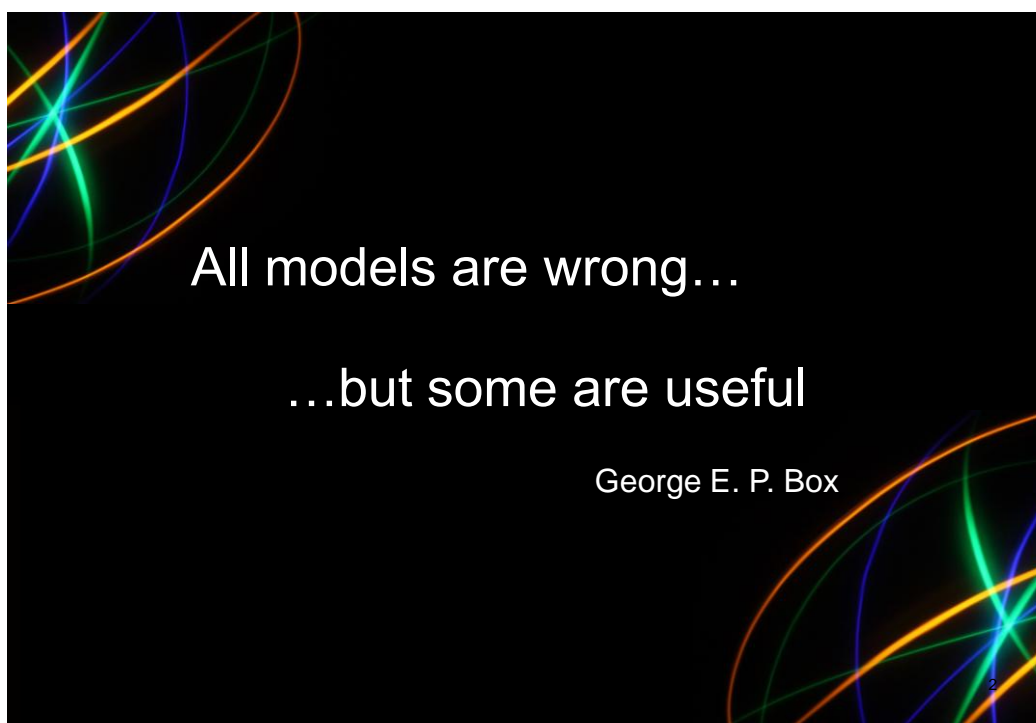


Institute
and Faculty
of Actuaries

GIRO40
10 October, Edinburgh



Why validate?

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- ECMs used in many ways, including
 - Inform process for managing risks & optimizing returns
 - Determine capital needed to support retained risks
 - Satisfy regulatory requirements
- Users (e.g. management, regulators, rating agencies) should
 - Understand model assumptions, restrictions and output
 - Ensure the ECM is **suitable** for its intended use

All models are wrong... so how wrong might this one be, and does that keep it from being useful?

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Seems simple enough, but...

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"In some cases, [the validation] scope is too narrow while in others work is simply incomplete."

"...some of the validation policies we have seen have been so vague that we have not been able to draw any assurance from them."

— Julian Adams, FSA Director of Insurance, May 2012

- Practitioners are not sure what really needs to be done; literature offers rather vague, general principles
- We believe this is a consequence of **imprecise definitions of model risk**

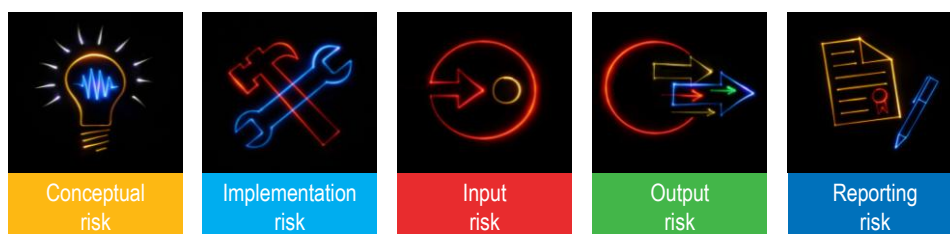
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Validate what?

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- Purpose of validation is to assess level of model risk
- To do this rigorously, we need a clean, clear definition

Model risk sub-categories:



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Validate what?

