



## World City Risk 2025

August 2014

# World City Risk Analysis

Understanding the Economics of Urban Catastrophes

Centre for  
**Risk Studies**



UNIVERSITY OF  
CAMBRIDGE  
Judge Business School

# Acknowledgements

The Cambridge Centre for Risk Studies acknowledges the generous support provided for this research by Lloyd's



Results and outputs of this research do not imply any endorsement by Lloyd's

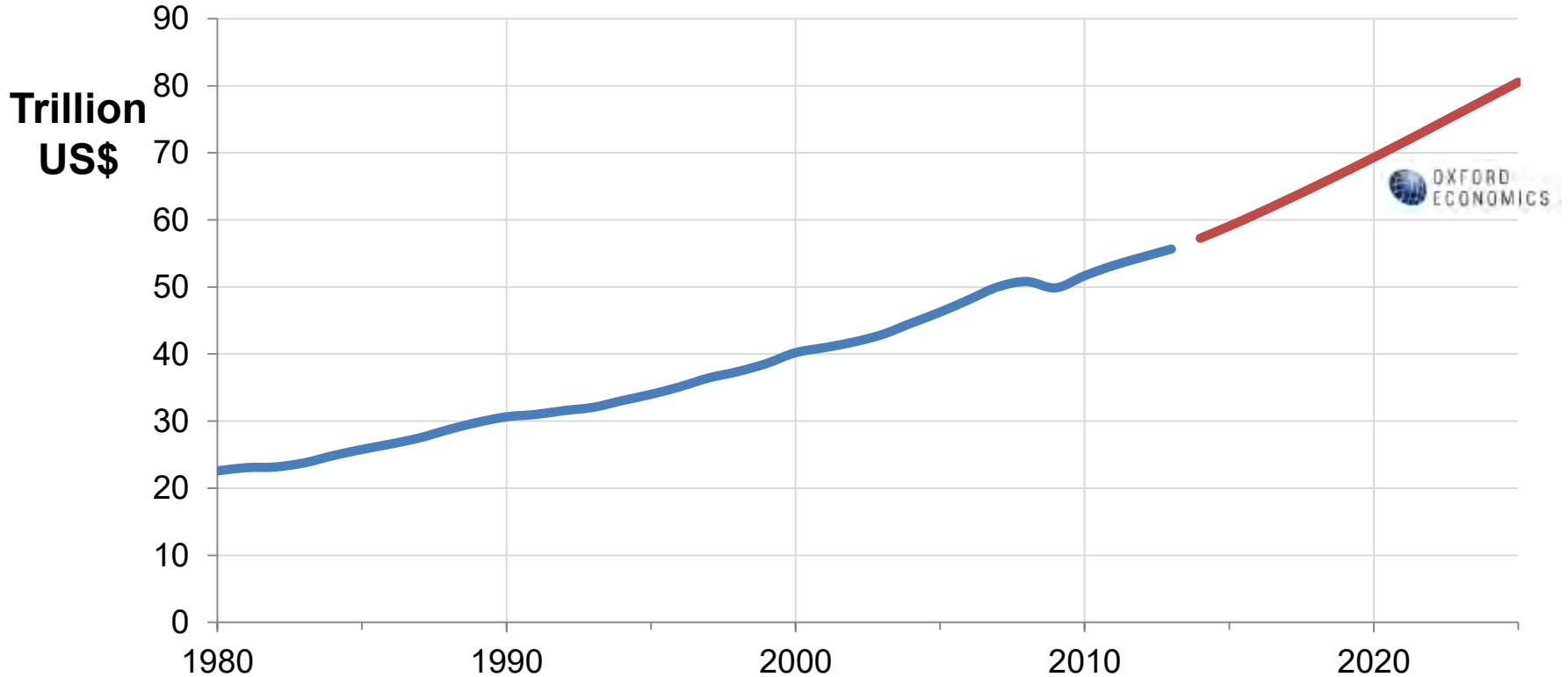
Any errors and omissions are entirely those of the research team of the Cambridge Centre for Risk Studies

We acknowledge the generous support from all of the supporters of the Centre for Risk Studies for the development of the Cambridge Risk Framework, Catastronomics methodologies, and underlying datasets used in this analysis

# Agenda

- Context
  - Economic growth, Cities and Catastrophes
- The Cambridge Analysis
  - Developing the threat models
  - How we analyze the risks to cities
- Presentation of Results
- Insights and Narrative that this provides

# Future Outlook for Global Economy is Rosy



Global GDP 1980: **\$22.5 Trillion**

Historical Average Annual Growth Rate 1980-2006: **3.0%**

Global GDP 2013: **\$55.6 Trillion**

OE Economic Forecast Global GDP 2025: **\$80.5 Trillion**

Forecast Size of Global Economy in 2025, relative to today: **145%**

Forecast Average Annual Growth Rate 2014-2025: **3.2%**



South Sea Bubble  
1720



# But the Road to Growth is Rocky



World War II  
1939



American Revolution  
1775-1783



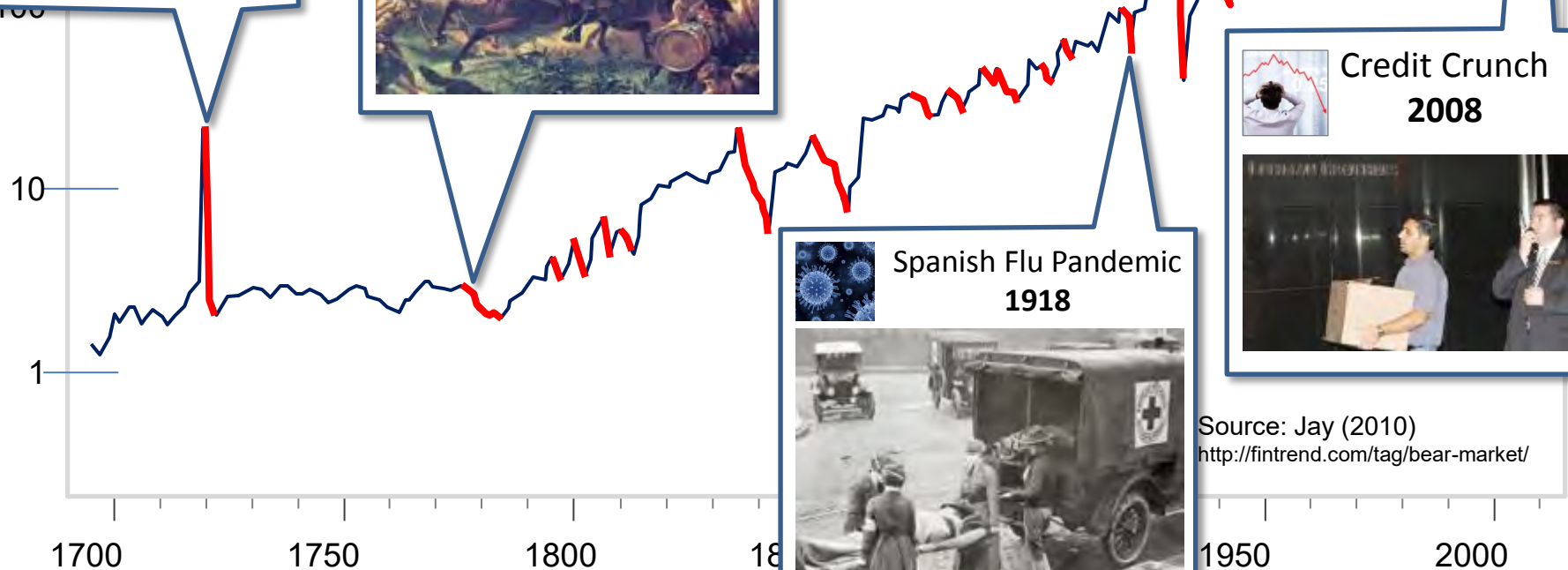
Spanish Flu Pandemic  
1918



Credit Crunch  
2008



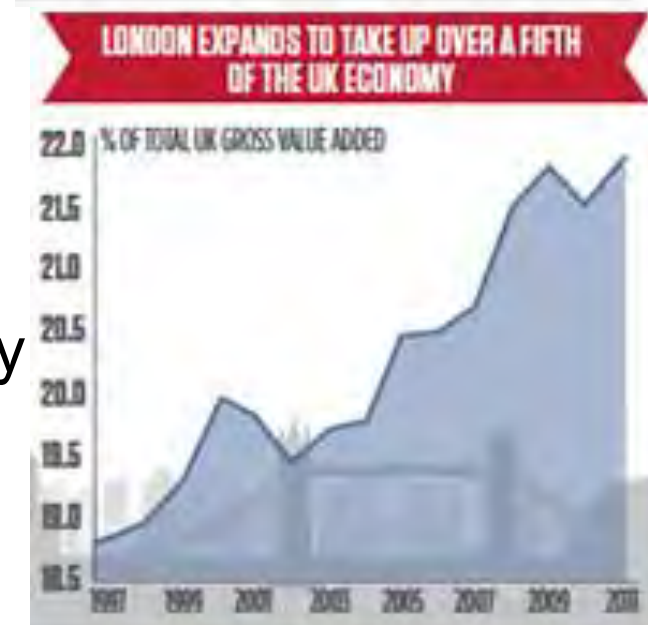
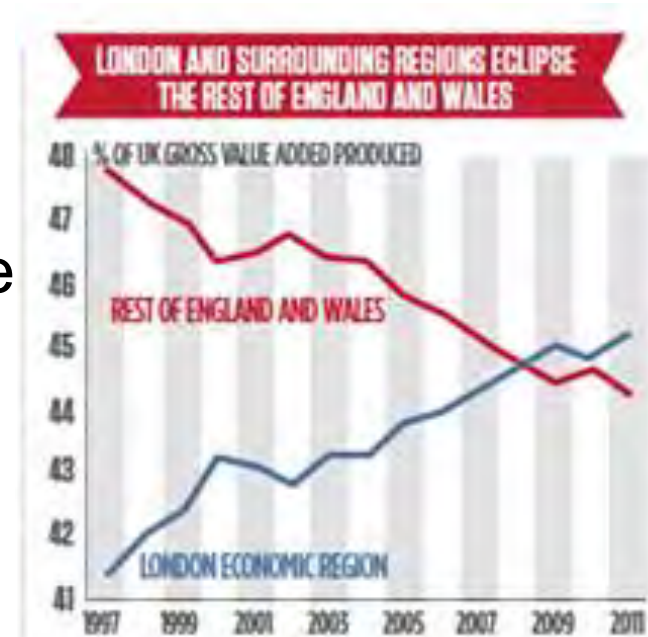
Source: Jay (2010)  
<http://fintrend.com/tag/bear-market/>





