Cambridge Centre for Risk Studies
Advisory Board Research Showcase – 24 January 2017

Multi-Threat Cascades
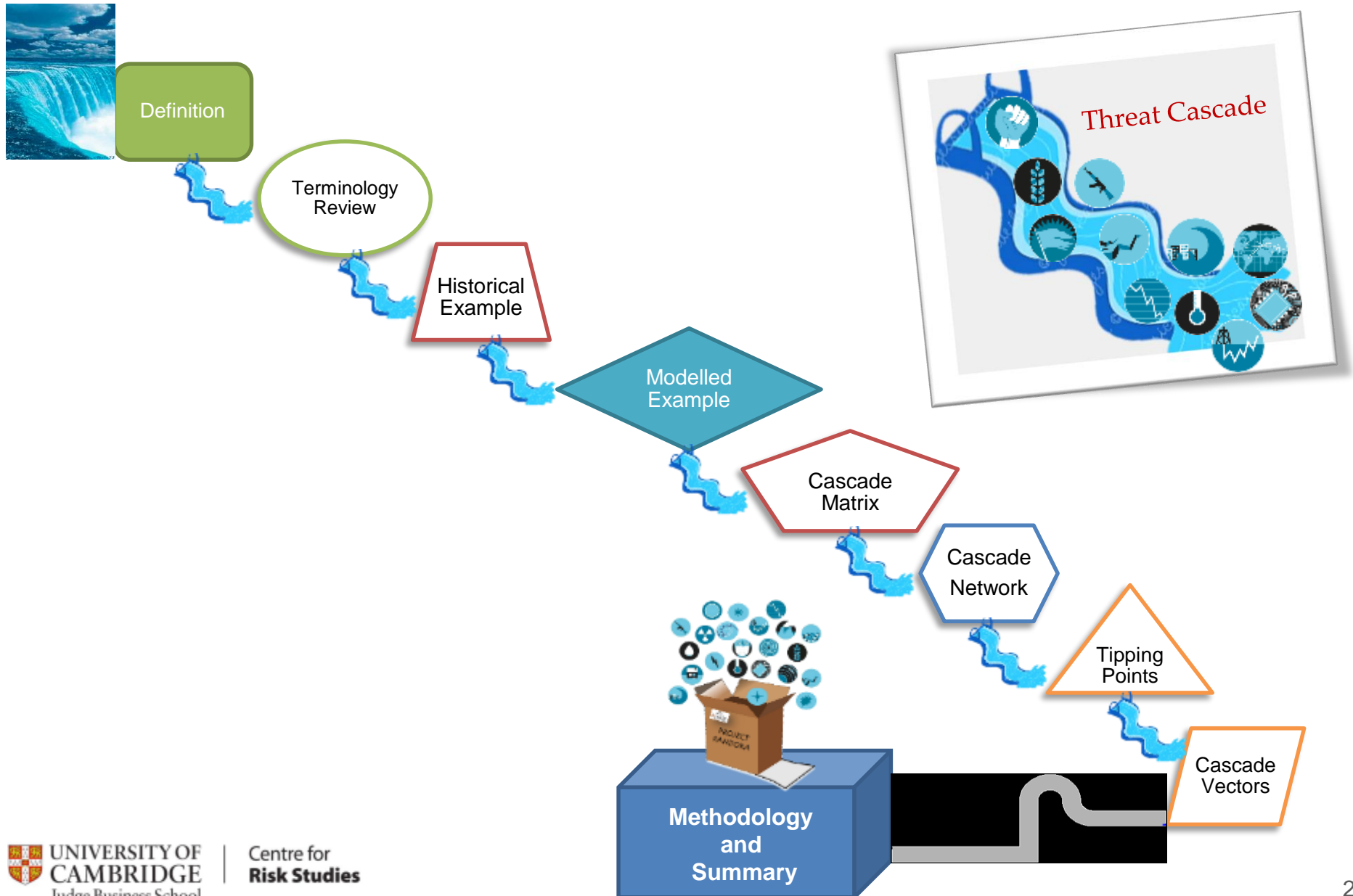
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In today's cascade, we flow through…

Definition

Terminology Review

Historical Example

Modelled Example

Cascade Matrix

Cascade Network

Tipping Points

Cascade Vectors

Methodology and Summary

Threat Cascade

Multi-threat Cascade: is one where…

- A threat event affecting one city results in **another** threat event that affects the same and/or any other city in the world.

