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# Model Risk

## Daring to open up the black box

*Interactive Session*

*Tim Ford, Nirav Morjaria, Andreas Tsanakas*

**IFoA ERM Seminar, 29 April 2015**

# Agenda

1. Introduction
2. Deep dive: The West Coast Mainline Rail Franchise
3. How can model risk be managed?
4. Governance and model cultures
5. Conclusions



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# 1. Introduction

29 April 2015



# The IFoA Model Risk Working Party

## Working Party Members:

Ankur Aggarwal

Andrew Smith

Michael Bruce Beck

Yvonne Taylor

Matthew Cann

Andreas Tsanakas (Sponsor)

Tim Ford

Louise Witts

Dan Georgescu

Ivy Ye

Nirav Morjaria (Chair)

## Working Party Objectives:

1. Raise industry awareness and understanding of model risk
2. Develop a framework for management and measurement of model risk
3. Foster good practice around the governance and control of models

**What keeps you awake at night about your models?**

# What is model risk?

- **Working definition of a model:**

“Any quantitative method, system, or approach that applies statistical, economic, financial, or mathematical theories, techniques, and assumptions to process input data into quantitative estimates.”

- **Why do we need models:**

The environments that financial firms have to navigate, and the portfolios and strategies they have to employ, are complex. We need models to help make the right decisions as human intuition and reasoning are not sufficient.

- **Model risk is the risk of...**

**adverse consequences from decisions based on incorrect or misused model outputs and reports.** Can lead to financial loss, poor business and strategic decision making, or damage to reputation.

- **Two main causes of model risk:**

1. Model has **fundamental errors** and produces inaccurate outputs
2. Model may be **used incorrectly or inappropriately**

# Models behaving badly... Some examples

Name	When	What happened	Misstatement and impacts
West Coast Mainline bid	2012	Model used to assess rival bids inconsistent and incorrect conclusion drawn	<ul style="list-style-type: none"> <li>– Cost to UK taxpayers over £50m</li> <li>– Re-run tender</li> <li>– First Group's business plan damaged</li> </ul>
Welsh NHS spending cuts	2011	Spreadsheet calculation error in think-tank's assessment of spending cuts	<ul style="list-style-type: none"> <li>– Cuts overstated by £130m</li> <li>– Reputational damage</li> </ul>
Mouchel Pension Fund	2011	Independent actuaries made an error in a spreadsheet for the scheme valuation	<ul style="list-style-type: none"> <li>– CEO resigned</li> <li>– Share price fell by a third</li> </ul>
AXA Rosenberg	2011	Spreadsheet error over-estimated client investment losses, failed to declare mistake	<ul style="list-style-type: none"> <li>– \$242m fine</li> <li>– Reputational damage</li> </ul>
JP Morgan (London Whale)	2012	Ignored control warnings, changed how VaR measured	<ul style="list-style-type: none"> <li>– \$6bn losses</li> <li>– Spreadsheet error at least £250m</li> </ul>
Fidelity Magellan	1995	Omission of minus sign lead to over-statement of capital gains and distribution not made	<ul style="list-style-type: none"> <li>– \$2.6bn overstatement</li> <li>– Reputational damage</li> </ul>
US Federal Reserve	2010	Spreadsheet error in Fed's Consumer Credit calculations	<ul style="list-style-type: none"> <li>– \$4bn error</li> <li>– Reputational damage</li> </ul>
Millennium Bridge	2000	Design calculations and modelling overlooked the fact the Bridge had a resonant frequency of lateral motion similar to that of the gait of pedestrians	<ul style="list-style-type: none"> <li>– Bridge closed for 18 months</li> <li>– Remedial works cost £5m</li> </ul>
LTCM Hedge Fund	1997	Lack of stress testing	<ul style="list-style-type: none"> <li>– \$4.5bn</li> </ul>
Over-reliance on Gaussian copulas	2007-12	Mis-price risk of CDOs, poorly understood, over-reliance	<ul style="list-style-type: none"> <li>– Important role in the 2008 financial crisis</li> </ul>



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## 2. The West Coast Mainline Rail Franchise

29 April 2015

# Deep dive: West coast mainline franchise

## Background

In January 2012, the UK Department for Transport (DfT) launched a tender process for the right to operate the InterCity West Coast rail line, then operated by Virgin Trains.

At the completion of the tender process, the DfT awarded the contract to First Group. However, following public pressure from Virgin questioning the viability of First Group's bid and aspects of the DfT's conduct of the tender, the UK Government cancelled the tender process in October 2012 and an inquiry was launched.

The inquiry, known as the Laidlaw Inquiry found serious failings on the part of the DfT.

The tender assessment process required the DfT to calculate the NPV of future payments to the government over the 15 year lease term, and to assess the likelihood that the bidding entity would go insolvent during that period.

In evaluating the bids, the DfT was required to adjust the bid cashflows for certain risks and then use an economic scenario generator model to determine the probability of the bidder going insolvent and potentially defaulting on their franchise obligations.

This model was then used to assess the necessary capital required to maintain the risk of insolvency at an acceptably low level.

# West coast mainline: where did it go wrong?

## **Model was not designed for its purpose**

The model developed by the DfT was designed for internal purposes to evaluate probability of default, not assess capital required to mitigate default risk.

## **Model not considered robust**

The model was not built or reviewed to an appropriate standard that management could feel confident in its results, or allow it to be distributed to bidding groups. Despite guidance to bidders to the contrary, the DfT ultimately applied a significant judgement overlay in calculating the capital required by each bidder.

## **Incorrectly parameterised**

A review of the model found certain key parameters were inconsistent with those disclosed to bidders. This impact was estimated to understate the capital required by up to 300%.

## **Outputs not understood**

The model produced outputs in real terms, but these outputs were incorrectly interpreted as being nominal. This led to the capital required being understated by up to 50%.

