

Cambridge JBS Seminar
11th March, 2010

The Policy Maker's Tale

Stress testing policy and strategy proposals for extreme events – hope for the best, plan for the worst

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www.stat.unc.edu/faculty/rsmith.html

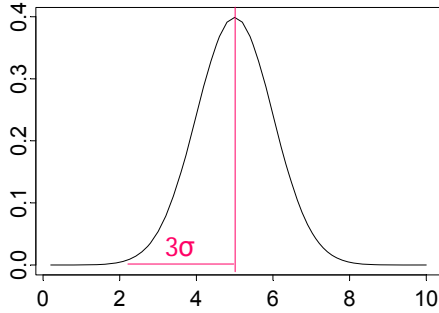
www.math.ethz.ch/~embrechts/

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THE TAIL

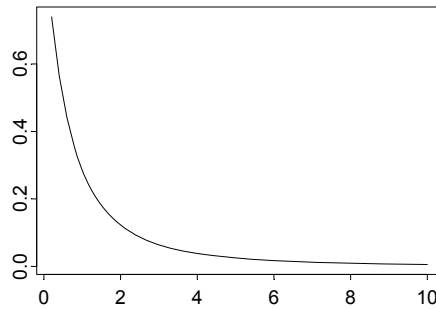
Gaussian

Mean of 5, standard deviation 1



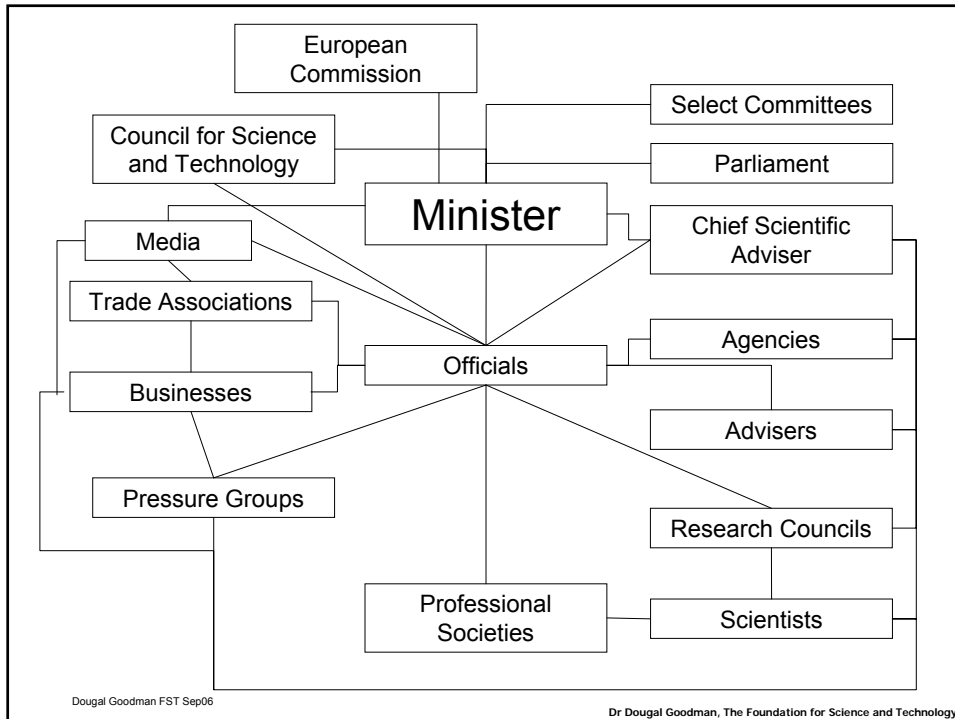
Generalised Pareto

Shape parameter is 0.6, beta is 1

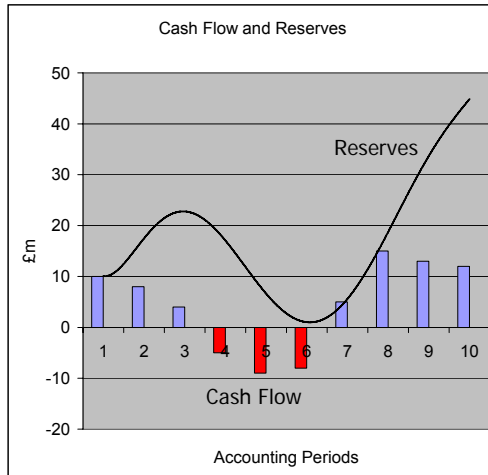


Break out of thinking that all distributions are normal distributions.

