Global Risk Management Day by Copenhagen Compliance

March 11, 2021, Online Conference

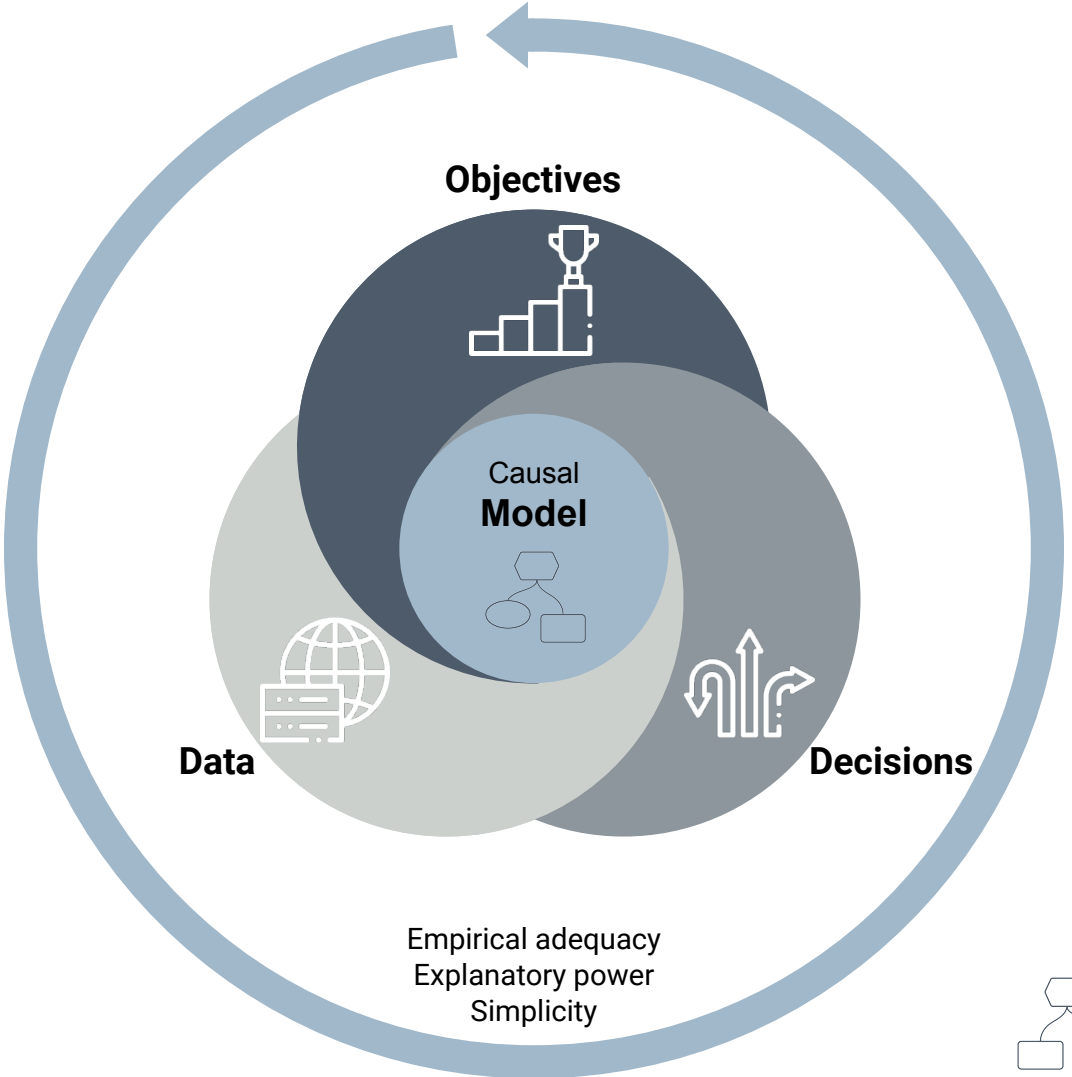
# A quantitative framework for enterprise risk management

**Graeme Keith**

Stochastic ApS

Mathematical modelling for business & the business of mathematical modelling

# Stochastic Modelling Paradigm

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# ERM

**Strategy & Risk Policy**

**Strategy** articulates desired returns and the irreducible risk (e.g. commodity price) its prepared to accept to achieve them. Mainly managed through portfolio optimization (hedging / diversification) through investment committee.
**Risk policy** articulates the risk the company is willing to accept for a given return and specific risks that it is and is not willing to accept

Primary instrument for realizing risk policy through divestment and investment, both M&A and strategic projects

**Investment committee**

**Operational Risk Committee**

**Regional Risk Committee**

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**Regional Risk Committee**

**Disciplines**

- M&A
- Finance
- Legal
- HSSE
- Projects
- Engineering
- IT
- HR

**Enterprise risks**

Risks that can only be managed at enterprise level, e.g. commodity price, exchange rates. Global risks, e.g. staff availability, cyber.