## **Issues not escalated**

A number of the issues raised above were identified and raised by DfT staff or external advisors during the tender process, however they were not escalated to an appropriate level. In particular, senior DfT officials were not made aware of the judgement overlay applied in calculating capital requirements for bidders.

## **Insufficient senior management involvement**

The tender process was not given sufficient senior management attention for a project of its size and complexity.

## **QA procedures were not effective**

While the model was reviewed, the results of these reviews were not documented and there was no accountability for resolution of the findings.

# West coast mainline: recommendations

Inquiry recommendations relevant to model risk management:

1. Review of QA procedures and various bodies responsible for those procedures.
  2. Formalise QA procedures in respect of modelling, encompassing best practice, audit and other testing procedures at appropriate stages of procurement.
  3. Timing and scope of internal audit reviews are set according to risk, and are not subject to amendment by project teams.
  4. Identification of a senior responsible officer with oversight of the tender process who is first point of contact for escalation of issues.
  5. Development of clear mechanisms to escalate risks and concerns.
  6. Completion of a review of skills and capability within the DfT and any external support required to fill capability gaps.
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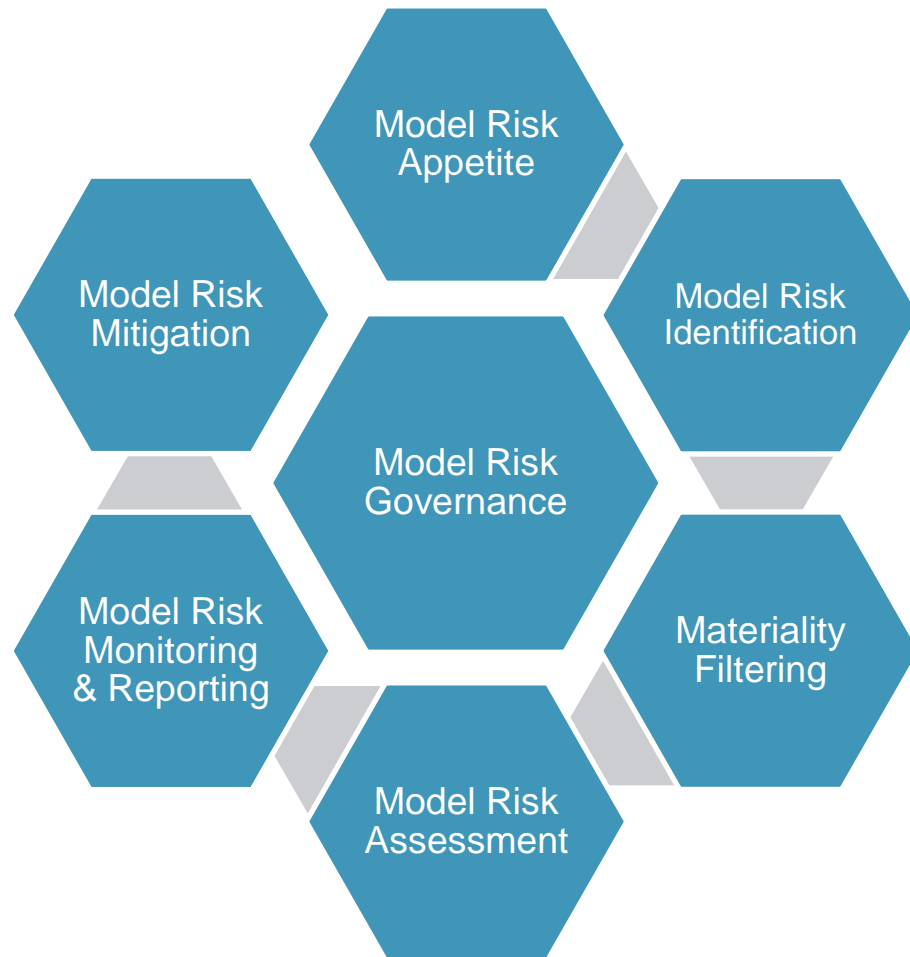


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### 3. How can model risk be managed?



# The Model Risk Management Framework



## **Model Risk Governance**

Model Risk Policy, Modelling Standards

## **Model Risk Appetite**

Amount of model risk the Board is willing to take

## **Model Risk Identification**

Identify the model risks the organisation is exposed to (model inventory and model development logs)

