



Cambridge Centre for Risk Studies

Introduction to System Shock Project Review Meeting
Supply Network Disruptions

18 June 2012

Danny Ralph and many others

Centre for
Risk Studies



UNIVERSITY OF
CAMBRIDGE
Judge Business School

Cambridge Risk Centre: Research Programme

Selected Risk Research Projects



- **System Shock Framework** – creating a taxonomy for developing coherent strategies for assessing shocks on business, social and economic systems
 - **International Supply Chain Resilience** – Maritime Network Shocks
- **Corporate Risk Governance and Strategy** – the association of risk to a firm’s forward strategy. E.g. evaluating signals of strategy, opportunities in volatility, innovation & creativity for business models, role of uncertainty in strategy.
- **Energy Investment Risks** – Embedding Risk into planning beyond traditional risk neutral valuations
- **Measuring Risk: Credit Estimation and Ratings** – better understanding the impacts of future externalities and their ratings implications



<http://sisters.natracare.com/media/en-GB/dynamic-content/Sisters/smokestack-x.jpg>

Supply chain risk categories

- Inability of firm to match demand and supply. [Hendricks & Singhal 05]

Risk issues

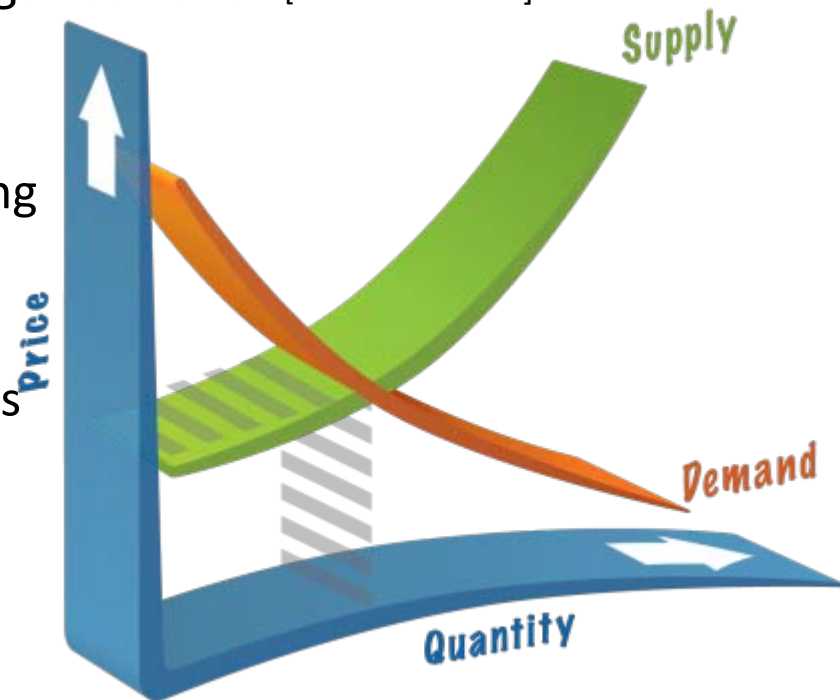
- demand side; supply side; regulatory, legal and bureaucratic; infrastructure; and catastrophic [Wagner & Bode 08]
- intellectual property, behavioural and political/societal [Tang & Tomlin 08]
- reputational, financial, fiscal, regulatory, legal [Harland et al 03]
- environmental, network-related, organisational [Juttner et al 03]

■ Supply risks

- Capacity limits
- Process volatility in cost, quality, timing
- Supply chain disruptions

■ Demand risks

- Seasonal variation, fads, new products
- Competition
- Regulation
- Reputation
- Risks affecting your customers

