Cambridge Global Risk Index 2017
5 December 2016

How Bad Could it Get?
Identifying Trillion Dollar Scenarios

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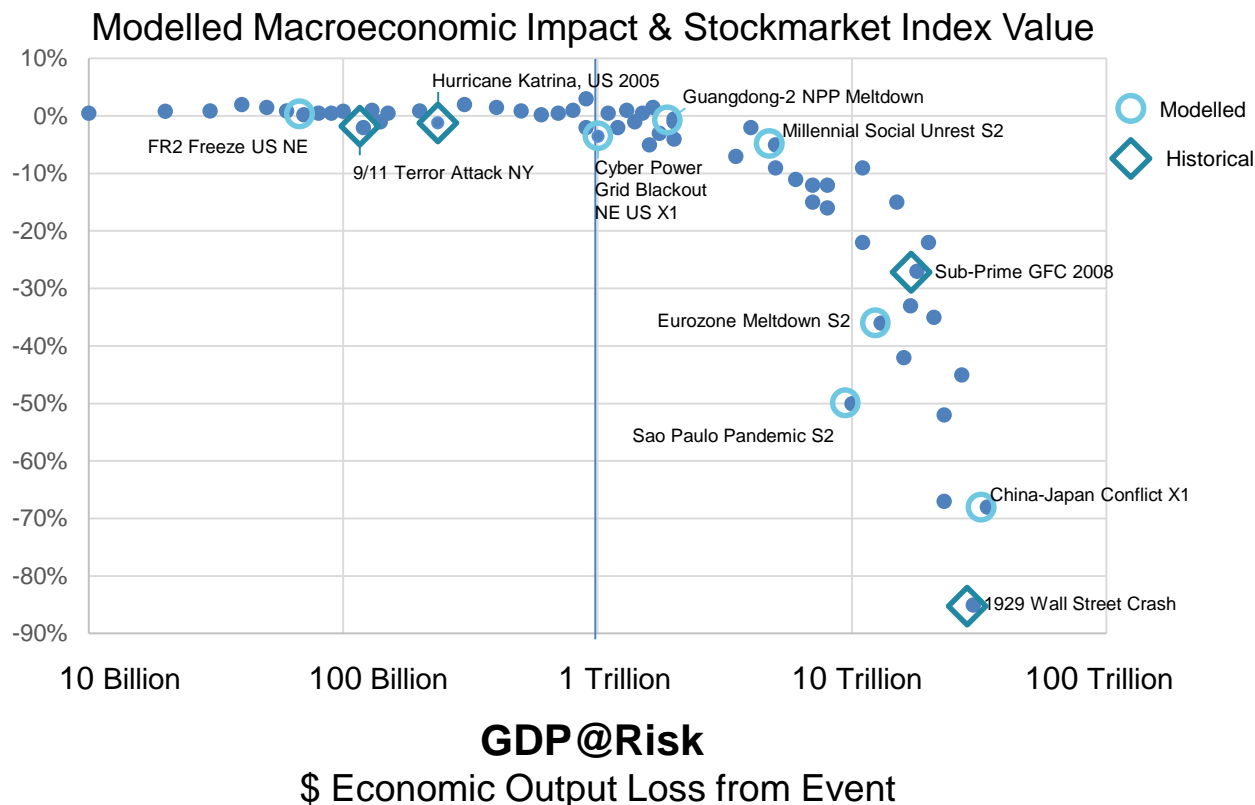
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Defining ALL the Trillion Dollar Event Scenarios

- The economy is relatively robust to minor and localized shocks
- A shock that destroys **a trillion dollars or more** of economic output is sufficiently large to trigger significant stockmarket equity devaluations
    - It becomes systemic and impacts connections and wider scale relationships
- Our objective to define all the likely causes of trillion dollar shocks to the global economy in a scenario event set

Stockmarket Shock
Reduction of S&P500 Index in One Quarter

Modelled Macroeconomic Impact & Stockmarket Index Value

Chart labels: Hurricane Katrina, US 2005; Guangdong-2 NPP Meltdown; Millennial Social Unrest S2; FR2 Freeze US NE; 9/11 Terror Attack NY; Cyber Power Grid Blackout NE US X1; Sub-Prime GFC 2008; Eurozone Meltdown S2; Sao Paulo Pandemic S2; China-Japan Conflict X1; 1929 Wall Street Crash. Legend: Modelled, Historical. Y-axis: 10% to -90%. X-axis: 10 Billion, 100 Billion, 1 Trillion, 10 Trillion, 100 Trillion