## **Materiality Filtering**

Which model risks are material enough to warrant more comprehensive management

## **Model Risk Assessment**

Quantitative, and qualitative (RAG rating) assessments for each material model

## **Model Risk Monitoring and Reporting**

Key model risk MI to be monitored and reported to relevant delegated authority

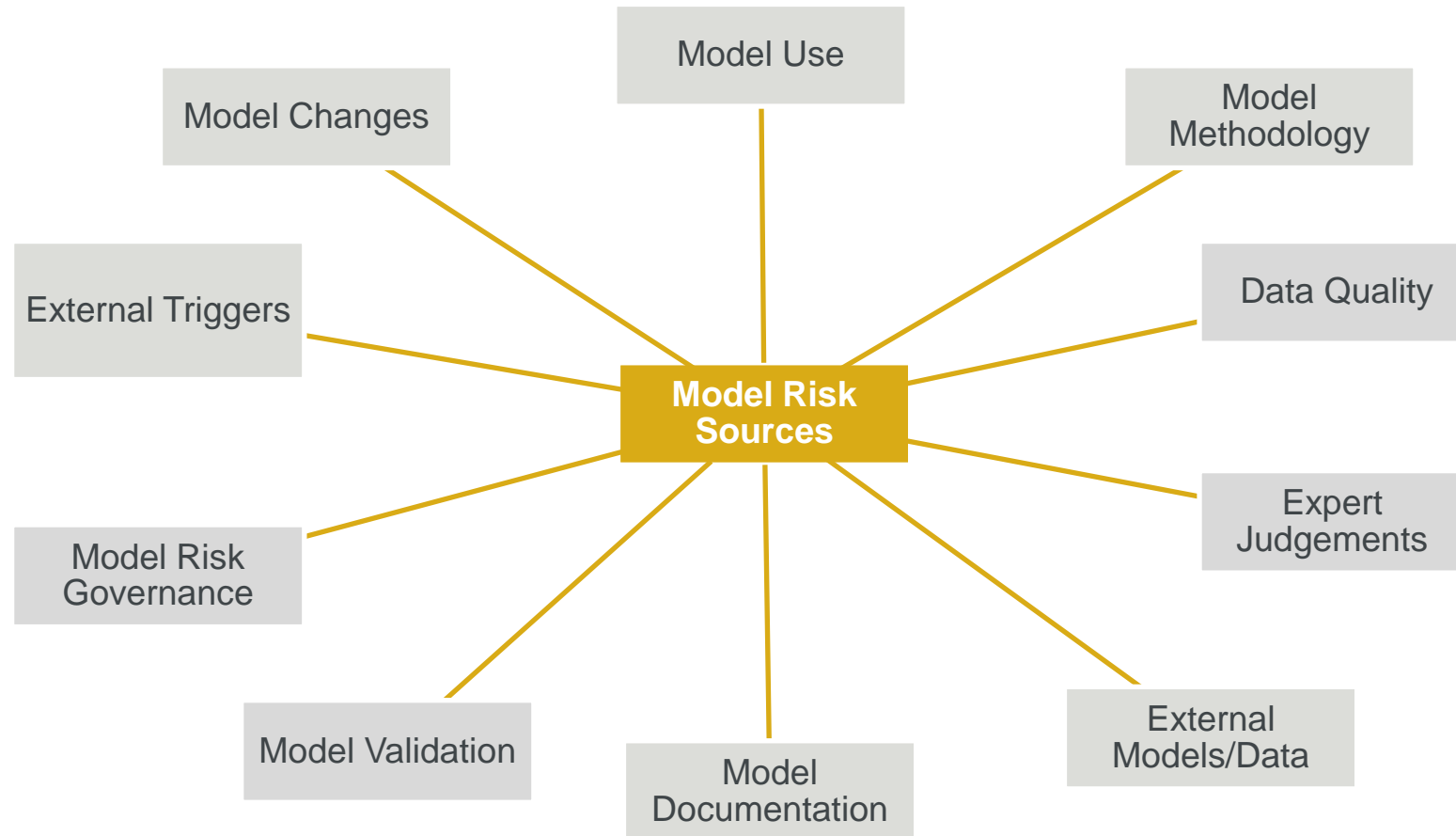
## **Model Risk Mitigation**

Actions to manage model risk profile within appetite

**Should model risk be managed in the same way as other risks? Do you already capture model risk in your operational risk frameworks?**