# Growing Concentration in Wealth Creation

- Wealth creation worldwide is currently going through an unprecedented phase of concentration
- Major cities are emerging as international hubs of global wealth creation
- They are sucking commercial activity from smaller cities and towns
- For example the London economic region has increased its share of UK output from 15% in 1960s to 45% today



# The 300

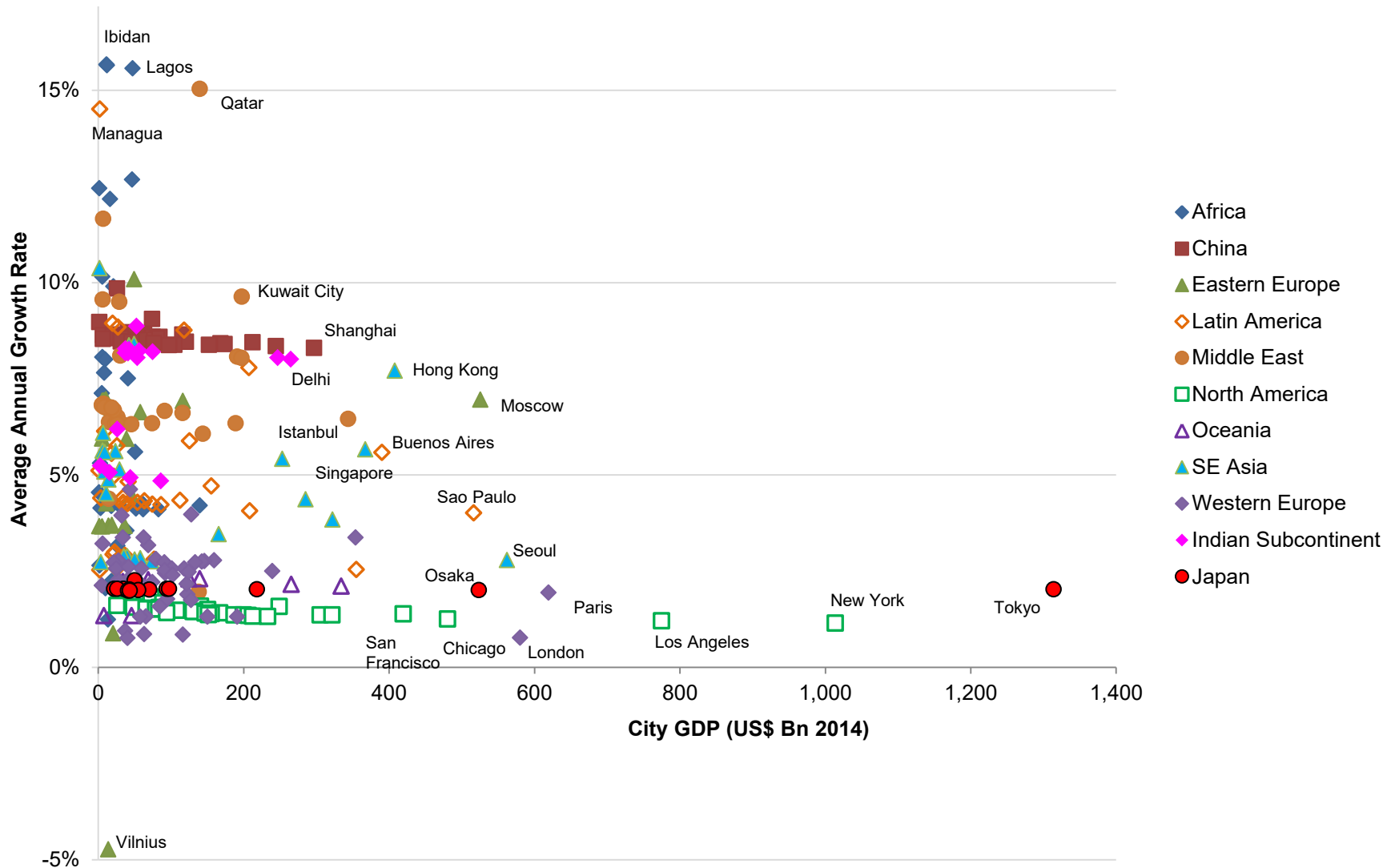


We picked the 'A List' of the world's cities for this analysis, which:

- Are responsible for **half** of the World's GDP today
- Will be responsible for **two-thirds** of the World's GDP in **2025**
- Are the largest cities in the 50 largest economies in the world
  - Top 25 cities in US (#1 economy) and top 32 cities in China (#2 economy)
  - Between 5 and 12 top cities for each of the rest of the top 17 economies
- Include all cities over 3m population in the world
- Consist of half of the world's capital cities

# Cities, GDP and Projected Growth Rates

## Growth Rates and GDP Size





# The Rocky Road to Growth for the 300

Economists like to project smooth growth curves but that's unrealistic. The 300 cities have not had a smooth path to the world's A list.

In the past 50 years they have:

- Lost more than a million of their citizens to earthquakes
- 32 cities have had to cope with a volcanic eruption within 100km of the city
- Half of them have suffered a serious flood
  - a quarter of them have been flooded more than 5 times
- Seen a third or more of their economic capital wiped out by stockmarket crashes 5 times on average
- Had to cope with the financial crisis of their government defaulting on sovereign debts on more than 50 different occasions
- Been involved in more than 50 wars
  - More than [a dozen] cities have been bombed to ruins
- Seen political instability through separatism and social unrest of its citizens, including being embroiled in over a dozen civil wars
- Suffered thousands of terrorist attacks, including 1000 car bombs in city centres
- Had technology failures that have degraded the IT productivity tools that underpin their economic growth, including experiencing thousands of cyber attacks
- Collectively had to combat the outbreak of a new type of disease five times

# What Should Businesses Expect Over the Next Decade?

- We analyse the future threats to the economic growth of the world's most important cities
- We use the technique of 'castronomics' to measure the economic impacts of future catastrophes
- We have developed a Risk Atlas to map the threats to these cities around the world
- We have achieved this for 23 of the worst threats of catastrophic events that could reduce economic growth
- We have compiled this data into a risk model that calculates the amount of GDP that could be lost from future catastrophes in these 300 cities
- **This identifies the growth-engine cities most at risk from different types of future catastrophes**

# Phase 1 Catastrophe Threats

Delivered 21 July 2014



Earthquake



Volcanic  
Eruption



Flood



Market  
Crash



Sovereign  
Default



Interstate  
Conflict



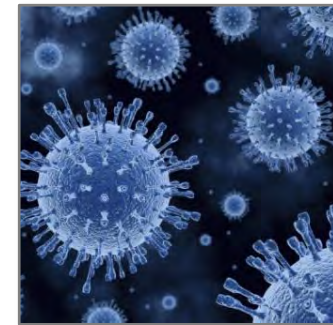
Separatism



Terrorism



Cyber  
Catastrophe



Human  
Epidemic

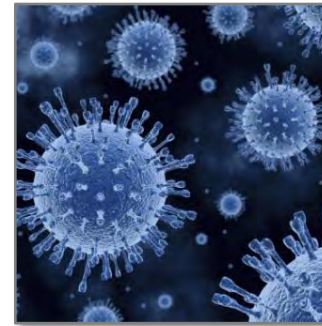
**Which two of these have caused international crises since then?**

# Two International Crises from Our Phase 1 Threat List have Occurred Since 21 July...



Sovereign  
Default

**Default of Argentina**  
31 July 2014



Human  
Epidemic

**Ebola Outbreak**  
August 2014

**Forbes** New Posts Most Popular Lists

LISTS: THURSDAY 8 JULY 10:27 AM

## Argentina In Default

Everyone Lost, From Cristina Kirchner And Paul Singer's Elliott To Judge Griesa



Cristina Kirchner with Finance Minister Axel Kicillof to her left - (Photo credit: Ministerio de Cultura de la Nación)

Things couldn't have come out worse. Everyone lost: Argentina defaulted on its sovereign debt for the second time in nearly 13 years, the holdout bond holders were left empty handed, and Federal Judge Thomas Griesa's strategy to force Argentine to negotiate a settlement with the so-called venture funds failed. Furthermore, a last ditch effort by a group of Argentina bankers led by Banco Macro's Jorge Brito fell through at the last second.

**BBC** Sign in News Sport Weather iPlayer TV Radio More...

**NEWS BUSINESS**



**Ebola crisis: Toll on regional economies**

15 August 2014 Last updated at 09:50 BST

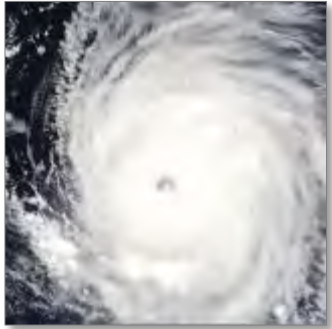
As the death toll from Ebola mounts across west Africa, there is growing concern about what the region's economies.

Our Africa Business Correspondent, Lerato Mbele, looks at the economic picture on the ground.

[Read more](#)



# Phase 2: Additional Catastrophe Threats



Windstorm

- Tropical
- Temperate



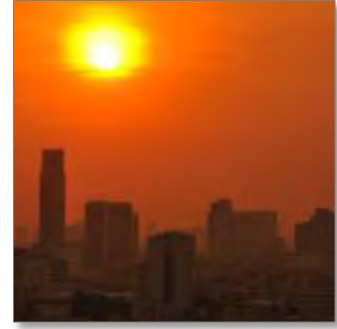
Tsunami



Drought



Freeze



Heatwave



Oil Price Shock



Electrical  
Power Outage



Solar Storm



Nuclear Power  
Plant Accident



Plant Epidemic  
Crop Failure



1



# Natural Catastrophe & Climate



Earthquake



Volcanic  
Eruption



Windstorm  
• Tropical  
• Temperate



Flood



Tsunami



Drought



Freeze



Heatwave

2



# Financial, Trade & Business



Market  
Crash



Sovereign  
Default



Oil Price  
Shock

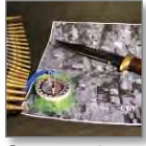
3



# Politics, Crime & Security



Interstate  
War



Separatism



Terrorism



Social  
Unrest

4



# Technology & Space



Power  
Outage



Cyber  
Catastrophe



Solar  
Storm

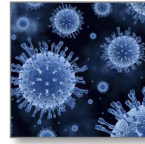


Nuclear  
Meltdown

5



# Health & Environmental



Human  
Epidemic



Plant Epidemic  
Crop Failure

23 Threats Modelled

# Why are These the Threats to Worry About?

- Cambridge CRS has conducted an extensive review of potential causes of macroeconomic shocks
- We went through 1000 years of historical records to capture historical examples of shocks to society
- The review included
  - A. Chronological Histories
  - B. Disaster Catalogues
  - C. Counter-factual evidence
  - D. Scientific conjecture
  - E. Peer review
  - F. Other Approaches
- We developed a comprehensive Taxonomy of Threats
- This consists of 11 broad families of threat with around 50 threat types
- The 23 threats modelled here are from this taxonomy
- They represent the most important risks from the known threat universe