**Policies / GMS**

Discipline leads determine processes by which risks are identified and managed (workflows, best practices, compliance)

Fatherland

Local discipline leads (technical authorities) identify and manage risks locally according to global policies and processes

Middle Nowhere

Outer Nowhere

**Headquarters**

**Regions**

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both M&A

**Local risk modelling**

**Decisions.**
Choice of mitigations: prevention, protections, etc.
Local disposition of resources as well as rules and policies in line with global framework

**Objectives**
Maximize performance (expected loss)
Manage tail risk (VaR, CES)

**Data**
Local historical data
Local subject matter expertise

**Models**
Fit for purpose, but anything goes:
Minimum: Incidence / severity assessment for range of options
Preferred: Bow tie for event risks
Causal map where appropriate and sufficient data to condition

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**Strategic risk modelling**

**Decisions.**
Investments and divestments
Strategic and transformational projects

**Objectives**
Cost effective portfolio performance (expected EBIT, for example)
Managed tail risk (VaR, CES)

**Data**
Current risk profile of enterprise and its constituents
Risk profiles of potential acquisitions
Modifications derived from transformational projects

**Models**
Portfolio models, switching options in and out of existing profile and incorporating enterprise uncertainties

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**Global operational risk modelling**

**Decisions.**
Global disposition of resources to manage risk as well as rules and policies to optimize risk management and reconcile risk profile with risk policy

**Objectives**
Cost effective portfolio performance (expected loss)
Managed tail risk (VaR, CES)

**Data**
Risk analyses, possibly aggregated
Specified optionality on policies and mitigation strategies

**Models**
Aggregation of individual locally modelled risks:
Concatentation of local models
Aggregation of loca model results
Covariance model

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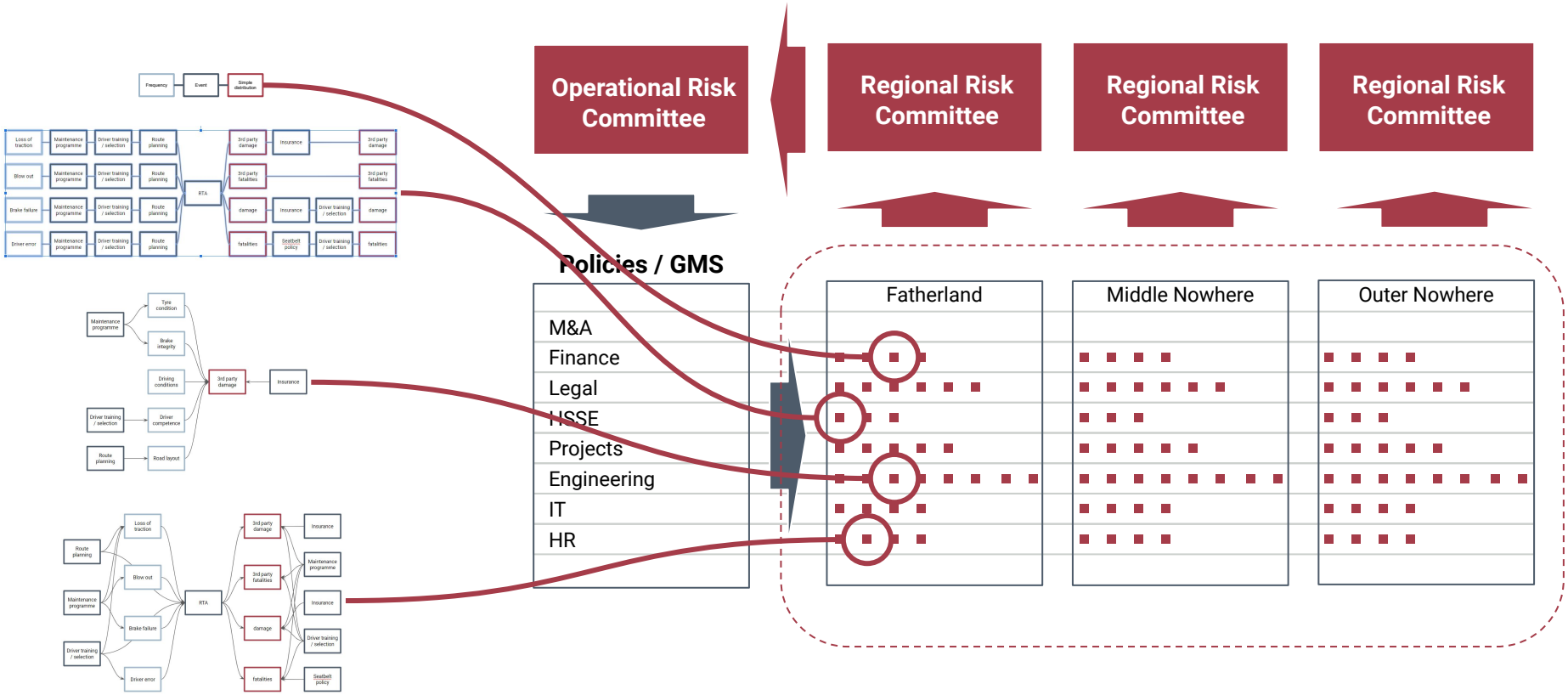
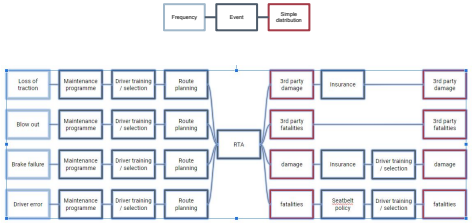
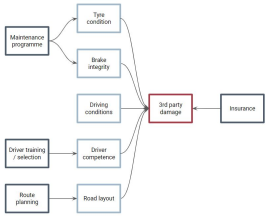
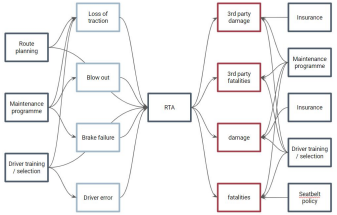
# Global operational risk model based on an aggregation of the results of local risk models