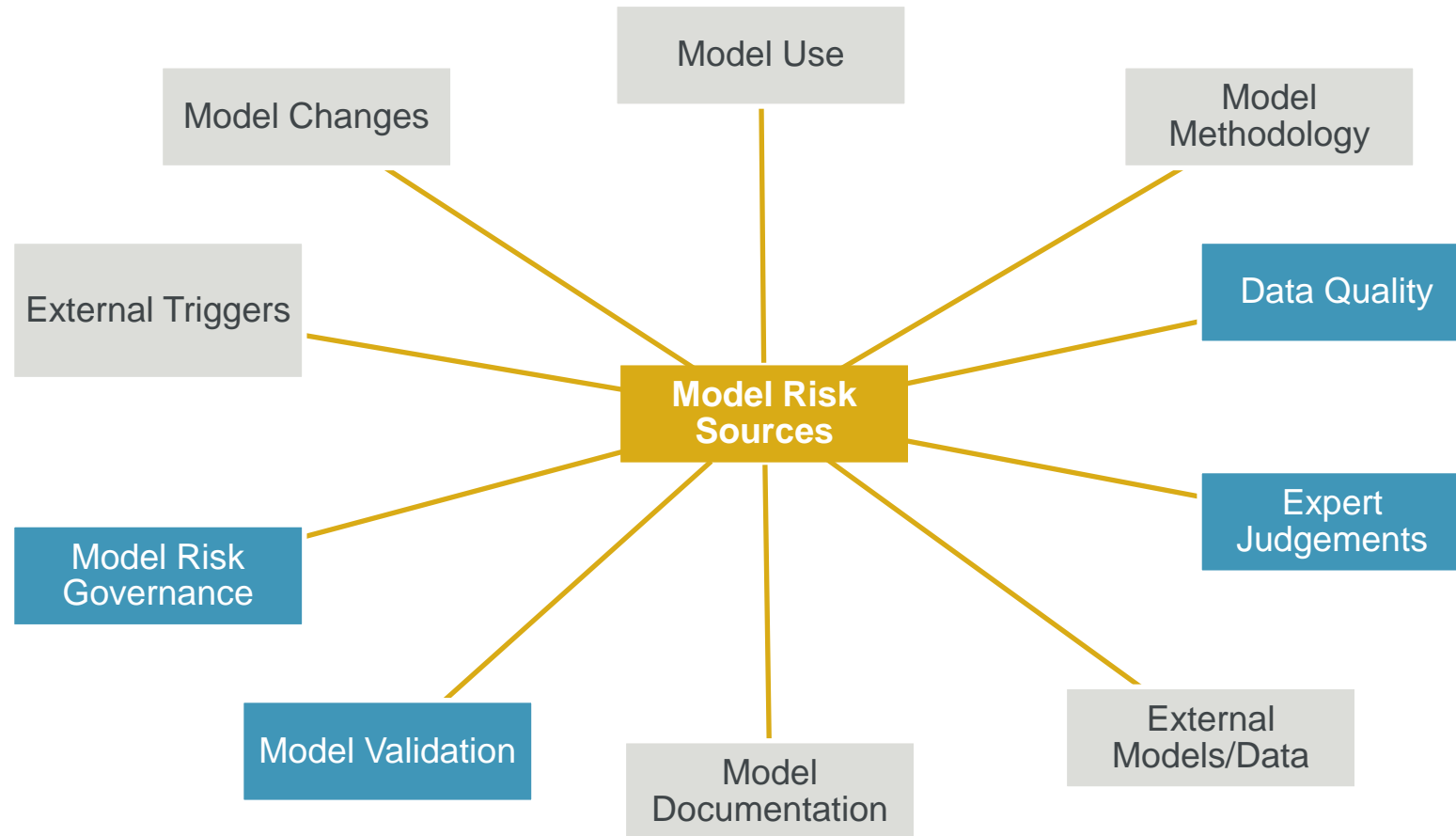
# Qualitative Model Risk Assessment

## West Coast Mainline Rail Franchise



# Qualitative Model Risk Assessment

## West Coast Mainline Rail Franchise



# Quantitative Model Risk Assessment

## Financial impact of model risk

- When a model produces the “wrong answer”, we distinguish:
  - The mis-statement, that is, right minus wrong model answers
  - The financial loss sustained as a result of that mis-statement
- These might be equal, or might not be:
  - A \$100m overvaluation in a take-over results in \$100m over-payment
  - Financial losses could include consequences of wrong decisions, compensating third parties, remediating the model
  - There may be no financial loss if a model does not affect decisions
- How far wrong might a model be if someone entered a figure with the decimal point in the wrong place?
- Can break down model error risk into expected and unexpected components
- Little benefit from upside model risk, so could use option pricing techniques to measure model risk

**Should we be trying to quantify model risk?**



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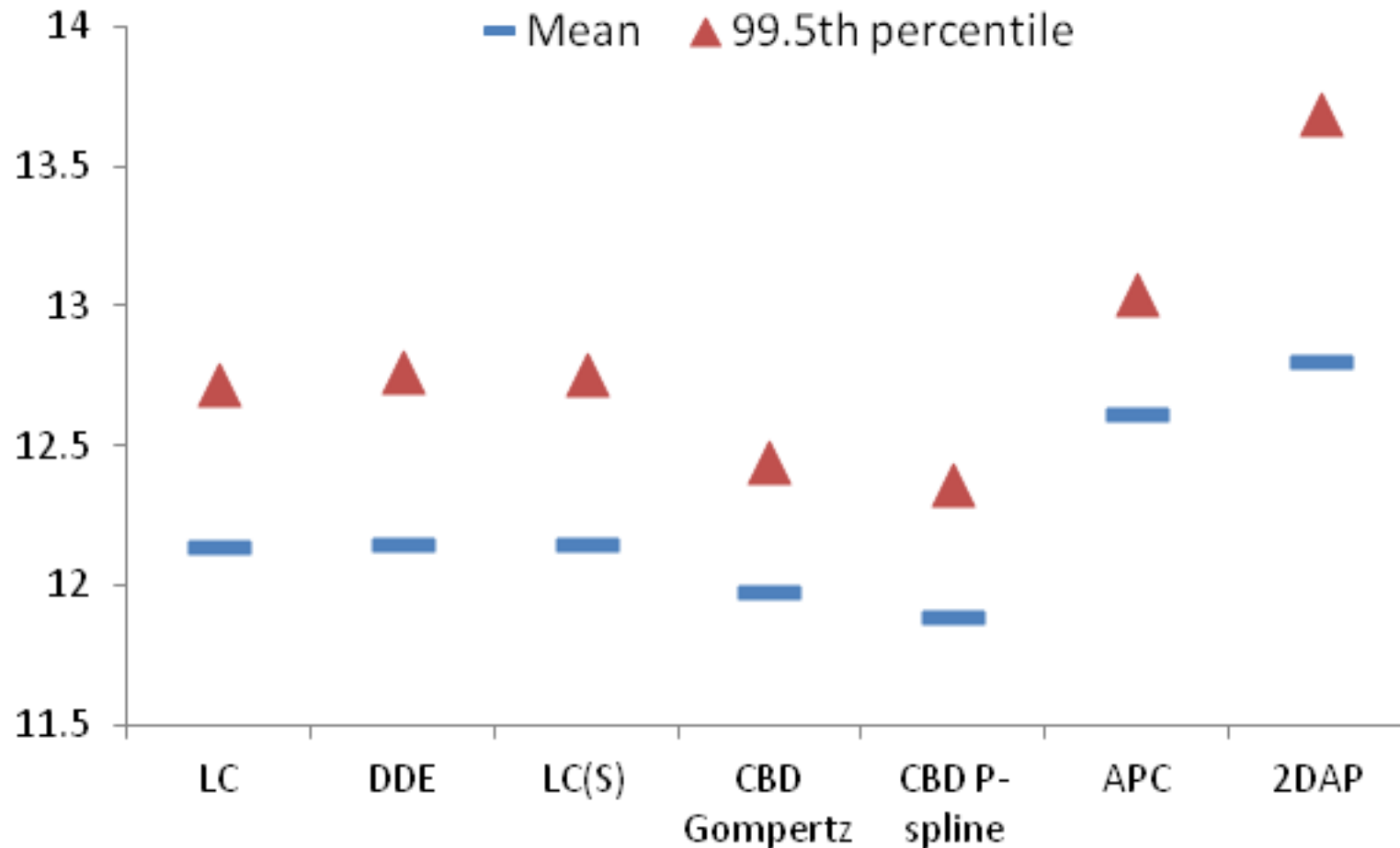
## 4. Governance and Model Cultures

