Origin of risk

Risk – origin of the term…

- The term risk can be traced to several possible origins:
  - Classical Greek, meaning root, stone or cut from firm land.
  - Latin: resicum, riscus.
  - Italian: risico, risco, rischio
  - Spanish: riesgo.
  - French: risque.
- Today, we talk about risk in terms of any deviation from the optimum solution or process, usually described in terms of expected loss.

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Risk – how it began…

From God to measurement in 400 years…

Pre-1494 it's fate!

1494 - Pacioli coin tossing puzzle

1654 – Fermi solves puzzle - probability theory

1711 – Bernoulli law of large numbers

1738 – deMoivre develops normal distribution

1763 – Bayes develops idea of prior beliefs

1800's – theory of expected loss developed

Origin of risk

Risk – bringing it up to date..

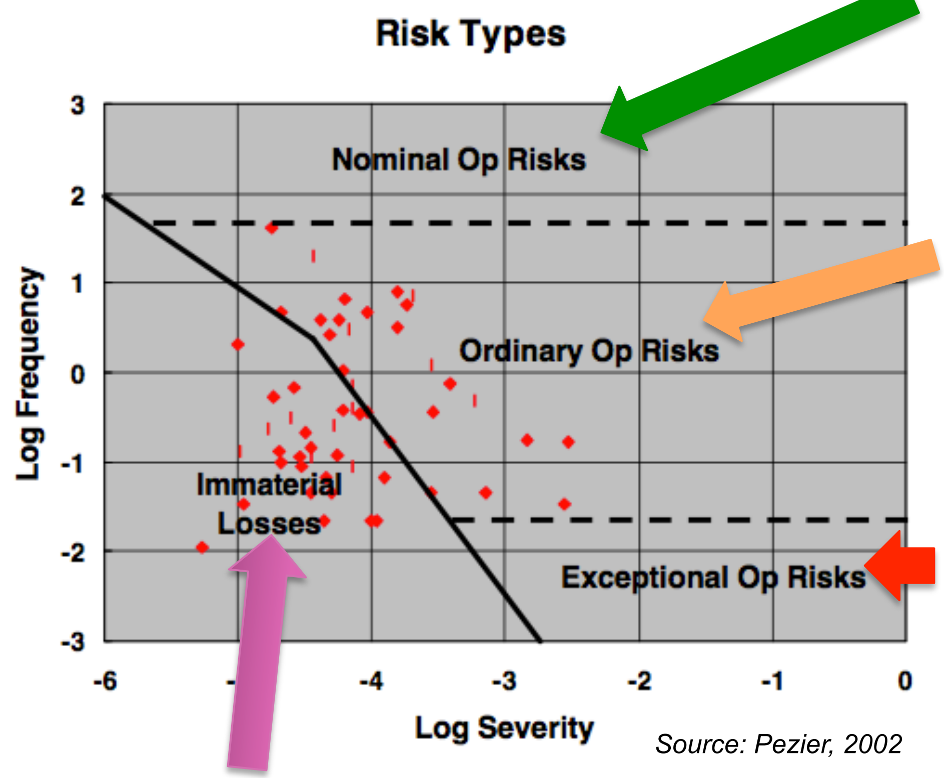
From measurement to precision in only 50 years …

- 1952 – Markowitz develops diversification
- 1964 – Sharp and Lintner develop CAPM
- 1976 – Ross develops no-arbitrage theory
- 1992 – Fama & French develop multi-factor risk
- 1994 – JP Morgan develops Value at Risk (VaR)
- **1998 – BIS adopts VaR as standard**

Loss versus risk

A loss v risk perspective….

- Categorising risks and losses based on degree of severity and frequency of occurrence.
- Confusion concerning probability and frequency of occurrence.



Source: Pezier, 2002

Nominal Op. Risks
Expected losses more important than risks

Ordinary Op. Risks
Both expected risks & expected losses are significant

Exceptional Op. Risks
Risks are much more important than expected losses

Immaterial Losses
Both expected losses and risks are negligible

Risk and uncertainty

Uncertainty

- The unknown-unknowns
- No probabilities

Risk

- The known-unknowns
- Probabilities exist and are assignable
- Likelihood and frequency of occurrence

Models capture dynamic behaviour but contain uncertainties

BUT, are frequency, likelihood and chance the same as probability?

Risk and uncertainty

Risk managers need to understand how uncertainty and complexity can be managed. Model-based scenario analysis is used to identify least attractive outcomes. Creates huge computational requirement.