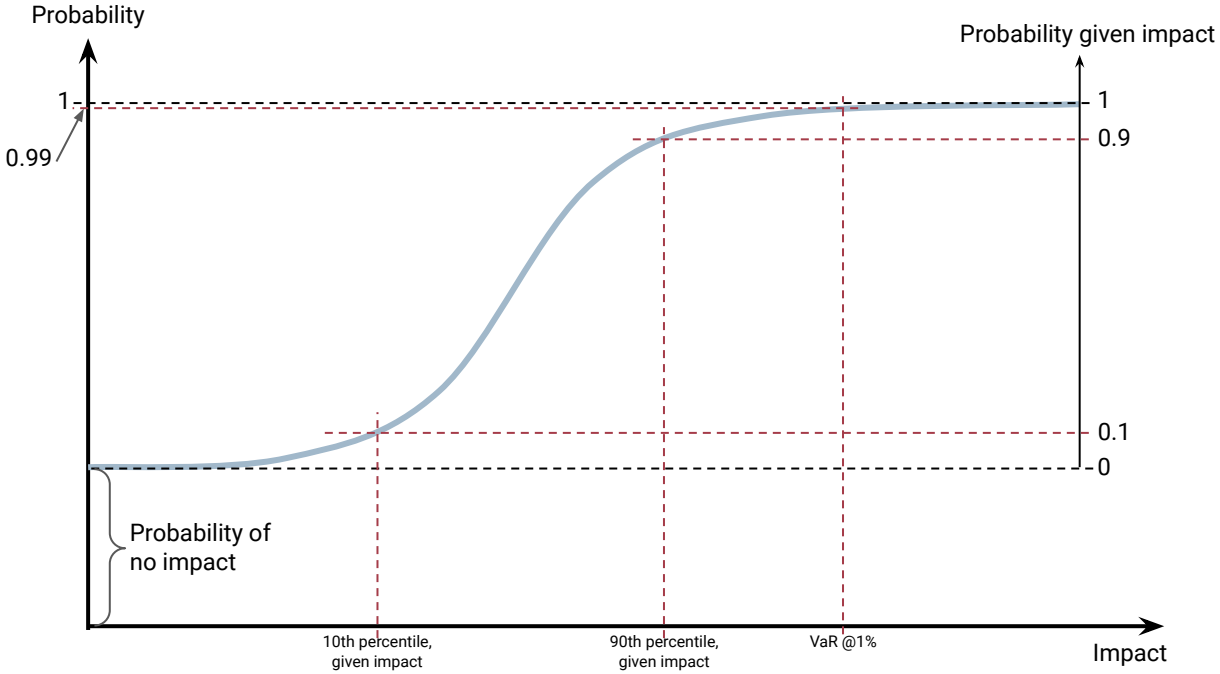


# Local risk models

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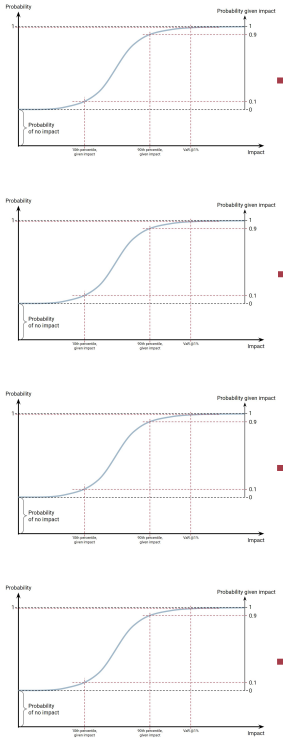


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# Aggregation of additive impacts