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Risk of ruin



Boards should manage businesses to protect the company from a deep downside rather than the most likely outcome.

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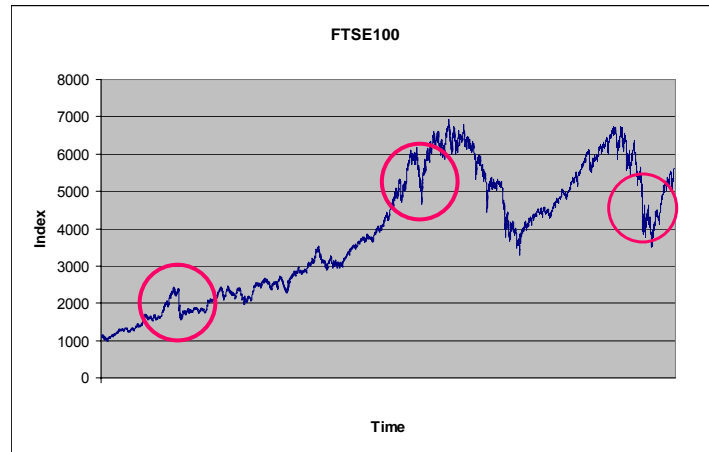
Deep downsides – only some can be quantified

- Sudden product price or margin fall
- Customers do not pay for goods or services
- Liability claim
- Loss of trust of employees
- Outrage of the public
- Projects fail to complete on time and within budget
- Business interruption from natural catastrophes
- Fire or explosion at a facility
- Fraud, accounting or trading failure
- Collapse of a supplier
- Regulatory or tax step change
- and so on...

Risk level controlled by elimination, management or transfer

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FTSE 100 – Steady growth or decline with occasional abrupt falls – extreme events



2 April 1984 to present

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New Orleans

Orleans East Bank - 17th Street Outfall Canal



In the tail extra correlations appear

From Dr Scott Steedman

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"AIG unravelled as the worst housing crisis since the Great Depression led to more than \$18 billion of losses in the past year.

A meltdown could have cost the financial industry \$180 billion, according to RBC Capital Markets, because AIG provided insurance on more than \$441 billion of fixed-income investments held by the world's biggest institutions, including \$57.8 billion in securities tied to sub prime mortgages."

Bloomberg – 16th September, 2008

Compare to insured losses for Katrina of \$60 billion

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It pays to be a historian?

- Savings and Loans crisis of the 1980s
- 1987 stock market crash
- 1998 US government steps in to save LTCM
- 9/11
- Katrina floods New Orleans - \$60 billion insurance loss
- 2008/2009 Financial Crisis
- etc

Extreme events do happen

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The robustness of policy and strategic choices should be tested for plausible extreme events

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There are known knowns. These are things we know that we know.

There are known unknowns. That is to say, there are things that we know we don't know.

But there are also unknown unknowns. There are things we don't know we don't know.

Donald Rumsfeld

Change will not come if we wait for some other person or some other time. We are the ones we've been waiting for. We are the change that we seek.