Dataflow computing is needed to deal with most challenging yet informative modelling situations

	Minimum uncertainty	Maximum uncertainty
Maximum complexity	Deterministic models	**Non-deterministic models/ scenario planning**
Minimum complexity	Point estimates	Confidence ranges

Why use scenario analysis?

Dynamic response to risk

Link actions and choices to outcomes of uncertain events – be better prepared by evaluating sequential and concurrent events.

Value of information

Useful perspective on the value of information in decision making – reduced error rate and avoidance of short-termism.

Risk management

Decide proactively and act on those events that should be guarded against and so avoid double counting or missing of risks.

The scenario analysis process

Identify factors
What are the most important factors that drive the change in value and contribute to the risk. What are the relationships between the factors?

Determine number of scenarios
Convergence, computational cost and time constraints all contribute to determine the acceptable number of scenarios that can be run.

Compute cash flows/event "payoffs"
Select model to compute cash flows that will generate the changes in value associated with the

Assign probabilities
Estimate objective and/or subjective probabilities and/or frequencies of occurrence. Assign probabilities to each scenario.

How will scenario analysis help my portfolio?

Should I invest in the S&P?
If so, how much and when?
If I invest, how should I protect my investment?

Source: Standard & Poor's, First Call, Compustat, FactSet, J.P. Morgan Asset Management.

S&P 500 Index: Valuation Measures				Historical Averages			
Valuation Measure	Description	Latest*	1-year ago	3-year avg.	5-year avg.	10-year avg.	15-year avg.
P/E	Price to Earnings	12.5x	11.8x	12.6x	12.8x	14.2x	16.7x
P/B	Price to Book	2.3	2.1	2.1	2.2	2.5	3.0
P/CF	Price to Cash Flow	8.5	8.1	8.4	8.4	9.7	11.0
P/S	Price to Sales	1.2	1.1	1.2	1.1	1.3	1.5
PEG	Price/Earnings to Growth	1.3	1.2	0.9	1.7	1.5	1.5
Div. Yield	Dividend Yield	2.4%	2.3%	2.2%	2.3%	2.1%	1.9%

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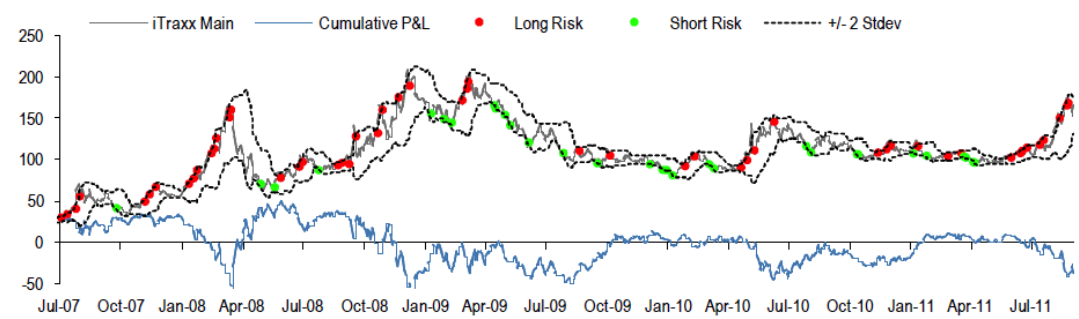
The need for factor coverage