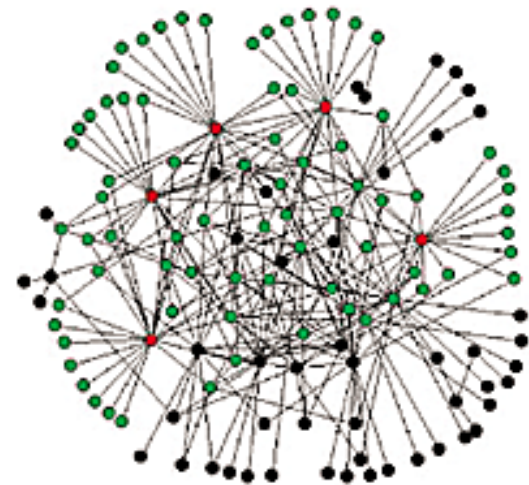


Risk frameworks in supply chain literature: Operations Management

- [Normann & Lindroth 04]
 - Unit of analysis
 - Type of risk/uncertainty
 - Stage of risk management process
- [Holweg et al 11] look at costs
 - Average labour or unit production cost: “Static”
 - Cost of managing fluctuations, eg, via inventory: “Dynamic”
 - Broader issues like increasing cost of energy: “Hidden”
- [Klibi & Martel 11] on types of uncertainty
 - Random, hazardous, catastrophic
 - Scenarios: amenable to statistics (“probabilistic”) or not
- Many others focus on statistical characterisations
 - Probability and consequence of an unfavourable event
 - Value at risk
 - Volatility and risk-return tradeoff
 - etc

Risk frameworks in supply chain literature: Operations Research modeling

- From Supply Chain to Supply Networks
- Problem features
 - Demand uncertainty vs. Capacity uncertainty;
 - Disruptions: Robustness vs. Resilience;
 - Single-echelon vs. Multi-echelon.
- Model features
 - Design models vs. Fortification models;
 - Network design vs. Facility location;
 - Expectation vs. Worst-case approach;
 - Stochastic optimization vs. Robust optimization;
 - Node failures vs. Arc failures (Network reliability).
- Supply Networks as Complex Networks
 - Join the network interacting with most central (ie., “popular”) nodes;
 - Scale-free network (world-wide web, social networks);
 - High vulnerability only at few nodes.