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Conceptual risk is fundamental:

- Risk that concepts underlying the model are not suitable for the intended application
- Terms “appropriate / inappropriate” describe instances that are “suitable / not suitable for the intended application”



Implementation risk arises from two sources:

- Wrong algorithms chosen to implement specified concepts
- Errors in implementation (i.e. “bugs” in coding of appropriate algorithms)

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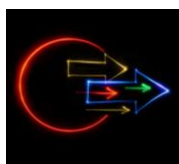
Validate what?

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Input risk is the risk that input parameters are

- Inappropriate
- Incomplete, or
- Inaccurate



Output risk is the risk that key statistics produced

- Are insufficient/not robust enough to support business purpose, or
- Are too sensitive with respect to input parameters



Reporting risk is distinct from output risk

- Deals with representation of output for business users
- Reports using valid output may be incomplete or misleading
- Reports driven by intended use; thus related to “use test”

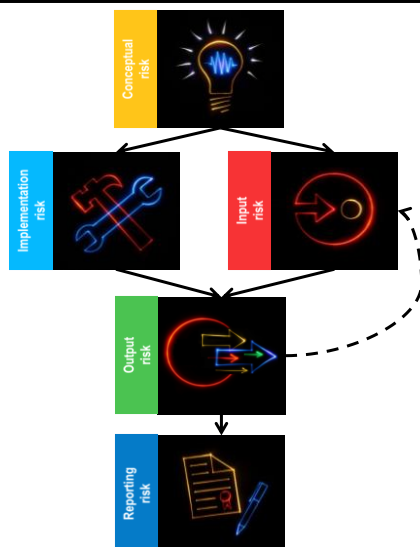
Who validates?

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- Internal audit is natural **owner** of validation process
 - Does **not** mean audit personnel must **perform** the validation
 - Internal audit should work with subject matter experts to establish validation policy and procedure
 - Then ensure that policy is followed
- Q: why shouldn't risk management “own” validation?
 - Typically they develop and often run the model
 - But validation requires **independent** review

OK... but how?

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Considerations include...

- Dependencies among model risk subcategories
 - Imply a logical order for validation process (see left)
- Sub-models
 - Can validate individually
 - But must **also** validate the aggregation
- Use of vendor models
- Re-validation

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The validation report

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- Documents **degree** to which each sub-model (and then also the aggregation of all sub-models) was checked, and **results** of assessment
 - Not to be confused with model documentation (checking model documentation is part of the validation process)
 - Conceptual diagram below

	Depth of validation performed	Specific checks	Validation results
	<ul style="list-style-type: none"> Superficial, further validation required Adequate, no further validation required Adequate, but ongoing validation required 	Detail the checks made for each type of risk (see following section)	<ul style="list-style-type: none"> Inadequate, requiring change or improvement Accepted
Sub-model 1			
Sub-model 2			
...
Sub-model n			
Aggregation of sub-models	Again, given the complexities of economic capital modeling, there is no simple way to aggregate individual sub-model assessments to yield a single score for the model; instead, the aggregation itself must be considered following the categories of model risk listed above.		



- Prerequisite: understand intended application, e.g.
 - Capital management
 - Risk management
 - Performance management
 - Product management
- **Model users**
 - Verify that reports are addressed to a well-defined audience
- **Which risks?**
 - Document business leaders' expert judgment / rationale
- **Modeling methods**
 - External references
 - How modeling pieces are connected and why they can be used together
 - Documentation of the limitations of the concepts
 - Vendor model concepts



Conceptual checks: example

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- One firm we reviewed had set up their investment model with modules to reflect each of several investment management firms



- But the model did not include any mechanism to correlate the results of similar assets managed by different firms
- We recommended they re-think this, as an implicit assumption of independence could drastically underestimate the volatility of the modeled investment performance

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Implementation checks

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- Development**
 - Risk modeling experts involved in algorithm selection
 - Limitations of the algorithms documented
 - Versioning
 - Clear accountability for code changes / bug fixes
- Code testing**
 - Automated test procedures
 - Specification of test cases
 - Test coverage reports
 - Test content
- Production environment testing**
 - User acceptance testing
 - Back-testing and P&L attribution

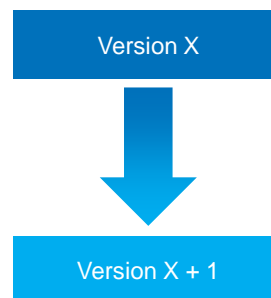


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Implementation checks: example

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- One firm used a commercial vendor catastrophe model as part of their economic capital model
- Each time a new version was released, the vendor helped them perform a careful check of the implementation of the new model
 - Ensured that test datasets yielded results that checked with vendor results
 - Also compared modeled results and run times against prior version and ensured that all differences were readily explainable
- We also noted that this firm maintained an excellent log of the dates when past versions had been implemented and patches applied