# Model risk measurement

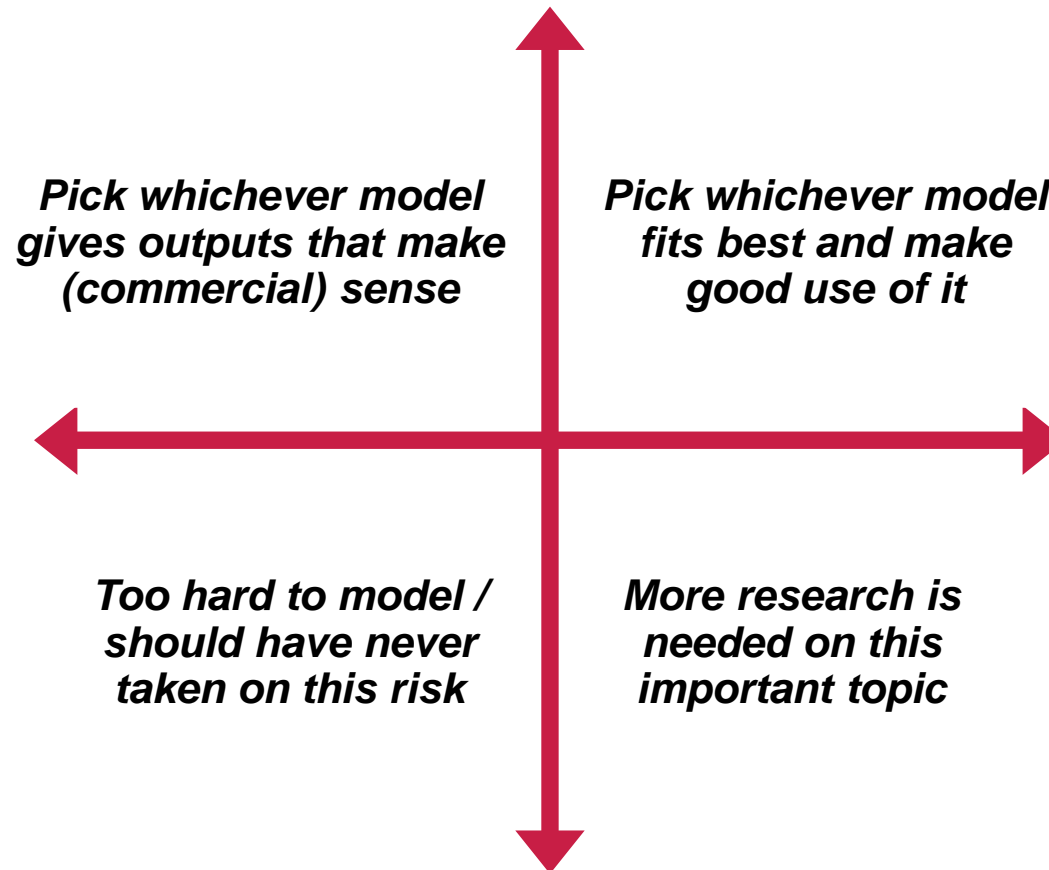
- Proxy models
  - Model error = approximation error
  - Can be precisely quantified
  - Accuracy v speed
- Longevity models
  - Chosen model may not be valid
  - Events outside historical data set may occur
  - Stress & scenario testing
  - Fitting multiple models

# Sensitivity of annuity value to model choice

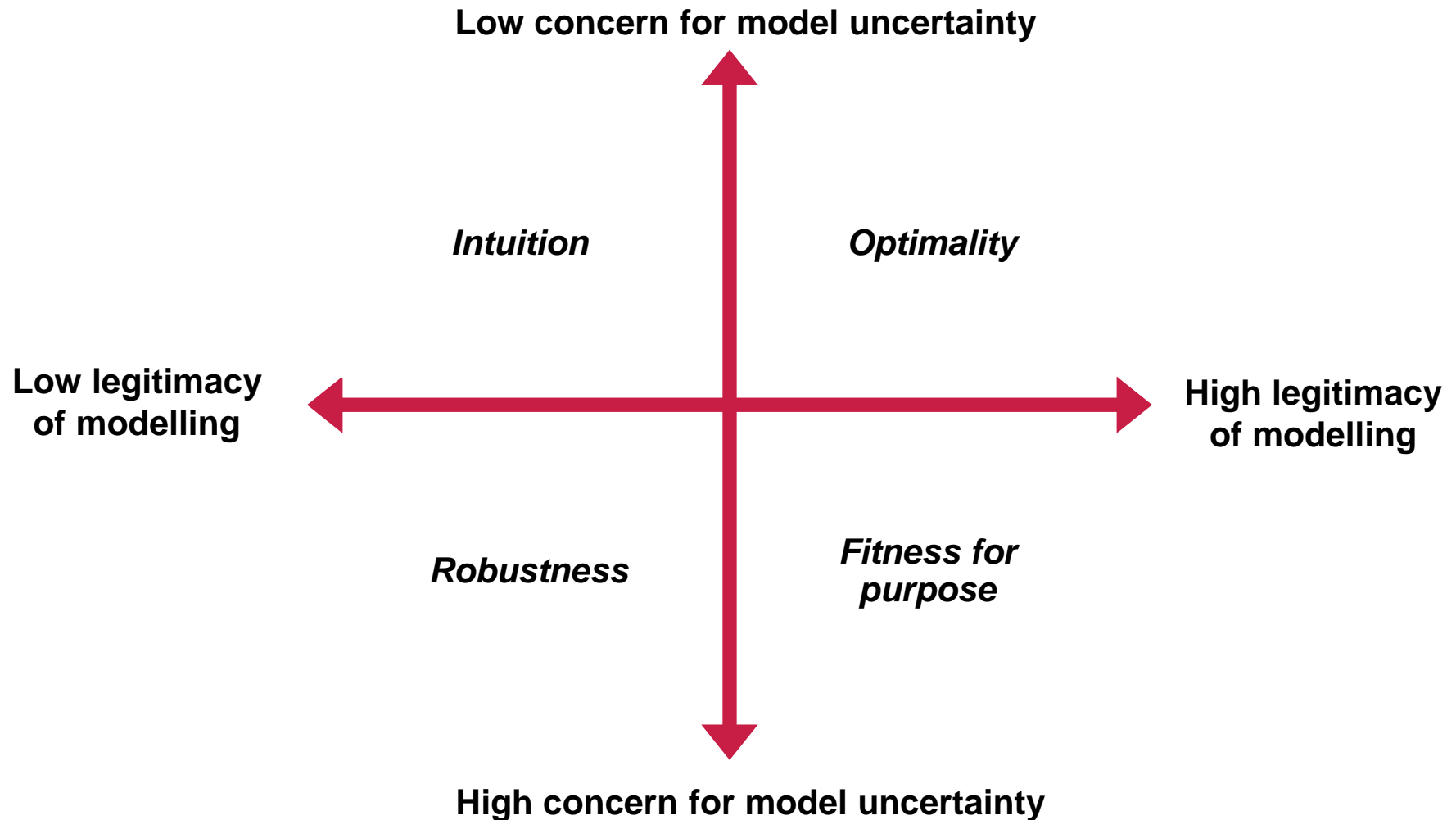
(70 year old male, discount at 3%; Richards et al, 2013)