The Cambridge Centre for Risk Studies publication that describes the development of the Cambridge Threat Taxonomy

Available for Download from Website:  
[CambridgeRiskFramework.com](http://CambridgeRiskFramework.com)

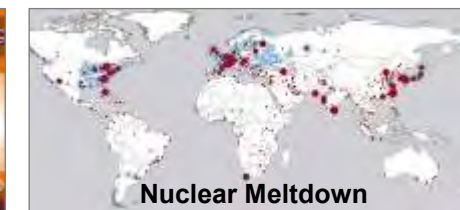
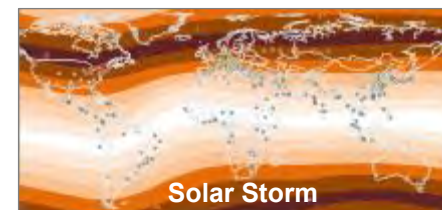
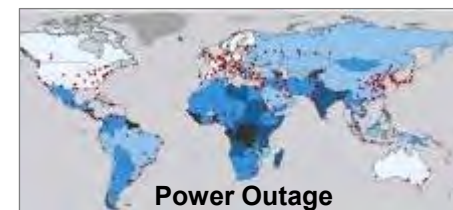
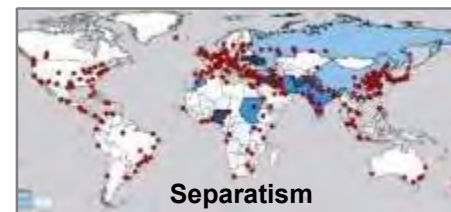
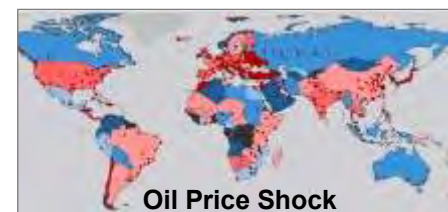
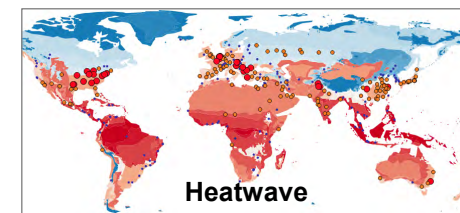
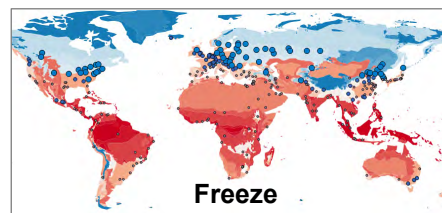
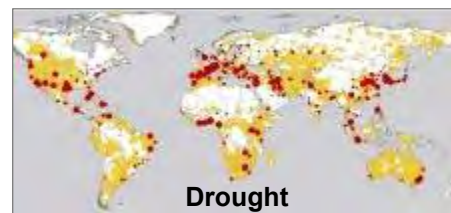
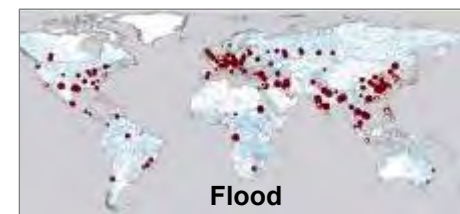
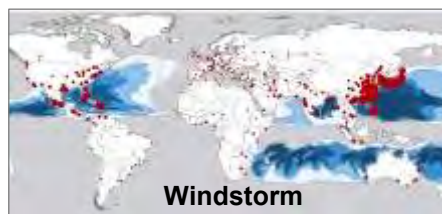
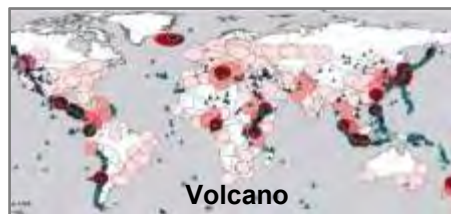
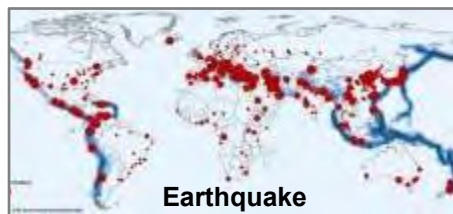
# A Model for Each Threat

- Identification of the authoritative science about each threat
  - Key data repository
- Geographical mapping of frequency and severity
  - Threat Assessment Grading for 300 cities
- Definition of a magnitude scale of occurrence
  - How big and how often might we expect this threat over the next 10 years?
- Quantification of the frequency and severity of each threat globally
  - Regional frequency and severity in many cases
- Definition of three 'characteristic scenarios' of each threat
- Definition of intensity scale for experiencing the threat scenarios at a location (city)
- Quantification of the economic impact of each characteristic scenario on a typical city
  - Incorporating physical vulnerability and social and economic resilience of the city
  - Output in terms of 'GDP@Risk' –a standard metric to compare different threats

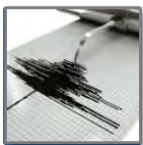
# Team

- Simon Ruffle, Project Manager
- Andrew Coburn, Technical Lead
- Danny Ralph, Review
- Roxane Foulser-Piggott, Modelling, data and vulnerability analysis
- Scott Kelly, Macroeconomic analysis
- Martin Hughes, Modeller
- Fabio Caccioli, Financial modelling
- Hannah Baker, CAR: Data assembly
- Gordon Woo, RMS, Terrorism analysis
- Joshua Wallace, Cytora, Geopolitical Conflict & Political Instability
- Antoine Feylessoufi, Recovery Precedent Studies
- Jaclyn Zhiyi Yeo, Macroeconomic analysis
- Helen Mulligan, Shrinking Cities analysis
- Tamara Evan, Editorial and Documentation

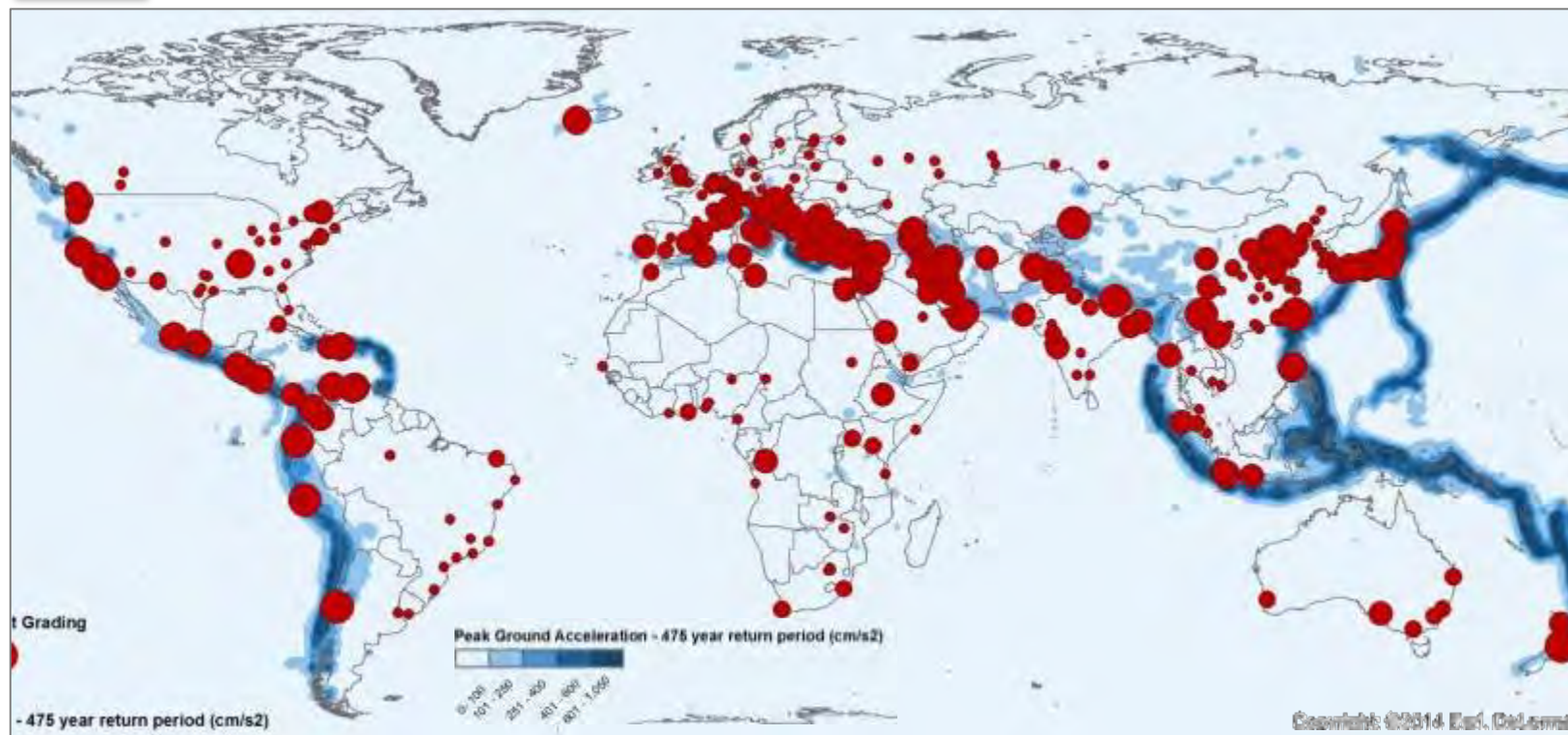








# Earthquake



- A - Very High Hazard; Great magnitude earthquakes can occur close to city
- B - High Hazard; Large magnitude earthquakes can occur near to the city
- C - Significant Hazard; Great earthquakes in vicinity; Large earthquakes nearby
- D - Some Hazard; large earthquakes possible in vicinity, Small earthquakes nearby
- E - Light Hazard; Rare, small earthquakes
- F - Minimal Hazard

