

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

# Scenario Development Methodologies

Centre for  
**Risk Studies**



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**CAMBRIDGE**  
Judge Business School

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# Project Pandora

Finance, Economic & Trade



Geopolitics & Society



Natural Catastrophe & Climate



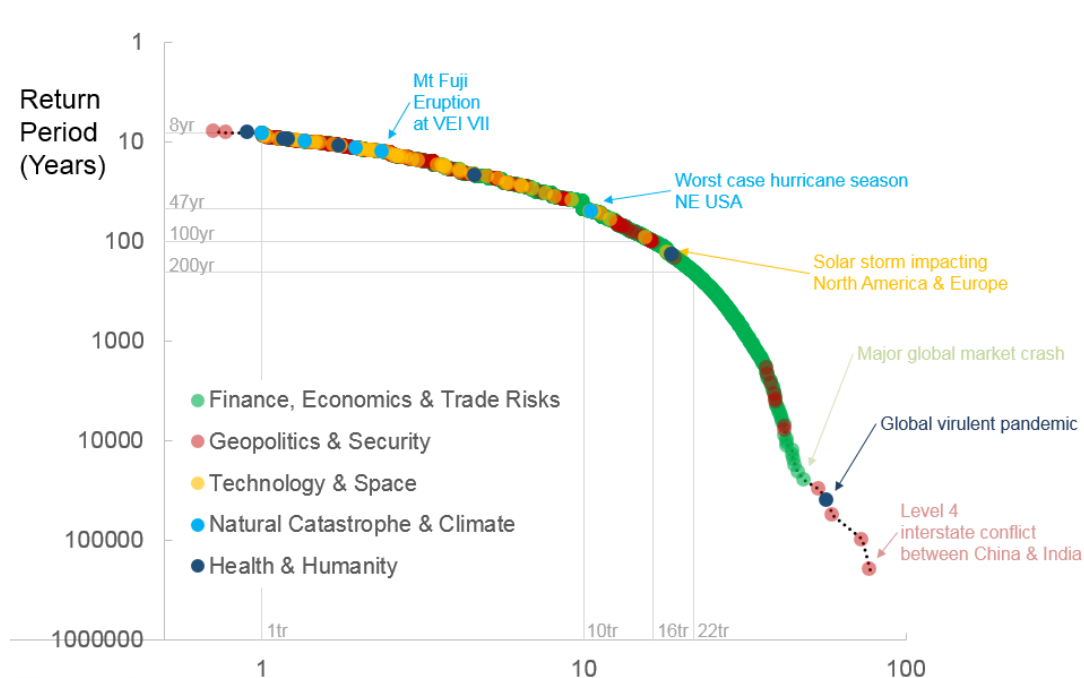
Technology & Space



Health & Humanity



- Cambridge Global Risk Index: GDP@Risk for 300 cities across 22 threats
- Move from city-level impacts to scenario-impacts
- Combine exposure to multiple threats into one framework
- Research question: How likely is the world economy to experience a loss of a trillion dollars? In what scenarios? **Define 'all' of them.**