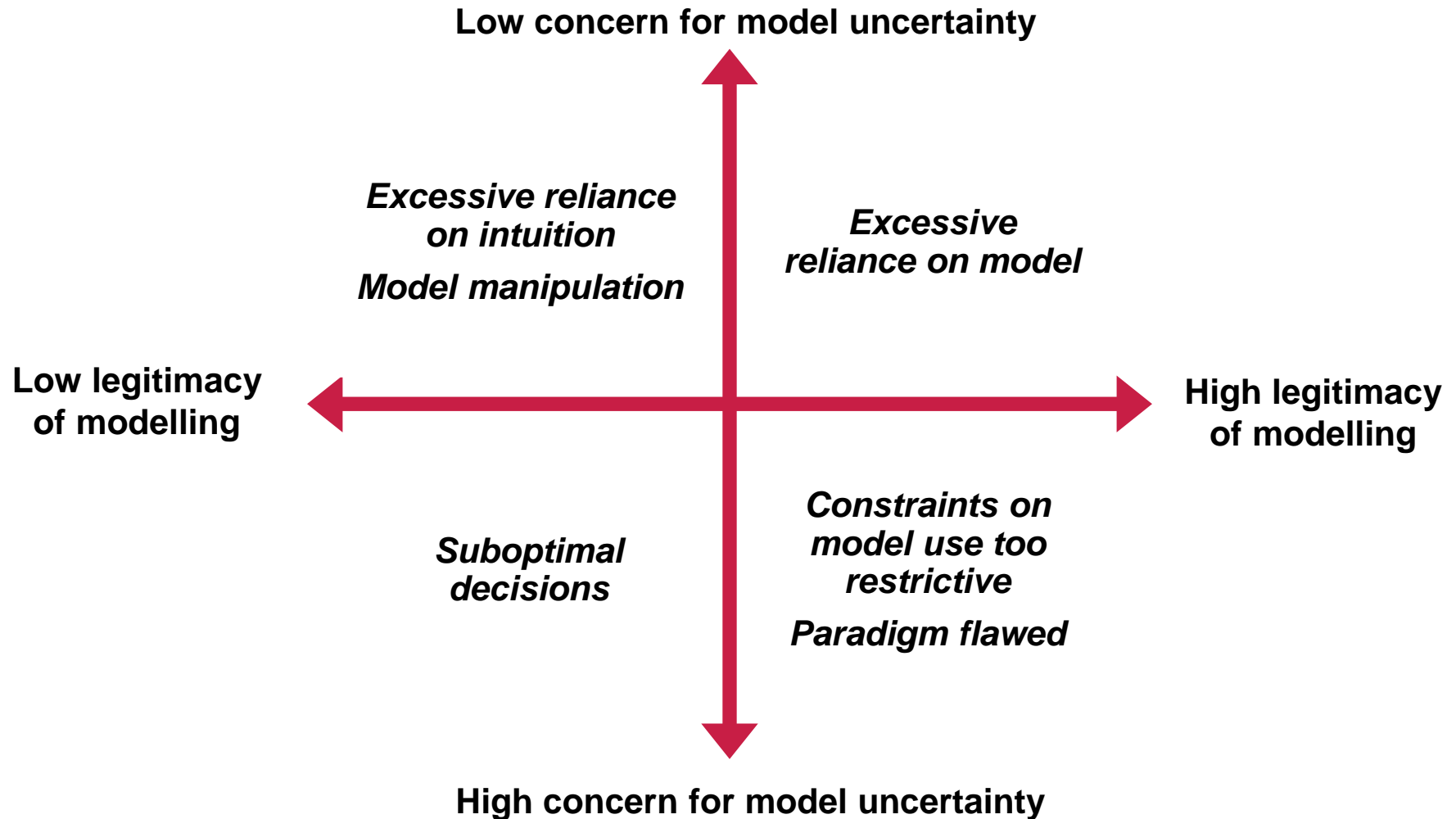
# How to respond?