## Characteristic Scenarios

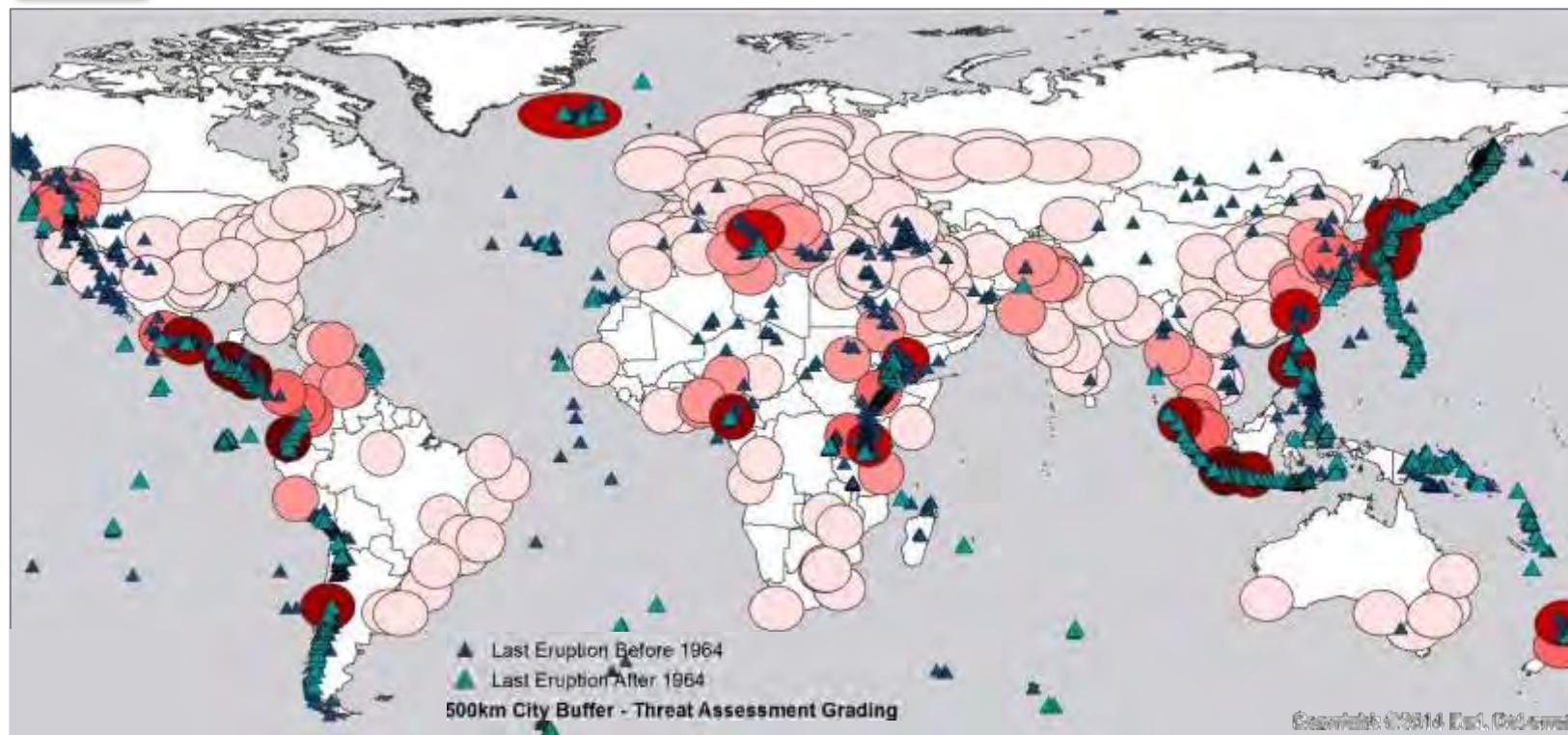
- EQ1** A 'Large Magnitude Earthquake' (Ms6.5) occurring at shallow depth with its epicentre within the city boundaries. Centroid of city experiences VII (PGA 250-400)
- EQ2** A 'Great Earthquake' (Ms7.0) occurring at shallow depth with its epicentre close to the edge of the city, just outside its boundaries. Centroid of city experiences VIII (PGA 400-600)
- EQ3** A 'Great Earthquake' (Ms7.5) occurring at shallow depth with its epicentre close to the centre of the city. Centroid of city experiences IX (PGA 600-1000)

Source:

**United States Geological Survey; GSHAP Mapping; Historical EQ Database**



# Volcanic Eruption



## Characteristic Scenarios

- VE1** Ashcloud shuts city for 3 months, and covers it with several centimeters of ash, preventing air travel, road traffic, port functions, and normal business activity.
- VE2** Ashcloud covers city to 1m depth, takes 1 year for recovery
- VE3** Parts of the city impacted by pyroclastic gases, lahar flows, ejecta bombs and lava encroachment. City evacuated and population not allowed to return for many months.

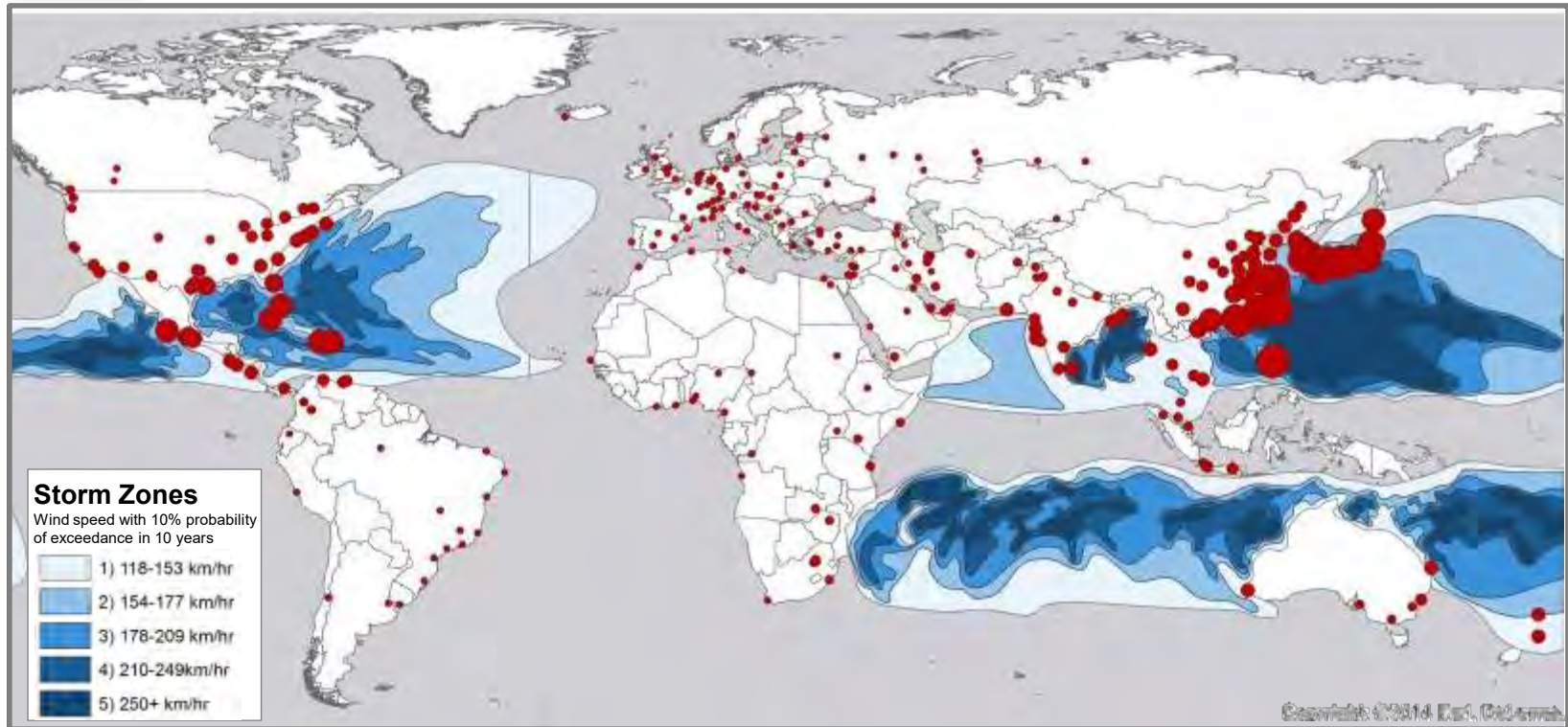
Source:

**Smithsonian Institute of Volcanology Database of Volcanoes & Eruptions**





# Windstorm: Tropical & Temperate



- A Very High Threat of Hurricane-Strength Winds
- B High Threat of Hurricane-Strength Winds
- C Moderately High Threat of Hurricane-Strength Winds
- D Moderate Threat of Hurricane-Strength Winds
- E Threat of Storm-Force Winds
- F Threat of Gale-Force Winds
- G Rare Threat of Strong Winds
- H Low Threat of Strong Winds

## Characteristic Scenarios

- HU1** Category 1 Hurricane, windspeed 118-153 km/hr
- HU2** Category 3 Hurricane, windspeed 178-209 km/hr
- HU3** Category 5 Hurricane, windspeed >250 km/hr

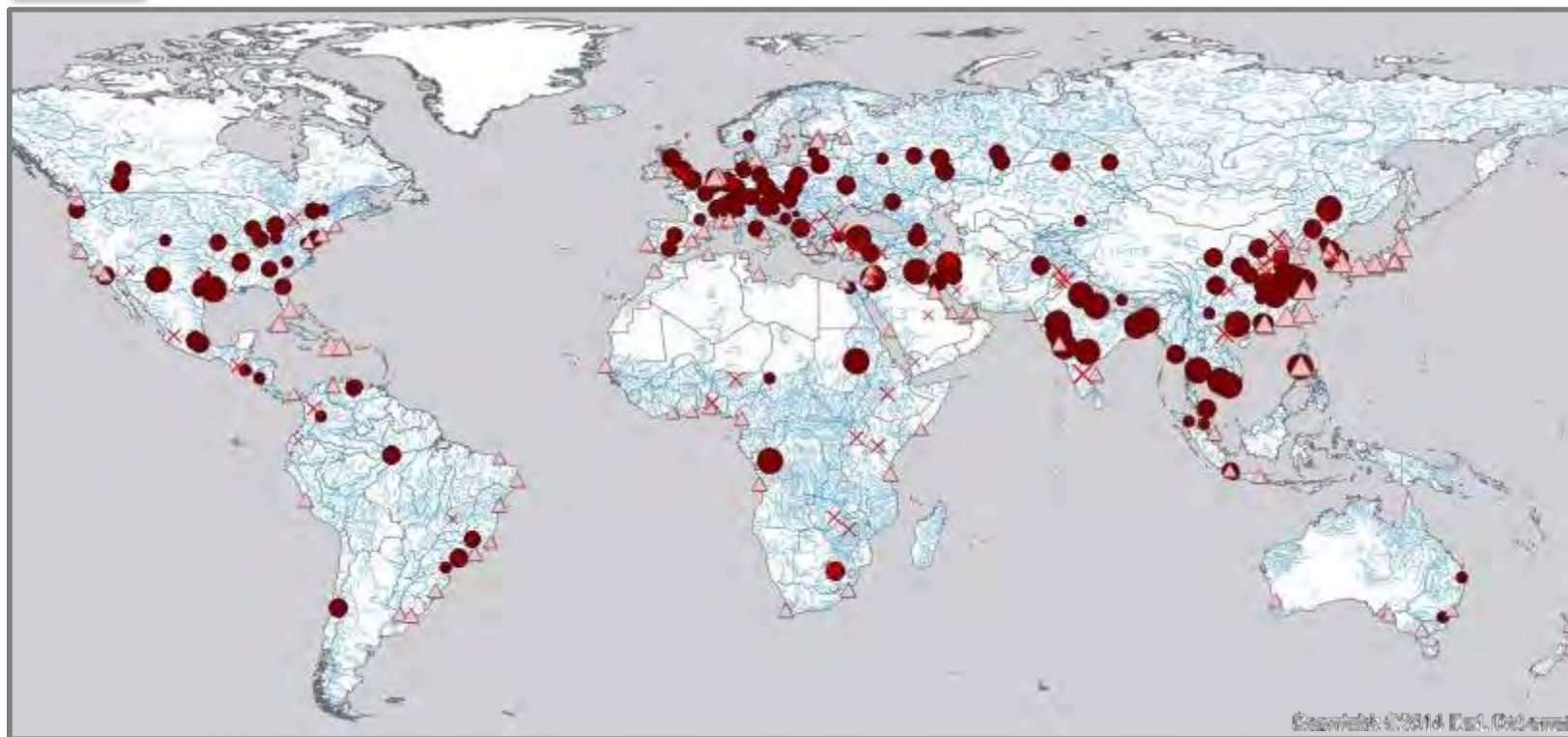
- WS1** Wind Storm of Beaufort Scale 10: Storm or Whole Gale (windspeeds of over 89 km/hr)
- WS2** Wind Storm of Beaufort Scale 11: Violent Storm (windspeeds of over 103 km/hr)
- WS3** Wind Storm of Beaufort Scale 12: Hurricane (windspeeds of over 118 km/hr)

Source:

**EM-DAT Windstorm DB; Pacific Research Center; Munich Re**



# Flood Version 2



## Coastal Storm Surge - City TAG

- △ A - High Threat of Flood
- △ B - Moderately High Threat of Flood
- △ C - Moderate Threat of Flood
- △ D - Moderately Low Threat of Flood
- △ E - Low Threat of Flood

## Riverine Flooding - City TAG

- A - High Threat of Flood
- B - Moderately High Threat of Flood
- C - Moderate Threat of Flood
- D - Moderately Low Threat of Flood
- E - Low Threat of Flood

## Flash Flood - City TAG

- × A - High Threat of Flood
- × B - Moderately High Threat of Flood
- × C - Moderate Threat of Flood
- × D - Moderately Low Threat of Flood
- × E - Low Threat of Flood

## Characteristic Scenarios

- FL1** 10% of city affected by flooding, reaching 1m depth in parts, low velocity water, months recovery period
- FL2** 25% of city area affected by flood waters that reach over 3m depth (more than one storey) in parts; Moderate velocity flowing water moderately contaminated.
- FL3** Over 50% of city land area affected by flooding, reaching more than two storeys in parts, high velocity destructive water flows and highly polluted waters

Source:

**UNEP/DEWA/GRID-Europe Flood Risk Rating**



# Coastal City Database

China



Japan



Brazil

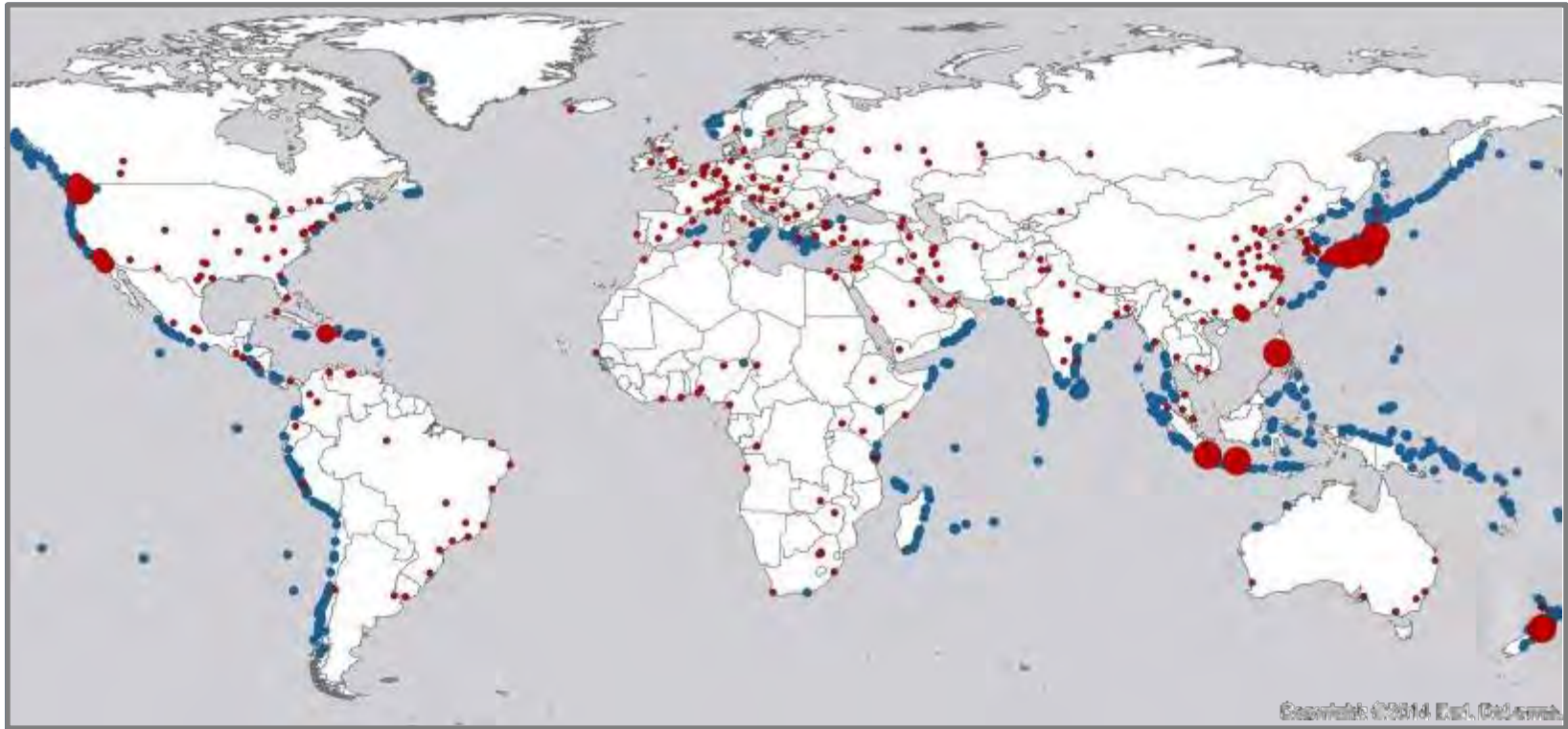


120 of the 300 cities are coastal  
95 are associated with a major port





# Tsunami



Copyright © 2014 Prof. C. G. L. G. L.

- A Major Tsunami Threat from Offshore Great Earthquakes
- B Tsunami Threat from Offshore Large Magnitude Earthquakes
- C Rare Tsunami Threat from Distant Earthquakes
- D Minimal or No Tsunami Threat
- Tsunami-Prone Coastline Location  
(Affected since 1900 by over 1m run-up)

## Characteristic Scenarios

**TS1** Tsunami with 3m run-up

**TS2** Tsunami with 6 m runup

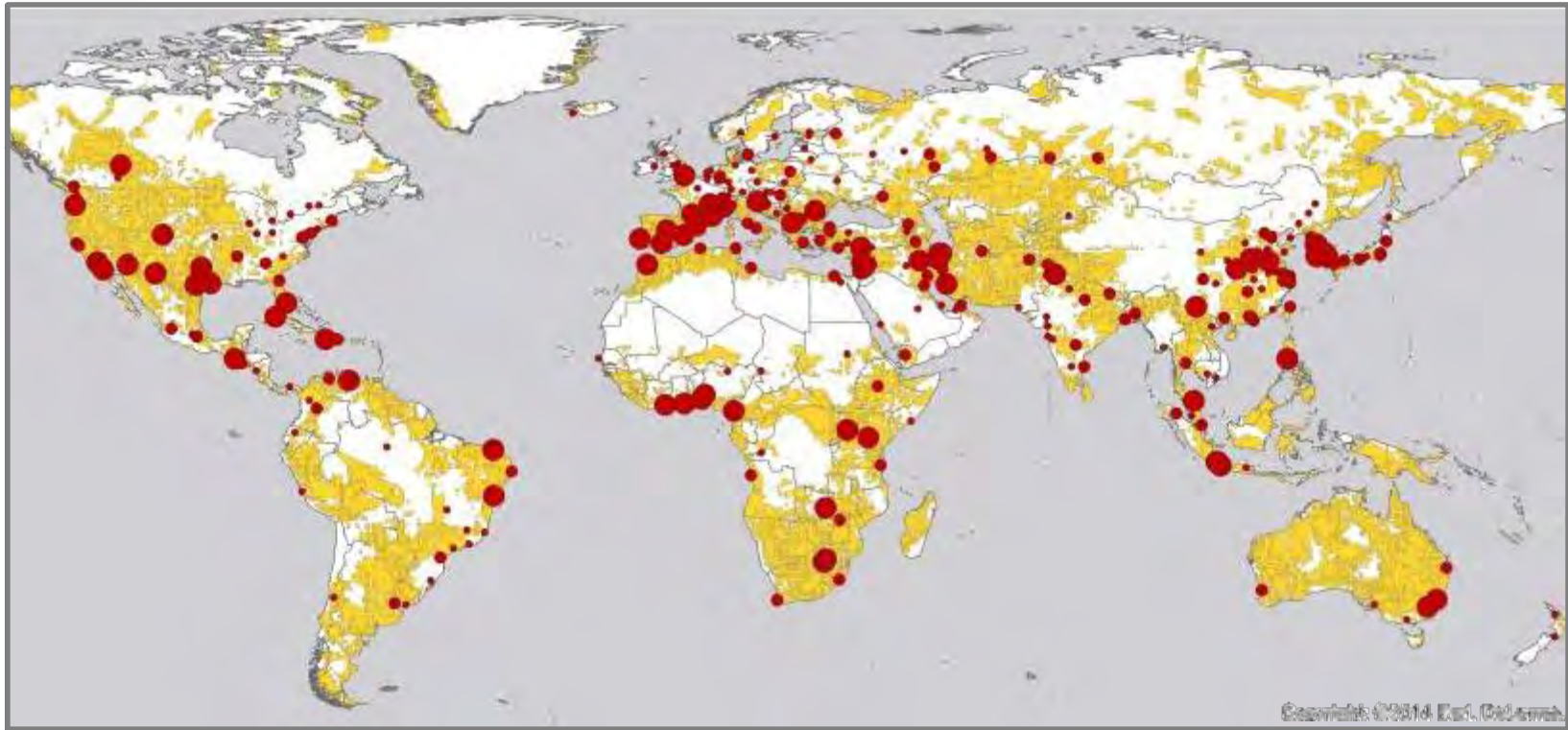
**TS3** Tsunami with 12 m run-up

Source:

**US NOAA NGDC Historical Tsunami Database**



# Drought



- A High Threat of Drought
- B Moderate Threat of Drought
- C Low Threat of Drought

■ Historical Drought Event  
(Since 1980)

Source:  
**US National Center for Atmospheric Research; US Drought Portal**

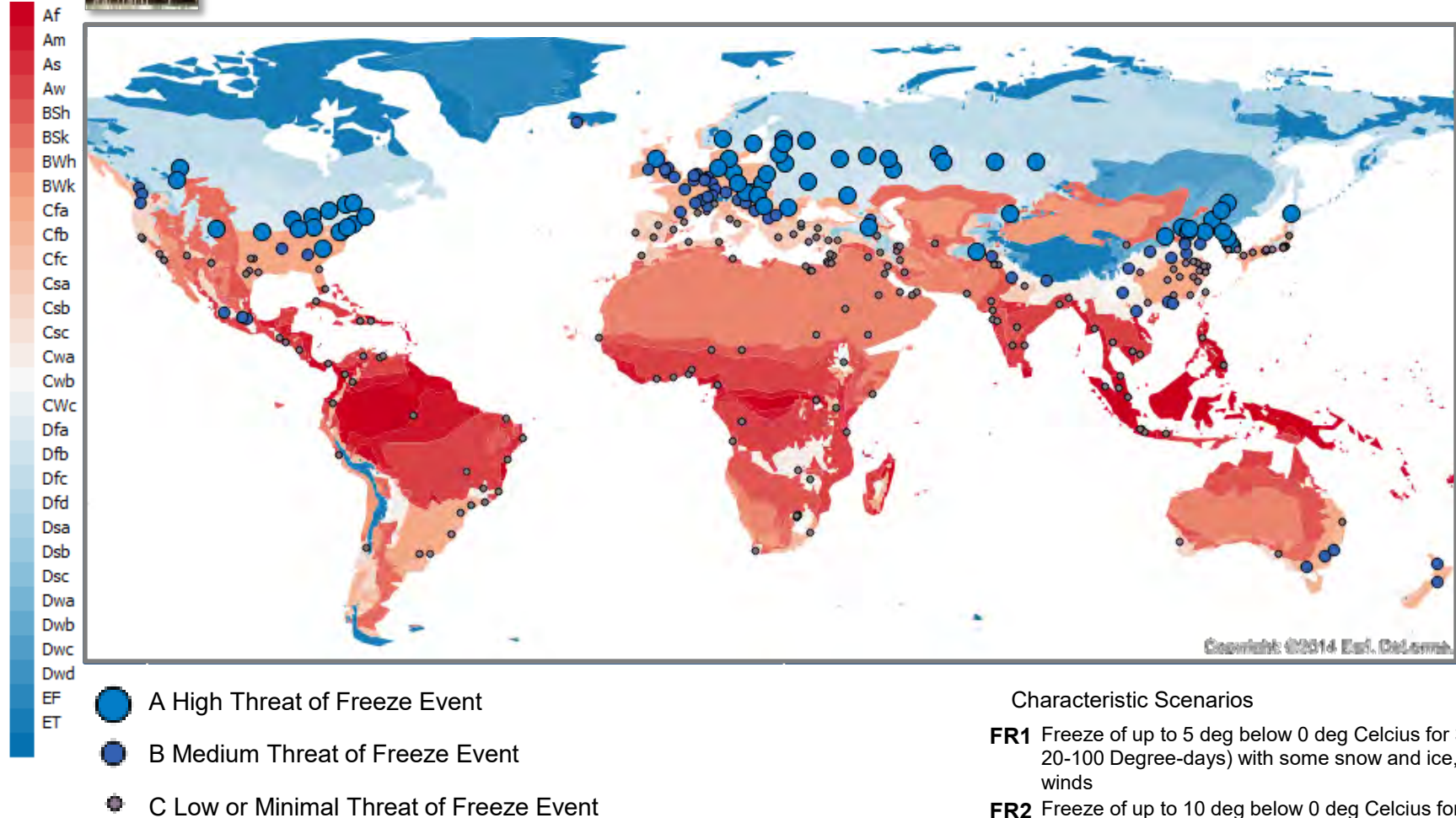
## Characteristic Scenarios

- DR1** D2 'Severe Drought': Localized drought causes water consumption restrictions for that city for 6 months, resulting in water rationing for businesses and residential. Water prioritized for industry, agriculture and emergency provision
- DR2** D3 'Extreme Drought' Three successive seasons of record levels of below average rainfall results in major water shortages for several years
- DR3** D4 'Exceptional Drought', sustained for multiple years. Major change in precipitation patterns causes extended drought, which results in severe water consumption restrictions for several years

# Freeze



Climatic Zones of the World



## Characteristic Scenarios

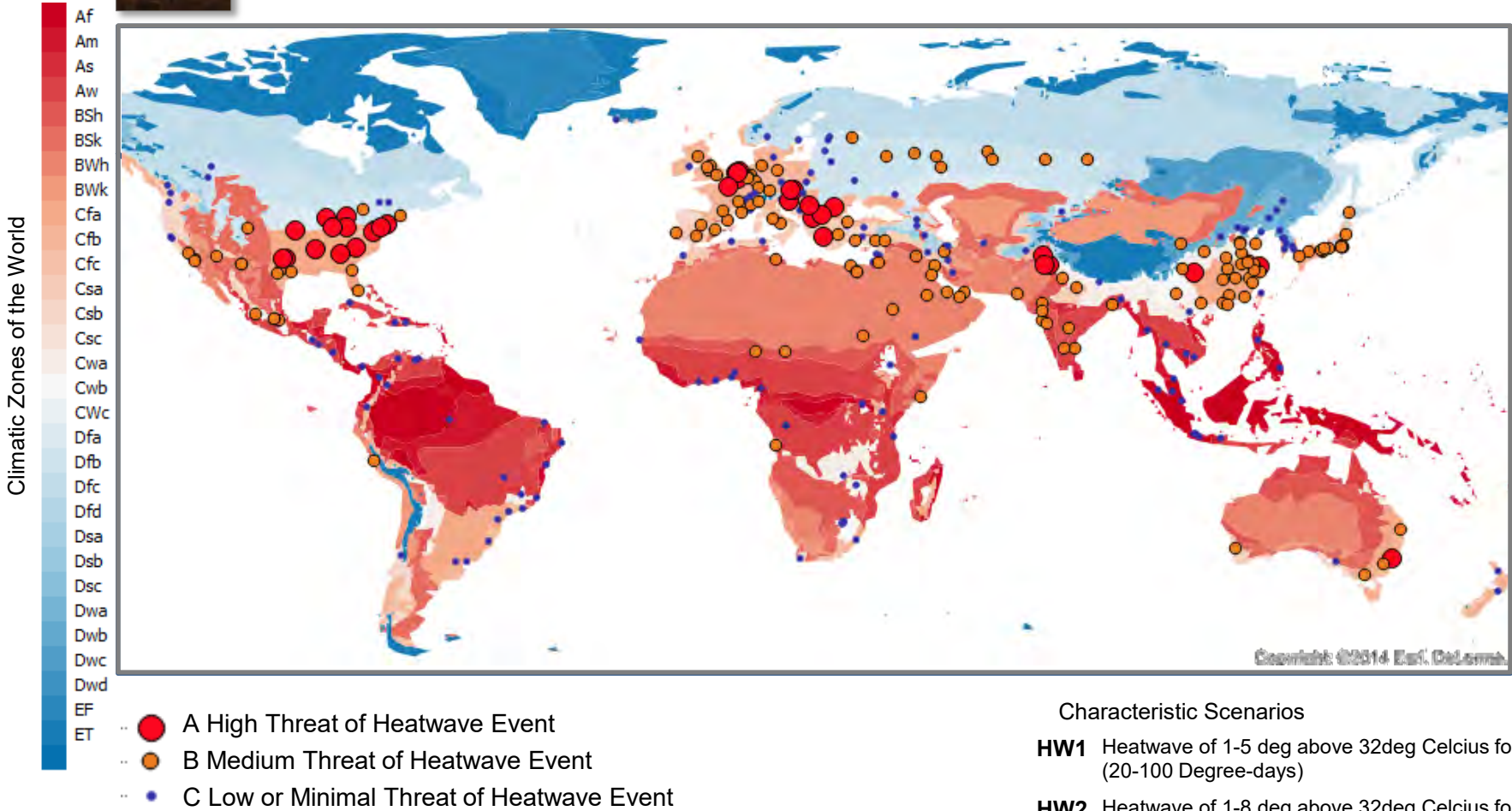
- FR1** Freeze of up to 5 deg below 0 deg Celcius for 3 weeks (-20-100 Degree-days) with some snow and ice, moderate winds
- FR2** Freeze of up to 10 deg below 0 deg Celcius for 8 weeks, combined with deep snow and high winds
- FR3** Freeze of up to 20 degrees below 0 deg Celcius for 12 weeks, combined with heavy snow and severe ice loads periodically