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Input checks

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- **Clear designation as either raw or calibrated inputs**
 - Raw inputs: verify that the tool does not allow user edits
 - Calibrated inputs: verify well-defined data source, documented calibration procedure performed by people with the required skills
- **Input calibration process**
 - Verify that the calibration process uses the data consistently
 - Verify that a peer review process is in place for calibrated inputs
- **Input parameter benchmarking**
 - Review major changes in source data & input parameter values since last validation
 - Benchmark major input parameters against industry / peer values



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Input checks: example

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- We reviewed the model of one firm who had explicitly assumed zero dependency between the modeled market value of bond and stock portfolios
 - Not a conceptual issue: the model structure did allow for dependency via a copula
 - However, the selected input was complete independence



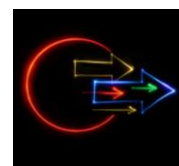
- That may be correct over a very short time horizon, under the assumption that interest rates will remain flat while stocks will move
- But over the long run, market values of bonds and stocks are positively correlated
 - In fact, for this firm, if correlations reverted to long term averages in the future, the calculated economic capital might change by as much as \$100M

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Output checks

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- **Operational issues**
 - Outputs identify correct input data set and model version
 - Outputs can be reproduced
 - Outputs indicate breaches of input parameter limits
- **Dynamic behavior**
 - Inputs for testing output sensitivity; resulting output sensitivity
 - Check materiality of input parameters based on the sensitivities
 - If necessary, recalibrate input; iterate until validation team satisfied
 - Verify that ranges of key output figures are made available
 - Check whether benchmarking was used to validate the output
- **Model change analysis**
 - Check that analysis of change starts from a validated model / input data set
 - Documentation of **how** the changes applied as well as rationale for selected **order** of changes

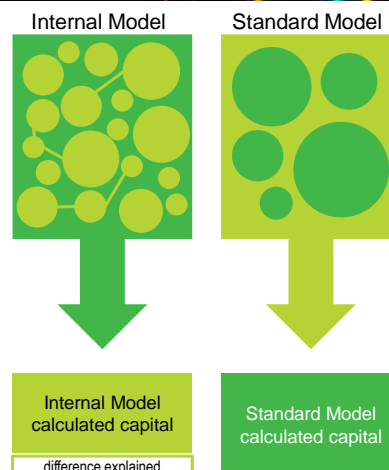


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Output checks: example

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- Benchmarking economic capital calculated by an internal model against results of the Standard Model is very useful
 - It is very likely that regulators and rating agencies will make such comparisons!
- The expectation is **not** that these simpler models yield the same output
 - Otherwise no reason to expend resource building an internal model
- But experts should be able to **explain** and document reasons for the differences
 - Essentially, creating a value proposition for the internal model



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Reporting checks

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- Clarity**
 - Verify that reports clearly indicate model version and data version
 - Verify that results are communicated using institutionally accepted metrics
- Context**
 - Confirm that reports are suitable for intended use
 - Business users should be notified when parameters fall outside a comfort range
 - Check whether report conveys robustness of key figures
 - Confirm that reports communicate the range of normal business volatility
- Frequency**
 - Ensure alignment with relevant decisions



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Reporting checks: example

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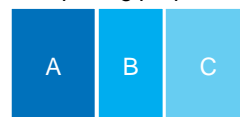
- We worked with one firm that used TVaR to determine economic capital
- Model reports showed each business unit's contribution to TVaR
- Business unit managers used this to set prices to achieve a target ROE
 - This was not an intended use of the model; the risk modeling team recognized that
 - Small business units might have little to no contribution to TVaR and so become underpriced
 - Changes outside a business unit could lead to drastic price shifts
 - Though the figures were perfectly accurate, they were misunderstood and misapplied
- We recommended that the TVAR contribution be replaced on the report with a capital allocation **intended** for setting price levels

TVaR contribution



≠

firm's capital allocation
for pricing purposes



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Putting it all together

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- Remember, each sub-model of the ECM will need to be checked against each sub-category of model risk
- And THEN the aggregation of sub-models must also be checked against each sub-category of model risk
 - Validating each sub-model is necessary but not sufficient!

	Depth of validation performed	Specific checks	Validation results
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Sub-model 2			
...
Sub-model n			
Aggregation of sub-models	Again, given the complexities of economic capital modeling, there is no simple way to aggregate individual sub-model assessments to yield a single score for the model; instead, the aggregation itself must be considered following the categories of model risk listed above.		