Global events

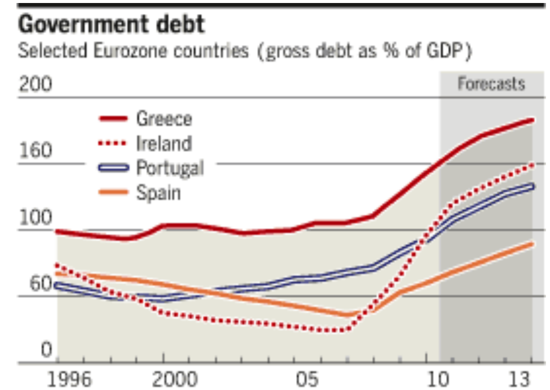
Tsunamis and hurricanes

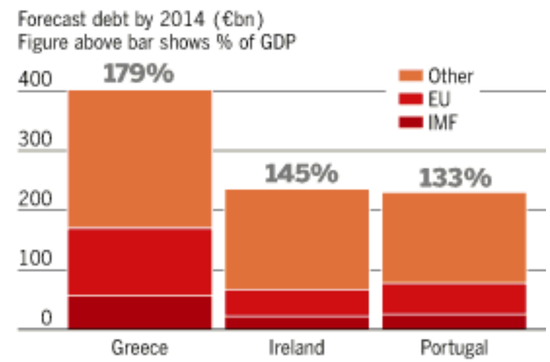
Macro economic factors

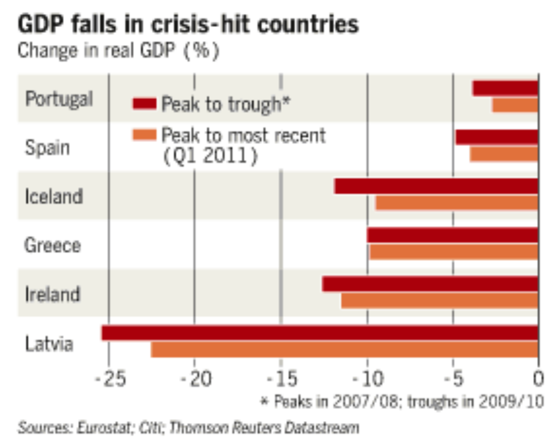
Rules based algorithmic trading strategies for credit markets



Source: J.P. Morgan.







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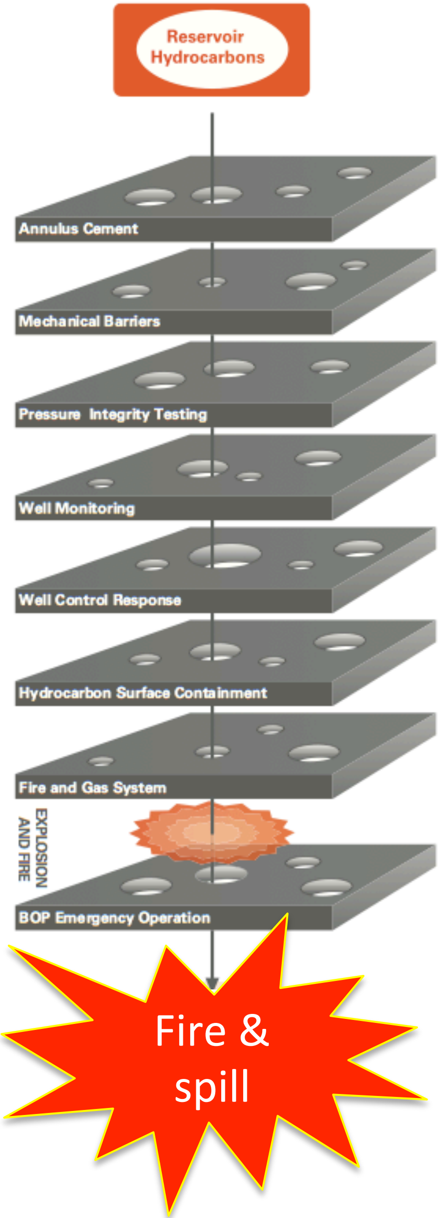
Other problems: Deepwater Horizon



- No mechanism for control of riser or BOP at surface ➔ 5,000 ft of pipe in sea and 13,000 ft in the well.
- All 18,00 ft contained combustible fluids when disaster struck.
- Loss of power ➔ loss of dynamic positioning of vessel ➔ disaster.
- Disconnect from riser too slow and BOP failed.
- Blind sheer ram (part of BOP) failed to cut riser, failed to close top of the well, failed to seal pipe.