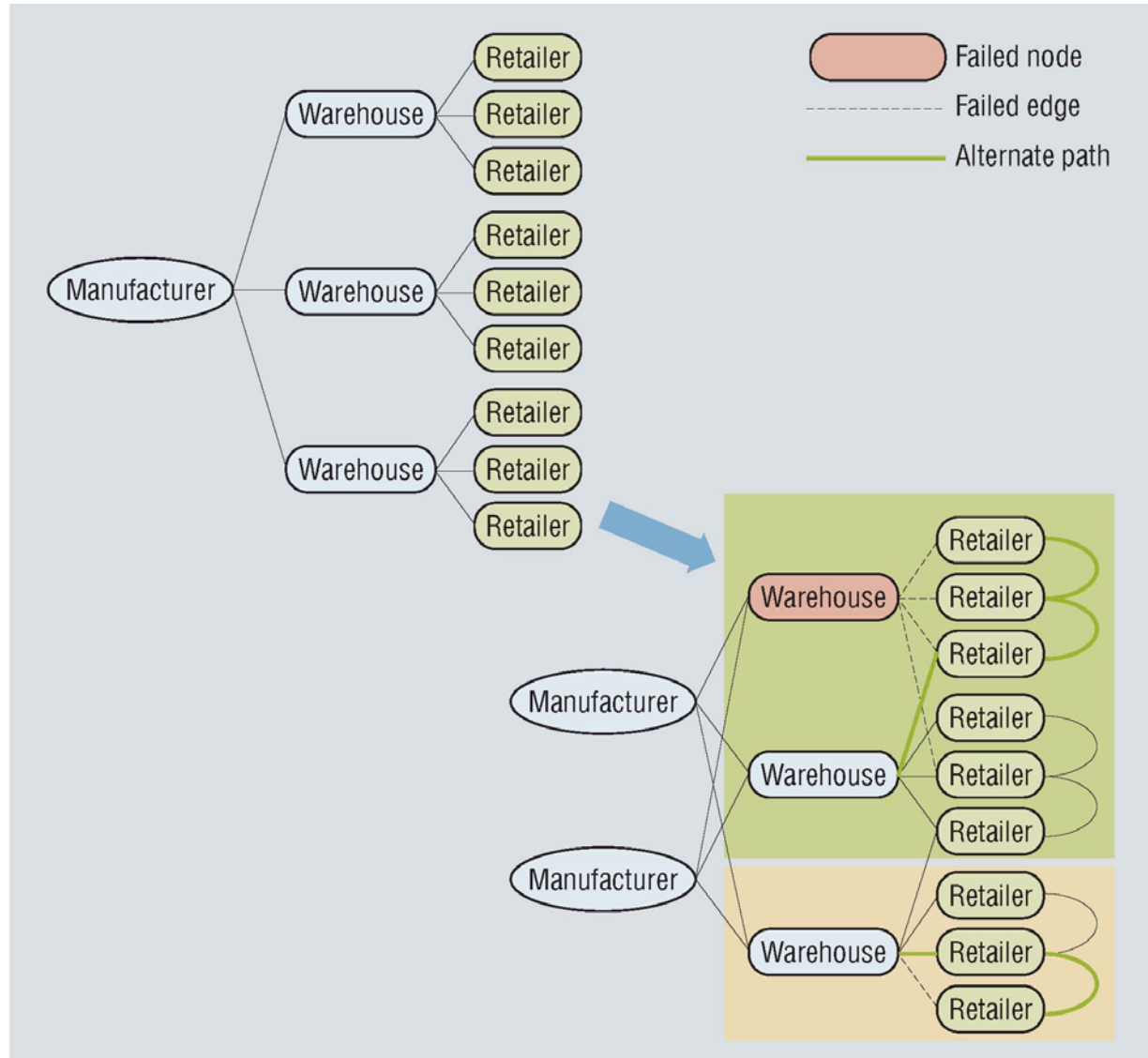


Albert, Jeong, Barabási Nature 2000

Supply network survivability

Design supply networks with inherent survivability components:

- *Low characteristic path length.*
- *Good clustering.*
- *Robustness to random and targeted failure.*
- *Efficient rewiring.*



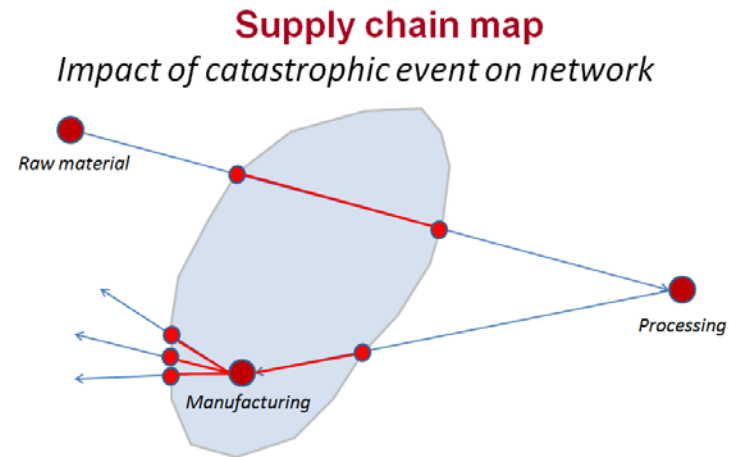
System Shock

- Risk categorisation: Taxonomy <http://systemshock.org.uk/>
- Historical record: Populate the taxonomy categories with data including metrics (quantification)

 1 Financial Shocks <ul style="list-style-type: none">1.1 Asset Bubble1.2 Financial Irregularity1.3 Bank Run / Credit Default1.4 Sovereign Structural Failure	 5 Natural Catastrophe <ul style="list-style-type: none">5.1 Windstorm5.2 Tsunami5.3 Flooding5.4 Volcanic Eruption5.5 Geotechnical Hazards	 9 Disease Outbreaks <ul style="list-style-type: none">9.1 Human Epidemics9.2 Animal Epidemics9.3 Plant Epidemics
 2 Trade Disputes <ul style="list-style-type: none">2.1 Trade Sanctions2.2 Tariff Wars2.3 Nationalization2.4 Cartel Pressure	 6 Climatic Catastrophe <ul style="list-style-type: none">6.1 Drought6.2 Freeze Event6.3 Heat Wave	 10 Demographic Stress <ul style="list-style-type: none">10.1 Longevity Stress10.2 Population Migrations
 3 Geopolitical Conflicts <ul style="list-style-type: none">3.1 Military Land War3.2 Civil War3.3 Blockades3.4 External Interventions	 7 Environmental Catastrophe <ul style="list-style-type: none">7.2 Oceanic Circulatory System Change7.3 Atmospheric System Change7.4 Pollution Event7.5 Destruction of Natural Habitat5.6 Geotechnical Hazards	 11 Externalities <ul style="list-style-type: none">11.1 Meteorite11.2 Space Weather
 4 Political Violence <ul style="list-style-type: none">4.1 Terrorism4.2 Separatism4.3 Civil Disorder4.4 Assassination	 8 Technological Catastrophe <ul style="list-style-type: none">8.1 Nuclear Power Plant Accident8.2 Industrial Accident8.3 Infrastructure Breakdown8.4 Technological Accident8.5 Cyber-Catastrophe	 12 Other Shocks

