with alternative	

Validation tools: Testing against experience

	Overall tests	Key events tests
Examples	• χ^2 test on lognormal distribution fit to large claims • Q-Q plot of combined ultimate UWY loss ratios for two classes vs. model output distribution (tests class distributions and dependency structure)	• Property per risk. There are 7 years of large claims data; the largest revalued claim is £23m. The frequency*severity model for large claims indicates a return period of 15 years for a £23m claim. The agent decides to revise its frequency*severity model to give a lower return period for claims of this size. • log-log plot of tail of empirical vs. fitted distribution
Other uses	• May help to identify other risk factors • Limited use apart from validation	

Validation tools: Sensitivity testing

Purpose	Identification of the key assumptions underlying the model and the quantitative assessment of their significance (8.78)
Areas validated	**Assumptions**, **expert judgement** (especially important) and **methods**
Validation cycle	
1) Tool application	Vary model inputs (parameters and methods) and measure change in outputs
2) Analysis of results	The inputs driving the largest sensitivities should be prioritised in the validation The sensitivity testing results should be consistent with the materiality of the corresponding risks
3) Possible changes	Parameters or methods may need to be replaced if small changes to inputs yield large differences in outputs

Validation tools: Sensitivity testing

Examples	• Assumption: distribution for operational risk. The distribution has been parameterised with expert judgement. Small changes in the maximum value/upper bound result in significant changes in the SCR. The agent tests other distributions with thinner tails; it selects an alternative less sensitive to changes in the max.
	• Assumption: exposure curve used to parameterise the frequency severity model for property per risk. The exposure curve was selected with expert judgement. The agent finds that changes in the shape of the exposure curve do not result in disproportionately large changes in the SCR. It decides that the exposure curve assumption is not of high significance to the IM.
Other uses	Identification of key assumptions in business plan

Validation tools: Stress & scenario testing

Purpose	To assess the impact of a well defined single event or combination of events (8.92)
Areas validated	**Assumptions**, **expert judgement** and **methods**
Validation cycle	
1) Tool application	• Define a stress event or scenario (focus on extreme events) • Run the events through the model
2) Analysis of results	Analyse the impact of the event on the outputs
3) Possible changes	If the model does not adequately reflect the risk from extreme scenarios, then it may need to be revised

Validation tools: Stress & scenario testing

Examples	- Terrorism. E.g. explosion of dirty bomb in City. Identify exposure and use expert judgement, RiskLink, etc. to quantify damage. Assess impact on balance sheet. - Lloyd's Realistic Disaster Scenarios - Reverse stress testing - Determine which scenarios could challenge the viability of the business - Consider scenarios beyond normal business settings (FSA definition: start from an outcome of business failure and identify how this might occur) - Examples: financial contagion and reputational damage
Other uses	- Long term business planning - Capital allocation - Reinsurance purchase - Reverse stress testing an help to uncover hidden risks and interactions

TABLE DISCUSSIONS FOLLOWED BY ROUND UP & QUESTIONS

NEXT STEPS

Wrap up

- Remember the **4 key messages on validation**

  1. Validation is a process not a test

  2. There is a common theme in validation: identification/ explanation/ materiality/ justification and limitations/

  3. Materiality is more important than definitions

  4. Methods must be validated

- Slides will be made available on lloyds.com after both workshops

What happens next?

- Evidence template will be available by 31 March via lloyds.com

  o submission due by 28 April

- Model reviews and walkthroughs will begin in early April

  o Internal Model SCR workshop 4/6 April will provide further detail

  o Output from model questionnaire

- Next model validation workshop 9/10 May – invites early April

- But before you go, a few last questions….

How useful have you found today's session?

A. Very useful and provided helpful practical guidance

B. We have clear views on Lloyd's expectations for this workstream

C. Greater detail needed on format and timing of Lloyd's reviews

D. Not very useful

E. I'm too polite to say!

How have you found format of today's workshop?

A. It was a good balance between presentation and discussion

B. Would prefer less presentation and more discussion

C. Would prefer less discussion and more presentation

D. Other.

On which of the following areas would you most like to see further guidance from Lloyd's?

A. Interpretation of guidance

B. Examples of evidence

C. Extent and content of evidence required

D. Feedback on what we have already done

E. Other

WORKSHOP VOTING RESULTS 15 MARCH

At what stage would you describe your internal model validation policy?

A. Fully defined and embedded.

B. Pretty much well defined, but still needs finalisation and approval.

C. Drafted, but still subject to significant debate.

D. Not well defined and a lot of work is still to be completed.

E. None of the above!

Which element of validation is currently causing most issues?