Barack Obama

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Stress testing of policy choices – the toolkit

- Scenario testing
- Realistic disaster scenarios
- Analysis of history
- Simulation
- Conversations – what ifs
- An effective challenge process

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Multiple Dimensions

- Loss of labour
 - Influenza pandemic
- Loss of communications
 - Stock exchange denial of service
- Loss of facilities
 - 2007 Floods
- Loss of liquidity or capital
 - Credit crunch
- Loss of trust
 - Northern Rock
- Breakdown of governance
 - Baring Brothers
- Loss of supplies or rapidly rising supply costs
 - Oil price rises
- Loss of customers
 - Exxon post Exxon Valdez

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Paint a picture of the context

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Role of the regulators



Annual report by FSA to
help businesses think
about risks

UK Financial Services Authority Financial Risk Outlook 2007

1 Firms must be prepared to respond to
extreme risk scenarios – influenza
pandemic, climate change as examples

2 Terrorism

3 Illiquid financial instruments

4 Trade confirmations for derivative trades

5 Financial crime

6 International regulatory reform

7 High levels of personal borrowing

8 Consumer understanding of risks

9 Fair treatment of customers

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FSA Priority Risks – January 2007

- Existing business models of some financial institutions are under strain as a result of adverse market conditions.
- Increased financial pressures may lead to financial firms shifting their efforts away from focusing on conduct-of-business requirements and from maintaining and strengthening business-as-usual processes.
- Market participants and consumers may lose confidence in financial institutions and in the authorities' ability to safeguard the financial system.
- A significant minority of consumers could experience financial problems because of their high levels of borrowing.
- Tighter economic conditions could increase the incidence or discovery of some types of financial crime or lead to firms' resources being diverted away from tackling financial crime.

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FSA Financial Risk Outlook 2008 – published in January

Consensus forecasts, on which our *Central economic scenario* is based, indicate a less benign economic outlook for the UK and global economies than we have experienced in recent years.

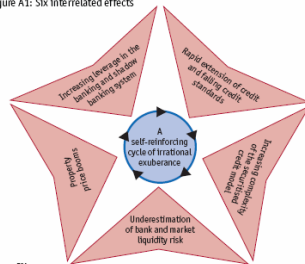
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FSA Outlook 2009

- 1 Increased leverage in the banking and shadow banking system
- 2 Property price booms
- 3 Rapid extension of credit and falling credit standards
- 4 Increasing complexity of the securities credit model
- 5 Underestimation of bank and market liquidity risk

Figure A1: Six interrelated effects



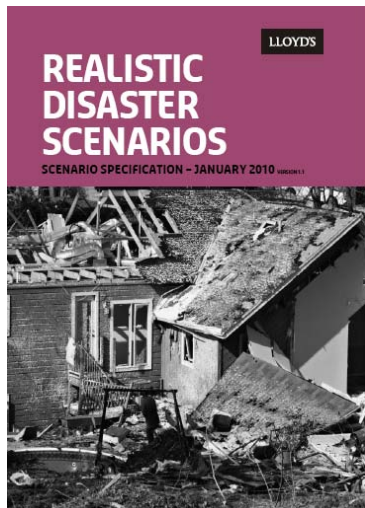
Source: FSA

“A self-reinforcing cycle of exuberance”

New processes required for the better management of risk

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Lloyd's Market Process



Lloyd's Realistic Disaster Scenarios

- 1 Two events – North East US hurricane and a Carolinas windstorm event
- 2 Florida windstorm
- 3 Gulf of Mexico windstorm
- 4 European windstorm
- 5 Japanese windstorm
- 6 California earthquake
- 7 New Madrid earthquake
- 8 Japanese earthquake
- 9 UK flood
- 10 Terrorist event
- 11 Marine
- 12 Loss of major complex
- 13 Aviation loss
- 14 Satellite risk
- 15 Liability exposure
- 16 Political risk

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Plate 1: Flash flooding – Abingdon, July 2007



Plate 2: Surface runoff – South Croxton, Leicestershire, July 2007



Plate 3: Red Brook – Shrewsbury, July 2007



Plate 4: River Severn – Tewkesbury, July 2007

The threat to electricity and waste water treatment infrastructure was very high.

There could have been widespread business disruption.