System Shock

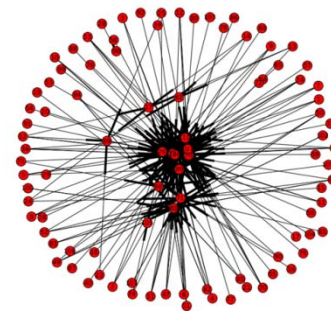
- **Risk categorisation:** Taxonomy <http://systemshock.org.uk/>
- **Historical record:** Populate the taxonomy categories with data including metrics (quantification)
- **Relationships:** represented by network
 - Spatial or geographical
 - Contractual
 - Economic
 - Social



System Shock

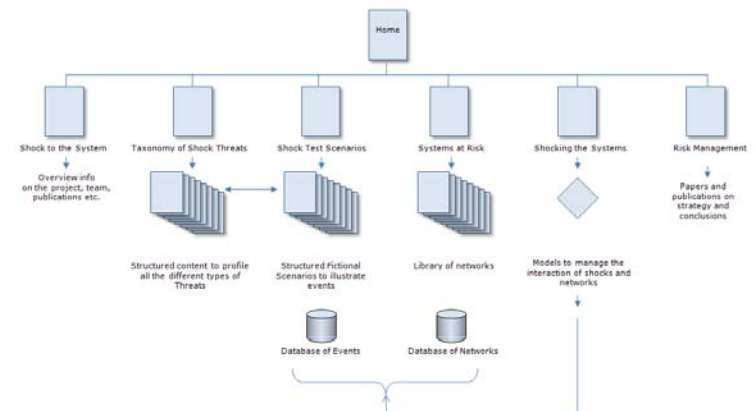
- **Risk categorisation:** Taxonomy <http://systemshock.org.uk/>
- **Historical record:** Populate the taxonomy categories with data including metrics (quantification)
- **Relationships:** represented by networks of nodes and links
 - Spatial or geographical
 - Contractual
 - Economic
 - Social
- **Algorithms and analytics**
 - Computer science on topology, robustness, resilience
 - System dynamics on effects over time