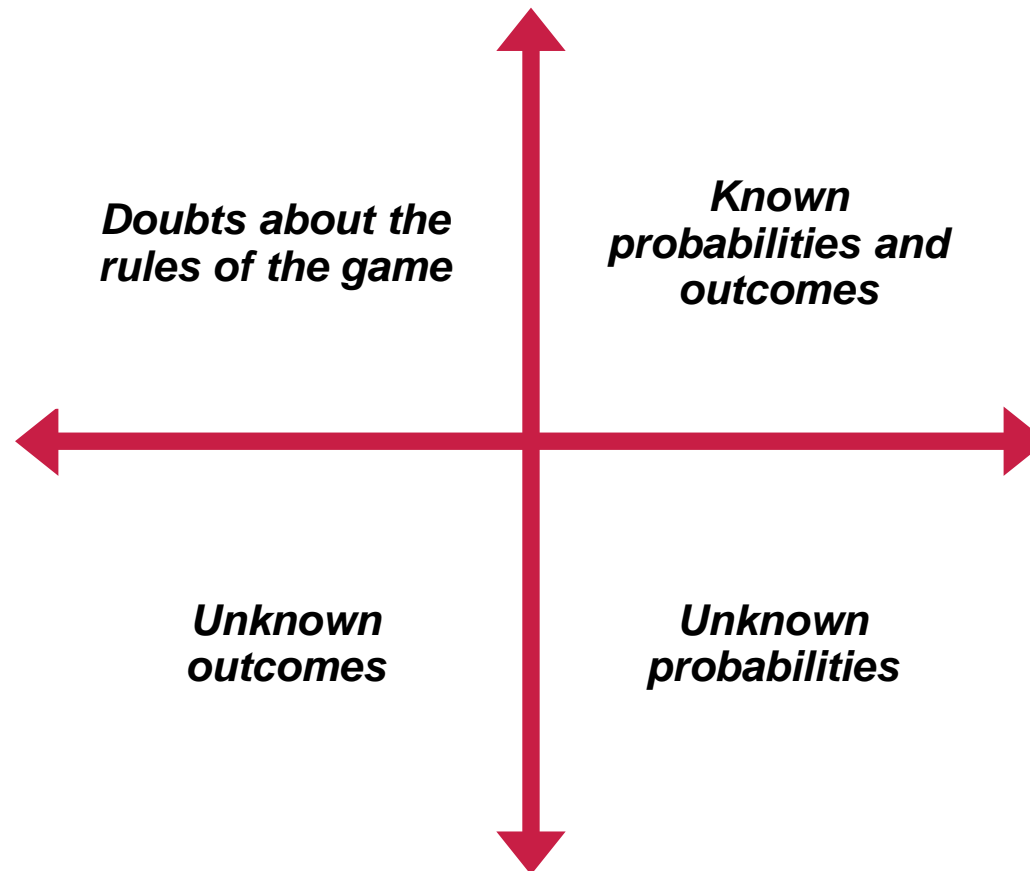
# Model perceptions...