GDP@Risk
$ Economic Output Loss from Event

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How One Shock Might Cascade into Another

Consequential Threat
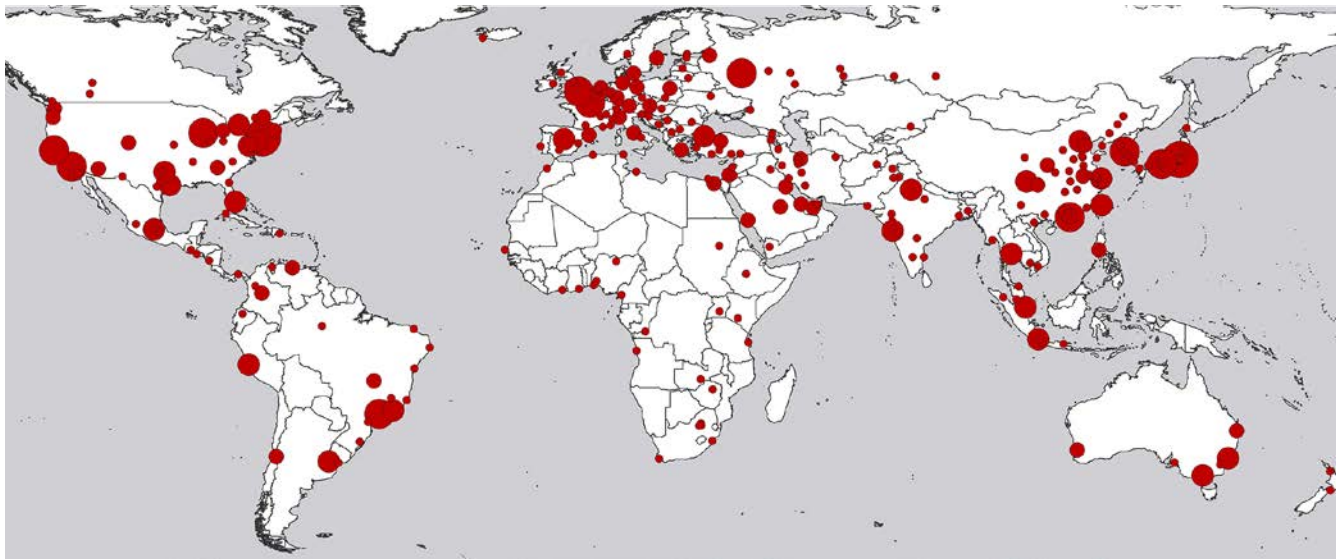
Primary Trigger

Primary Trigger	Threat	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	1	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	0	1	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	1	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	0	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

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**

Cambridge Global Risk Index

300 Cities
22 Threats

Market Crash · Sovereign Crisis · Commodity Prices · Interstate Conflict · Terrorism · Separatism Conflict · Social Unrest · Earthquake · Tropical Windstorm · Windstorm · Tsunami · Flood · Volcanic Eruption · Drought · Freeze · Heatwave · Nuclear Accident · Power Outage · Cyber Attack · Solar Storm · Human Pandemic · Plant Epidemic

- For each threat and each city we model the effects of Local Impact Severities (LIS):
- Estimated loss to the GDP economic output of each city from 3 levels of severity

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A Scenario is Defined By…

Interstate Conflict Scenario: **IC04**
Name: **Saudi Arabia & Iran**
Description: **Bilateral border conflict between two medium powers**

CRS City ID	City Name	Local Impact Severities ($US bn)		
		IC1 (small) City mobilized for war, but not attacked; mobilization switches civilian commerce to military production; population gripped by fear, consumer demand drops, parts of population flees. Investor confidence is affected; Conflict lasts a year.	**IC2 (medium)** City suffers sporadic attack from occasional missiles or aerial bombardment, possible damage to city infrastructure from military cyber attack; City is mobilized for war; significant emigration of population from city. Investors withdraw	**IC3 (large)** City is the target of strategic bombing by enemy forces, destroying industrial and commercial output and military facilities in the city; Major emigration by population. Possible rebuilding afterwards by major injection of capital. Conflict lasts 3 years.
SAU_ARI	Riyadh	43.6	**224.6**	391.8
SAU_JED	Jeddah	42.4	**218.6**	381.0
IRN_TER	Tehran	29.2	167.4	**296.4**
IRN_KHR	Mashhad	9.3	**53.8**	95.0
IRN_ISF	Isfahan	6.2	**35.9**	63.4
IRN_34807	Karaj	**5.4**	31.4	55.4
IRN_AEK	Tabriz	5.4	31.2	**55.0**
IRN_FAR	Shiraz	4.7	27.4	**48.3**
IRN_KHZ	Ahvaz	3.8	**21.8**	38.4
IRN_QOM	Qom	**3.7**	21.5	37.8
IRN_38338	Kermanshah	3.0	**17.6**	31.0