**Modelling options**

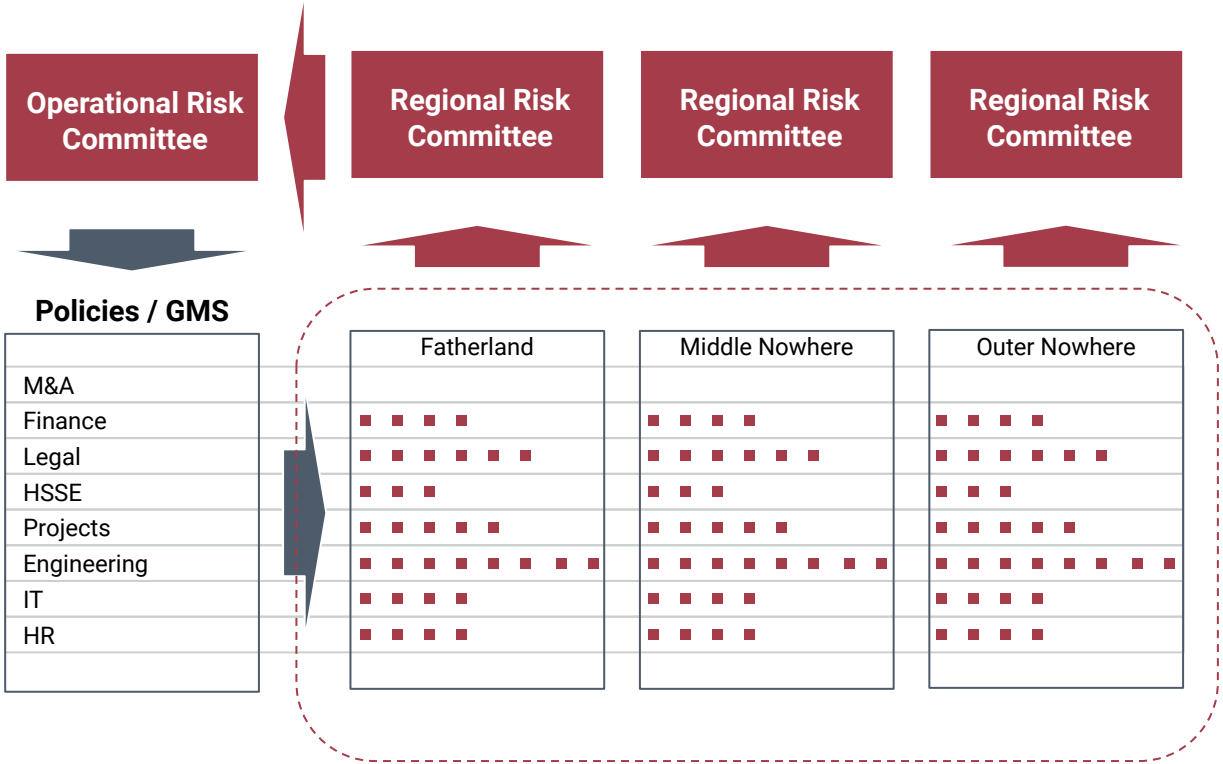
Concatenate the models

- *Treat it like a single great big model*

Aggregate the results

- *Take the distribution curves and add them up*
  - Simulate
  - Approximate

We have to simulate (or concatenate) if we want to manage the tail, but for the bulk of the distribution, we can approximate



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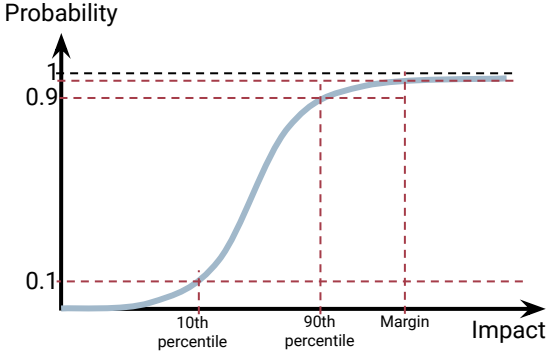
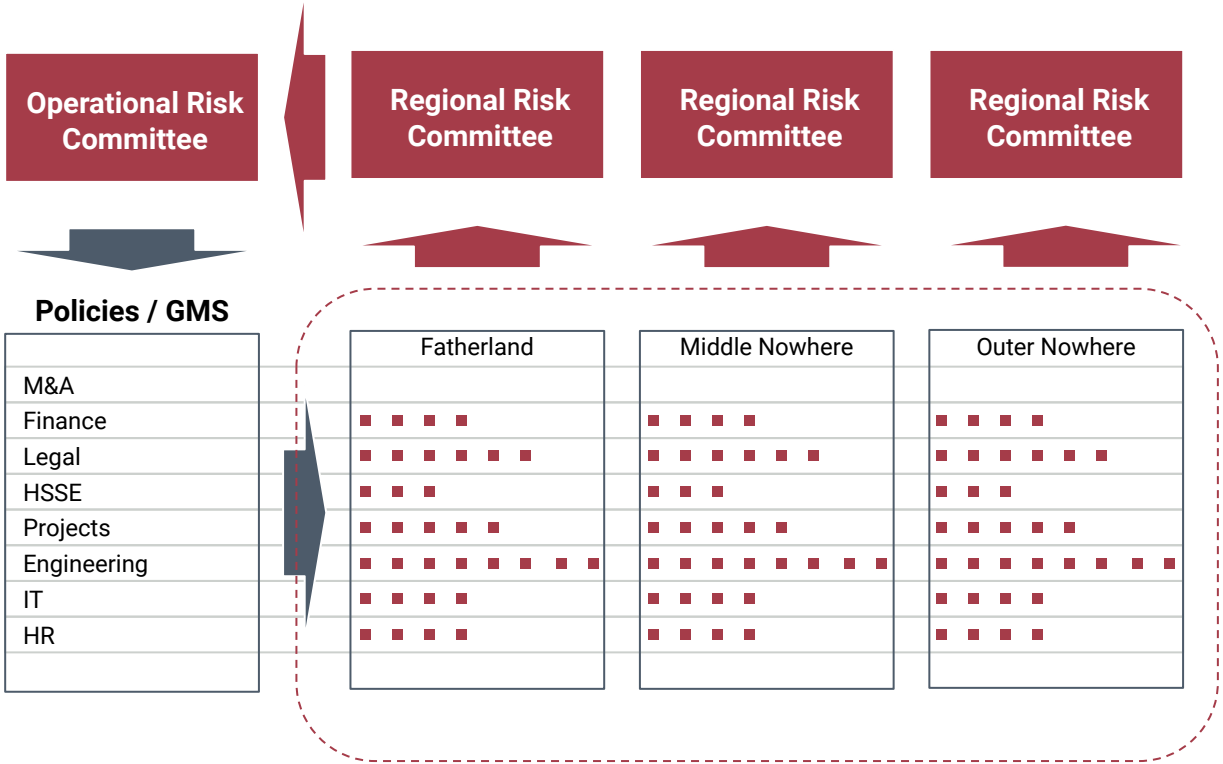



**Objectives**

- Maximize margin, by minimizing mean impact
- Constrain downside by constraining, for example probability of loss of margin

**Decision levers**

- Modifications of risk profile take place through policies in GMS
- Optimization requires optionality