Topological supply chain map



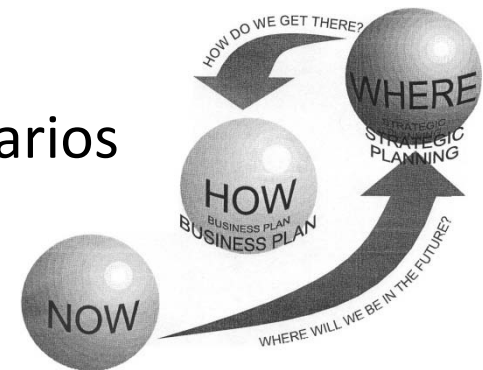
System Shock

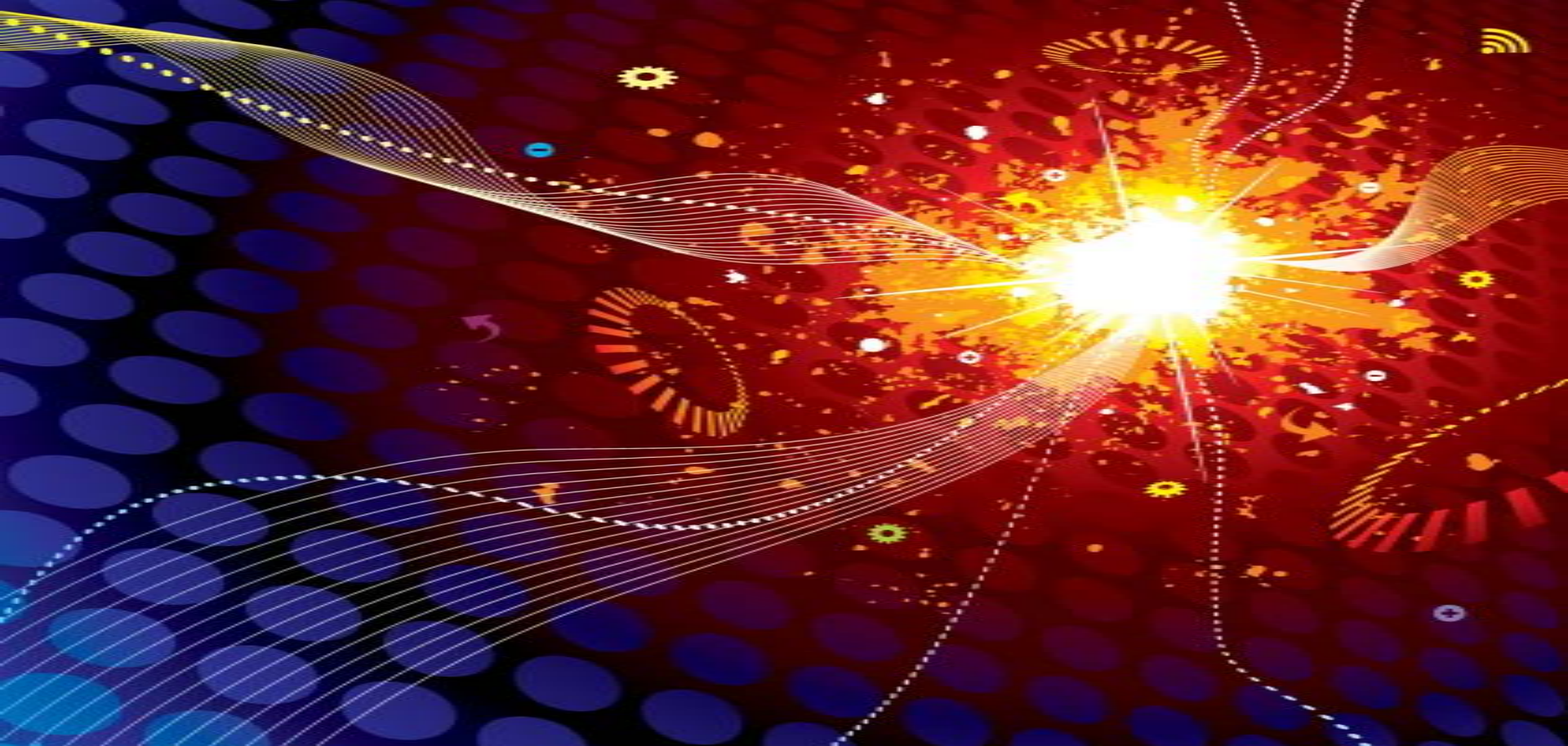
- **Risk categorisation:** Taxonomy <http://systemshock.org.uk/>
- **Historical record:** Populate the taxonomy categories with data including metrics (quantification)
- **Relationships:** represented by networks of nodes and links
 - Spatial or geographical
 - Contractual
 - Economic
 - Social
- **Algorithms and analytics**
 - Computer science on topology, robustness, resilience
 - System dynamics on effects over time
- **Tools**
 - Web based interfaces
 - Open Source development platform



Value added

- Recall [Holweg et al 11] look at costs
 - Average labour or unit production cost: “Static”
 - Cost of managing fluctuations, eg, via inventory: “Dynamic”
 - Broader issues like increasing cost of energy: “Hidden”
- System shock aims to
 - Represent the supply chain or other business processes
 - Include dynamics: cost of fluctuations or variability and timing/duration of supply chain interruptions
 - Provide modelling platform to connect hidden issues to explicit structures like supply chains
- Output is input for strategy
 - Quantitative representation of risk scenarios
 - Descriptive, not predictive





Thank you for listening
Look forward to your thoughts on today's presentations

Centre for
Risk Studies



**UNIVERSITY OF
CAMBRIDGE**
Judge Business School