A simple example of a start-up

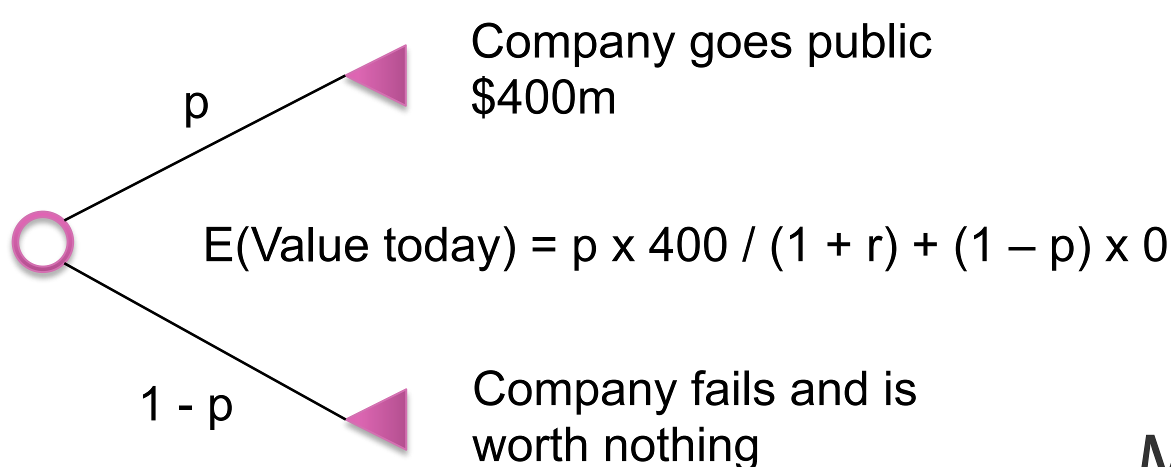
Venture capitalists value start-ups based on exit value using projected earnings and a multiple in the future, then discount the exit value at a target rate.

So, valuing an early-stage firm that is currently losing money, but expected to make profits of, say, \$10m in 5 years time – at which point the earnings multiple (EM) will be ~40x.

VC's often use a very high target discount rate – say 35%, which would value the firm as follows:

Value of firm in 5 years = Earnings in year 5 x EM = 10 x 40 = \$400m

Value of firm today = \$400m / $(1 + 0.35)^5$ = \$89.2m



Loss v risk

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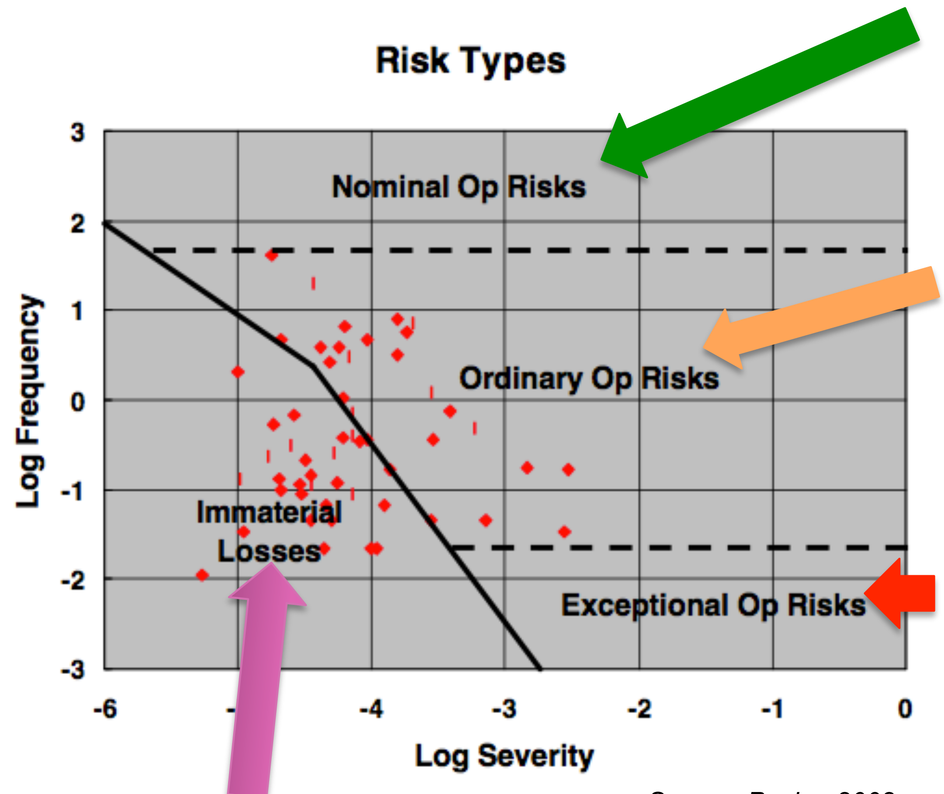

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What are the commonalities?