Total GDP@Risk ($US bn)	**1,009**
Estimated Return Period	**600**

Subject Matter Specialists and Collaborators

Finance, Economics & Trade

Cambridge Centre for Financial History
Dr. Duncan Needham, *Director*

Financial Network Analytics Ltd.
Dr. Kimmo Soramaki, *CEO*

Office of Financial Research U.S. Federal Reserve
Dr. Mark Flood, *Director*

Oxford Economics
Keith Church, *Senior Economist*

Geopolitics & Security

Cytora Ltd.
Richard Hartley *CEO*
Joshua Wallace, *Product Director*

International Centre for Political Violence and Terrorism Research
Prof. Rohan Gunaratna, *Director*

Natural Catastrophe & Climate

Risk Management Solutions Inc.

Cambridge Architectural Research Ltd
Dr. Robin Spence, *Director*

CatInsight
Dr. Richard Dixon, *Meteorologist*

Technology & Space

Cambridge Computer Labs CyberCrime Centre
Prof Frank Stajano, *Director*

British Antarctic Survey
Dr. Richard Horne, *Director, Space Weather*

Infrastructure Transitions Research Consortium
University of Oxford
Dr. Scott Thacker, *Infrastructure Systems*

Health & Humanity

Cambridge Infectious Disease Interdisciplinary Research Centre
Prof. James Wood, *Chair, CID*
Dr. Colin Russell, *Royal Society Research Fellow*

University of Cambridge Dept of Plant Sciences
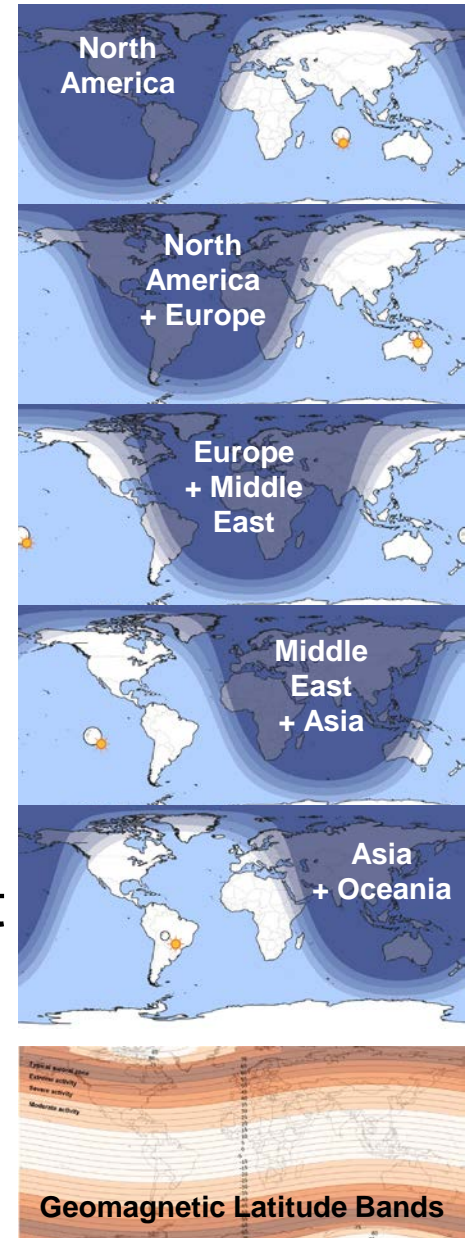Dr. Matt Castle
Senior Research Fellow

AgRisk
Dr. Claire Souch, *Product Manager*

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How do we Devise the Scenarios?