Source:  
**Global Climate Zoning Map**





# Heatwave



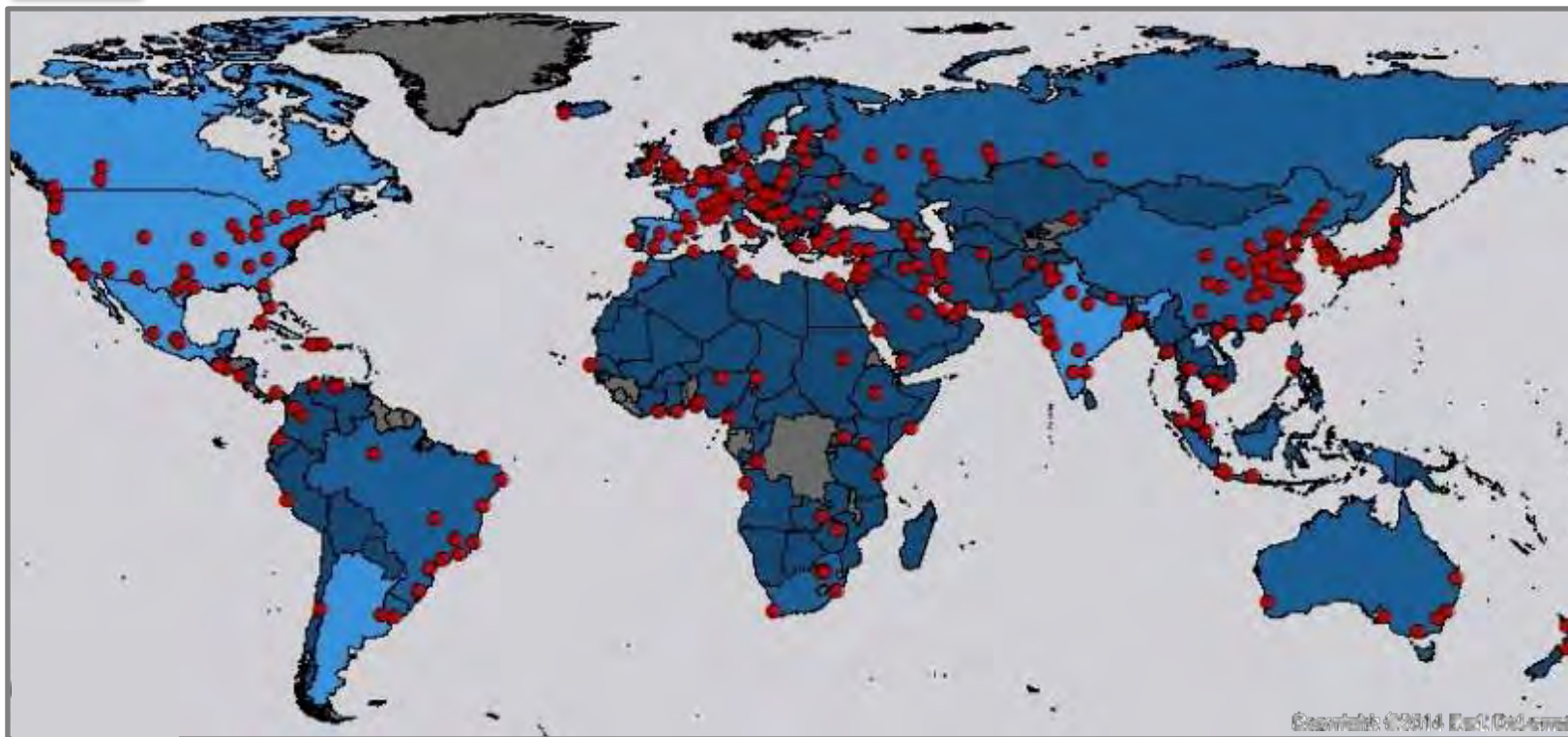
## Characteristic Scenarios

- HW1** Heatwave of 1-5 deg above 32deg Celcius for 4 weeks (20-100 Degree-days)
- HW2** Heatwave of 1-8 deg above 32deg Celcius for 8 weeks (50-500 Degree-days)
- HW3** Heatwave of 1-12 degrees above 32 deg Celcius for 16 weeks (112-1300 degree-days)

Source:  
**Global Climate Zoning Map**



# Financial Crisis - Market Crash



- A: Peripheral to International Financial System but Highly Affected
- B: Local Markets Volatile - Influenced by International Financial System
- C: Integral part of International Financial System - Stable, interlinked markets
- D: Isolated from International Financial System

## Characteristic Scenarios

- MC1** Stockmarket Index drops (peak to trough) by 10% in a single year (e.g. Asian Crisis 1997)
- MC2** Stockmarket Index drops 50% (peak to trough) in a single year (e.g. SubPrime 2008)
- MC3** Stockmarket Index drops 85% in a single quarter (e.g. Wall Street Crash 1929)

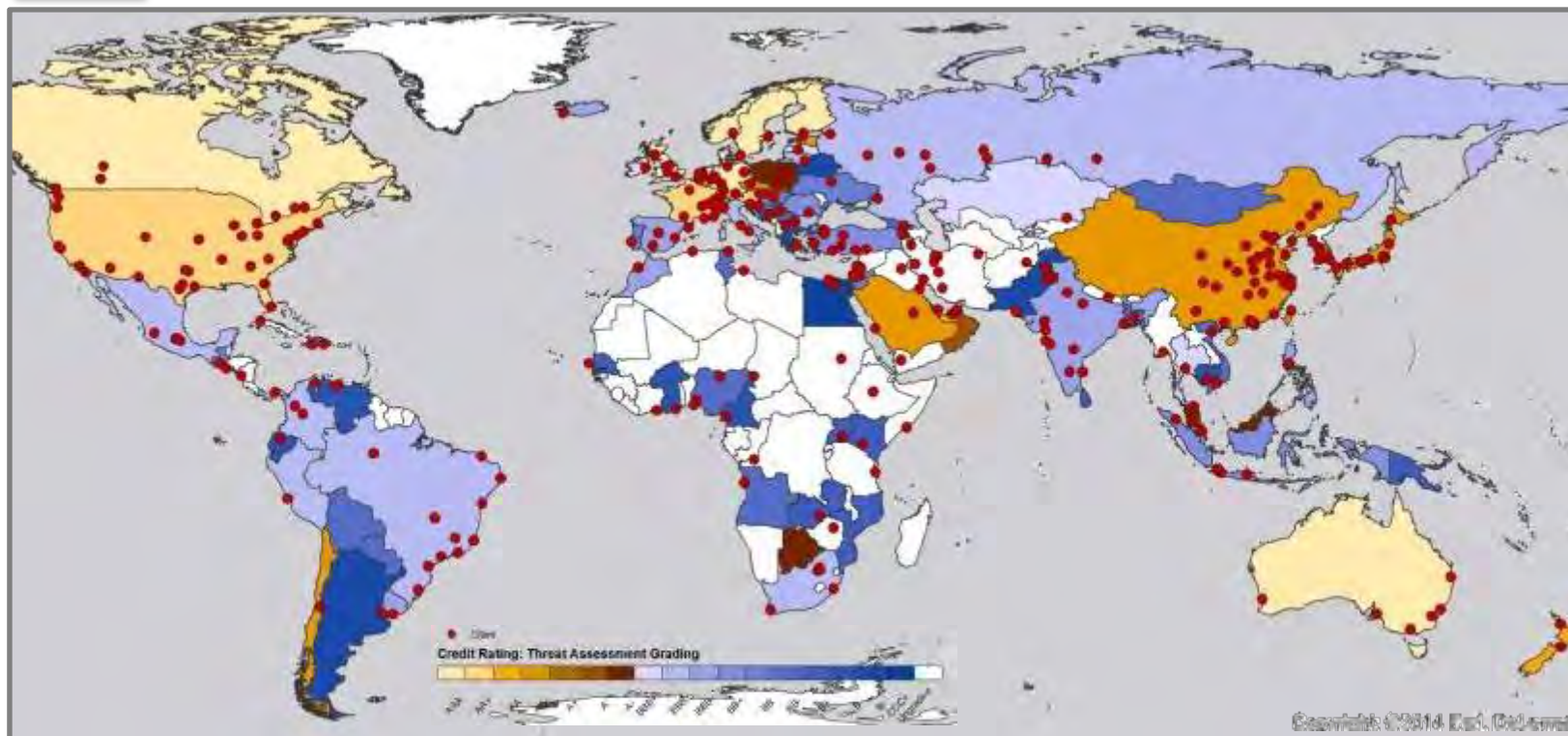
Source:

**International Monetary Fund & CRS Historical Financial Crisis Catalogue**





# Sovereign Default



## Characteristic Scenario

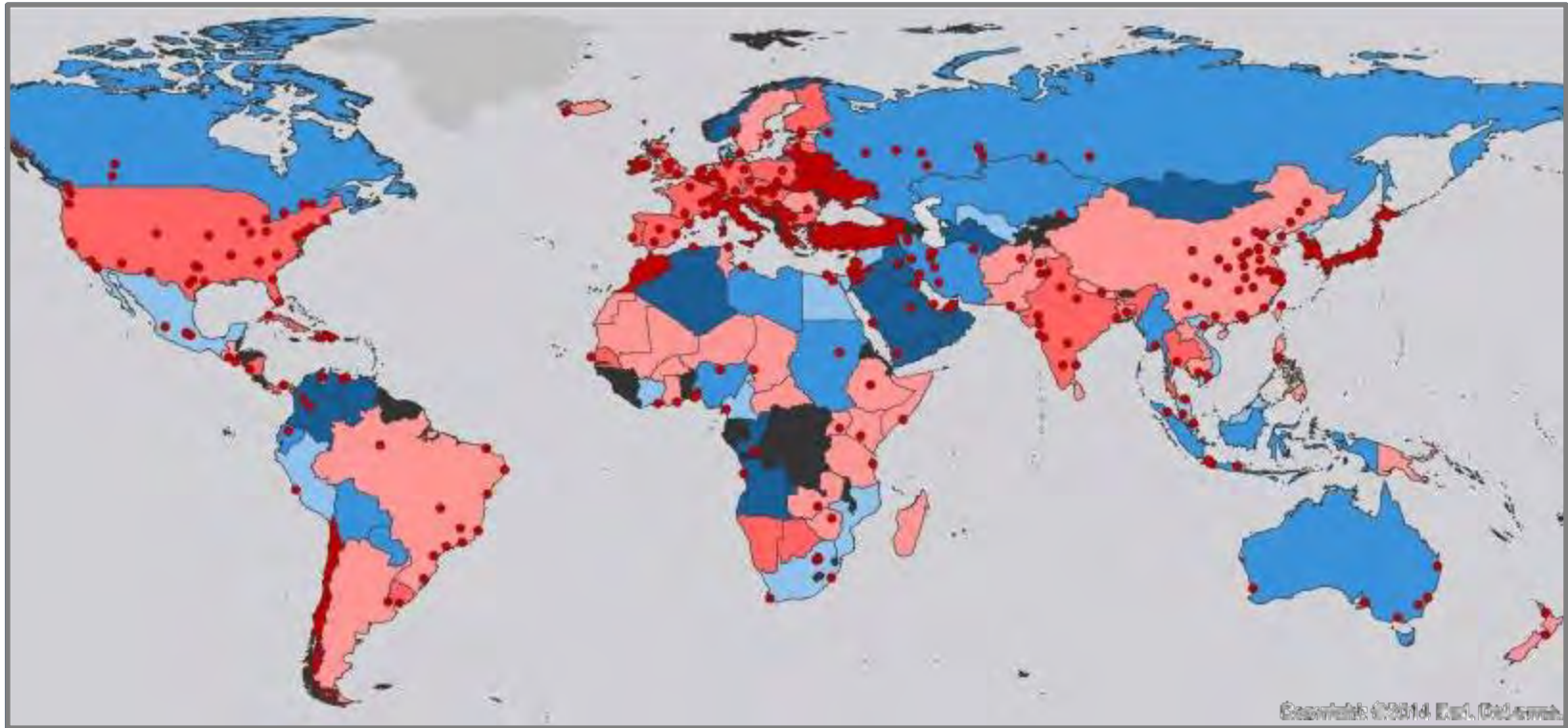
**SD1** Country defaults and reschedules its debt, devalues its currency substantially; Investors flee; Foreign Direct Investment Lost