- High dimensionality:
  - Many causative factors.
  - Factor interdependence.
- Factor ordering is critical:
  - Can't simply run arbitrary combinations of factors.
  - Permutative approach required to span event space – e.g. order of defaults, process failures.
- Need to run large number of scenarios to achieve stable and robust results.
- Very short time available to run computations

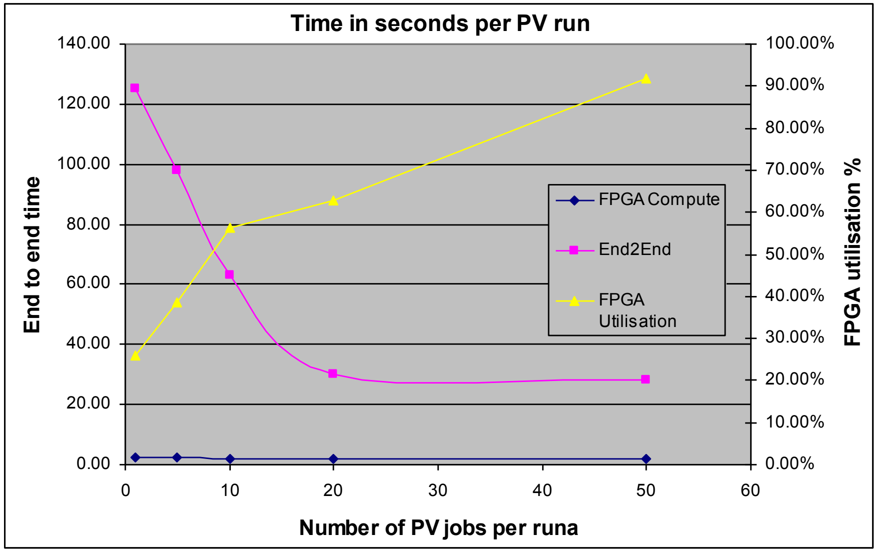
Trading risk

Credit derivatives risk at JP Morgan – 125x faster

American Finance in T

(Runs ~125x end-to-end in production for intraday risk and valuation application)

- PV runs reduced to under 3 seconds/run when running batches of 100 runs.
- Risk runs reduced to under 4 minutes from 8 hours.
- Previously impossible permutative and combinatoric scenarios, run in seconds.
- Run hundreds of thousands of scenarios in the trading day.
- Enabled optimisation of hedging and capital usage.



Number of Scenarios	DFE compute	End2End	FPGA Utilisation
1	2.57	125.21	25.99%
5	2.35	98.02	38.54%
10	2.06	66.68	56.24%
20	1.86	30.88	62.63%
50	1.80	28.27	91.97%

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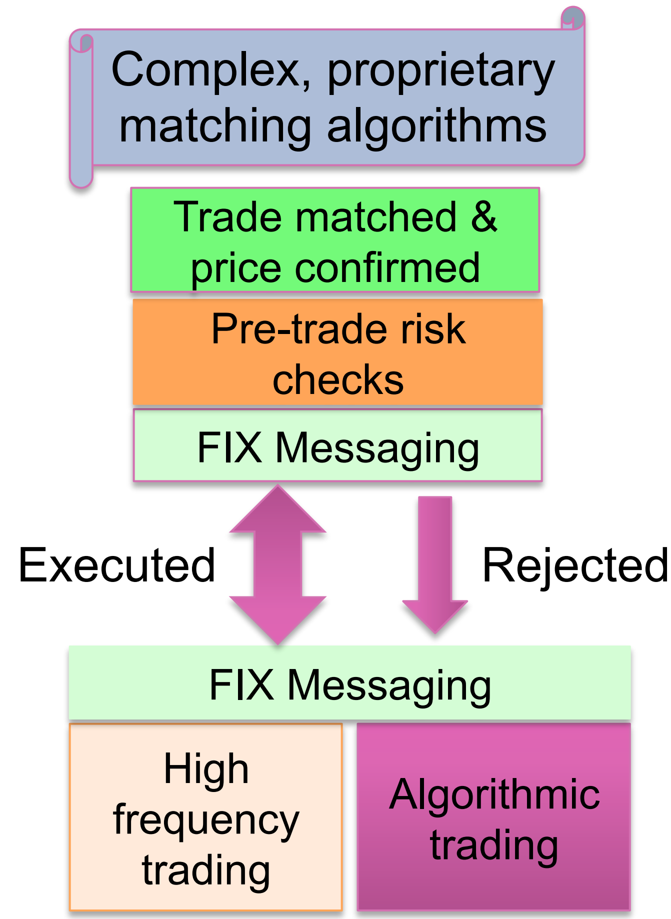
Exchange risk

- Continuous trading using a real-time auction mechanism.
- Real-time price dissemination, order matching and trading.
- A fully integrated front-to-back solution for matching, clearing, pre-trade credit checks and post-trade risk management.
- Solution now handles hundreds of thousands of orders per second - scalable to millions of orders per second.