		ID	Threat	Phase	Hazard Map	Severity Scale	Cause	Projection	Uncertainty
Natural Catastrophe & Climate									
	1.1	EQ	**Earthquake**	1	United States Geological Survey; GSHAP	Ms (Surface-wave Magnitude)	Natural	Constant	Low
	1.2	VE	**Volcanic Eruption**	1	Smithsonian Institute of Volcanology	VEI (Volcanic Explosiivity Index)	Natural	Constant	Medium
	1.3	HU	**Tropical Windstorm**	2	EM-DAT; Pacific Research Center; Munich Re	Saffir-Simpson CAT Hurricane Scale	Natural	CC Trend	Low
	1.4	WS	**Temperate Windstorm**	2	EM-DAT Windstorm Database	Beaufort Wind Scale	Natural	CC Trend	Low
●	1.5	FL	**Flood**	1&2	UNEP/DEWA/GRID-Europe Flood Risk Rating	Depth and velocity of flood water	Natural	CC Trend	Low
	1.7	TS	**Tsunami**	2	NOAA NCDC Historical Tsunami Database	Run-up height	Natural	CC Trend	Medium
	1.8	DR	**Drought**	2	US National Center for Atmospheric Research	Palmer Drought Severity Scale	Natural	CC Trend	Medium
	1.10	FR	**Freeze**	2	Global Climate Zoning Map	Degree-Days below 0C	Natural	CC Trend	Medium
	1.11	HW	**Heatwave**	2	Global Climate Zoning Map	Degree-Days Above 32C	Natural	CC Trend	Medium
Financial, Trade & Business									
	2.1	MC	**Market Crash**	1	IMF Banking Network Core-Periphery Designation	S&P500 Index reduction	Man-Made	Dynamic	High
●	2.2	SD	**Sovereign Crisis**	1	S&P National Credit Ratings	% Devaluation of national currency	Man-Made	Dynamic	Medium
	2.3	OP	**Commodity Prices**	2	UN imported oil intensity of GDP output	% increase in oil price (Brent Crude)	Man-Made	Dynamic	Medium
Political, Crime & Security									
	3.1	IW	**Interstate Conflict**	1	Cytora Interstate Conflict Scenario Set	War Magnitude Scale	Man-Made	Dynamic	High
	3.2	SP	**Separatism Conflict**	1	Encyclopedia of Modern Separatist Movements	Civil War Intensity (deaths)	Man-Made	Dynamic	Medium
	3.3	TR	**Terrorism**	1	IEP START Global Terrorism Index	Terrorism Severity Scale	Man-Made	Dynamic	Medium
	3.4	SU	**Social Unrest**	2	Cytora Social Unrest Event Index	Social Unrest Severity Scale		Dynamic	Medium
Technology & Space									
	4.1	PO	**Power Outage**	2	Nation Master Electrical Outage Report	City-Days of Outage	Man-Made	Constant	Medium
	4.2	CY	**Cyber Attack**	1	McAfee International Cyber Risk Report	Cyber Magnitude & Revenue@Risk	Man-Made	Dynamic	High
●	4.3	SS	**Solar Storm**	2	US National Oceanic and Atmospheric Administration	US NOAA Space Weather Scale	Natural	Constant	High
	4.4	NP	**Nuclear Accident**	2	World Nuclear Association Information Library	Intntl Nuclear Events Scale (INES)	Man-Made	Constant	Low
Health & Environmental									
	5.1	HE	**Human Pandemic**	1	Emerging Infectious Diseases, Institute of Zoology	US CDC Pandemic Severity Index	Natural	Dynamic	Medium
	5.2	PE	**Plant Epidemic**	2	Wallingford Distribution Maps of Plant Diseases	Staple Crop (Wheat) Price Index	Natural	Dynamic	Medium

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Solar Storm Scenarios

- **Solar storms can hit different regions on the night side of Earth with different severity levels**
  - Storms consist of charged particles from a Coronal Mass Ejection being accelerated towards Earth
  - Primary impacts are widespread blackouts caused by disruption to electricity network assets
- **We consider five discrete 'night shadows' and six geomagnetic latitude bands**
- **Storm scenarios consider, for each of the night shadows, different severity levels at each geomagnetic latitude band**
- **We infer from historical events the likelihood of a storm impacting a geomagnetic latitude at a given severity level**
  - Overall scenario probabilities are then estimated from bottom-up city-level probabilities