- The second threat event that may pass on the shock further along to another threat until the shock eventually dies out

- This arises from the interconnected network structure of the world economies and also due to the interplay of other vectors such as natural sciences, politics, and physical and social networks

- Currently exploring this phase of our research; we aim to assess the value in modelling inter-threat shock propagation(cascades) thereby building on our current and previous work at the centre
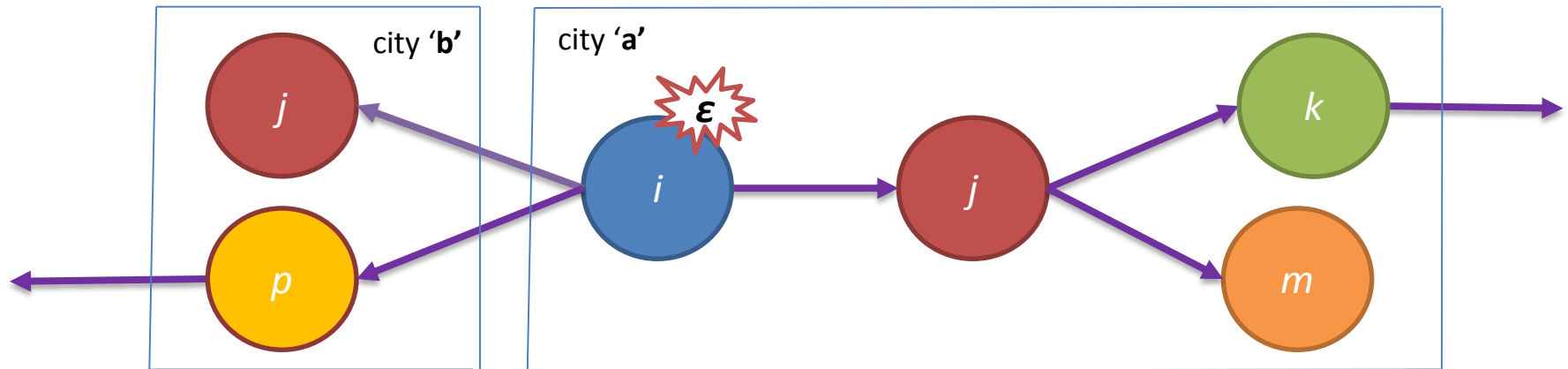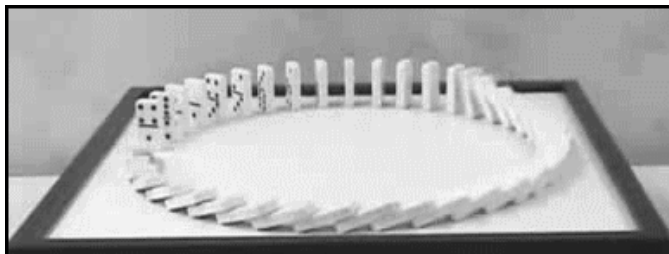
Multi-threat Cascade: snakes and ladders
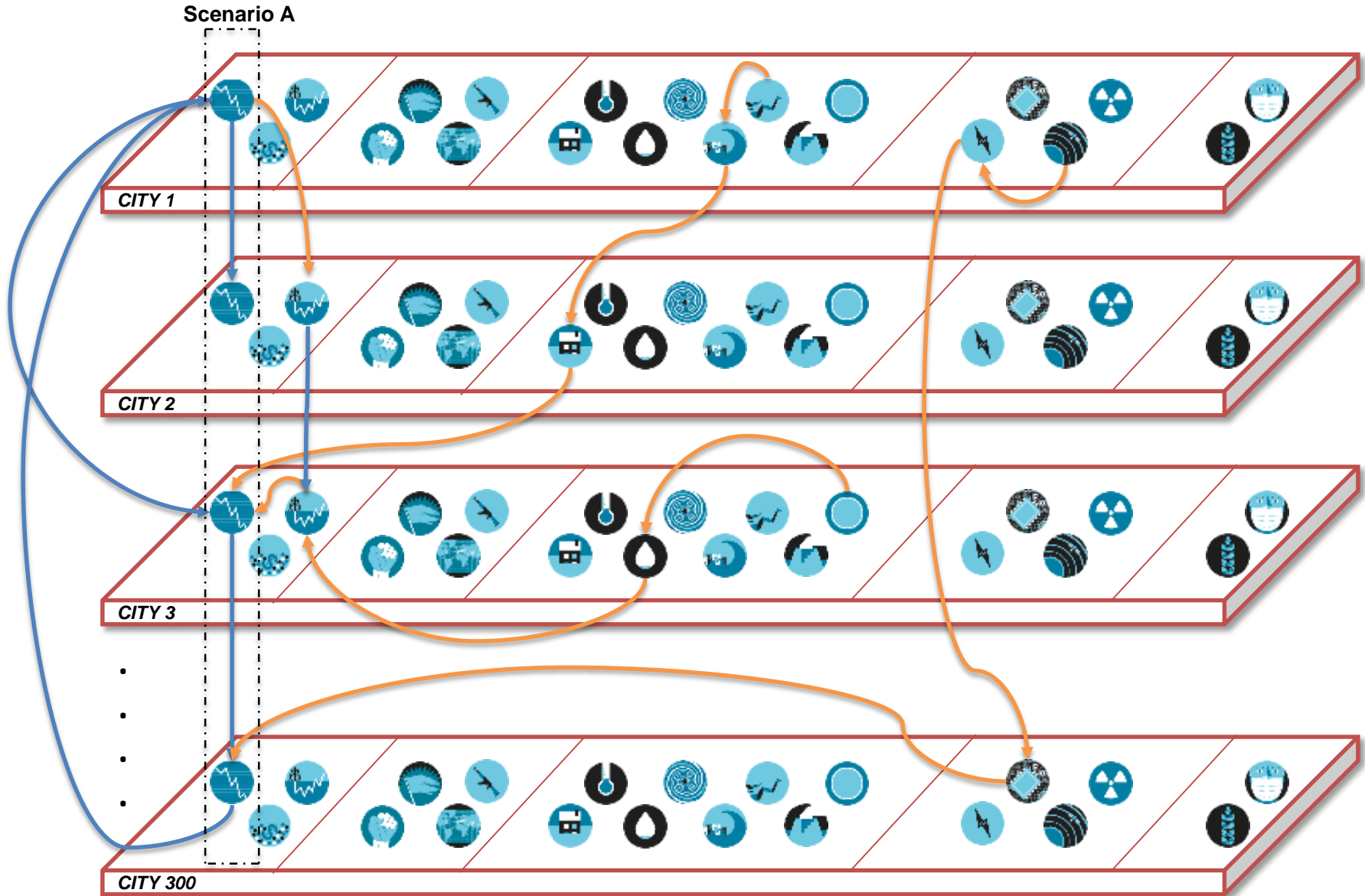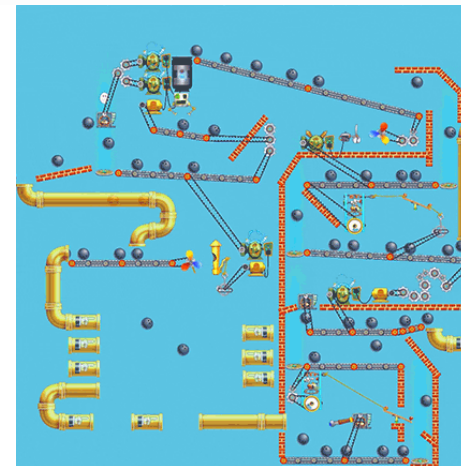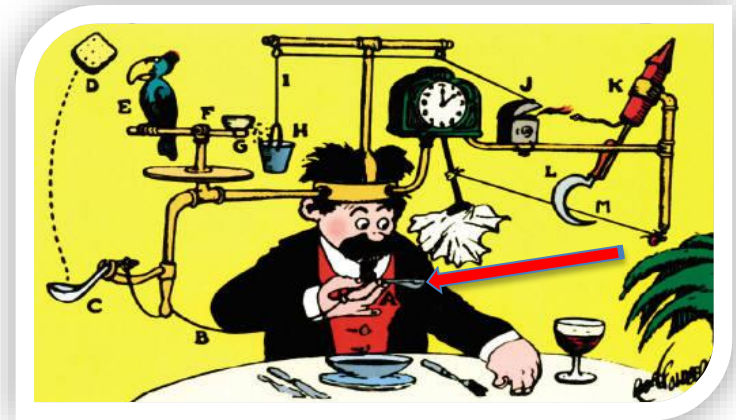
Terminology Review: the differences are…