The summer 2007 floods in England & Wales – a hydrological appraisal, Terry Marsh and Jamie Hannaford, CEH and BGS, 2007

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Whitehall Risk Review

"The handling of risks to the public has become more challenging in recent years, as information sources multiply and public expectations change" (*Risk; improving Government's capability to handle risk and uncertainty. Cabinet Office Strategy Unit*)

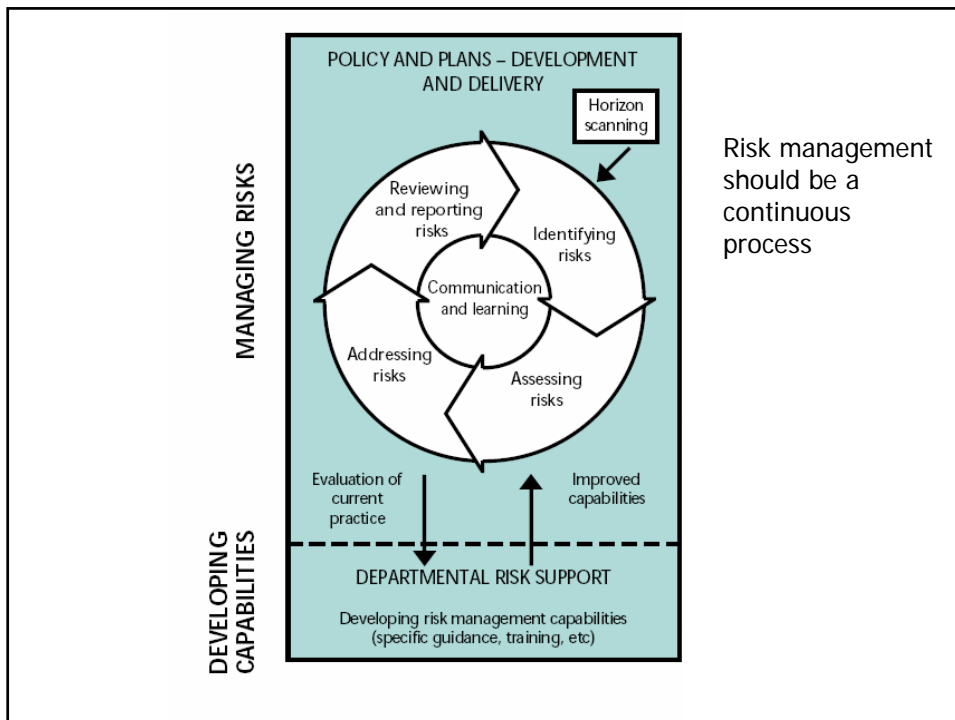
A crisis is like a tidal wave. Everything you have been used to at work is turned upside down, control has been lost, and the world - particularly the media - is screaming at you. This is what happens when policy risks become live issues - when they turn into crisis - and you are caught unawares.

It doesn't have to be this way. Risk can generally be identified, planned for, and dealt with effectively if it does turn to crisis.

Guidance for businesses and departments at

www.ukresilience.gov.uk

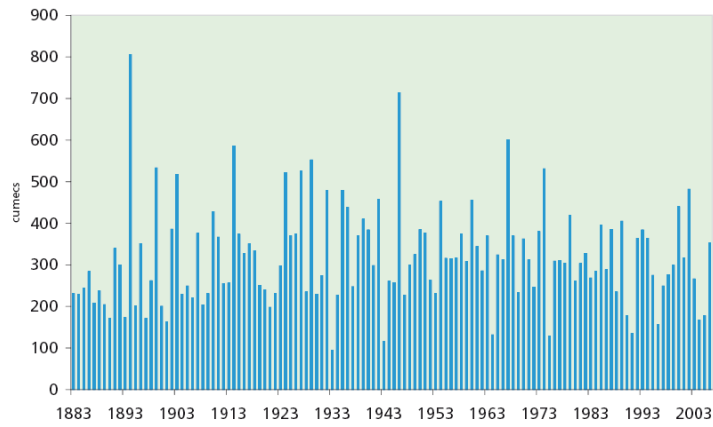
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Examine the history both qualitatively and quantitatively

Changing land use, asset values
and river defences change the risk
over time

Maximum flows for the River Thames



The summer 2007 floods in England & Wales – a hydrological appraisal, Terry Marsh and Jamie Hannaford, CEH and BGS, 2007

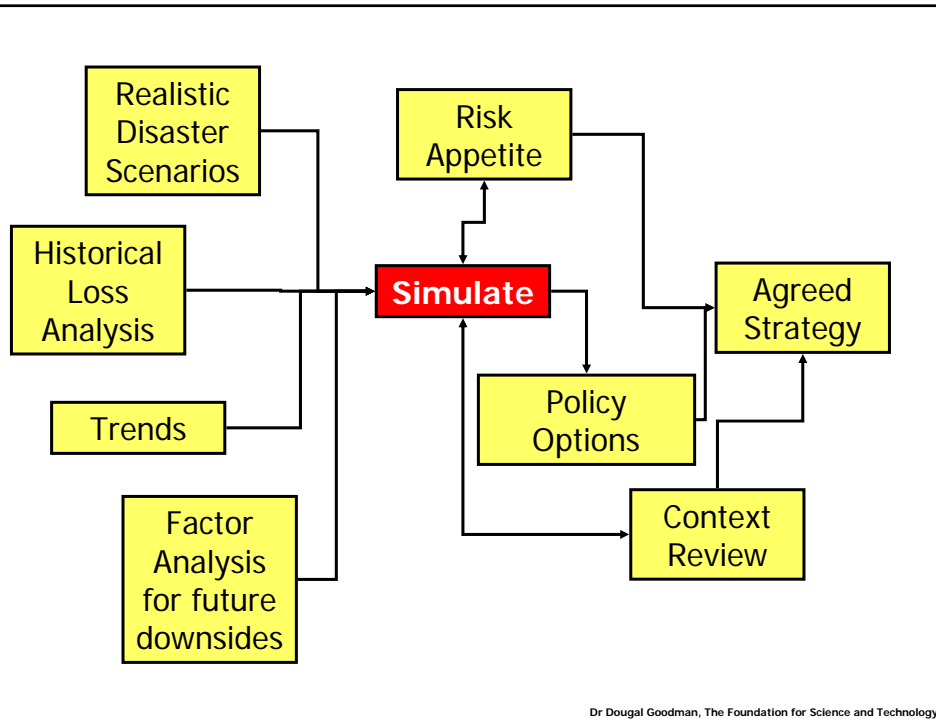
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Build a model and
stress test

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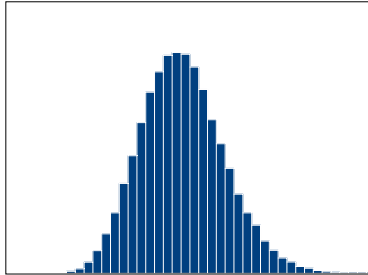


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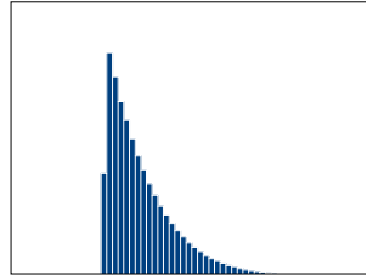


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Analysis Scheme



Poisson Process – mean time between events

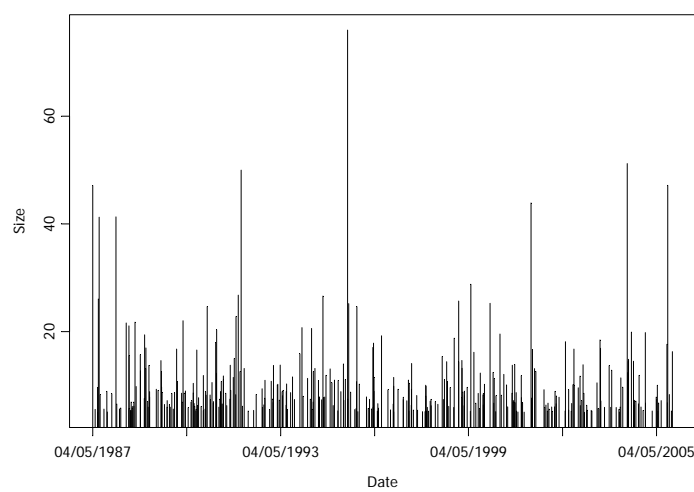


How big is an event once it occurs? - GPD

Detrend the data before estimating distribution parameters

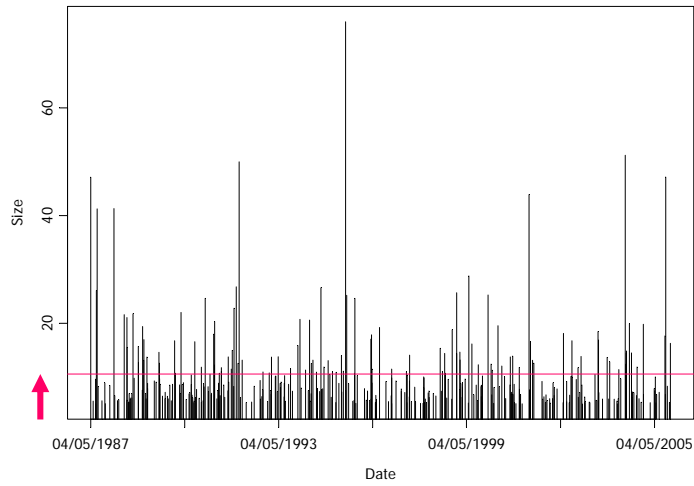
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Typical time series



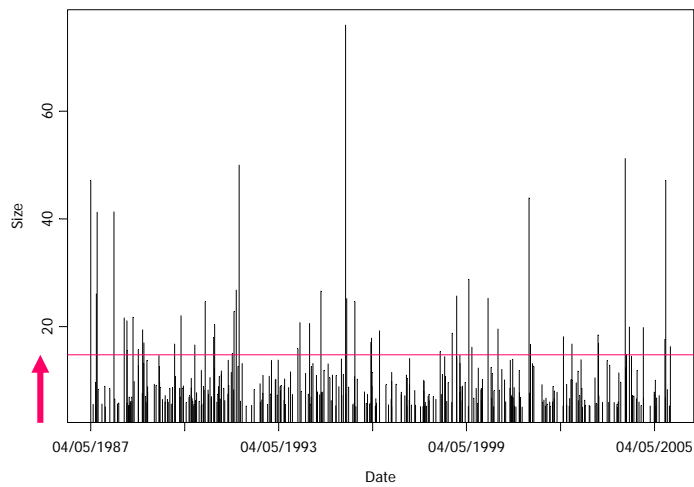
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Typical time series



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Typical time series



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Generalised Extreme Value Distribution

Only three types of extreme value limit laws for set of identically distributed random variables

$$\begin{aligned} \text{Type I:} \quad & \Lambda(x) = \exp(-e^{-x}), \quad -\infty < x < \infty, \\ \text{Type II:} \quad & \Phi_\alpha(x) = \begin{cases} 0, & x \leq 0, \\ \exp(-x^{-\alpha}), & x > 0, \end{cases} \\ \text{Type III:} \quad & \Psi_\alpha(x) = \begin{cases} \exp\{-(-x)^\alpha\}, & x \leq 0, \\ 1, & x > 0. \end{cases} \end{aligned}$$

In Types II and III, α is a positive parameter. The three types may also be combined into a single *generalised extreme value* distribution, first proposed by von Mises (1936), of form

$$G(x) = \exp \left\{ - \left(1 + \xi \frac{x - \mu}{\psi} \right)_+^{-1/\xi} \right\}, \quad (2.2)$$

where $y_+ = \max(y, 0)$, $\sigma > 0$ and μ and ξ are arbitrary real parameters. The case $\xi > 0$ corresponds to Type II with $\alpha = 1/\xi$, $\xi < 0$ to Type III with $\alpha = -1/\xi$, and the limit $\xi \rightarrow 0$ to Type I.

From Richard L Smith, UNC

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Generalised Pareto Distribution

Distribution of excess values (z)

$$F_u(y) = \Pr\{X \leq u + y \mid X > u\} = \frac{F(u + y) - F(u)}{1 - F(u)}, \quad y > 0. \quad (2.3)$$

By analogy with classical EVT, there is a theory about the asymptotic form of $F_u(y)$, first given by Pickands (1975). According to this, if the underlying distribution function F is such that a classical extreme value distribution (2.1) exists, then there are constants $c_u > 0$ such that as $u \rightarrow \omega_F$ ⁴

$$F_u(c_u z) \rightarrow H(z), \quad (2.4)$$

where

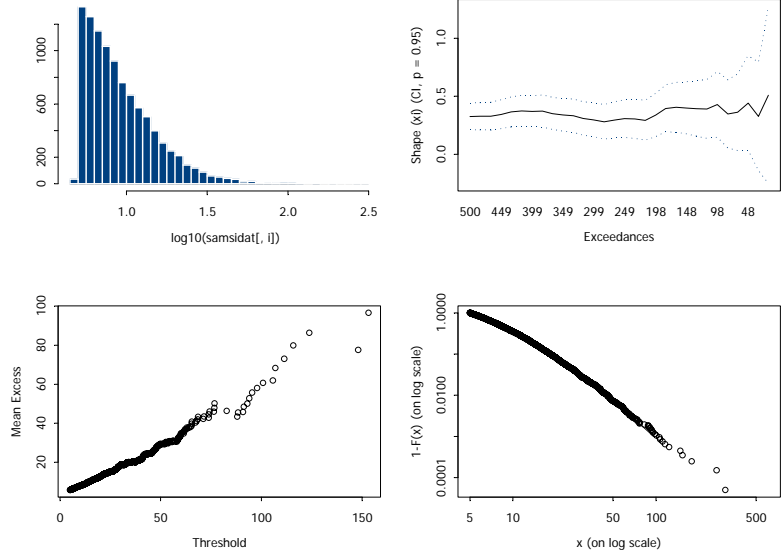
$$H(z) = \begin{cases} 1 - \left(1 + \frac{\xi z}{\sigma} \right)_+^{-1/\xi}, & \xi \neq 0, \\ 1 - e^{-z/\sigma}, & \xi = 0, \end{cases} \quad (2.5)$$

where $\sigma > 0$ and $-\infty < \xi < \infty$. This is known as the *generalised Pareto distribution* (GPD).

From Richard L Smith, UNC

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Fit a GPD above a threshold



Using Alex McNeil's S-Plus routines

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Set out the policy options and the downside risks of each option

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What are the top ten extreme events that could bring UK industry to its knees?

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What are the top ten extreme events that could bring UK industry to its knees?

- 1 Energy shortages
- 2 Influenza pandemic
- 3 Freight transport disruption
- 4 Banking crisis – loans dry up, normal banking suspended
- 5 Return of very high oil and gas prices
- 6 Terrorist attack on critical infrastructure
- 7 Mass departure of Eastern European workers
- 8 Failure of a major UK company
- 9 Major public transport disruption
- 10 Persistent cyber attacks on companies

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Summary

- Simulations help to communicate a range of outcomes
- Realistic Disaster Scenarios add to historical data to include events that could occur but have not been observed
- Stress testing with plausible scenarios tests the boundaries of the analysis
- Analysis can only go so far – decisions are often based on a combination of analysis and very nebulous information and context
- Plan for deep downsides

**Chaucer told tales..
Use stories to promote debate about downsides**

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