North America

North America + Europe

Europe + Middle East

Middle East + Asia

Asia + Oceania

Geomagnetic Latitude Bands

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Flood Scenarios

- Flood scenarios consider the potential for
  - Storm surge flooding
  - Riverine, pluvial and flash flooding related to extreme rainfall and snowmelt
  - And a combination of these causes
- Scenarios are defined either as single events or multiple geographically correlated events within a 12 month period
- Ten scenarios identified by exploration of correlation structures
  - Two single event scenarios
    - Kanto Plain floods (Tokyo, Yokohama, Chiba, Kawasaki and Saitama)
    - North Sea floods (Amsterdam, the Hague, Rotterdam and London)
  - Eight multi event scenarios
    - Northeast USA floods (Boston, New York, Philadelphia, Baltimore and Washington DC)
    - California floods (San Diego, Los Angeles, San Jose and San Francisco)
    - West Europe floods (Paris, Rotterdam, the Hague, Lyon, Geneva, Turin, Milan, Dortmund, Cologne, Dusseldorf and Frankfurt)
    - Pearl River Delta floods (Hong Kong, Shenzhen, Guangzhou and Dongguan)
    - Great Lakes floods (Toronto, Ottawa, Chicago and Detroit)
    - Lower Yangtze River floods (Shanghai, Changzhou, Hefei, Nanjing, Suzhou, Wuxi and Hangzhou)
    - Central Europe floods (Hamburg, Berlin, Prague, Munich, Vienna, Budapest, Bratislava, Ljubljana and Zagreb)
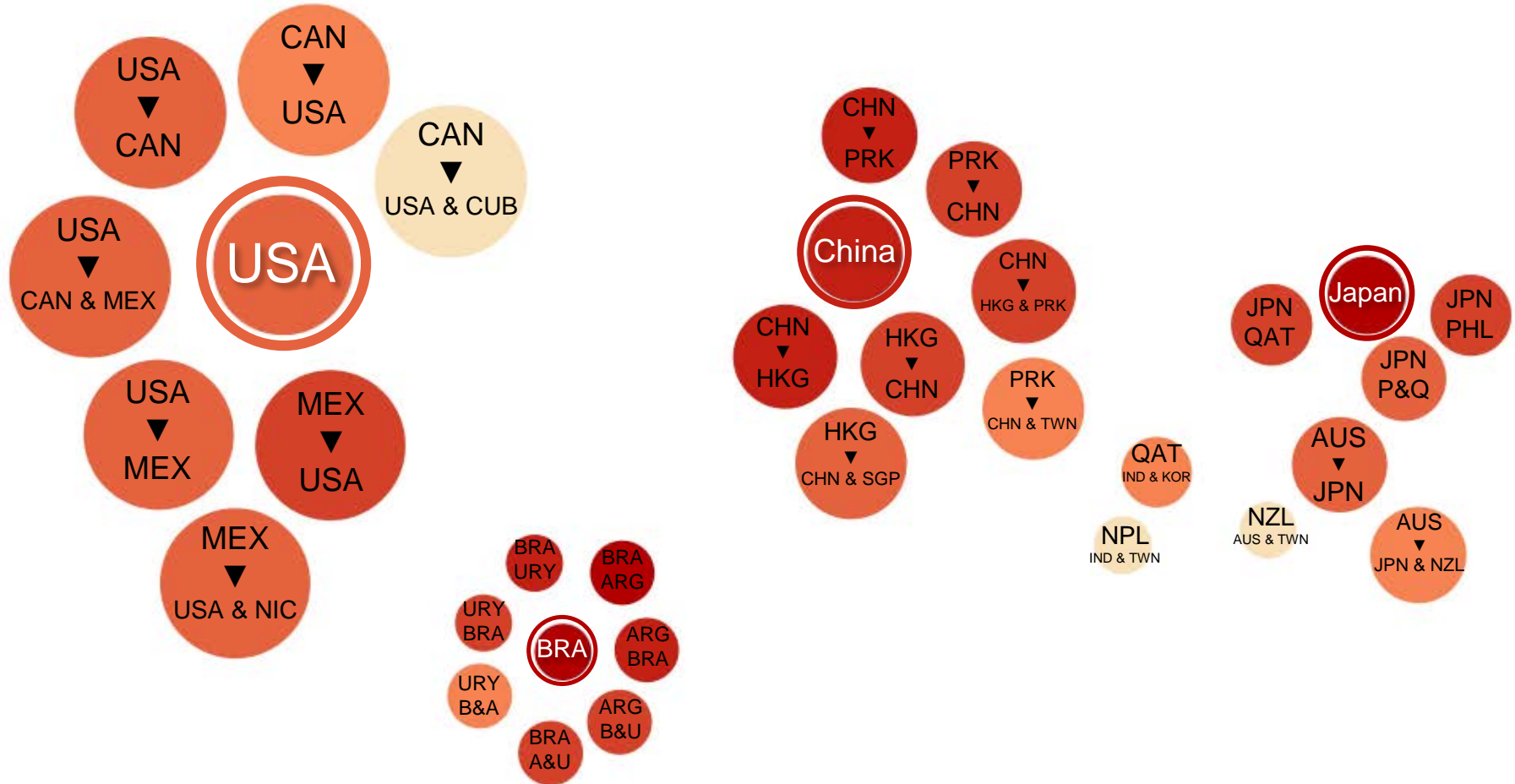   - Bohai Economic Rim floods (Beijing, Dalian, Qingdao, Shenyang and Tianjin)