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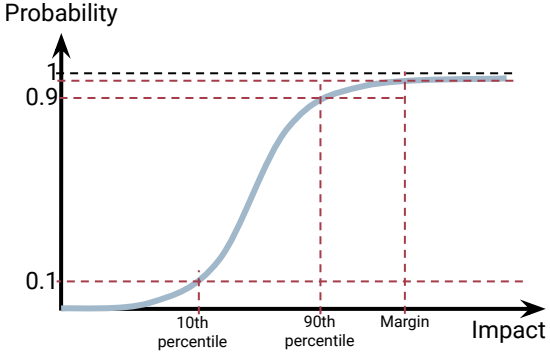


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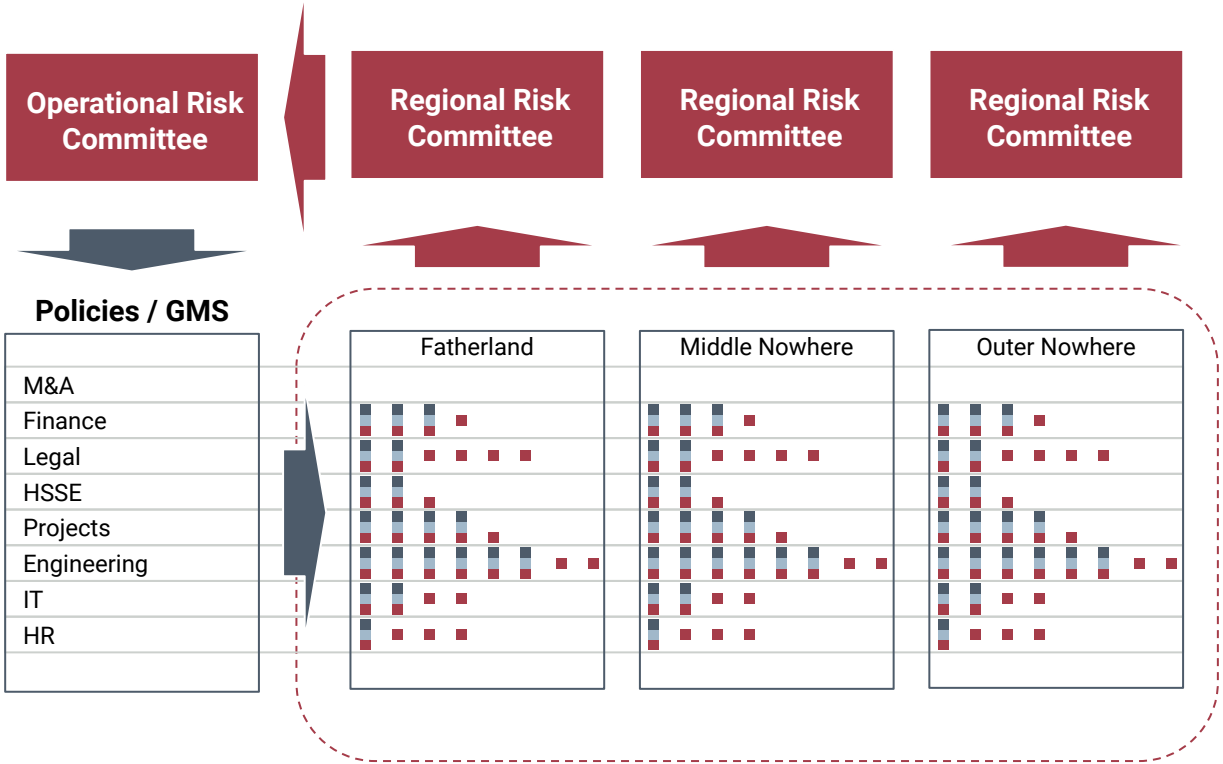
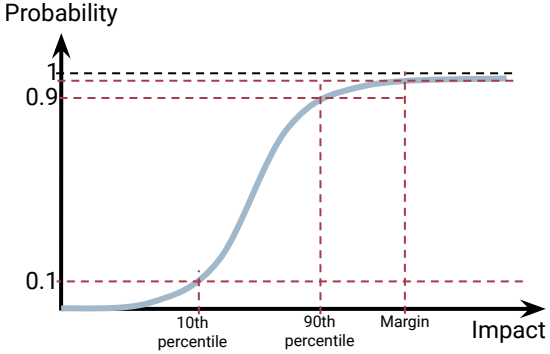
**Options**

- Disciplines provide 3 different scenarios for their major risk categories (costed)