CONTAGION

- city-to-city
- Same threat

CASCADE

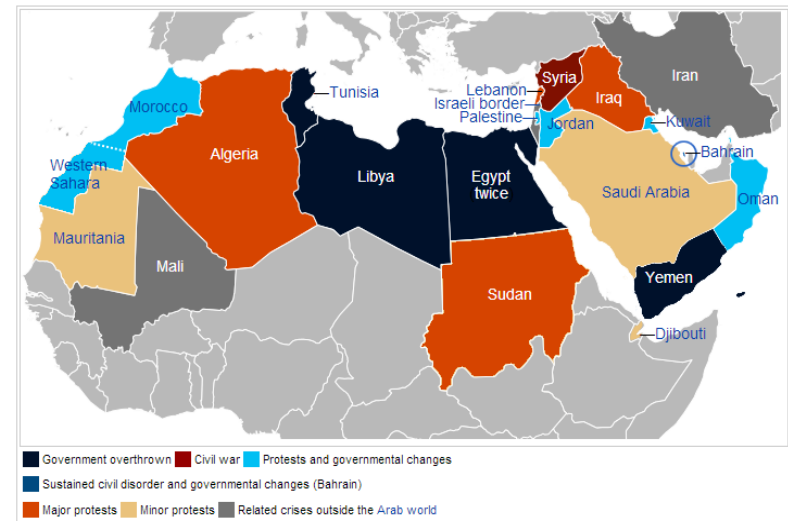- threat-to-threat
- Same or different city

Historical Example: it was the case that…

Remember, remember the 17th of December?

Arab Spring revolution

- Climate change effects in wheat and grain producing nations, specifically, droughts in Russia, China and Argentina; and storms in Canada, Australia and Brazil, resulted in lower crop produce and hence in commodity price shock

- A global food crisis and the existing economic strain from the financial crisis thus catalysed this movement that exacerbated the existing socio-political and economic tensions in the region

- In December 2010, these culminated in social unrest which manifested in protests, riots, civil wars, insurgencies, coup, etc…to take down the current regime, towards a power struggle for democracy

Government overthrown　Civil war　Protests and governmental changes
Sustained civil disorder and governmental changes (Bahrain)
Major protests　Minor protests　Related crises outside the Arab world

MARKET CRASH + DROUGHT + WINDSTORMS

COMMODITY PRICE SHOCK

SOCIAL UNREST

Modelled Example: currently by CCRS

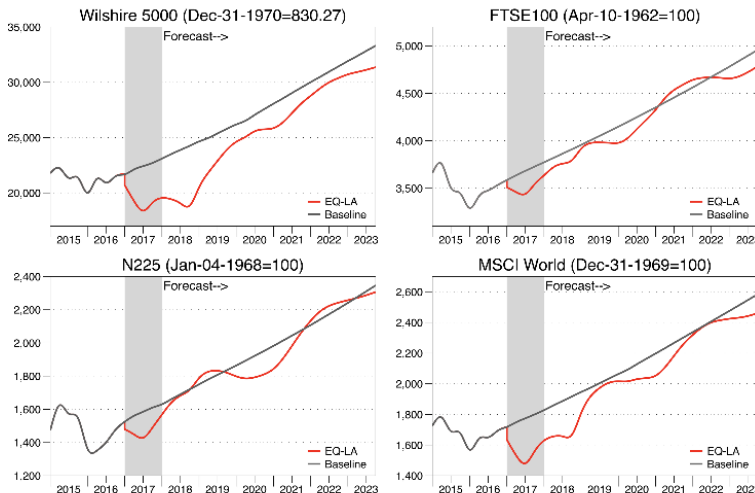**Bankrupt by Nature:**

- Historically, NatCat impacts were assumed uncorrelated with market risk (FinCat)

- *Aim*: Assess the potential market impacts of NatCat events

- *Scenarios*: 2 of earthquake, hurricane and volcano each

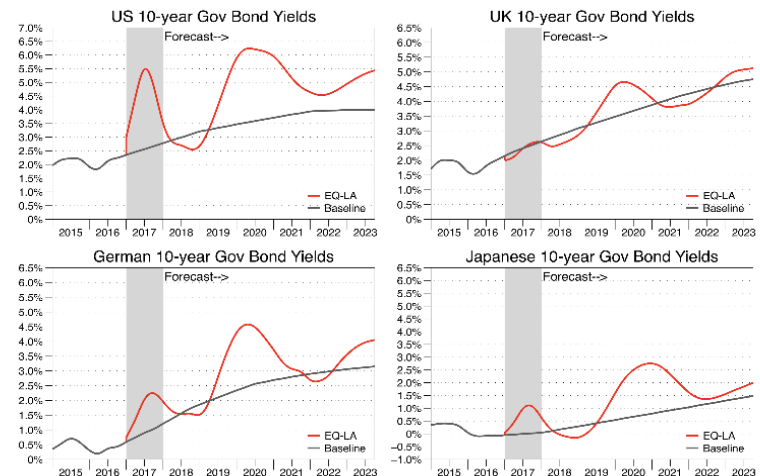Assessment Methodology
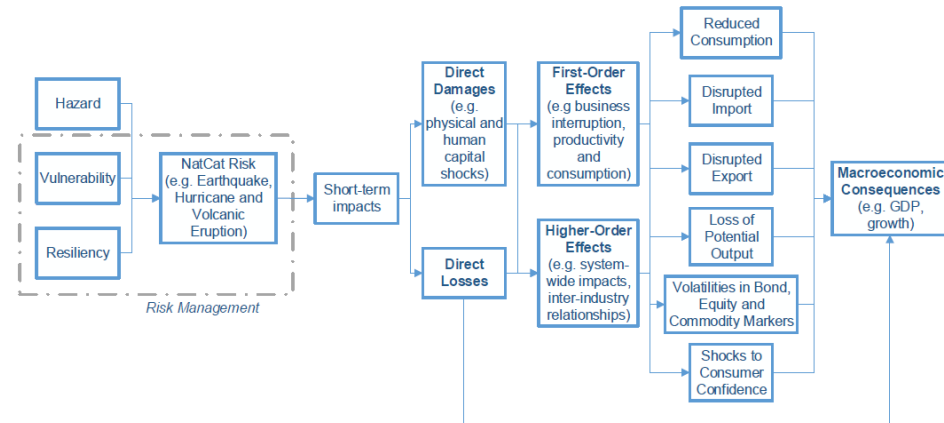
Equity market impact of EQ-LA

Long-term bond market impact of EQ-LA

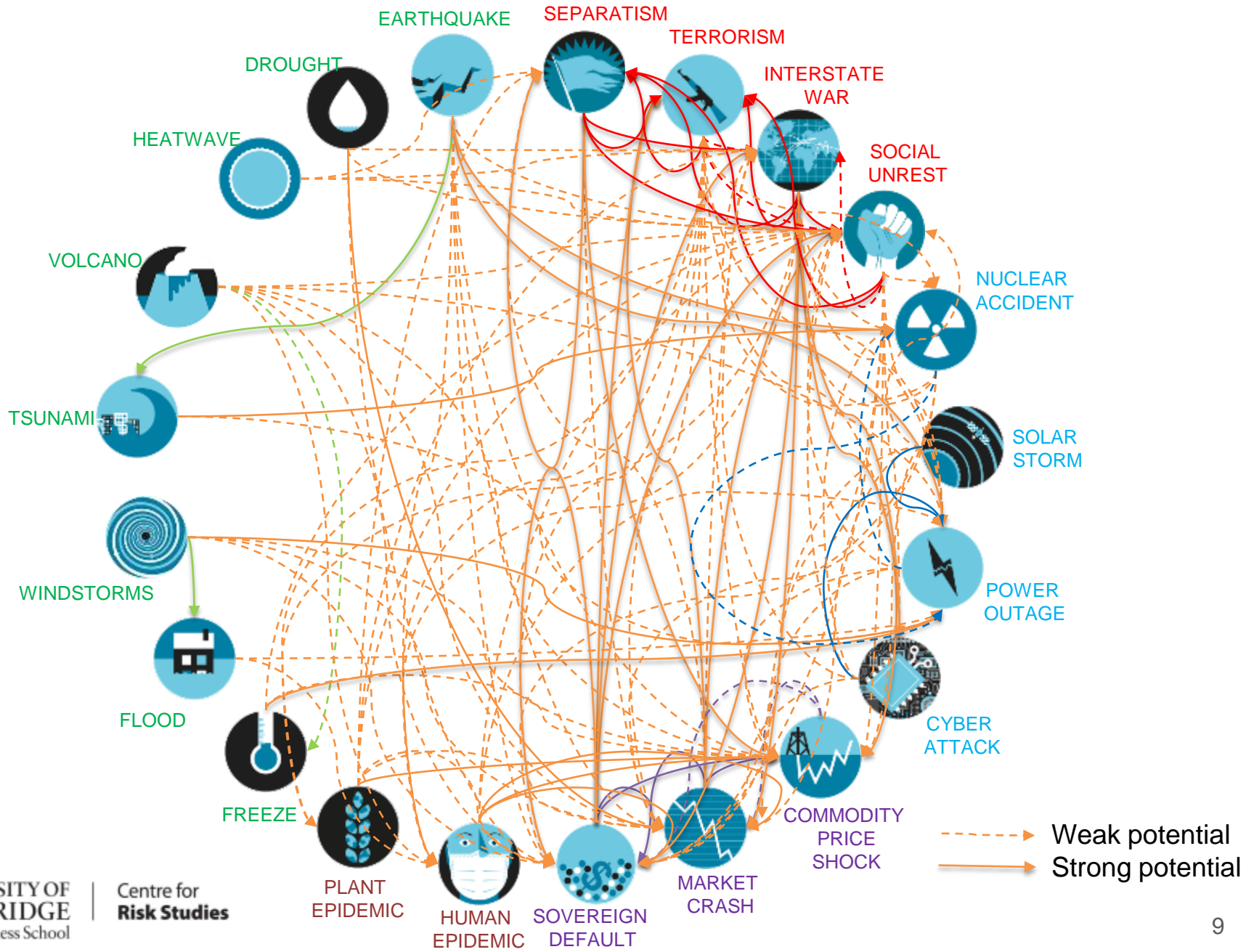UNIVERSITY OF CAMBRIDGE
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Cascade Matrix: Qualitative Quantification

Consequential Threat

Primary Trigger

Primary Trigger Class	Primary Trigger	Market Crash	Sovereign Crisis	Price Shock	Interstate War	Terrorism	Separatism	Social Unrest	Earthquake	Volcanic Eruption	Tropical Windstorm	Temperate Windstorm	Flood	Tsunami	Drought	Freeze	Heatwave	Power Outage	Cyber Attack	Solar Storm	Nuclear Accident	Human Epidemic	Plant Epidemic
Finance, Economics & Trade	Market Crash	4	3	3	2	3	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Sovereign Crisis	3	4	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Price Shock	2	2	4	2	2	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Geopolitics & Security	Interstate War	3	3	3	4	3	3	3	1	1	1	1	1	1	1	1	1	2	3	1	2	2	2
	Terrorism	2	2	2	2	4	3	2	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2
	Separatism	2	3	3	3	3	4	3	1	1	1	1	1	1	1	1	1	2	2	1	2	1	1
	Social Unrest	2	2	2	2	3	3	4	1	1	1	1	1	1	1	1	1	2	2	1	2	1	1
Natural Catastrophe & Climate	Earthquake	2	2	2	1	1	1	2	0	0	0	1	1	3	0	0	0	3	0	0	3	2	1
	Volcanic Eruption	2	2	2	1	1	1	2	0	0	0	0	0	0	0	2	0	2	0	0	0	2	1
	Tropical Windstorm	2	2	2	1	1	1	1	0	0	0	0	3	0	0	0	0	3	0	1	1	1	0
	Temperate Windstorm	1	1	1	1	1	1	1	0	0	0	0	2	0	0	1	0	3	0	1	0	0	0
	Flood	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	2	0	0	1	2	0
	Tsunami	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	2	0	0	3	0	0
	Drought	1	2	3	2	1	1	2	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
	Freeze	1	1	2	1	0	0	2	0	0	0	0	0	0	0	0	0	3	0	1	1	1	1
	Heatwave	1	1	1	2	1	2	2	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Technology & Space	Power Outage	1	2	2	1	0	0	2	1	1	1	1	1	1	1	1	1	4	0	0	2	1	1
	Cyber Attack	1	2	1	2	0	1	2	0	0	0	0	0	0	0	0	0	3	4	0	2	0	0
	Solar Storm	2	2	2	0	0	0	2	0	0	0	0	0	0	0	1	1	3	0	0	2	0	0
	Nuclear Accident	2	2	1	2	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Health & Humanity	Human Epidemic	3	3	3	1	1	0	2	1	1	1	1	1	1	1	1	1	2	1	1	1	2	0
	Plant Epidemic	2	2	3	2	1	2	2	0	1	0	0	0	0	1	1	1	0	0	0	0	0	2

- Some connections are strong, others weak
- Differences in likelihood of cascade between different threats
- Likelihoods are not symmetric, depends on the trigger
- Existence of feedback loops may intensive the overall magnitude of GDP@Risk

Legend

- **0** — No causal linkage / No significant ability to exacerbate
- **1** — **No causal linkage**, but would exacerbate consequences if they occur
- **2** — **Weak potential** to trigger threat occurrence
- **3** — **Strong potential** to trigger threat occurrence
- **4** — Ability to trigger **Other threats within same type class**

Cascade Network: Shocks Pass-Through

EARTHQUAKE
DROUGHT
HEATWAVE
VOLCANO
TSUNAMI
WINDSTORMS
FLOOD
FREEZE
PLANT EPIDEMIC
HUMAN EPIDEMIC
SOVEREIGN DEFAULT
MARKET CRASH
COMMODITY PRICE SHOCK
CYBER ATTACK
POWER OUTAGE
SOLAR STORM
NUCLEAR ACCIDENT
SOCIAL UNREST
INTERSTATE WAR
TERRORISM
SEPARATISM

- - - → Weak potential
——→ Strong potential

Tipping Points: Who Moved my Domino?

- Not always does a shock successfully propagate through all threats in a given cascade pathway/trajectory
- They could die out along the trajectory if the value is below a threshold, due to lack of critical amount of shock (analogous to excitation energy in quantum physics), at the threat linkage in question
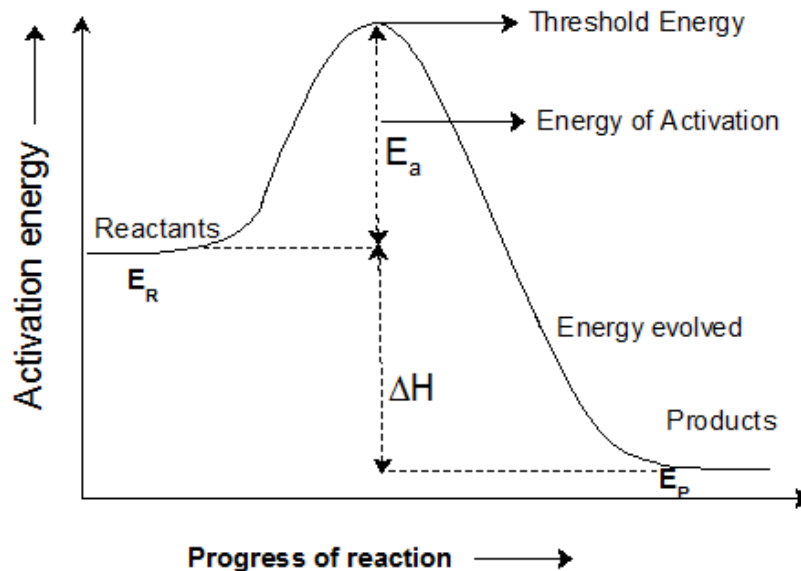

Tipping point not achieved

Cascade Vectors are…

- **Factors** that are not explicitly modelled which serve as mediators that allow propagation of shock from one threat to another in a scenario

- **Examples**:
    - *Moving Out scenario:* Low economic output due to drought or market conditions results in migration that escalates to social unrest
    - *Dark War scenario:* Interstate war between countries results in bombing of electricity infrastructure thereby widespread power outage
    - Other factors like reputation loss, confidence shock, etc…

Potential Methodology

- Define shock at primary trigger
- Identify and map cascade pathways connecting primary to its consequential triggers
- Assign conditional probabilities of shock propagation through this network
- Define tipping point (threshold) and estimate extent of propagation
- Account for existence of cascade vectors between threats
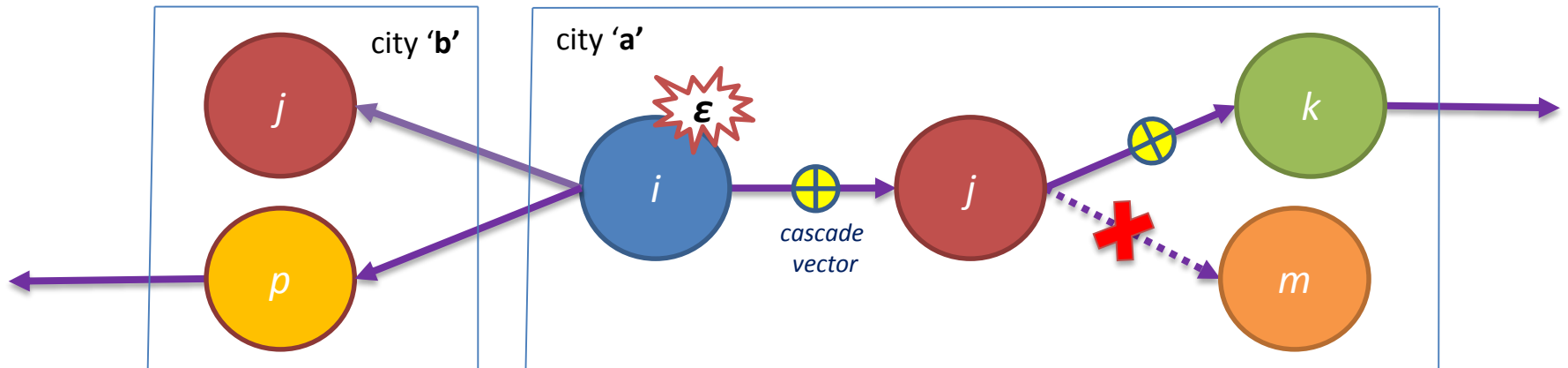
Summary: Where We Go From Here…

- Proposed way forward:
  - Learn from past cascade events to inform future analyses
  - Identify all threat cascades that are potentially feasible (and of interest)
  - Model the propagation of threat cascades using mathematical/algorithmic formalisms
  - Quantify the relevant macroeconomic variables of interest, Eg. GDP@Risk

Threat Cascade

PROJECT PANDORA

RISK PERCEPTION   RISK ANALYSIS   RISK MANAGEMENT
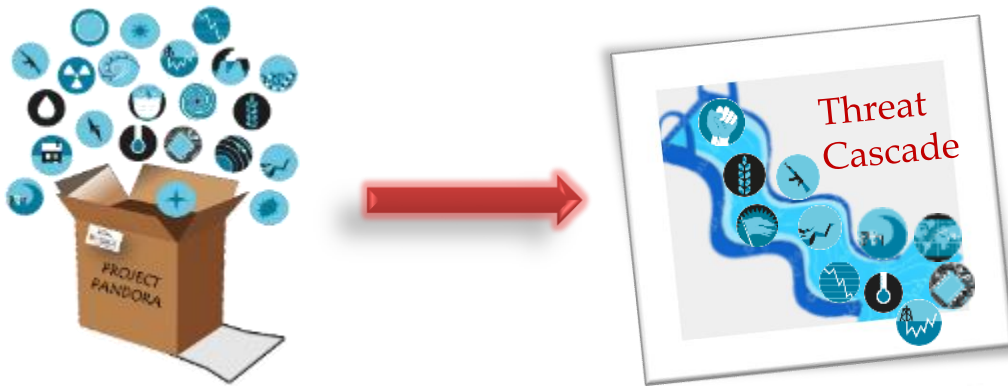
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