



We
care
about
here



How to Manage a Portfolio of Models

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Credit Risk and Credit Control XVI

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What is Model Risk?

Model Risk – the risk of loss by the use of a model.

- **Erroneous assumptions, data and process**
- **Mis-specification**
- **Incorrect implementation, use and interpretation**

Model Risk Management is now embedded in banking regulations

 US Fed SR11-7;  ECB TRIM;  PRA SS3/18

Over the last decade, Model Risk Management has become an active independent professional risk discipline.

Look out for Model Risk Managers International Association (MRMIA) on LinkedIn



Model Risk Management

“Model Risk should be managed like other kinds of risk”

OCC 2011-12a / FR SR11-7

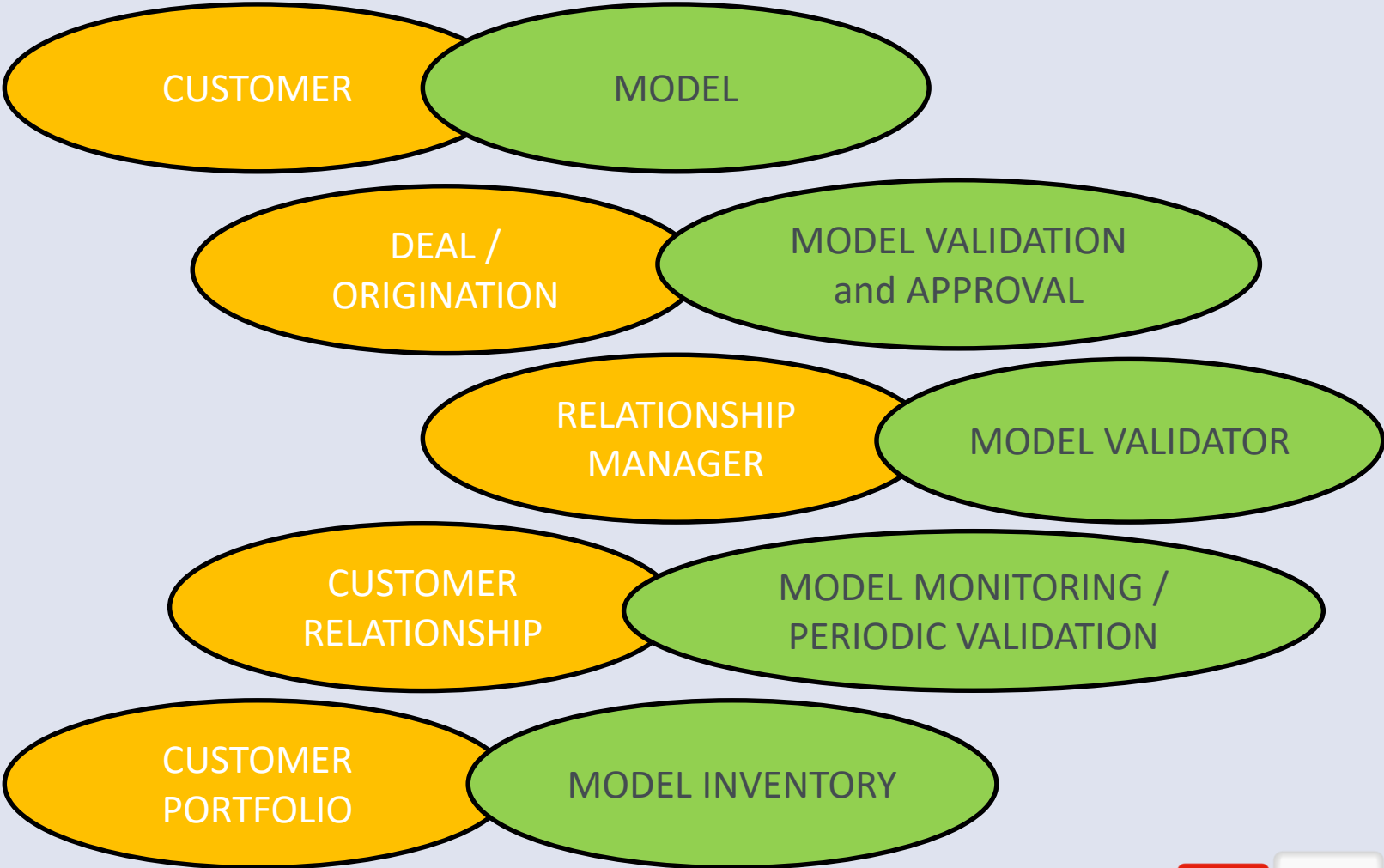
How do we manage models? Like we manage customers?