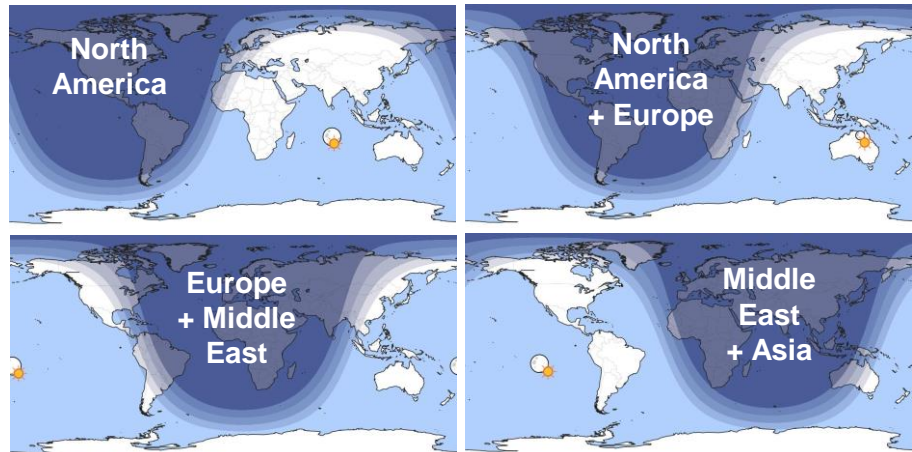


# Presentation Agenda

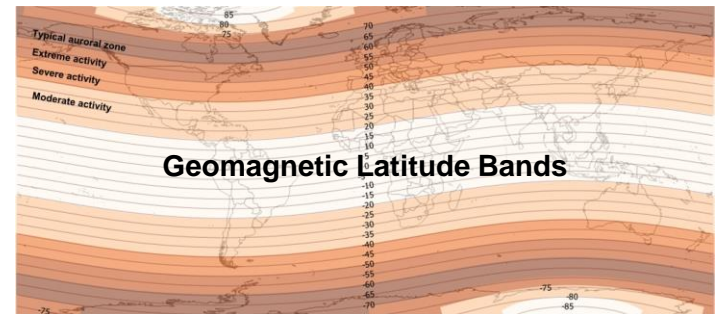
- Methodology behind scenario generation
- In-depth examples for 2 threats:
  - Flood and Market Crash
- Individual threat-level exceedance probability curves
- Future steps and challenges ahead

# Methodology: Defining the Scenario Footprint

- Define size and location of scenario footprint:
  - **Define trigger** - where does it start?
  - **Define boundary** – how much does it spread?



- For each city impacted within the footprint, we assign one of 3 'LIS' severity levels:



**Go through this exercise for each threat**

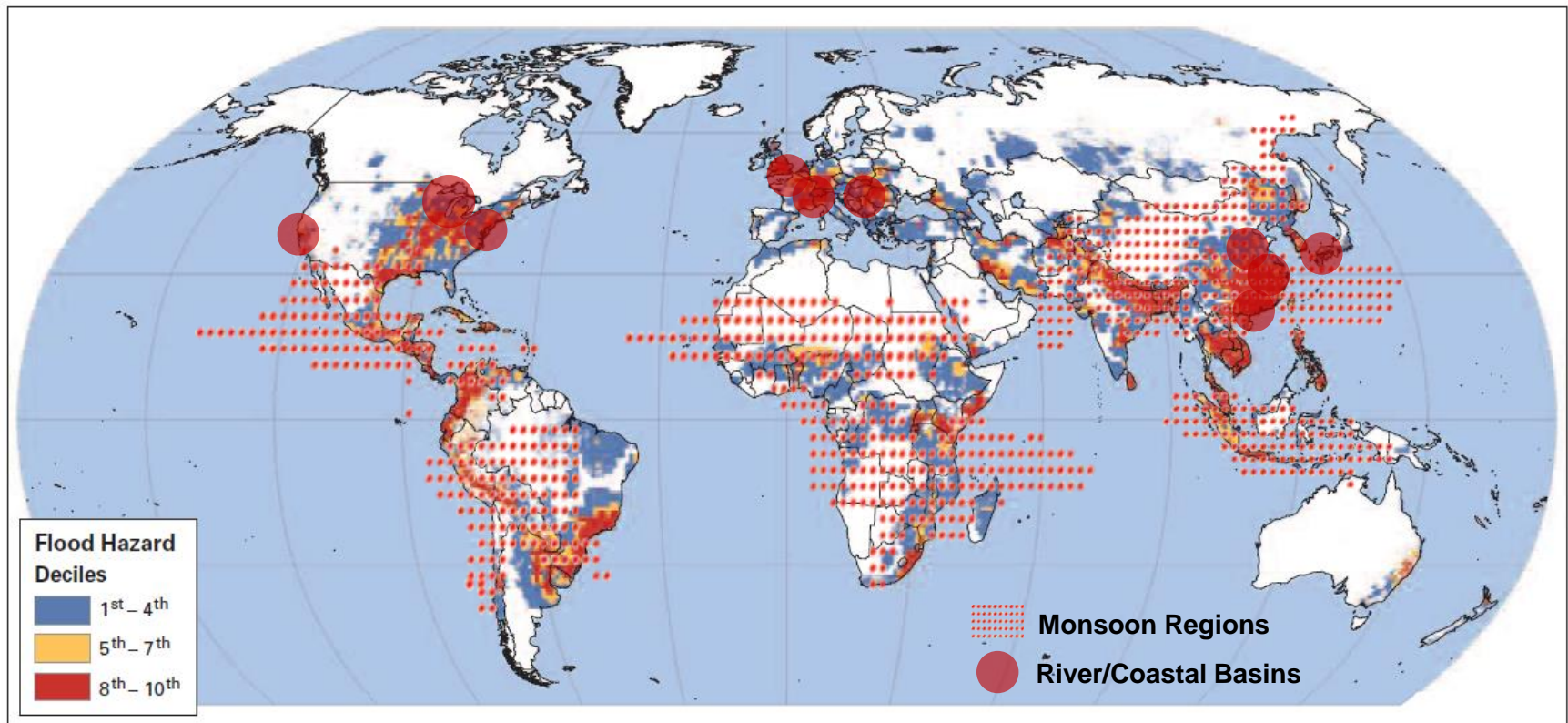
# Methodology: Hand-crafted vs. Systematic

- Top-down: Focus on agglomerations with potential trillion dollar impact
  - Hand-crafted
  - Example: Ranked list of possible interstate conflicts; likelihood assigned to each one
  - Filter out near-impossible scenarios, low impact scenarios, but may miss extreme tail scenarios
- Bottom-up: Generate 'all' possible scenarios
  - Systematic
  - Example: Possibility of sovereign default in any country
  - More likely to capture wider range of scenarios and severity, and produces higher number of scenarios
- Mix: Expand top-down scenarios, generate variants of it
  - Example: Interstate conflict – starts between two states, can involve other states
- Have we accounted for sufficient range in scenarios in terms of severity and geography?



# Scenario Generation Example: Flood Scenarios

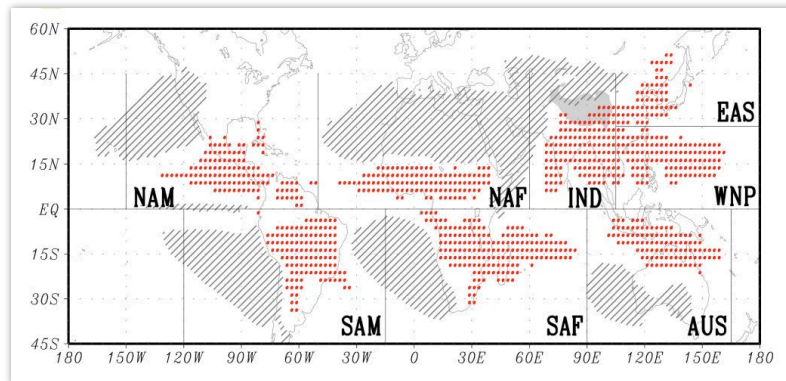
- Top-down methodology
- Identify geographically correlated events with high GDP and/or high risk of flooding
  - Monsoon regions
  - River/Coastal basins
  - Hurricane and Typhoons – captured in HU and TY scenarios



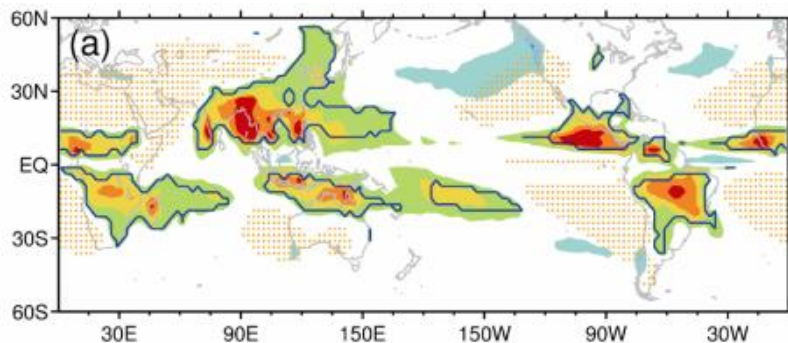
Dilley, Maxx. *Natural disaster hotspots: a global risk analysis*. Vol. 5. World Bank Publications, 2005. & CRS Analysis

# Scenario Example: Monsoon Floods

- Eight defined monsoon regions globally. For each region:
  - 'Centre' with higher intensity, varying between severity levels of 1-3
  - 'Footprint' also impacted varying between severity levels of 0-3
  - Each scenario represents variations in rainfall in one monsoon summer season



World Climate Research Programme:  
[http://www.wcrp-climate.org/documents/monsoon\\_factsheet.pdf](http://www.wcrp-climate.org/documents/monsoon_factsheet.pdf)



Huo-Po, C., Sun. Jian-Qi. "How large precipitation changes over global monsoon regions by CMIP5 models?." *Atmospheric and Oceanic Science Letters* 6.5 (2013): 306-311.

Monsoon	Country	City	FL0	FL1	FL2	FL3
IND	Afghanistan	Kabul	0.0	0.4	4.7	15.2
IND	Bangladesh	Dhaka	0.0	2.1	8.3	35.5
IND	China	Lanzhou	0.0	0.5	5.9	28.5
IND	China	Chengtu	0.0	4.8	62.2	301.0
IND	China	Kunming	0.0	0.1	1.9	9.1
IND	Indonesia	Medan	0.0	0.1	1.3	6.7
IND	India	Ahmedabad	0.0	6.7	27.0	115.4
IND	India	Bombay (Mumbai)	0.0	23.3	94.1	403.3
IND	India	Chennai	0.0	4.8	19.7	84.3
IND	India	Delhi	0.0	21.8	87.9	376.7
IND	India	Bangalore	0.0	3.6	14.7	62.8
IND	India	Poona	0.0	5.0	20.3	86.8
IND	India	Hyderabad	0.0	3.3	13.4	57.2
IND	India	Surat	0.0	3.8	15.3	65.3
IND	India	Kanpur	0.0	3.3	13.6	58.1
IND	India	Calcutta	0.0	4.7	19.2	82.1
IND	Cambodia	Phnom Penh	0.0	0.0	0.4	1.1
IND	Myanmar	Yangon	0.0	0.2	1.6	4.8
IND	Malaysia	Kuala Lumpur	0.0	0.6	4.3	23.6
IND	Malaysia	Kota Bharu	0.0	0.2	1.3	6.9
IND	Nepal	Kathmandu	0.0	0.0	0.2	1.0
IND	Pakistan	Islamabad	0.0	0.1	0.6	3.1
IND	Pakistan	Karachi	0.0	1.6	19.7	96.9
IND	Pakistan	Lahore	0.0	0.8	10.2	50.1
IND	Pakistan	Faisalabad	0.0	0.3	3.6	17.7
IND	Singapore	Singapore	0.0	38.7	87.1	242.0
IND	Thailand	Bangkok	0.0	5.3	40.6	219.6

**Scenario Loss Total (\$bn) 847**

# Scenario Example: Riverine Flood

- We identified 10 river basin regions with high economic production, primarily in East Asia, Northeast USA and Western Europe
- For each river basin region:
  - Vary scenario intensity levels between 1-3
  - Can extend to more variation within river basin, but for most regions, only widespread severe flooding could cause economic damage given small size of basins

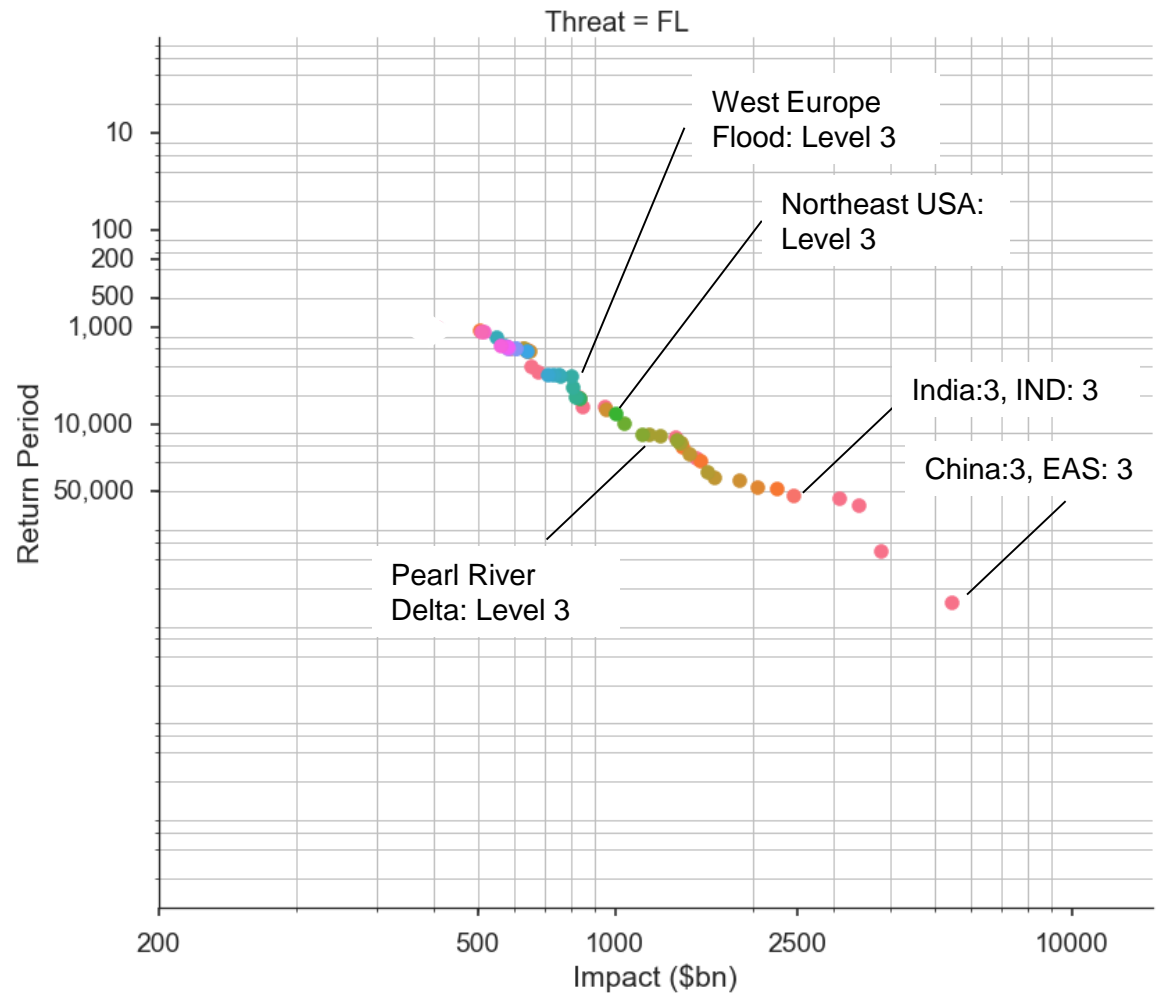


Flood Region	City	FL0	FL1	FL2	FL3
West Europe	Paris	0	55	123	341
West Europe	Milan	0	16	37	154
West Europe	Frankfurt	0	12	27	76
West Europe	Turin	0	5	11	47
West Europe	Cologne	0	7	16	46
West Europe	Lyon	0	7	15	42
West Europe	Rotterdam	0	5	12	34
West Europe	Geneva	0	3	7	20
West Europe	Dortmund	0	3	6	16
West Europe	The Hague	0	2	5	14
West Europe	Dusseldorf	0	2	4	12
<b>Scenario Loss Total (\$bn)</b>					<b>801</b>



# Flood Exceedance Probability Curve

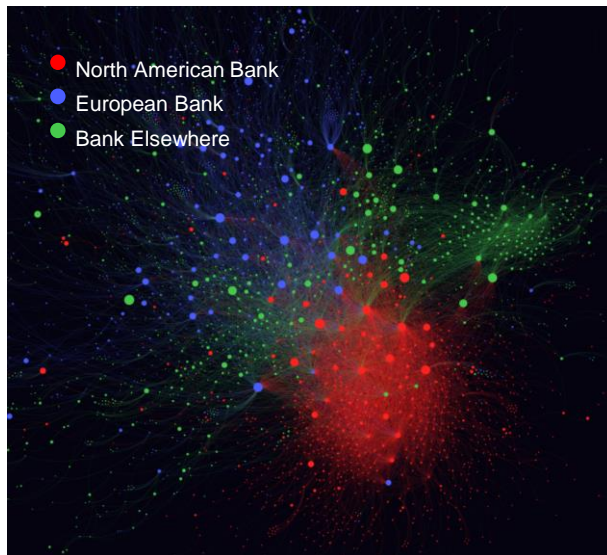
- 60 scenarios generated with impacts ranging from \$0.5trn to \$5.4trn
- How to assign probabilities?
  - Anchor flood probabilities to historical examples
  - Requires further validation and multiple points
  - Challenge: how to assign relative probability of scenarios with no historical precedence



# Scenario Generation Example: Market Crash

- Bottom-up approach
- Stylized financial system network - segmented into seven financial clusters:
  - UK, China, US, Europe, Developed Markets, Emerging Markets, Frontier Markets
  - Aligned with MSCI country classification – widely used for asset allocation
- Financial crisis can initiate in any banking or financial system globally
  - With different probabilities
- Market impact spreads through financial system
  - Multiple contagion mechanisms – interbank lending, fire-sales, repo margin calls

Complex Network



Simplified Network

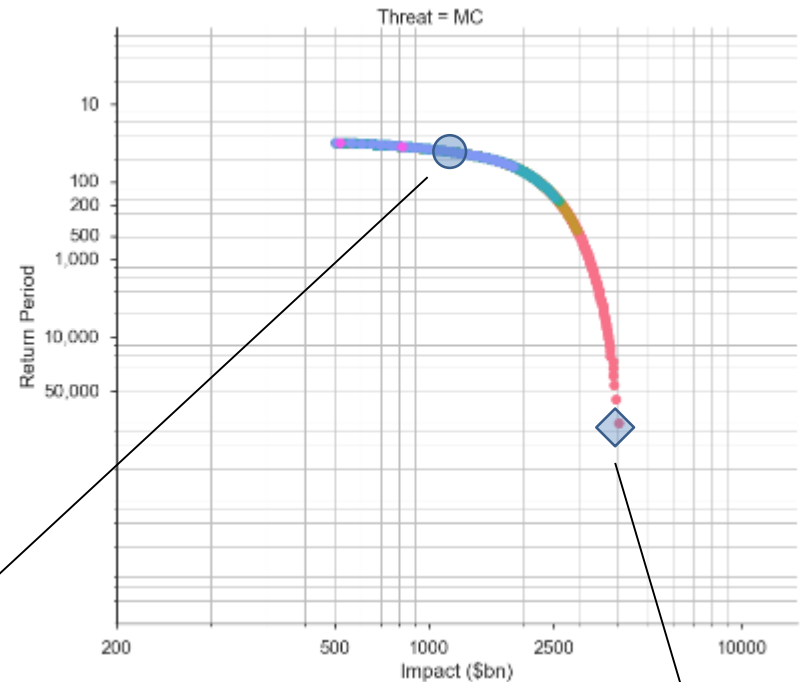
**Impact Boundary**

	UK	China	US	Europe	Developed	Emerging	Frontier
UK	3	1	2	3	2	1	1
China	2	3	2	2	2	2	1
US	3	2	3	3	2	2	2
Europe	3	1	2	3	2	1	1
Developed	1	1	1	1	3	0	1
Emerging	2	1	1	1	1	3	1
Frontier	0	0	0	0	0	1	3

# Scenario Generation Example: Market Crash

- Make minimal assumptions about degree of contagion/network linkages, only maximum degree of contagion
- Assign probability post-scenario generation

	UK	China	US	Europe	Developed	Emerging	Frontier
UK	3	1	2	3	2	1	1
China	2	3	2	2	2	2	1
US	3	2	3	3	2	2	2
Europe	3	1	2	3	2	1	1
Developed	1	1	1	1	3	0	1
Emerging	2	1	1	1	1	3	1
Frontier	0	0	0	0	0	1	3



## Minimum intra-threat contagion:

Market	MC0	MC1	MC2	MC3
United Kingdom	0	44	78	174
China	0	133	309	663
United States	0	329	592	1,315
Europe	0	194	369	813
Developed	0	236	490	1,067
Emerging	0	298	685	1,471
Frontier	0	91	246	518
<b>Loss Total (\$bn)</b>	<b>1,315</b>			

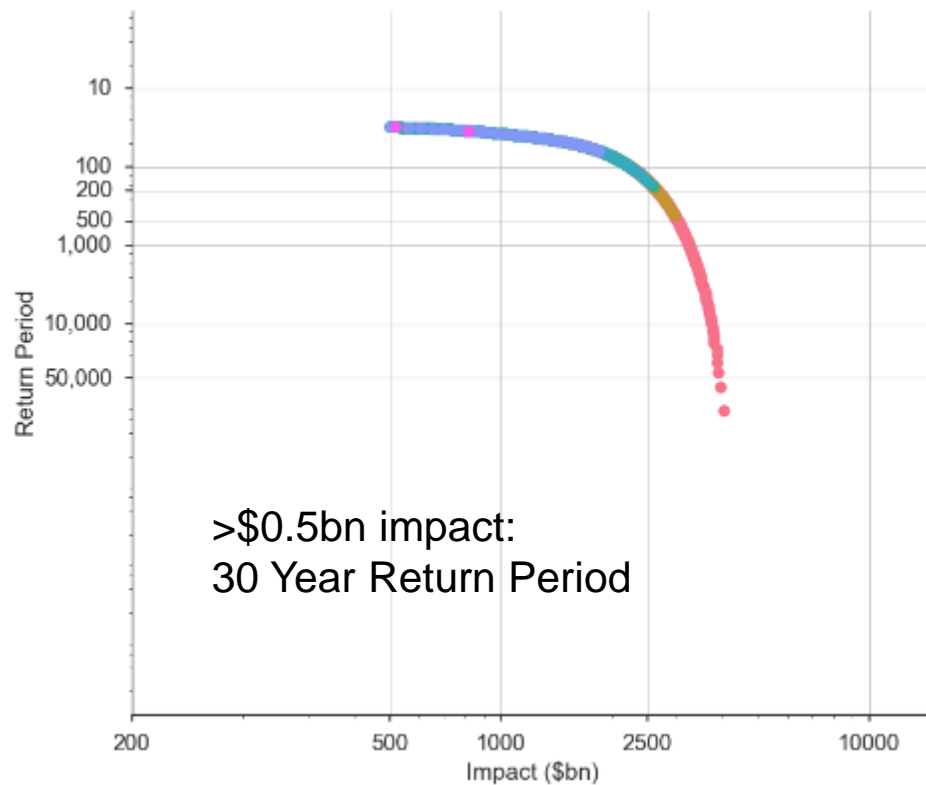
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Frontier	0	91	246	518
<b>Loss Total (\$bn)</b>	<b>4,033</b>			