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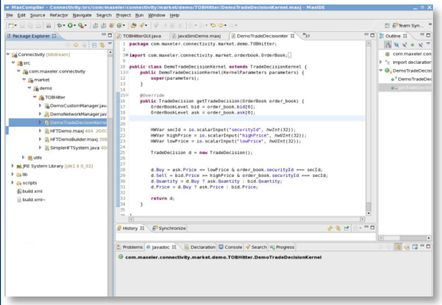
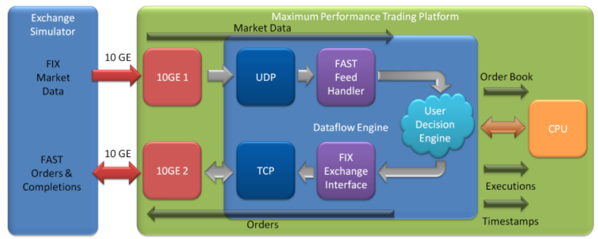
Scenario Analysis

Low latency

High-frequency trading and risk management at major hedge fund





MaxCompilerMPT

- Integrated hardware and software programming
- Dataflow Technology for simple development
- Simulated DFEs for fast delivery

Exchange Interfaces

- Optimized industry-standard connectivity
- User configurable functionality and formats

MPT-10G Trading Platform

- Multiple 10GE connected hardware DFEs
- Datacenter-ready with simple deployment
- Precision timing support (internal and external)

Trading strategies developed, evaluated and deployed rapidly

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Commonality of risk

- Reservoir simulation:
  - Modelling the geology
  - Flow modelling
- Financial modelling
  - Macro-economic
  - Micro-economic - pricing
- Dataflow based simulation scales across problems:

Dataflow can be used to accelerate Mallinson's work to increase the number of simulations within target timescale. Already developed Monte Carlo framework

Black-Scholes VaR

Portfolio type	1,000 options
Analytic model	Black Scholes
Num. Scenarios	10,000,000
Clock Time	11.43 secs
Speedup DFE v CPU	33x

Multiple factors, multiple MC paths; consistent speedup

Bermudan Swaptions

Portfolio type	100,000 swaptions
Analytic model	3-factor LMM
Num. Scenarios	30,000 paths
Clock Time	15.01 secs
Speedup DFE v CPU	30x

Above comparisons are between a Maxeler 1U-node MPC-X Dataflow Engine against a 1U-node Intel Sandybridge EP CPU compiled with AVX and OpenMP

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When order matters…

- Many risk managers run scenarios in an attempt to reduce uncertainty.
- Most scenario analysis is ad hoc:
  - Application of arbitrary shifts to perceived “key” variables – simple combinatoric approach.
  - Most scenario analysis is designed to find assumed “worst case” outcomes – minimax/ maximin.
- But, by using permutation driven scenario analysis, it is possible to span the even space and identify interesting and/or critical cases that may have been missed.