Conclusion

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- Standardized ECM validation processes can help maximize
 - Efficiency
 - Objectivity
 - Understanding
- To design an appropriate process, must be clear about
 - What the goal is
 - Who will own the process
 - How it will be conducted and documented
- Purpose of validation is to assess the level of model risk
 - So, should be driven by a **clear definition of model risk**

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Discussion

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Questions

Comments

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APPENDIX: SPECIFIC TYPES OF SUB-MODELS

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Underwriting sub-model

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- **Conceptual risk:** does modeling framework capture nuances of the lines of business?
 - Long-tailed and short-tailed business
 - Attritional, large individual and catastrophic losses
 - Systemic risks
- **Input risk:** selection of frequency and severity of losses by line of business, dependency strength, projected rate levels, and the parameter uncertainty inherent in these factors
 - Selection of parameter values is well documented
 - Trends in loss development and rate change assumptions need to be evaluated in light of company history and also benchmarked against industry movements
- **Output risk**
 - Check for comparisons to prior results
- **Reporting risk**
 - Check whether the loss potential and loss scenarios are presented in relation to the underwriting profit

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Natural catastrophe sub-model

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- **Conceptual risk**
 - Assess whether the internal modeling team is familiar with the modeling concepts
 - Check whether the model covers all major risks in company's exposure
 - Documentation of rationale for updating the model or staying with older version
- **Implementation risk**
 - How rigorous and transparent is vendor in communicating bug fixes & improvements?
 - Verify that internal team checks influence of bug fixes with own relevant test cases
- **Input risk**
 - Hazard component
 - Whether observed and modeled events appear to be reasonably overlapping
 - Selection of historical events is appropriate
 - Measures for goodness of fit
 - Choices of data flow interpolation
 - Parameterization of the probability distribution

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Natural catastrophe sub-model (cont.)

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- **Input risk (cont.)**
 - Vulnerability component
 - Key drivers to loss generation in line with the portfolio's key loss drivers
 - Claims data used to develop vulnerability functions interpreted correctly (e.g. policy conditions)
 - Damage curve data fitted appropriately
 - Exposure data
 - Are risk descriptors (e.g. construction) captured in source systems or estimated?
 - Financial modeling
 - Check whether flow of loss correctly reflects policy conditions
- **Output risk**
 - Sensitivity to model settings (e.g. loss amplification, storm surge, etc.)
 - Benchmarking of modeled results (e.g. industry losses, claims history, other models)
- **Integration risk**
 - Is cat model output directly used in the economic capital model, or is it adjusted?
 - ECM should reproduce cat model output if the non-cat exposures set to zero

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Reserve sub-model

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- **Conceptual risk**
 - Method applied to calibrate data
 - Method for creating reserve variability
 - Check whether the model deals with correlations
 - Underwriting cycle effects
- **Input risk**
 - Documentation of data sources used for calibration
 - Have data sources been merged?
 - Is the segmentation which has been applied reasonable and stable over time?
 - Documentation for any aggregations applied before using the data
 - Are gross, net, and ceded amounts consistently treated, taking into account changes in reinsurance treaty terms?
 - Documentation of adjustments applied to data before calibrating the model (e.g. claims inflation)
 - Changes in key figures (rates of settlement, caseloads, payout lags, etc.) should be monitored by the risk modeling team

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Counterparty risk sub-model

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- **Conceptual risk**
 - Check how model deals with the difference between the large number of investment counterparties and small number of reinsurance counterparties
 - Verify that model includes exposure to reinsurer default after the report year
 - Does model reflect correlation between reinsurer default and claims amounts?
 - Level of aggregation used to model investment risk
 - Verify whether the effects of market value changes are included
 - Confirm that variations of credit spreads are not being double-counted by inclusion in the interest rate models in addition to the credit risk models
- **Input risk**
 - Verify that the granularity of the data (especially investments) fits the model
- **Output risk**
 - Assess model back-testing and performance testing

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Investment sub-model

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- **Conceptual risk**
 - Valuation principles are well documented and fit well with the ESG
 - Confirm rationale for selecting a non-standard ESG
- **Input risk**
 - Assignment of investments to classes
 - Degree to which investments assigned to class have class properties
- **Output risk**
 - ALM: Check whether the liability model and the investment risk model produce consistent outputs
 - Check time aspects as well as level of detail, should be checked carefully
- **Reporting risk**
 - ALM decisions usually taken by a committee using reports; check carefully

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