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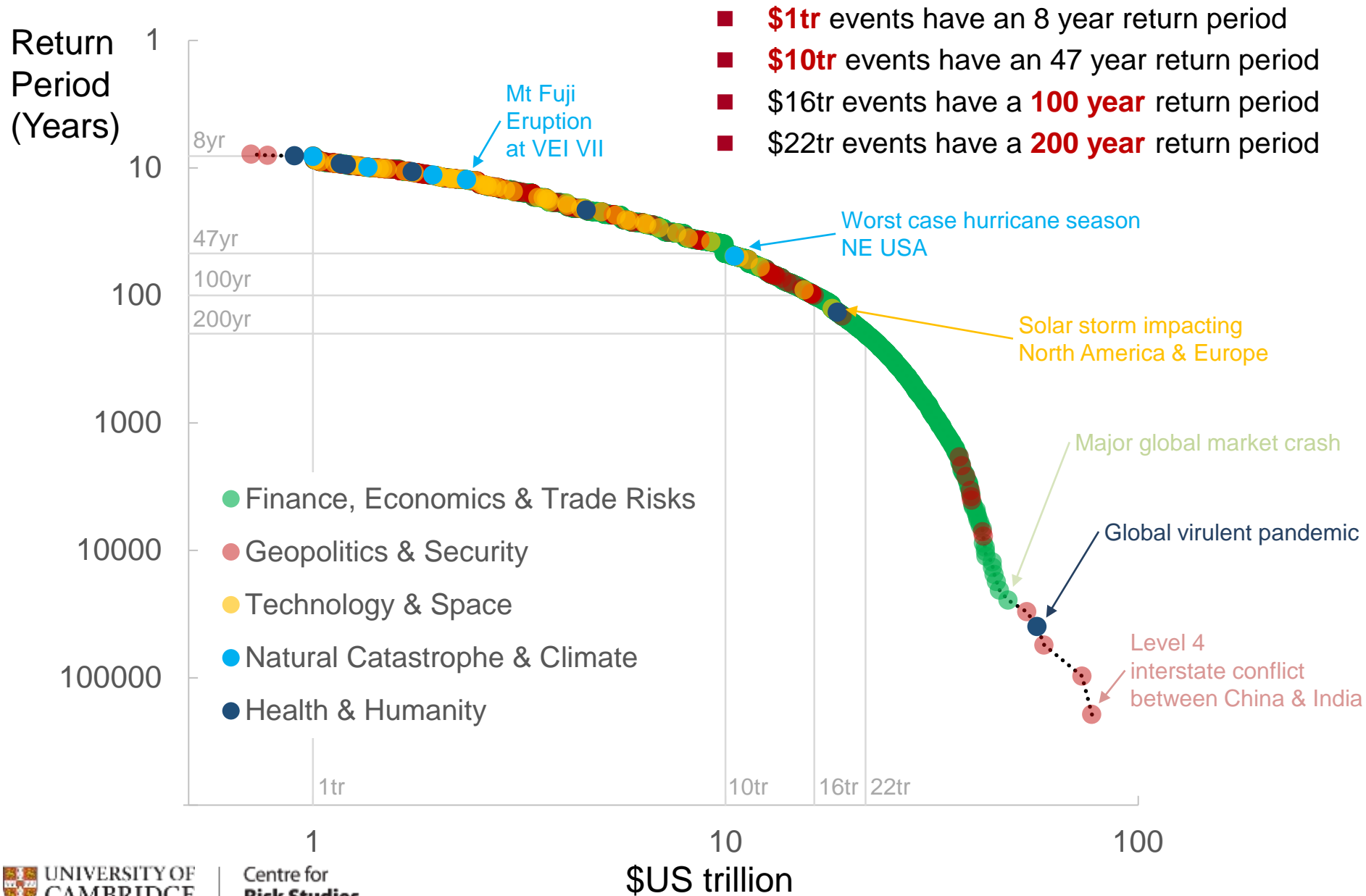**Risk Studies**