# Toy example: Global operational risk model

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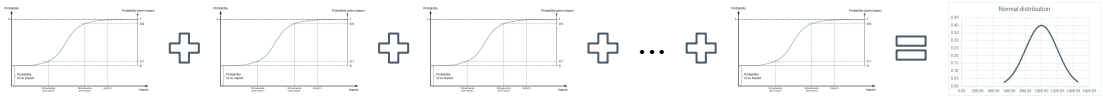
| | | | Risk 1 | Risk 2 | Risk 3 | Risk 4 | Risk 5 | Sum |
|---|---|---|---|---|---|---|---|---|
| **Status quo option (0)** | | Cost | 4,000 | 3,000 | 1,000 | 8,000 | 2,000 | 18,000 |
| | | Frequency | 0.02 | 0.03 | 0.20 | 0.07 | 0.30 | |
| | Impact | Median | 80,000 | 40,000 | 8,000 | 40,000 | 7,000 | |
| | | P90 | 200,000 | 80,000 | 15,000 | 60,000 | 10,000 | |
| | | Mean | 103,299 | 46,300 | 9,023 | 42,053 | 7,276 | |
| | | Std. Dev. | 84,383 | 26,990 | 4,706 | 13,645 | 2,065 | |
| | Contribution | Mean | 2,066 | 1,389 | 1,805 | 2,944 | 2,183 | 10,386 |
| | | Std. dev. | 11,934 | 4,675 | 2,105 | 3,611 | 1,132 | |
| **Low cost option (1)** | | Cost | 3,000 | 2,000 | 500 | 5,000 | 1,000 | 11,500 |
| | | Frequency | 0.04 | 0.03 | 0.30 | 0.15 | 0.50 | |
| | Impact | Median | 80,000 | 40,000 | 12,000 | 40,000 | 7,000 | |
| | | P90 | 200,000 | 120,000 | 15,000 | 80,000 | 10,000 | |
| | | Mean | 103,299 | 57,761 | 12,183 | 46,300 | 7,276 | |
| | | Std. Dev. | 84,383 | 60,173 | 2,138 | 26,990 | 2,065 | |
| | Contribution | Mean | 4,132 | 1,733 | 3,655 | 6,945 | 3,638 | 20,103 |
| | | Std. dev. | 16,877 | 10,422 | 1,172 | 10,454 | 1,461 | |
| **High cost option (2)** | | Cost | 8,000 | 4,000 | 2,500 | 10,000 | 2,800 | 27,300 |
| | | Frequency | 0.01 | 0.03 | 0.10 | 0.02 | 0.10 | |
| | Impact | Median | 80,000 | 40,000 | 4,000 | 40,000 | 7,000 | |
| | | P90 | 200,000 | 60,000 | 15,000 | 50,000 | 10,000 | |
| | | Mean | 103,299 | 42,053 | 6,808 | 40,611 | 7,276 | |
| | | Std. Dev. | 84,383 | 13,645 | 9,378 | 7,125 | 2,065 | |
| | Contribution | Mean | 516 | 1,262 | 681 | 812 | 728 | |
| | | Std. dev. | 5,967 | 2,364 | 2,966 | 1,008 | 654 | |

# Approximate aggregation of additive impacts

## Central limit theorem

- The distribution of enough things added together is approximately Normal




- When you add distributions, the means and variances grow faster than higher order moments (things like skew, kurtosis, etc.)
- Eventually the mean and variance is effectively all that's left (everything else disappears in the convolution wash)
- The distribution goes Normal because the Normal distribution is the distribution with a mean and variance and nothing else.
- To work out the Normal distribution, you need this mean and variance

**This is a very good approximation in the middle of the distribution, but it's rubbish in the tails. Don't use it in the tails. Please**

## Sum of variance

Variance of a sum of variables = Sum of variances + **Sum of covariances**

- We can't ignore the covariance between risks
  - Common causes.
  - Necessity and sufficiency conditions

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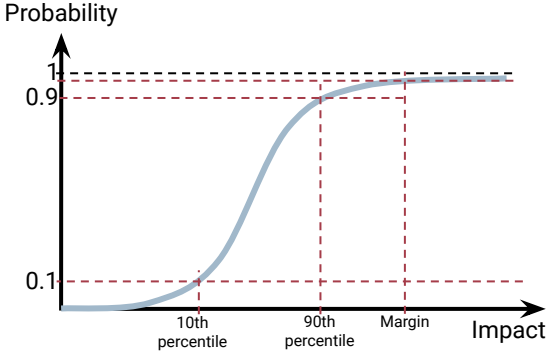


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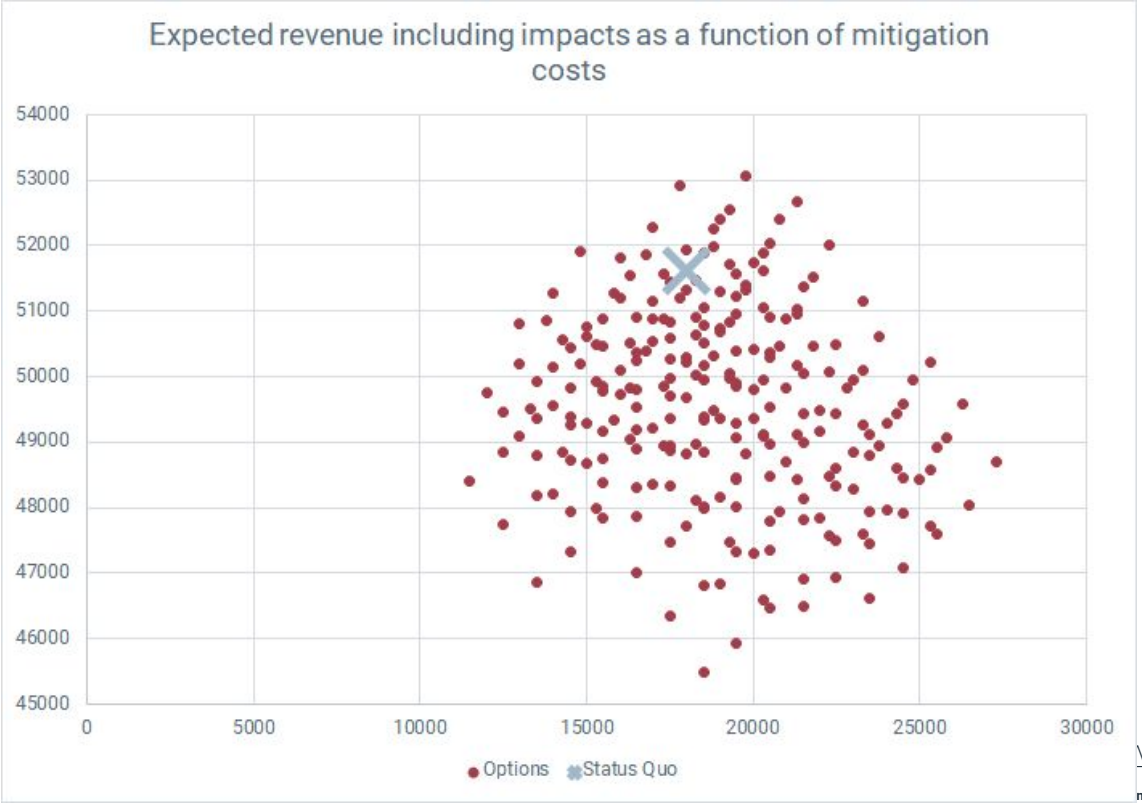