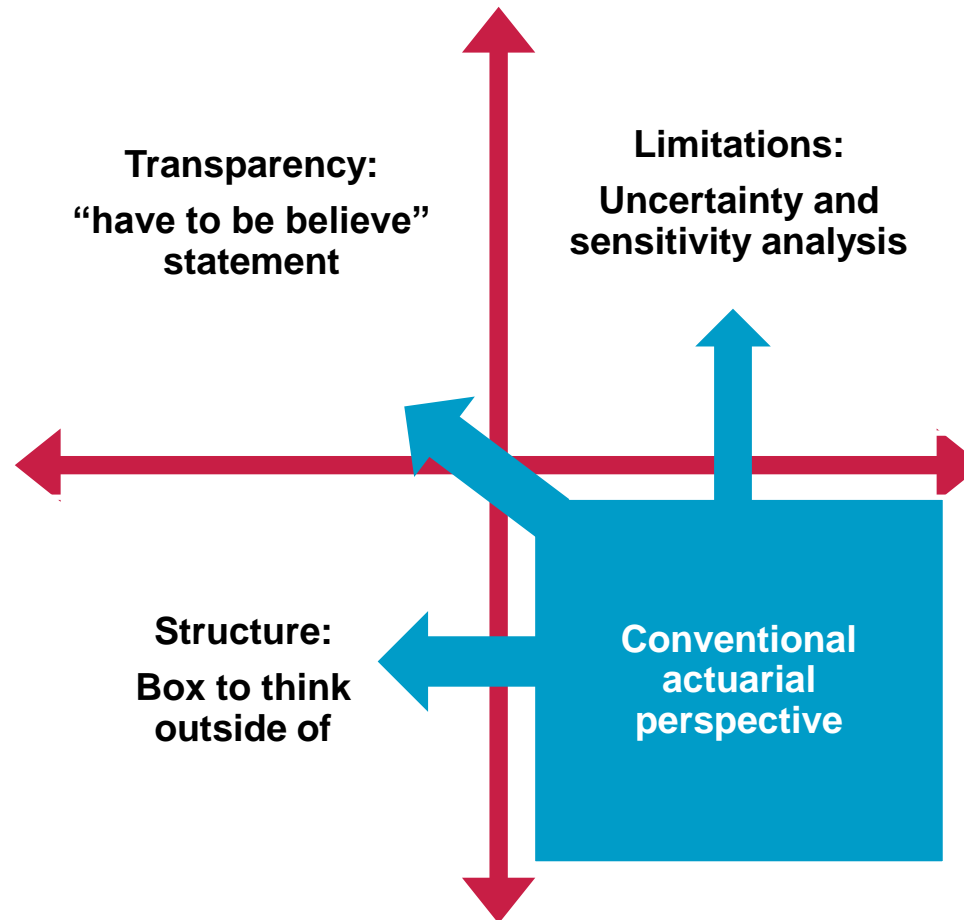
## ... and model risks



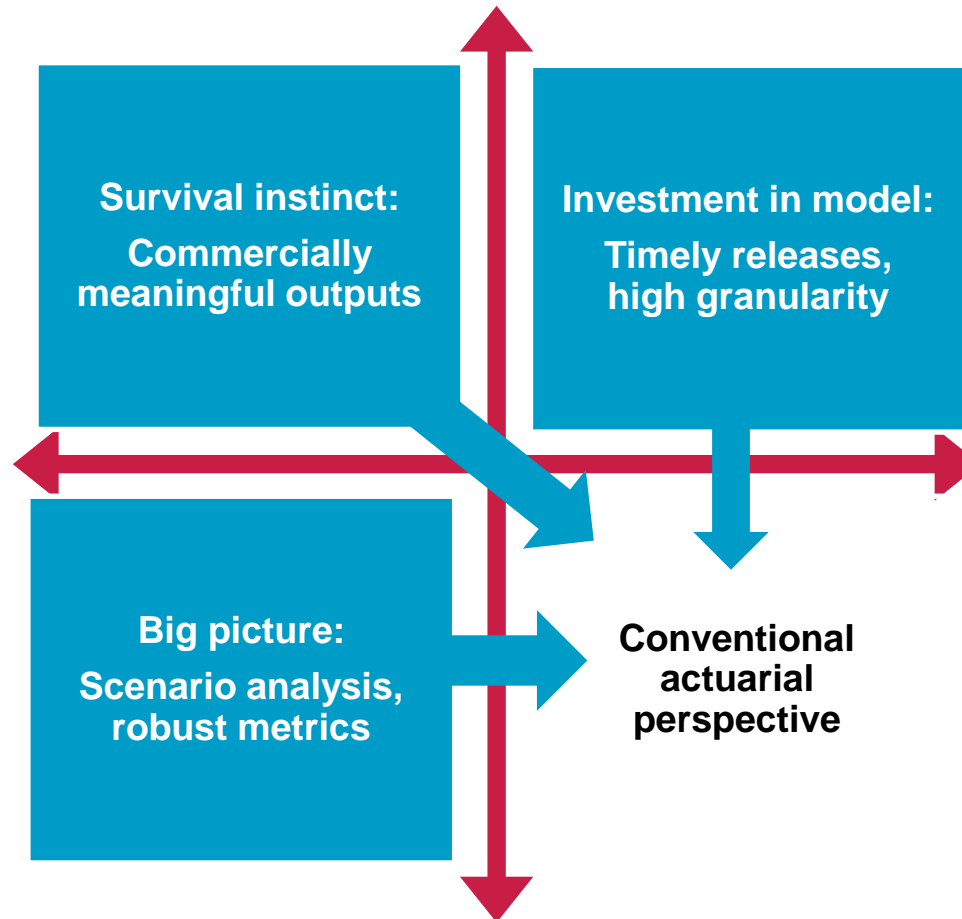
# Uncertainty classification



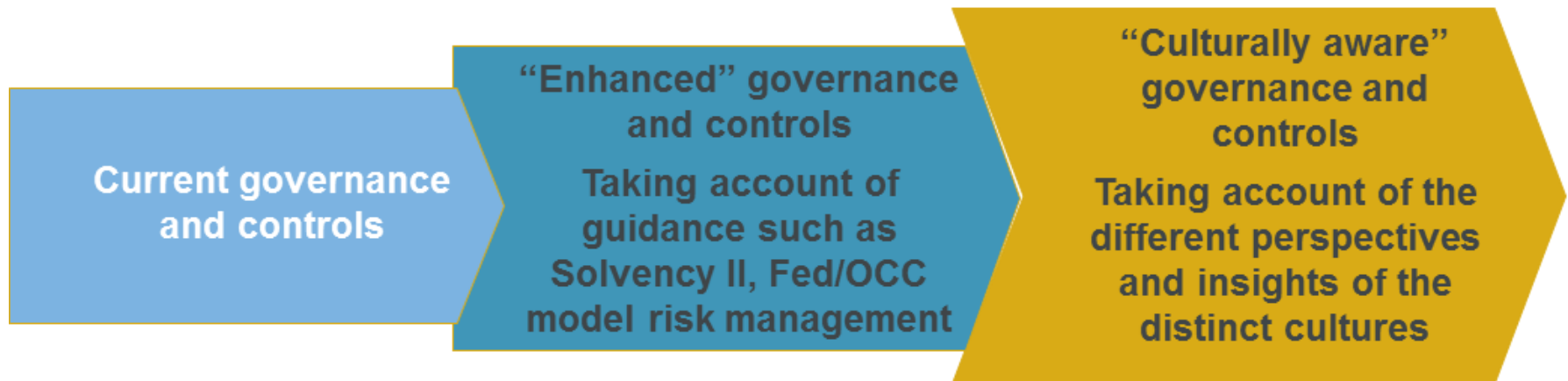
# What “we” offer to “them”...



## ... and what “they” give “us”



# Model governance evolution



# Questions

- What are in your **experience** the challenges of model governance?
  - Do you **recognize** the four perspectives discussed? Are there any more?
  - Do you accept that they should all have a voice in model **governance**?
  - Can you have such diversity **in practice** without paralysing decision making or creating more box-ticking
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## 4. Conclusions



# Key conclusions

- Model risk results from model errors / approximations or from inappropriate model use. Impacts can be substantial!
- Can be managed through a Model Risk Management Framework - requires Board engagement and support to set appetite for model risk and to manage model risk within these limits.
- Quantification of the financial impact of model risk is dependent on how the model outputs drive decisions. Specific methods will vary for different model types, results should be monitored and managed against appetite limits.
- Culturally aware governance and controls: optimal model risk management should consider all four perspectives equally, not just focusing on technical fitness for purpose.



# Questions



# Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenter.