



Institute
and Faculty
of Actuaries

The leading edge of risk research: projects and progress at the University of Cambridge

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Outline

- A tale of two centres
- Risk and uncertainty
- System shock and emerging risks

University of Cambridge Centre for Risk Studies



Complex systems and systemic shocks

- Emerging risks and threat assessment for corporate risk management
- Resiliency in International Supply Chains (RSIC)
- Financial crises and systemic risk in banking (FinCat)

Cambridge Centre for Risk Studies

The Centre for Risk Studies is a multidisciplinary centre of excellence for the study of societal and economic risks. The Centre focuses on impact-oriented research relating to the analysis, assessment, and mitigation of global risks. Emphasis on relevancy to industry and government is an overarching perspective of the Centre's activities and engagements.

Research Supporters



Cambridge Risk Framework is an approach and toolkit for researching systemic shocks

Annual **Risk Summit** Conference brings together practitioners and academics from many industries and disciplines



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Catastrophe Modelling Meets Complex Systems

- The Centre for Risk Studies arises from shared interests by the participants in exploring areas of intersection between
 - Catastrophe modelling and extreme risk analytics
 - Complex systems and networks failures
- Advance the scientific understanding of how systems can be made more resilient to the threat of catastrophic failures

To answer questions such as:

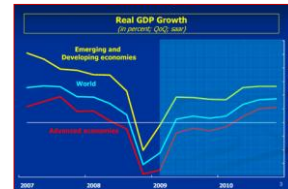
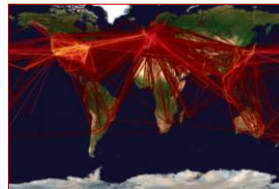
'What would be the impact of

a [War in Taiwan] on the [Air Travel Network] and how would this impact the [Global Economy]?

Regional Conflict

Air Travel Network

Global Economy



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Centre for Financial History



Facilitates cutting-edge research in financial history, encourages its application to economic theory and to public policy, and explores rigorous and lasting platforms for the dissemination of the fruits of research in financial history.



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Current projects include:

- English Corn Returns, 1770-1865
- Radical uncertainty and marine insurance pricing: an historical analysis
- Structural Heuristics of Economic Systems
- Renminbi internationalisation
- *Questioning Credible Commitment*
- North American Commodities Markets in the Interwar Period, 1925-1940
- *The History of Financial Crises* (Critical Concepts in Finance)
- First English Translation of *Les crises périodiques de surproduction*, by Albert Aftalion (1913)
- European state finance database
- Regular seminar series



Recent seminar topics

- The formative years of a modern corporation: the Dutch East India Company, 1602-1623
- Making the market: trading securities at the Bank of England during the late eighteenth century
- The Disappearing Equity Risk Premium on the 1920s NYSE
- Predicting the Past: Understanding the Causes of Bank Distress in the Netherlands in the 1920s
- The Role of Venture Capital in the Innovation Economy

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The History of Financial Crises



- To be published in 2014 in the Routledge series *Critical Concepts in Finance*
- Four volumes presenting the leading academic work on historical financial crises, since ancient times
- *This work will form the basis for the **Centre for Risk Studies** 'Financial shock' risk database*

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Radical uncertainty and marine insurance pricing: an historical enquiry

- An enquiry into the distinction between risk and uncertainty
 - Risk can be measured through probabilistic analysis
 - Uncertainty is probabilistically indeterminable

- Therefore, risk is insurable, but uncertainty is not
 - Frank Knight: uncertainty cannot be insured
 - J.M. Keynes: Insurance of uncertainties is simply wagering



Maris



Gentium

RISK VS. UNCERTAINTY: KNIGHT

- The distribution of the outcome in a group of instances is known (either through calculation *a priori* or from statistics of past experience), while in the case of uncertainty this is not true, the reason being in general that it is impossible to form a group of instances, because the situation dealt with is in a high degree unique ... The application of the insurance principle, converting a large contingent loss into a smaller fixed charge, depends upon the measurement of probability upon the basis of a fairly accurate grouping into a smaller fixed charge, depends upon the measurement of probability upon the basis of a fairly accurate grouping into classes.



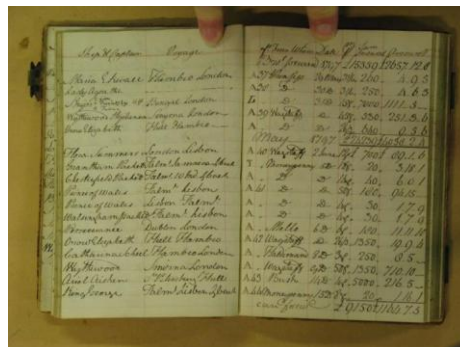
Frank Knight:
Risk, uncertainty and profit, 1921.

Radical uncertainty and marine insurance pricing: an historical enquiry

- In peacetime, risk prevails in marine insurance. Underwriters are able to set accurate prices based upon a probabilistic determination of the future
- War removes the ability to predict the future, shifting the object of insurance into a realm of uncertainty. Underwriters' decisions about rates become wagers
- Over time, as experience is gained, the characteristics of risk return

Data sources

- Underwriters' risk books provide the data
- c. 50,000 data points which present market prices for actual insured risks



Rating factors

- Project will involve categorising voyages into route/zones (eg 'Baltic') and then times of peace or war
- Other factors:
 - High frequency of naval conflict in the eighteenth century
 - Remarkably static institutional environment
 - Methodology of underwriting relatively unchanged from the beginning of the eighteenth century
 - Contract forms fixed from 1771
 - Government involvement in marine insurance underwriting limited



Example: London underwriter William Braund

- Insured vessels sailing to named North American mainland ports from 1759 and 1764
- In 1759, during the Seven Year's War, Braund charged ten discrete rates between 2.5% and 20%
- Mean rate is 7.1%; the standard deviation is 5.1 points
- Braund charged only three discrete rates in 1764: 2.5%, 3%, and 4% (mean of 3.2%, standard deviation of 0.76)
- From March 1764, his rate for the voyage did not vary from 2.5%.

Results of an initial analysis:

- Settled, adjusted prices for specific voyages illustrate stability in peace time and radical fluctuation during the threat of war and the early years of naval conflict.
- Prices return to higher, but stable levels when sufficient experience of the losses arising from naval war, including privateering, has been experienced.
- Pricing for peacetime voyages was essentially a steady, probabilistic market price: underwriters knew what loss levels to expect on various routes, during various seasons.
- Wartime voyages were subject to radical Knightian uncertainty, especially early in the conflict.
- Rigorous analysis of the expanded database will support or disprove these hypotheses.

Questions

- What further analyses may be interesting?
- Do we see uncertainty affecting pricing in today's market?
- What other research in this area would be useful?

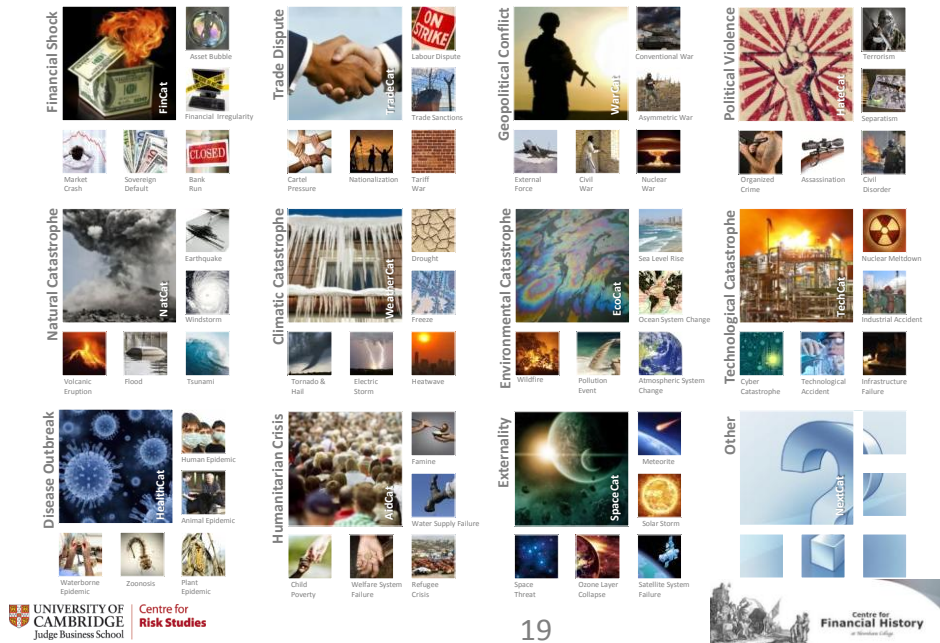
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System shock and emerging risks

- Looking at macro threats: A potential cause of a socio-economic catastrophe that would threaten human and financial capital, damage assets, and disrupt the systems that support our society, at a national or international level
- Taxonomy
- Scenario development

Cambridge Risk Framework Threat Taxonomy



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Profile of each Macro-Threat Class

We are preparing a monograph on each of the key threat categories:

- State-of-knowledge summary of the science
- Identify the leading authorities and publications on the subject
- Catalogue of historical events
- Map the geography of threat
- Define an index of severity ('magnitude scale')
- Assess a first-order magnitude-recurrence frequency (worldwide)
- **Provide illustrative 'Stress Test' scenarios of large magnitude events**
 - For e.g. 1-in-100 (or 1-in-1,000) annual probability
- System impact (vulnerability) knowledge
- Assessment of uncertainties

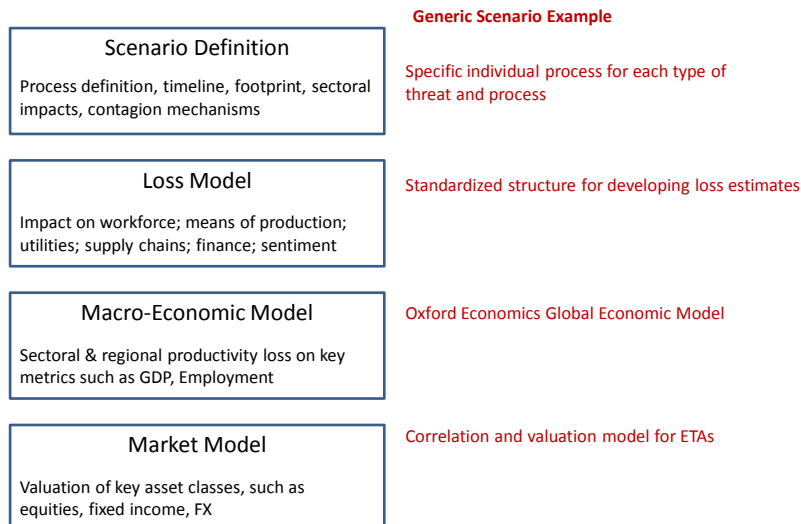
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Developing scenarios

- Work with subject matter experts to understand possible drivers
- Make it plausible, not probable
- Each step in a scenario has a documented historical parallel
- Make sure the whole scenario is coherent
- Make different scenarios have the same probability

Cambridge Risk Centre Scenario Development Process



Our Four Scenarios



Cyber Catastrophe

Sybil Logic Bomb Cyber Attack

Major compromise of commercial and national infrastructure IT systems by cyber attack

SME: Cambridge University Computer Laboratory; I/O Active

Sponsor: Catlin & Lockheed Martin



Geopolitical Conflict

Sino-Japanese Conflict in the East China Sea

Regional conflict in South China Sea embroiling Western military powers and SE Asian nations

SME: Cytora;

Sponsor: Catlin



Human Pandemic

Sao Paulo Flu Pandemic

Virulent influenza pandemic causes months of workforce absenteeism and economic disruption

SME: RMS

Sponsor: Catlin



Civil Disorder Risk

'Sack the Bankers' Worldwide Protest Movement

Austerity-driven riots and strikes across multiple cities in several Eurozone countries

SME: Cytora; Geneva School of Diplomacy

Sponsor: Munich Re

Stage A - Preparation

- Disgruntled employee of Sybil Inc. writes deliberate piece of malware code – a 'logic bomb'.
- The logic bomb corrupts the 'floating point algorithm' (or similar) to produce a low number of errors, randomly, in ways that are difficult to replicate.
- **Variant #1:** Potentially targeted at an industrial sector or target list to match the motivations of the perpetrator. Perpetrator could deliberately target the logic bomb at specific companies

Stage B – Attack Activation

- The 'logic bomb' is released as part of a routine update to Sybil's flagship database software.
- Once the update is installed, the logic bomb is activated. This slowly and unobtrusively introduces low-level errors into data stored in the Sybil database.
- All the various uses of the Sybil database are compromised.
- Errors that are observed are difficult to replicate. Some are assumed as hardware errors, leading to replacement of some computer systems.

Stage C: Detection

- After some duration of time the bomb is discovered.
- By then data backups have also been corrupted to the extent that a proportion of true data is unrecoverable.
- **Variant #2:** Bug discovered after [x] time; [y%] of Sybil's customers have unrecoverable data.
 - A. 1 month: 10% unrecoverable
 - B. 6 months: 50% unrecoverable
 - C. 2 years: 90% unrecoverable

D. Response to Contain the Attack

- The fix to stop the data corruption problem is relatively trivial: Sybil issues a new release of their software.
- All customers and users of Sybil software are contacted and urged to install the new release.
- Some costs are incurred to prioritize this upgrade over other things that the IT depts would otherwise be doing.

E/F. Containment and Recovery

- Companies are faced with corrupted databases that are impossible to validate where the errors are. Only a small % of records have errors and yet all are suspect.
- Losses occur from:
 - Paying compensation to customers who have suffered a loss as a result of a data error in company X's records
 - Legal proceedings from counterpart companies
 - Class action law suits from customers
 - Shareholder and analyst reactions in devaluing stock of affected companies
 - Sybil bankrupted as a result of law suits (insurer assumes they cover Sybil for legal liabilities)

Variant #3: Kinetic Damage & Power Blackouts

- Database corruption affects process control systems of manufacturing production
- Power systems thresholds setting software is affected, causing random fluctuations in power supplies, including blackout periods for parts of the grid

G. Post-Event Implications

- New regulatory environment aimed at improving quality of software.
- Software companies are prohibited from hiding behind limited warranty clauses
- Software costs increased by 20%

One application

■ New insurance products

- Under prices, constraints, terms and conditions that insurers could offer profitably
- And corporates would find attractive to protect themselves
- Limit the exposure so that it won't ruin the insurance company in the event of a catastrophe

Comparing and categorising scenarios

■ Estimating probability

- This particular scenario or one very like it in terms of risk area, impact, etc?

■ Measuring impact

- **Human Injury:** Kill more than [1,000] people or injure or make seriously ill more than [5,000] people
- **Disruption:** For a major region or nation, or for a particular international business sector, it would cause normal life patterns and commercial productivity to be substantially interrupted for more than [one week]
- **Cost:** Physical destruction of property and infrastructure costing [\$10 billion] to replace, or similar level of loss of value of assets
- **Economic impact:** At least one country loses at least [1%] of GDP

■ Standardised representation of impacts

- To enable effects on a specific organisation to be modelled or assessed

Questions