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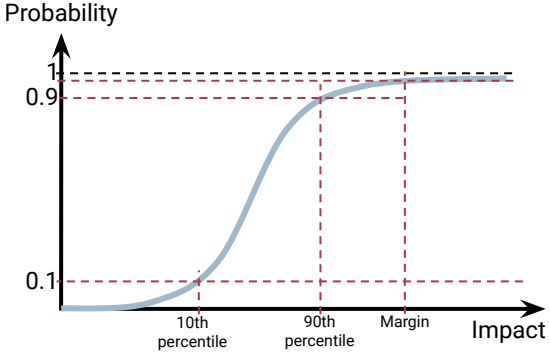


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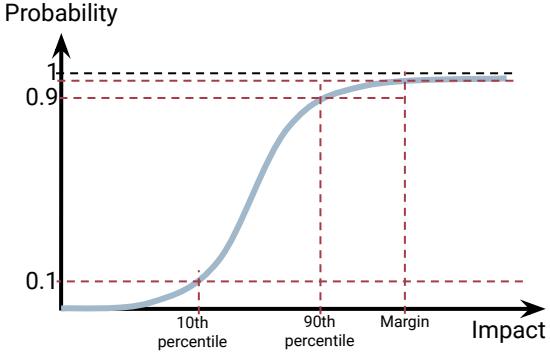


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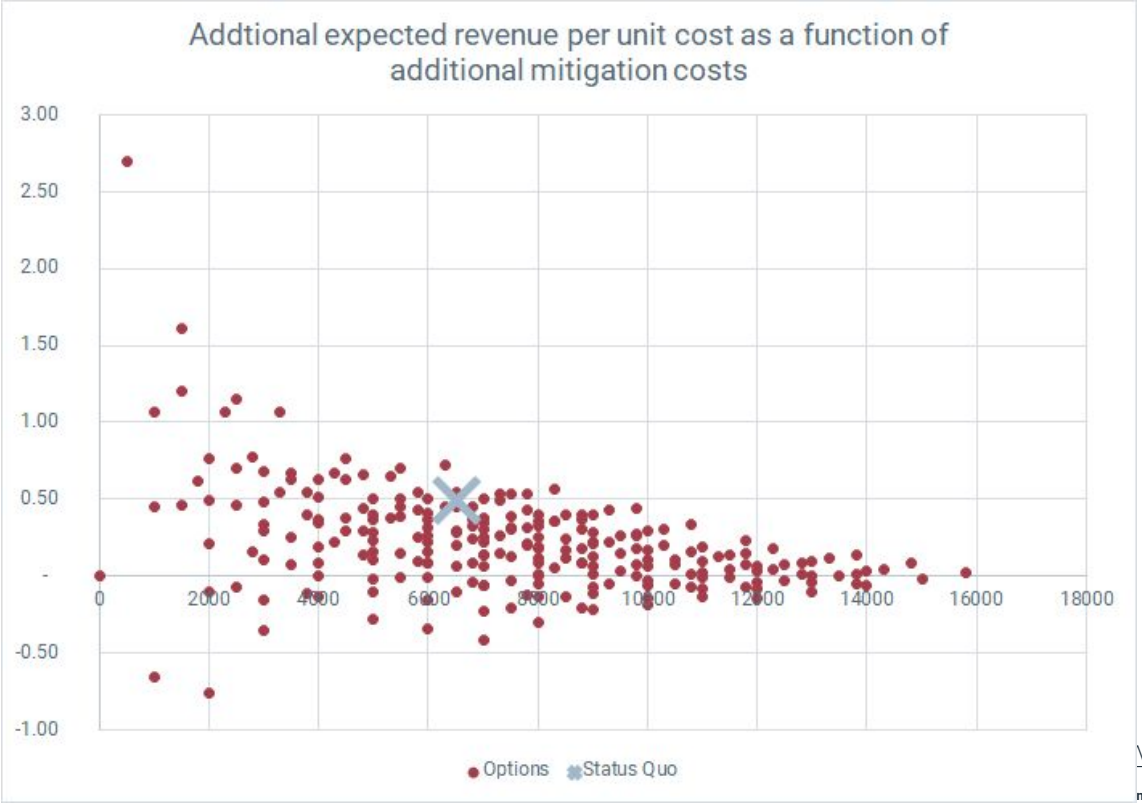