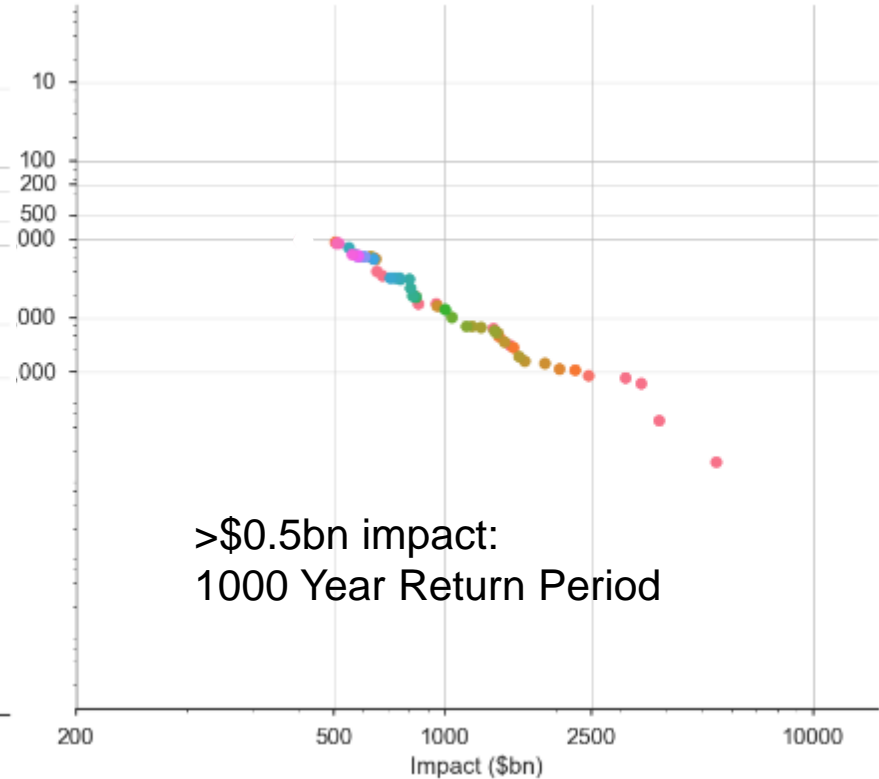
# Market Crash vs Flood EP Curves

- ~3000 Market Crash Scenarios vs. 60 Flood Scenarios
- Have seem to accounted for the most extreme scenarios in market crash
  - Have we captured the tail for floods?