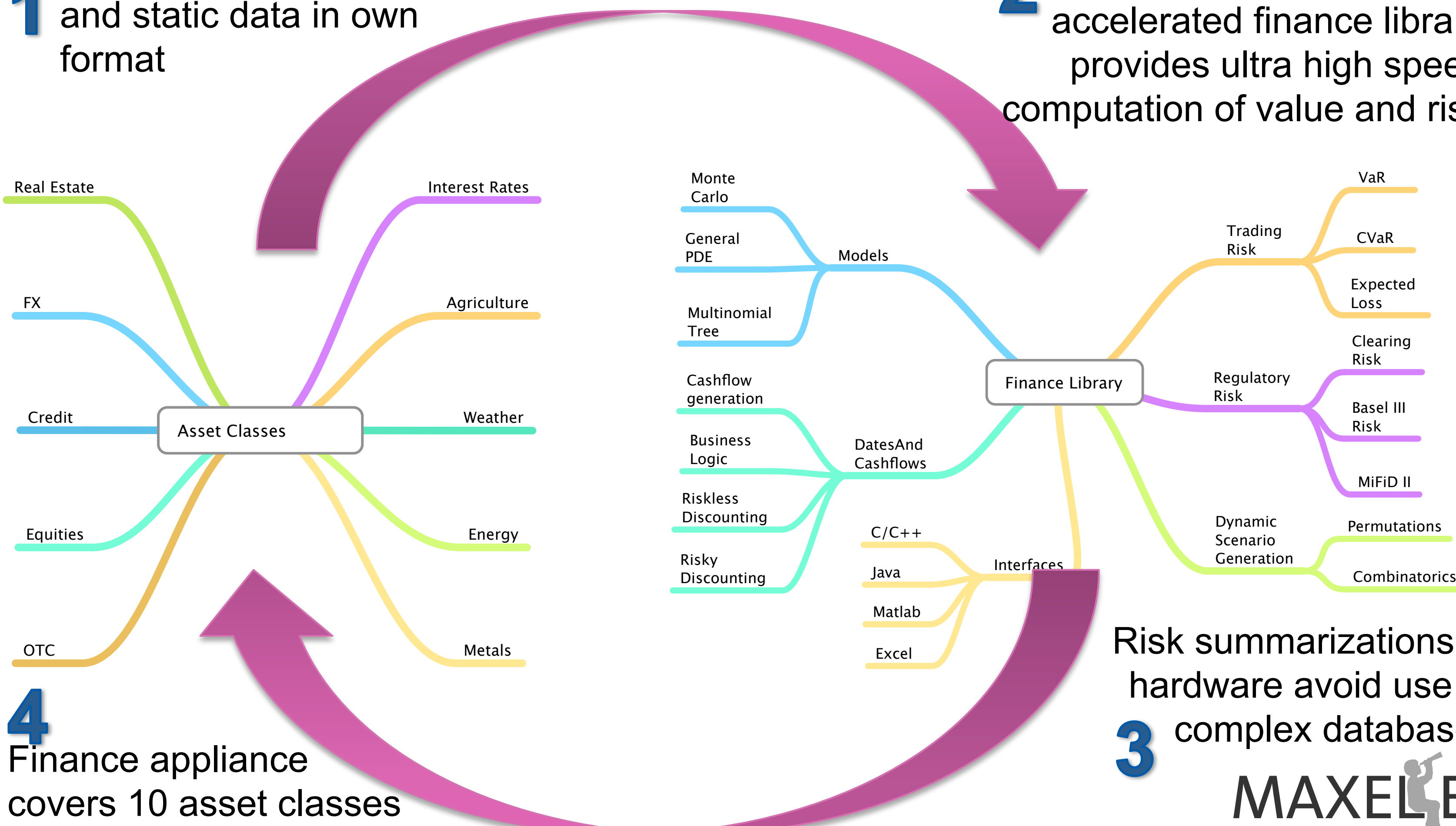
Uncertainty to risk via scenarios

Maxeler’s risk solutions…

Consistent, real-time, valuation and risk management calculations across all major asset classes

1 Client provides trade, market and static data in own format

2 Maxeler’s dataflow accelerated finance library provides ultra high speed computation of value and risk



3 Risk summarizations in hardware avoid use of complex databases

4 Finance appliance covers 10 asset classes

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Maxeler University Program Members

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- Stanford University
- Universität Hamburg — Der Forschung | Der Lehre | Der Bildung
- FAU Friedrich-Alexander Universität Erlangen-Nürnberg
- Max-Planck-Gesellschaft
- Manchester Metropolitan University
- Nanyang Technological University
- Universität Paderborn
- 香港中文大學 The Chinese University of Hong Kong
- Universidade de Lisboa
- KIT Karlsruhe Institute of Technology
- Politecnico di Milano
- The University of Tokyo
- Nagasaki University 長崎大学
- Heriot Watt University
- Berkeley University of California
- 復旦大學 Fudan University
- Goethe Universität Frankfurt am Main
- University of Windsor — thinking forward
- Chalmers
- University of Kragujevac
- Technion Israel Institute of Technology
- NUS National University of Singapore
- University of Oxford
- LMU Ludwig-Maximilians-Universität München
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- Technische Universität Kaiserslautern
- 東北大学 Tohoku University
- UIC University of Illinois at Chicago
- JAIST Japan Advanced Institute of Science and Technology 1990
- Ss. Cyril & Methodius University of Skopje, Macedonia
- UBC
- Technical University of Crete
- 清華大學 Tsinghua University
- The University of Manchester — Manchester Business School
- UiO University of Oslo
- Imperial College London
- The University of Hong Kong
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- UBC
- TU Delft Delft University of Technology
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