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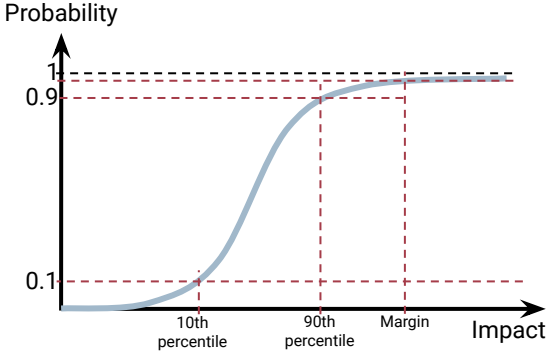


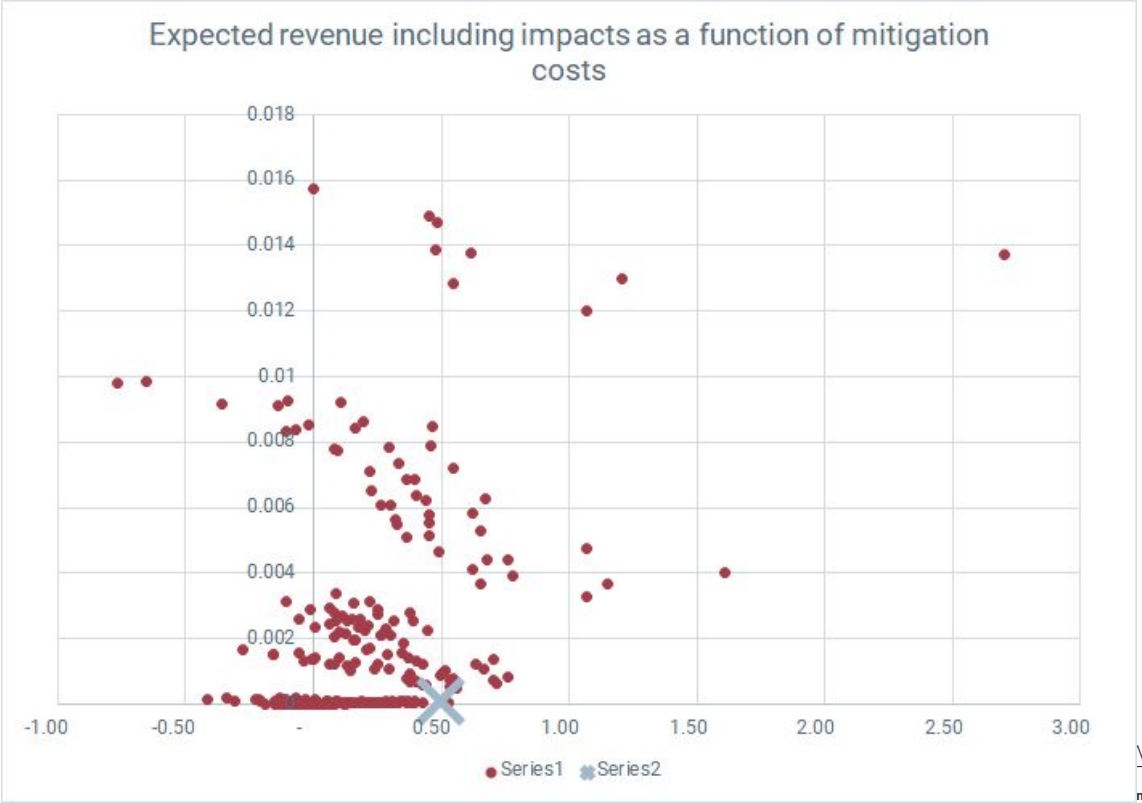


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# Take aways

Decisions and objectives are the poles on which uncertainty models are built

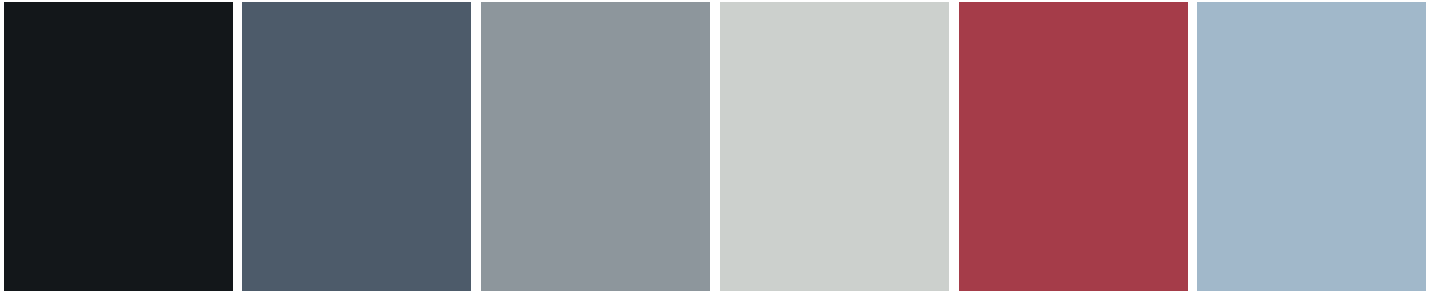
Models should seek to reconcile the granularity of decisions with the scope of objectives

Quantitative Enterprise Risk Management involves several levels of modelling, each with its own decisions and appropriate models

Analytical approximations provide a quick and dirty way to identify favourable portfolios

Models don’t make decisions. They support them

# Colours



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