Flood Scenarios
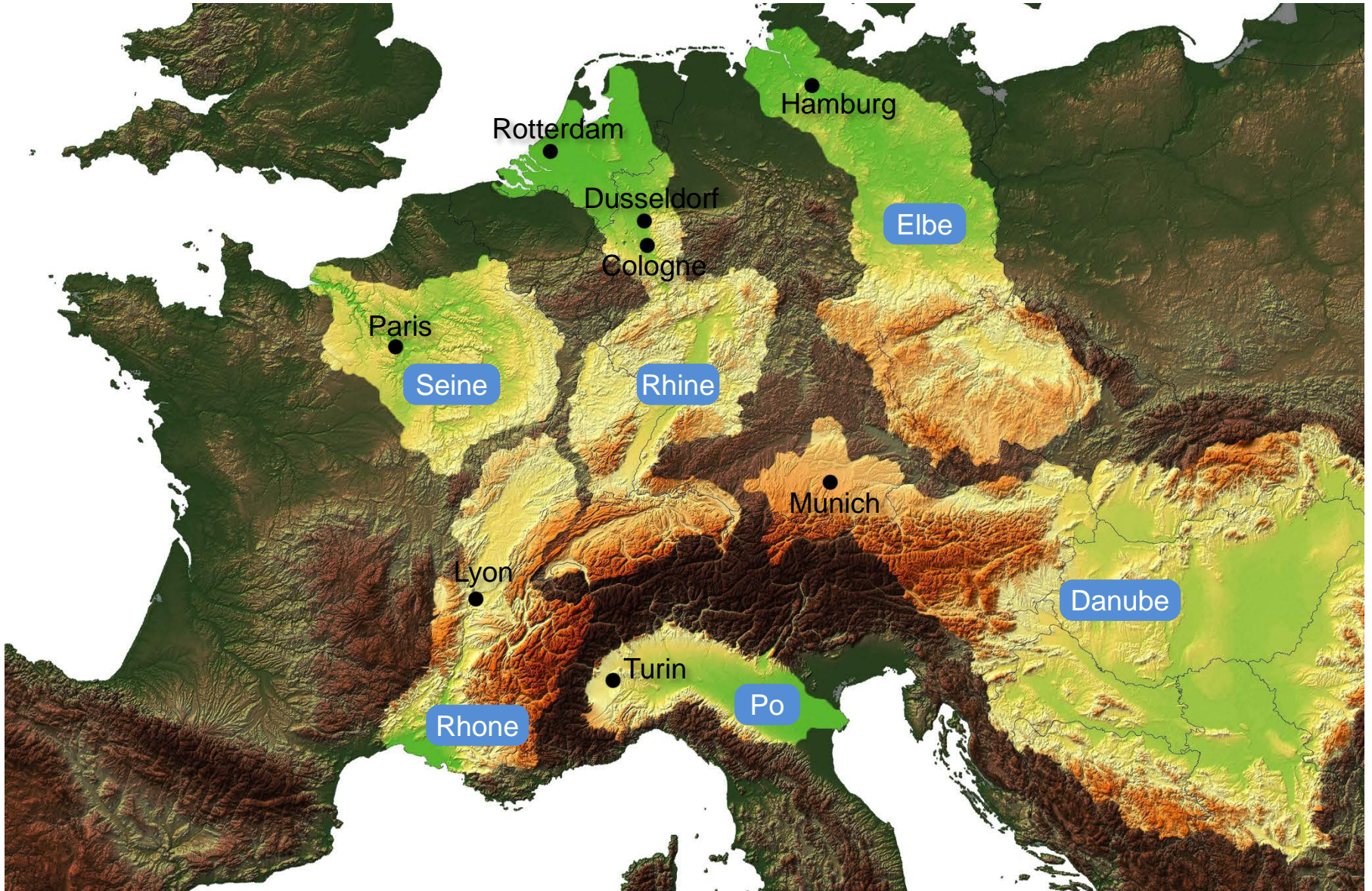
Sovereign Crisis Scenarios