## Market Crash EP Curve



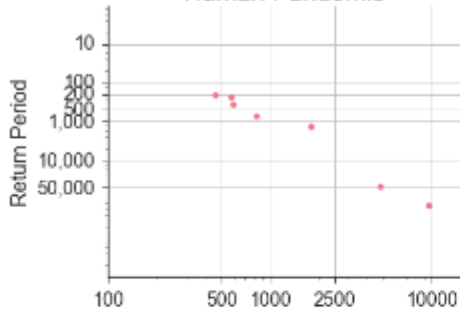
## Flood EP Curve



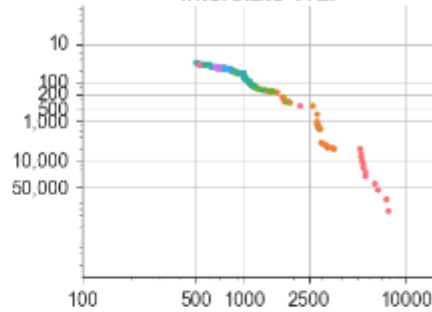


# Threat-level EP Curves

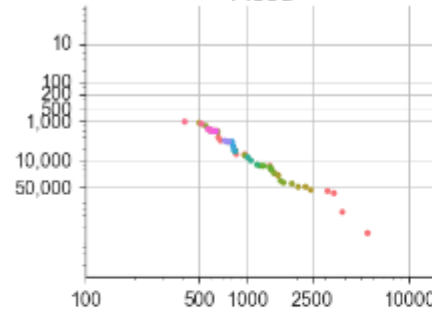
Human Pandemic



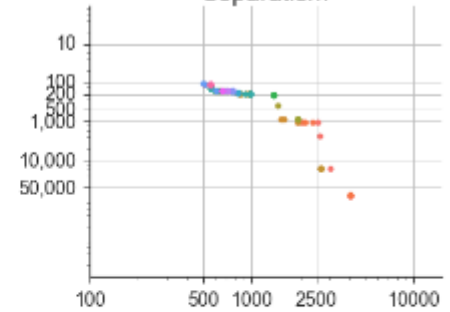
Interstate War



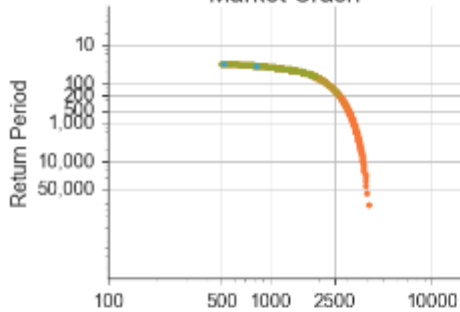
Flood



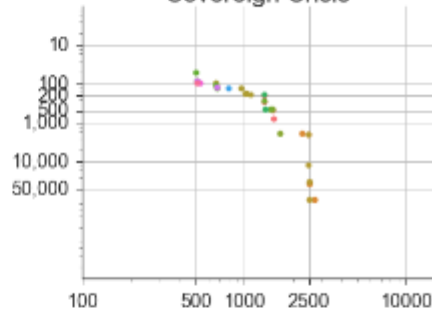
Separatism



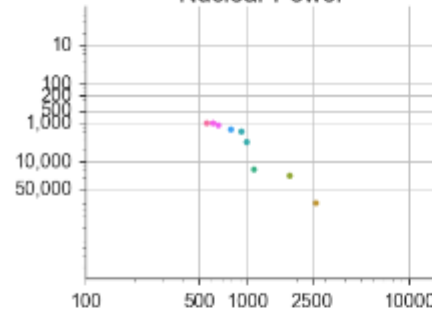
Market Crash



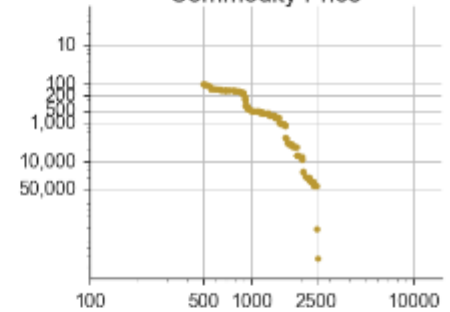
Sovereign Crisis



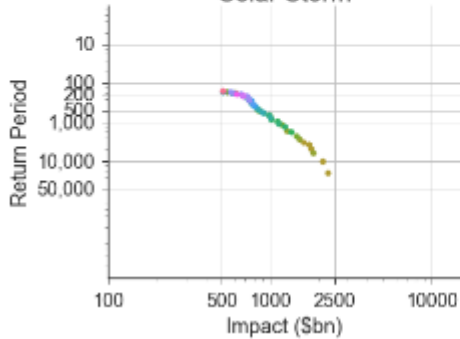
Nuclear Power



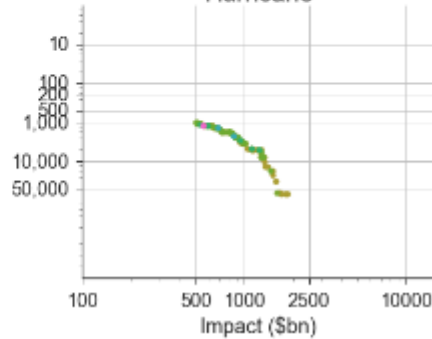
Commodity Price



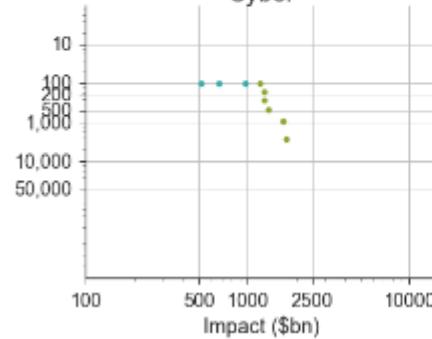
Solar Storm



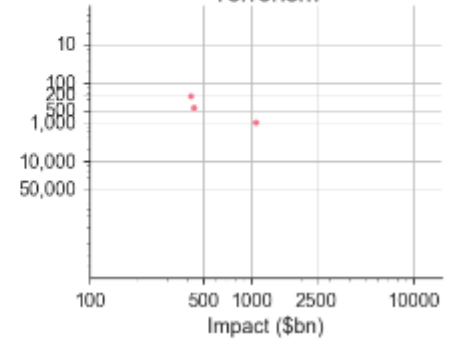
Hurricane



Cyber



Terrorism



# Challenges

- Ensure all threat types capture full range of scenario impacts
  - Threats are vastly different
  - Severity levels don't always represent levels of intensity
- Some threats cause small economic impact on its own, but potentially has significant contagion/cascade effect
- Some threats may have larger impact on GDP (growth/flow), while others have more significant impacts on capital (stock)
- Assign relative probabilities *within* threats, but also ensure probabilities *between* threats make sense

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