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.
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
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.

- **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

Source: Pezier, 2002
Risk and uncertainty

Uncertainty
- The unknown-unknowns
- No probabilities

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

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

Models capture dynamic behaviour but contain uncertainties.
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.

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<tr>
<th>Maximum uncertainty</th>
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<td>Point estimates</td>
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<td>Non-deterministic models/scenario planning</td>
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Note: The table structure is used to organize the information into categories of maximum and minimum uncertainty, complexity, and models.
Why use scenario analysis?

1. **Dynamic response to risk**
   Link actions and choices to outcomes of uncertain events – be better prepared by evaluating sequential and concurrent events.

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

3. **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

1. **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?

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

3. **Compute cash flows/event “payoffs”**
   Select model to compute cash flows that will generate the changes in value associated with the

4. **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?
The need for factor coverage

Macro economic factors

Global events

Tsunamis and hurricanes

Rules based algorithmic trading strategies for credit markets
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

![Diagram](chart.png)

- **Company goes public** $400m
- **E(Value today) = p x 400 / (1 + r) + (1 – p) x 0**
- **Company fails and is worth nothing**

$400m

$p$

$1 - p$
Categorising risks and losses based on degree of severity and frequency of occurrence. Confusion concerning probability and frequency of occurrence.

- **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.

Source: Pezier, 2002
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.

### Time in seconds per PV run

<table>
<thead>
<tr>
<th>Number of Scenarios</th>
<th>DFE compute</th>
<th>End2End</th>
<th>FPGA Utilisation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.57</td>
<td>125.21</td>
<td>25.99%</td>
</tr>
<tr>
<td>5</td>
<td>2.35</td>
<td>98.02</td>
<td>38.54%</td>
</tr>
<tr>
<td>10</td>
<td>2.06</td>
<td>66.68</td>
<td>56.24%</td>
</tr>
<tr>
<td>20</td>
<td>1.86</td>
<td>30.88</td>
<td>62.63%</td>
</tr>
<tr>
<td>50</td>
<td>1.80</td>
<td>28.27</td>
<td>91.97%</td>
</tr>
</tbody>
</table>
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.
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

Profit, Loss & Trading Risk
Commonality of risk

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

<table>
<thead>
<tr>
<th>Black-Scholes VaR</th>
<th>Bermudan Swaptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio type</td>
<td>1,000 options</td>
</tr>
<tr>
<td>Analytic model</td>
<td>Black Scholes</td>
</tr>
<tr>
<td>Num. Scenarios</td>
<td>10,000,000</td>
</tr>
<tr>
<td>Clock Time</td>
<td>11.43 secs</td>
</tr>
<tr>
<td>Speedup DFE v CPU</td>
<td>33x</td>
</tr>
<tr>
<td>Portfolio type</td>
<td>100,000 swaptions</td>
</tr>
<tr>
<td>Analytic model</td>
<td>3-factor LMM</td>
</tr>
<tr>
<td>Num. Scenarios</td>
<td>30,000 paths</td>
</tr>
<tr>
<td>Clock Time</td>
<td>15.01 secs</td>
</tr>
<tr>
<td>Speedup DFE v CPU</td>
<td>30x</td>
</tr>
</tbody>
</table>

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

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

Uncertainty to risk via scenarios

Asset Classes
- Real Estate
- Agriculture
- Energy
- Metals
- OTC
- FX
- Credit
- Equities
- Weather

Finance Library
- Monte Carlo
- General PDE
- Multinomial Tree
- Cashflow generation
- Riskless Discounting
- Business Logic
- Risky Discounting
- DatesAnd Cashflows
- C/C++
- Java
- Matlab
- Excel

Finance appliance covers 10 asset classes

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Maxeler University Program Members