- **Scenarios are defined at a country-level**
  - All cities within an affected country are assigned the same LIS severity level
- **We first define a set of scenarios that consist of a single sovereign crisis**
  - 5 year CDS spreads are used to estimate annual probability of crisis
  - E.g., Brazil is estimated to have a 3-4% annual chance of a sovereign crisis
- **The UN Comtrade trade network is used to identify countries that could fall into crisis as a consequence of another country being in crisis**
  - The probability of a cascading crisis is affected by the strength of bilateral trading relationships
  - E.g., a Brazilian crisis could trigger a crisis in Argentina
- **Another set of scenarios then define double and triple sovereign crisis cascades**
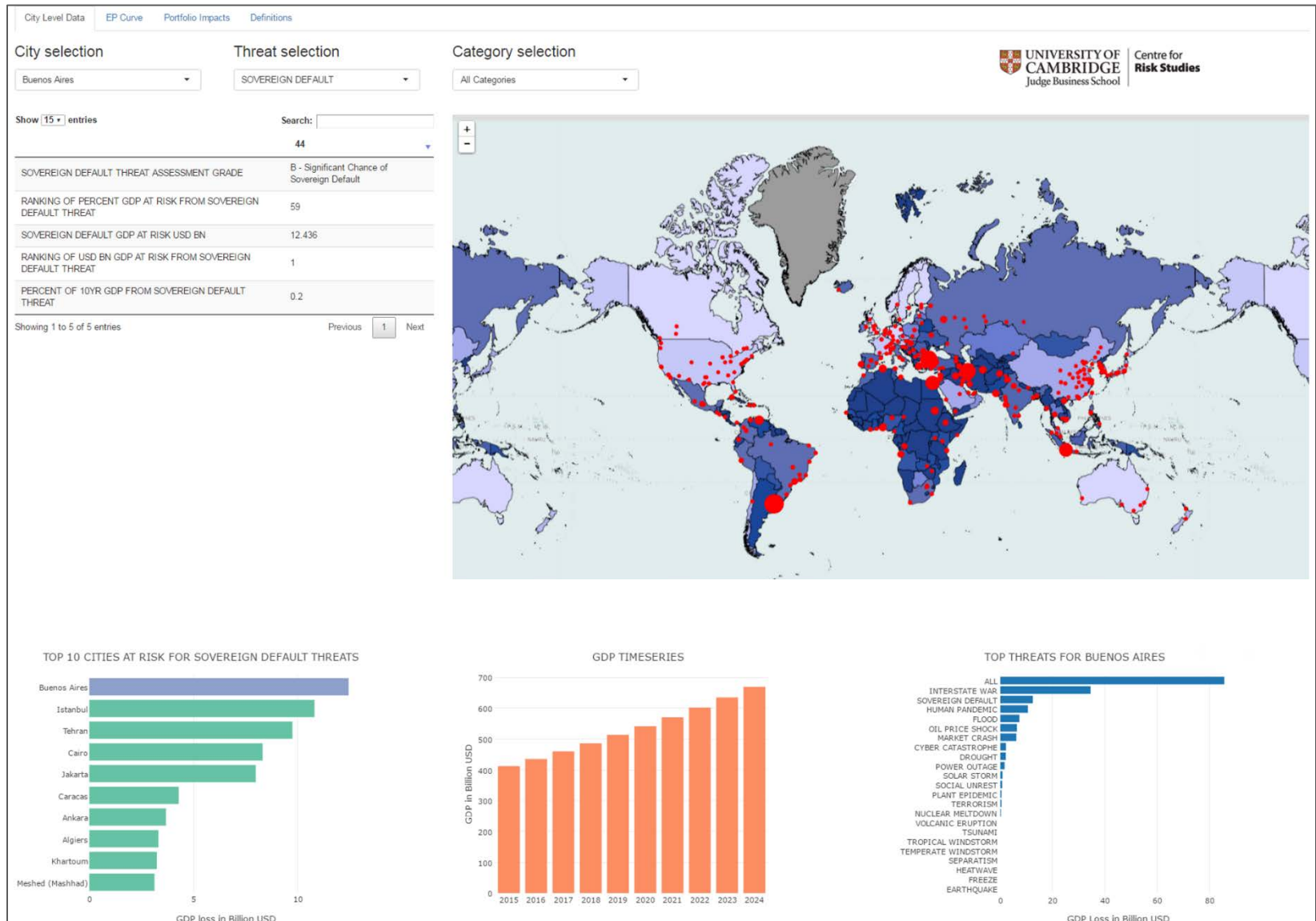
Sovereign Crisis Scenarios

Global Catastrophe Exceedance Probability Curve

Return Period (Years)

- **$1tr** events have an 8 year return period
- **$10tr** events have an 47 year return period
- $16tr events have a **100 year** return period
- $22tr events have a **200 year** return period

Mt Fuji Eruption at VEI VII

Worst case hurricane season NE USA

Solar storm impacting North America & Europe

Major global market crash

Global virulent pandemic

Level 4 interstate conflict between China & India

- Finance, Economics & Trade Risks
- Geopolitics & Security
- Technology & Space
- Natural Catastrophe & Climate
- Health & Humanity

$US trillion

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Cambridge Global Risk Platform

Dashboard developed in RStudio Shiny accessing data from Cambridge Global Risk Model via REST API

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