Can Model Risk learn from Credit Risk?

How far does the Credit Risk analogy stretch?



Credit Risk and Model Risk



Credit Risk and Model Risk

Best Practice

Model management, inventory and control – let's make it as good as our customer processes and the management of customer data.

Let's grade models into levels of model risk and treat them differently according to grade.

Let's have a Model Risk Appetite statement.

Interesting Questions

Can we tolerate a certain level of model failure, like credit defaults?

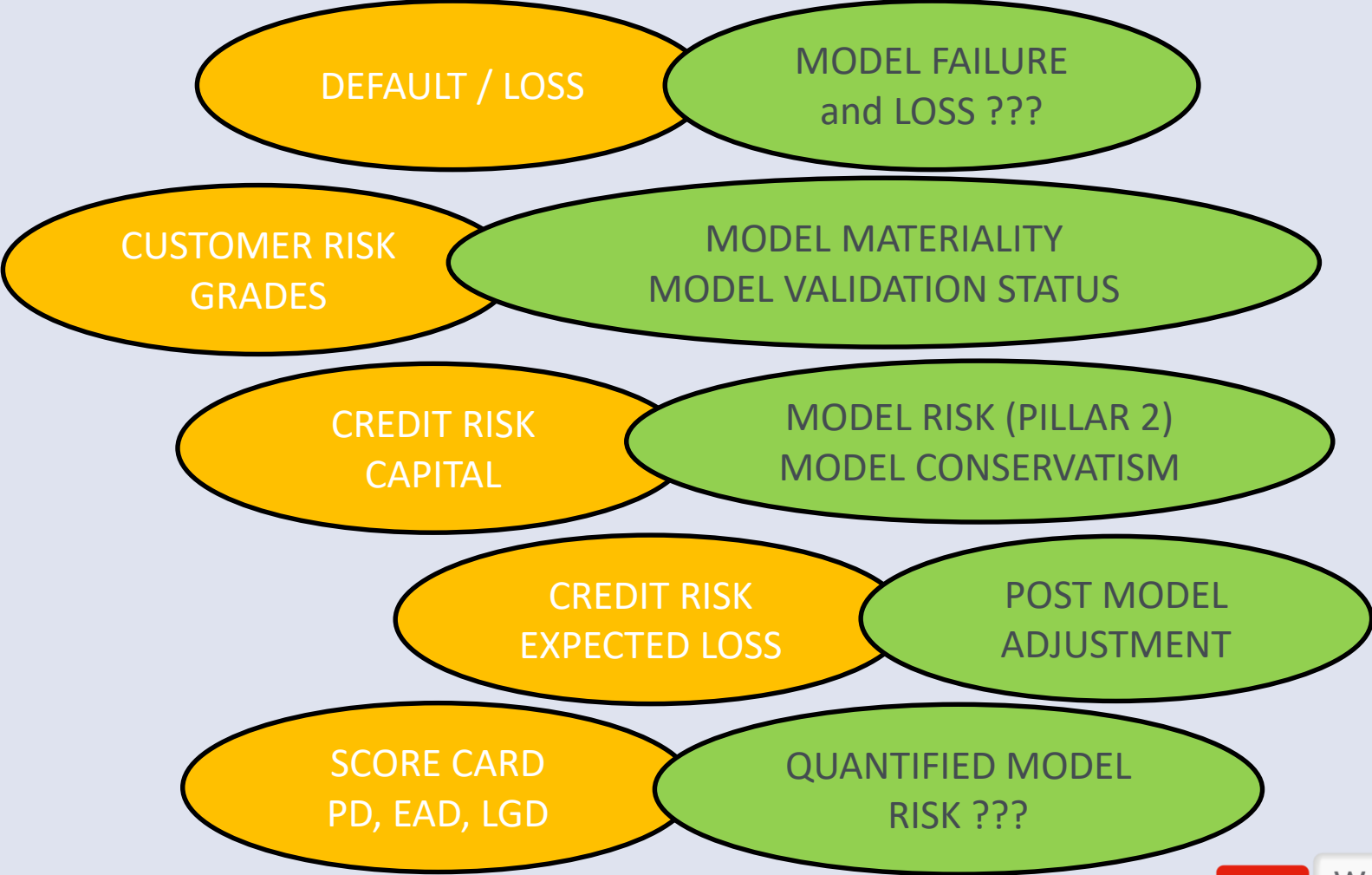
Retail or Wholesale? - Can we validate some models almost automatically?

How do we quantify Model Risk?

Individuals or Portfolios?



Credit Risk and Model Risk



Quantifying Model Specification Risk

How differently would we have built the model, if things were different?

What If...?

...the missing values were filled in by another method?

...our choice of factor went the other way?

...our backcast of default rates was perturbed?

...an expert-set parameter was chosen differently?

...there is (more or less) correlation between two model components?

...a different kind of model was used?

...we aimed to meet the conditions of a different stress scenario?

Leads to sensitivity analysis and to the quantification of sensitivities.



Specification Risk as a Data Shift Problem

Sensitivity analysis – if the data changes and we rebuild the model, how does the new model compare with the old?

This Data Shift Problem is an active area of mathematical research.

One recognised way to measure data shift and model shift is by Kullback Leibler divergence

$$D(p, q) = \int p \ln \frac{p}{q} dx$$

Seek to constrain the model shift by the data shift, in terms of KL divergence

$$D(m, m + \delta m) \leq CD(d, d + \delta d)$$

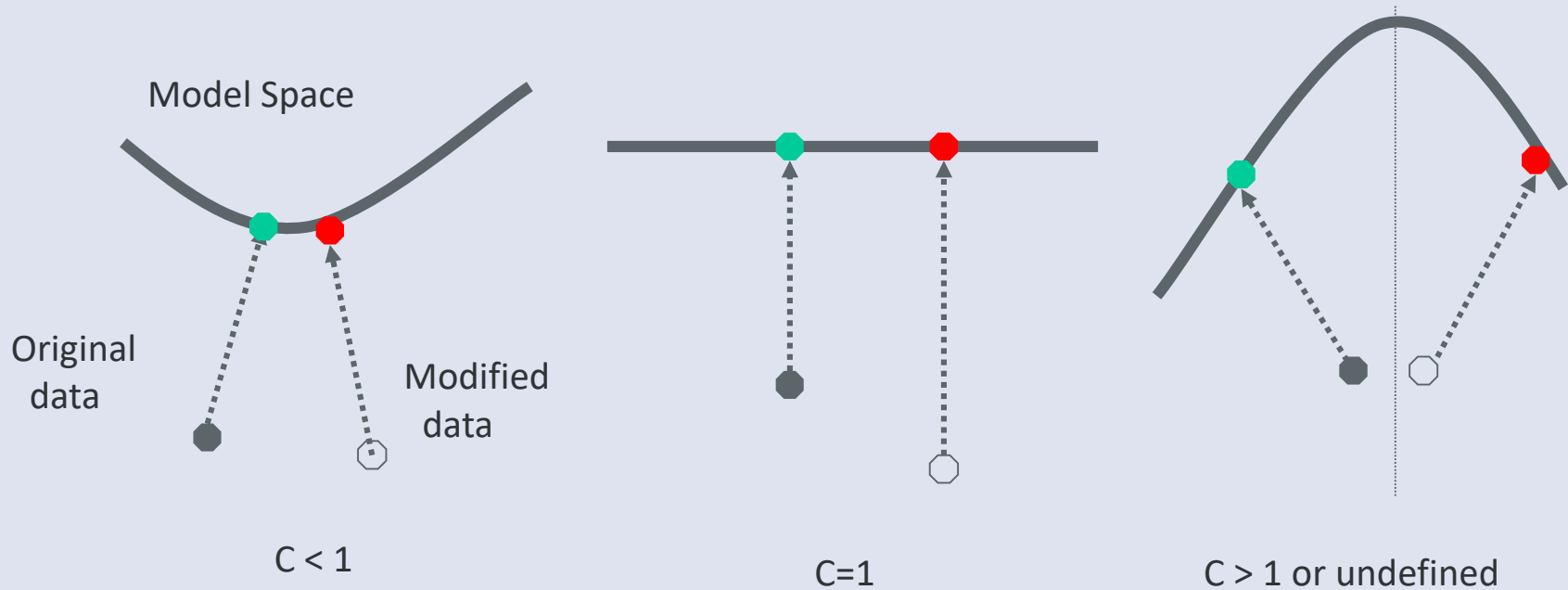
Centsov, Araki, Amara, et al.: General results and simplifications for regression modelling.



Specification Risk as a Data Shift Problem

As data changes, different models are selected from the Model Space.

Geometry and curvature control the sensitivity to changing data.



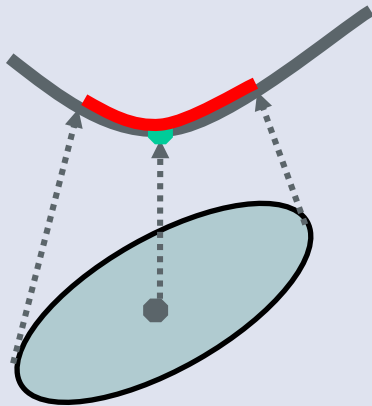
Data Shift in Practice

Classic models and modelling techniques have geometric interpretations

Single Factor Logistic Regression

Constant negative curvature

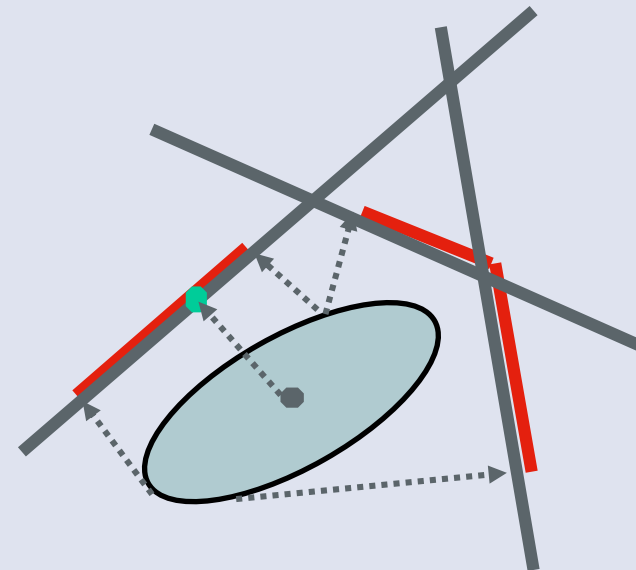
Zero torsion



Bootstrap variation

Standard Error

Decision Trees: unions of flat spaces



Random Forests average over the bootstrap variation



Data Shift in Practice

$E_p(h)$ measures the expected outcome of an objective h from a population p

To compare a shifted population, p , with a base population q , Pinsker's inequality gives

$$|E_p(h) - E_q(h)| \leq \sqrt{2D(p, q)} \|h\|_\infty$$

A refinement of this, more useful when h has wide variation

$$|E_p(h) - E_q(h)| \leq 2\sqrt{D(p, q)} \|h\|_{\Phi(dq)}$$

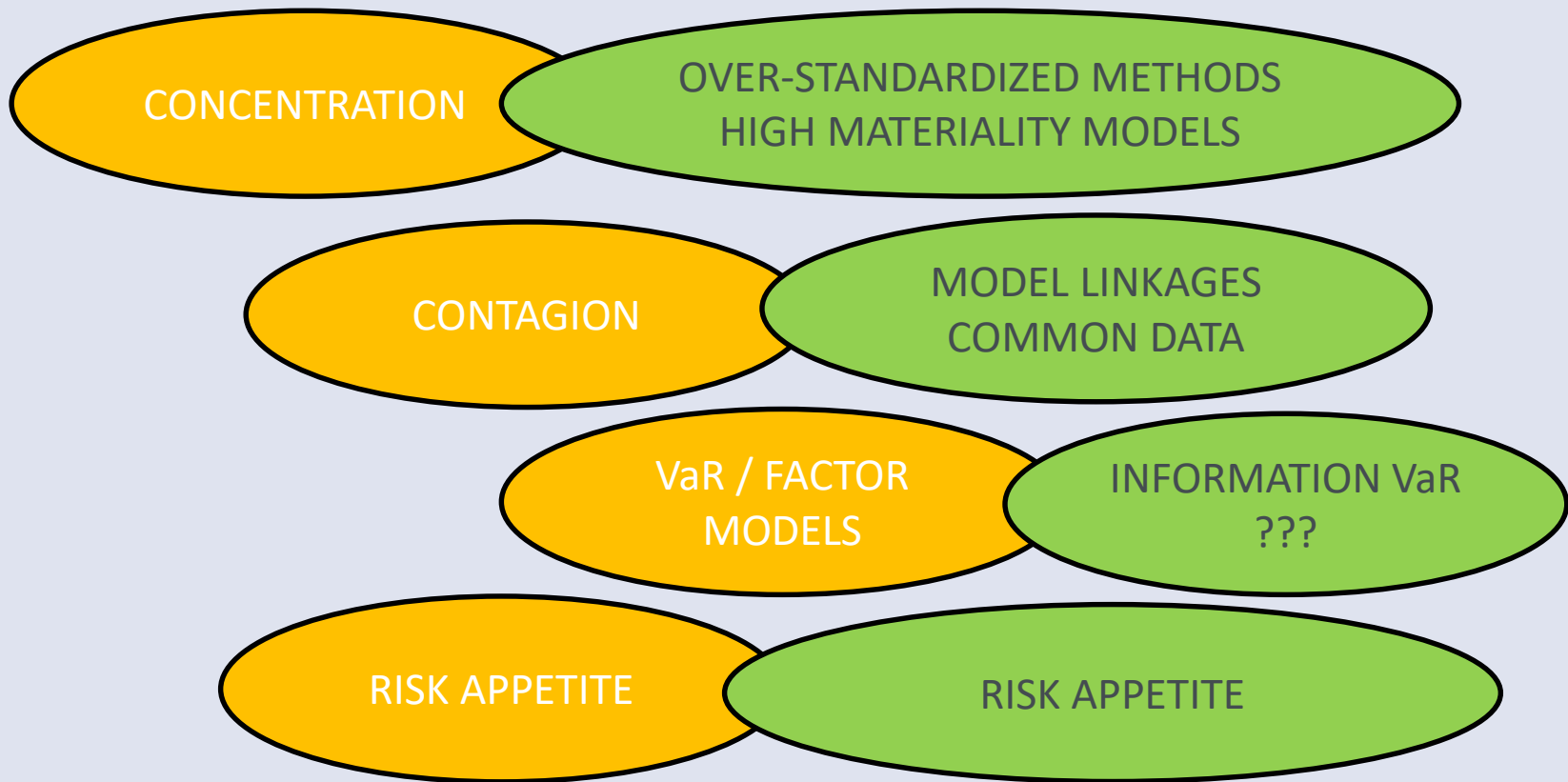
Where the exponential Orlicz-space norm is defined

$$\|h\|_{\Phi(dq)} = \inf \left\{ \lambda > 0 : \int \Phi\left(\frac{|h|}{\lambda}\right) q \, dx \leq 1 \right\}$$

$$\Phi(t) = \exp(t) - t - 1$$



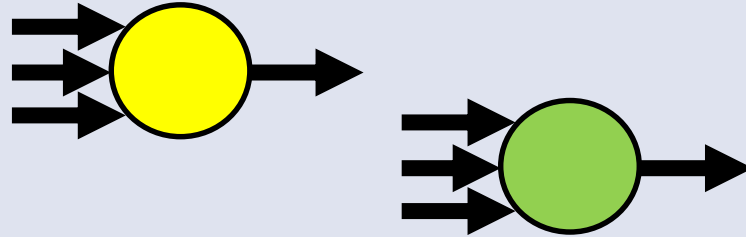
Credit Portfolio Risk and Model Risk



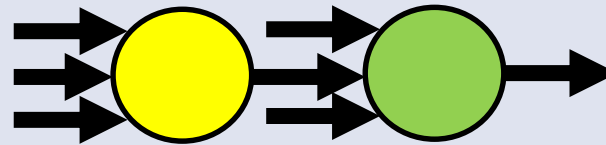
The Model Inventory is a Portfolio

Models are not just to be listed – they are related in many ways:

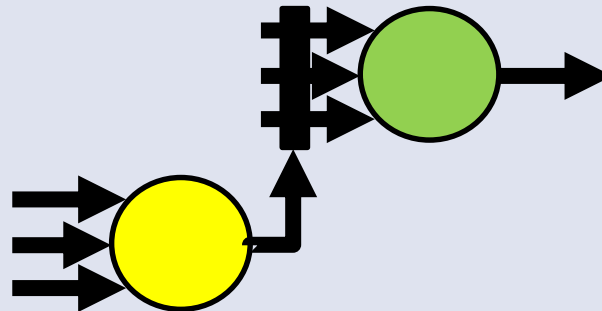
Models can be disjoint:



A model can feed another:

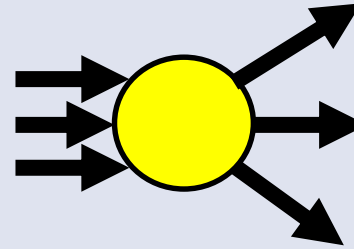


Models can interact strongly in other ways: eg PD controls the population of LGD



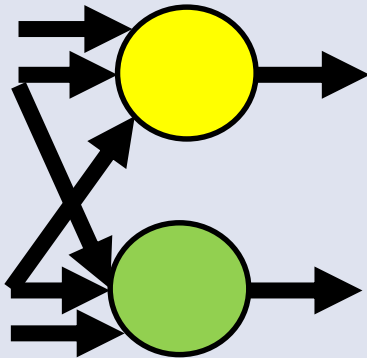
The Model Inventory is a Portfolio

Models can be used multiple times for different aims:

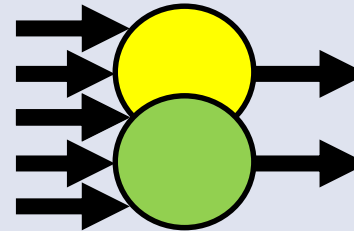


Models can have essential or accidental correlations:

Common factors

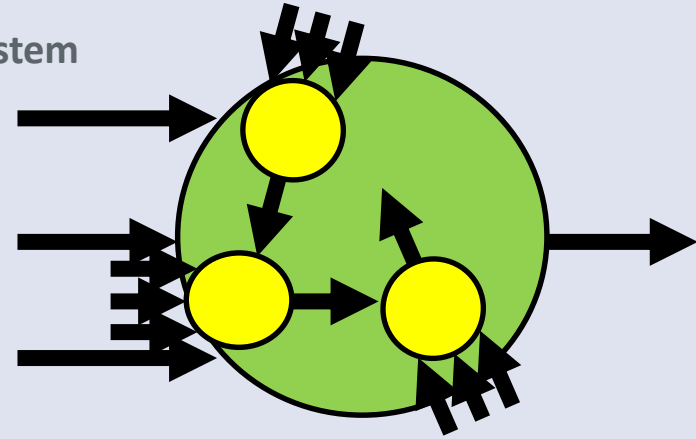


Common real phenomena

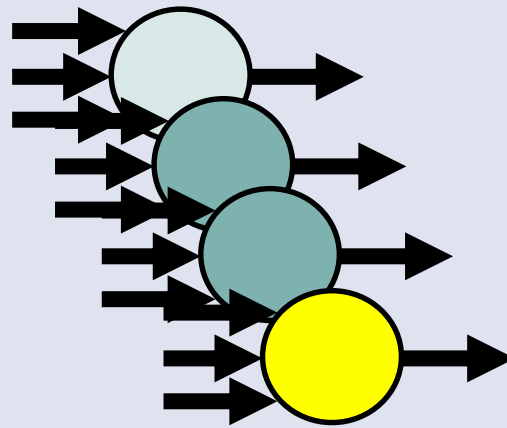


The Model Inventory is a Portfolio

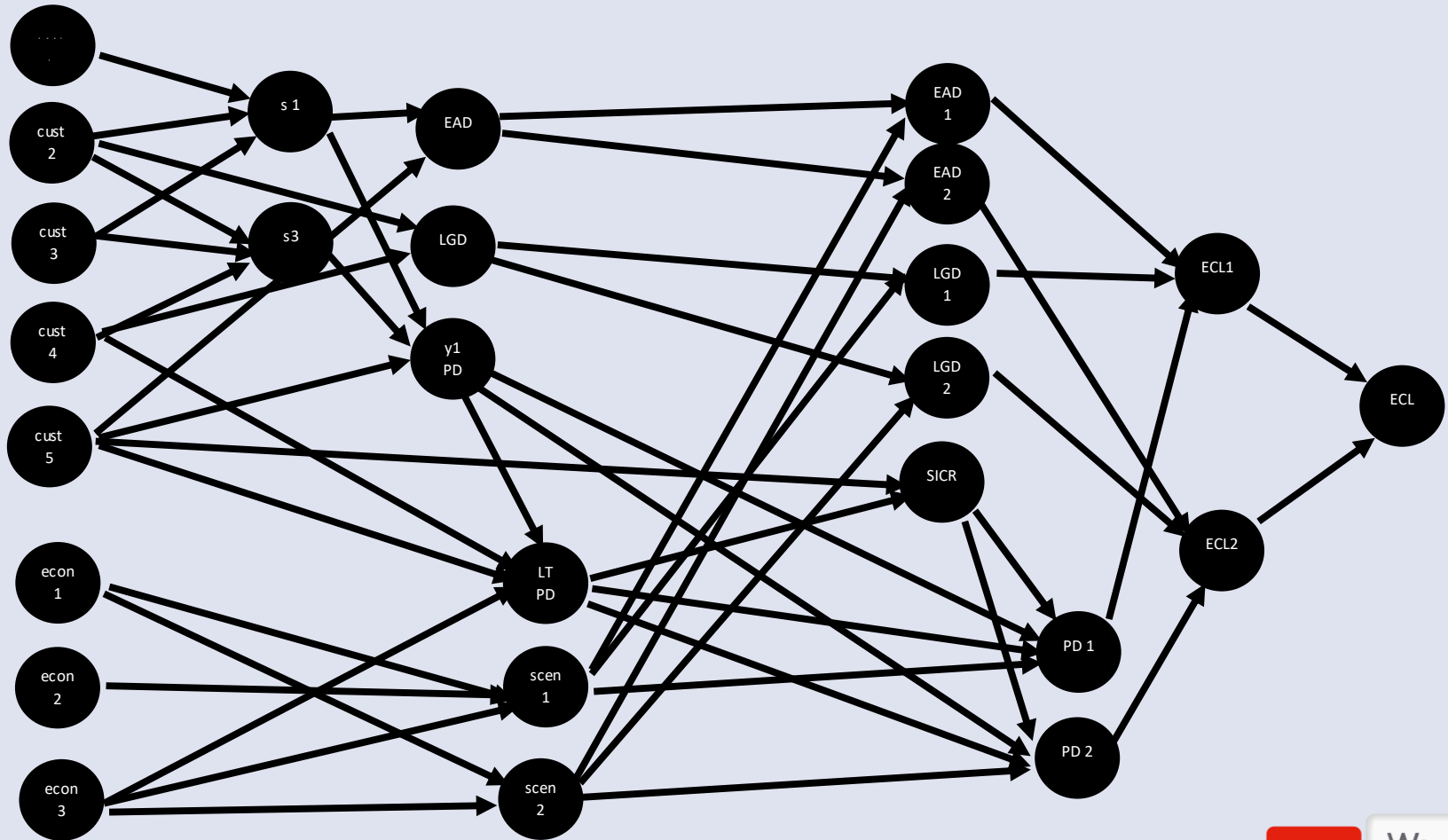
Models can be components of a larger modelled system



A model can be an old or parallel version of another, or a challenger of another



An IFRS9 Credit EL calculation (simplified)



Information and Model Portfolio Risk

Value at Risk and other portfolio-level models of loss exploit systematic assumptions about correlations within the portfolio.

Classically that's Pearson's Correlation, with underlying distributional assumptions.

Model shifts measured using Kullback-Liebler divergences, lead naturally to Joint Entropy and information theoretical measures of covariance.

These covariances can be computed for model structural variation as well as continuous parameter variations.

Look out, as Model Risk Quants develop variational approaches to Model Portfolio Risk.



Conclusions

Model Risk Management is a coherent professional risk discipline, supported by extensive and well-written regulation.

Model Risk can learn from Credit Risk, with new insight and practical perspective on Model Risk Management.

By analogy with Credit Risk measurement, the quantification of Model Risk is developing strongly, with interesting new mathematics and practical outcomes.

Individual Models can have their Model Risk quantified by asking “what if?” and making the connection with the data shift problem.

Portfolios of Models have yet to receive their quantitative risk treatment, but information measures of model shift and correlation look a good place to start.