A. Knowing what tests to apply

B. Producing evidence that guidance is met

C. Resource constraints

D. Independence and objective challenge

E. Other

What is an assumption ?

- Consider a frequency / severity model based on historical data

- Which of the following are assumptions?

  1. Adjustments made to data for parameterisation (e.g. inflation)

  2. Choice of poisson distribution for frequency and lognormal for severity

Vote:

A. Neither

B. 1 Only

C. 2 Only

D. Both

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How have you found format of today's workshop?

A. It was a good balance between presentation and discussion

B. Would prefer less presentation and more discussion

C. Would prefer less discussion and more presentation

D. Other.

70%   27%   4%   0%

A   B   C   D

On which of the following areas would you most like to see further guidance from Lloyd's?

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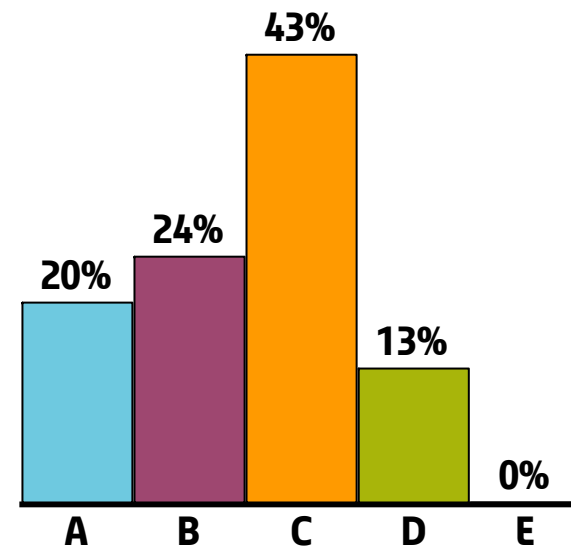E. Other

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© Lloyd's

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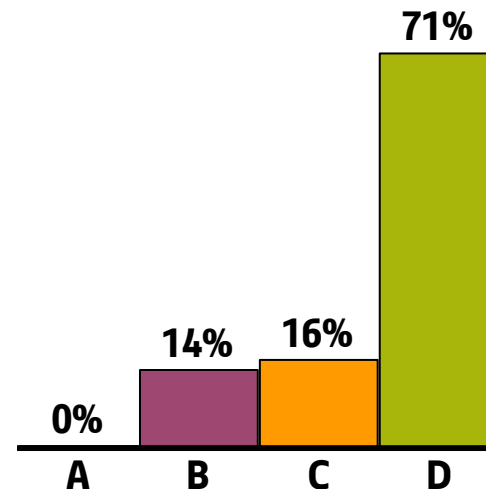
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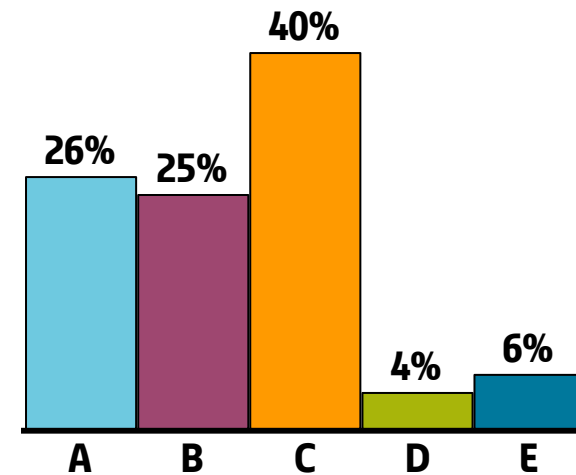 **2.** Choice of poisson distribution for frequency and lognormal for severity
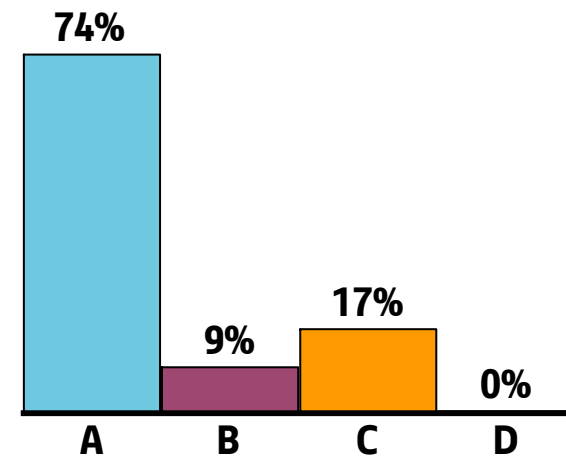
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