Source:

**Standard & Poor's Sovereign Credit Ratings, July 2014**



# Oil Price Shock



- A - High Vulnerability of Economy to Oil Price Shock
- B - Moderate Vulnerability of Economy to Oil Price Shock
- C - Some Vulnerability of Economy to Oil Price Shock
- X - Exports marginally more oil than it consumes - economy marginally benefits
- Y - Exports significantly more oil than it consumes - economy benefits
- Z - Exports a lot more oil than it consumes - Economy significantly benefits

## Characteristic Scenarios

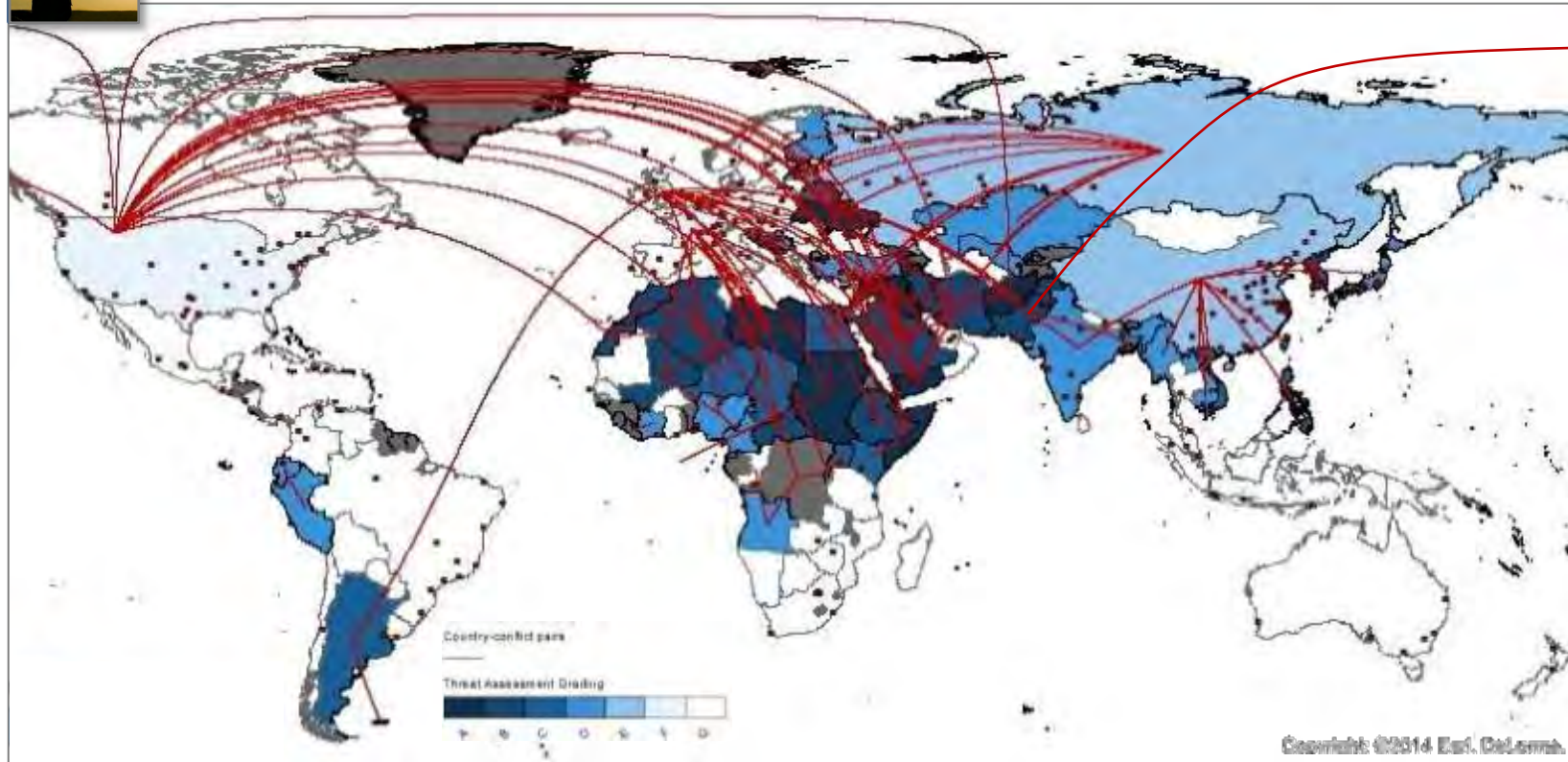
- OP1** Sudden increase in oil price by 10%
- OP2** Sudden increase in oil price by 25% (similar to Oil Price crisis of 1974)
- OP3** Sudden increase in oil price by 50%

Source:

**UN imported oil intensity of GDP Output**



# Interstate War



- A Very High Threat of Interstate Conflict Impacting Cities in Homeland
- B High Threat of Interstate Conflict Impacting Cities in Homeland
- C Moderate Threat of Interstate Conflict Impacting Cities in Homeland
- D Low Threat of Interstate Conflict Impacting Cities in Homeland
- E Major Power with Some Threat of Conflict Impacting Cities in Homeland
- F Major Power with Very Low Threat of Conflict Impacting Cities in Homeland
- G Conflict is Possible but No Scenarios Identified

Source:

**Cytora Analysis of Potential Future Conflicts** (commissioned by CRS)

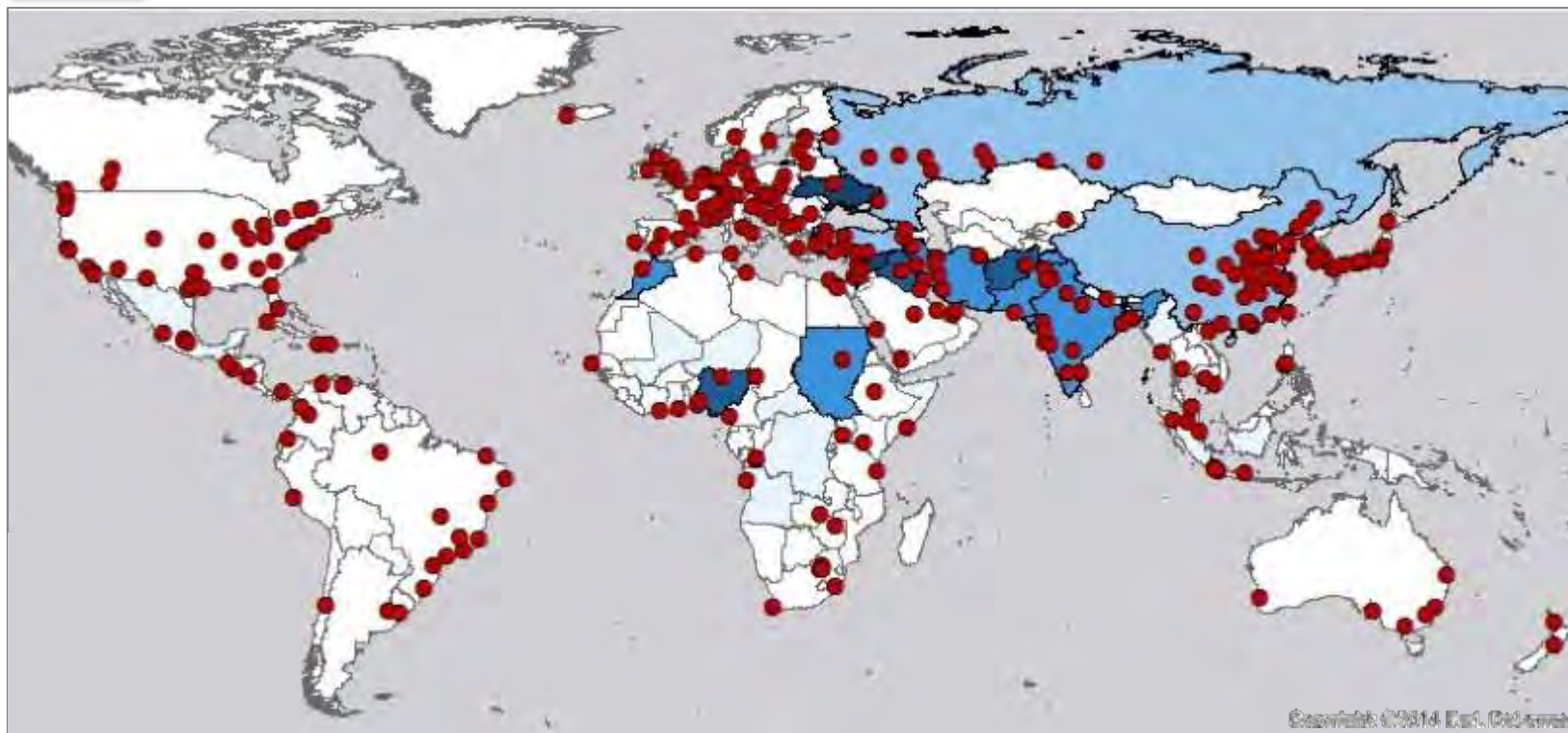
## Characteristic Scenarios

- IW1** City is mobilized for war, but not actually attacked; War mobilization entails switching industrial activity from commercial activities to military production; Population is affected by fear, consumer demand drops, parts of population flees. Investor confidence is affected; Conflict affects the country for 1 year
- IW2** City suffers sporadic attack from occasional missiles or aerial bombardment (and/or possible damage to city infrastructure from military cyber attack); City is mobilized for war and also city's inhabitants affected by fear and there is a significant emigration of population from city. Investors withdraw; Conflict affects the country for 1 year.
- IW3** 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 affects city for 3 years.





# Separatism



- A Very High Threat of Separatist Activity in Cities
- B High Threat of Separatist Activity in Cities
- C Moderate Threat of Separatist Activity in Some Cities
- D Moderately Low Threat or Localized Separatist Activity in Some Cities
- E Low Threat - Non-Violent or Localized Separatist Groups Operate within Country
- F No Known Separatist Movements

## Characteristic Scenarios

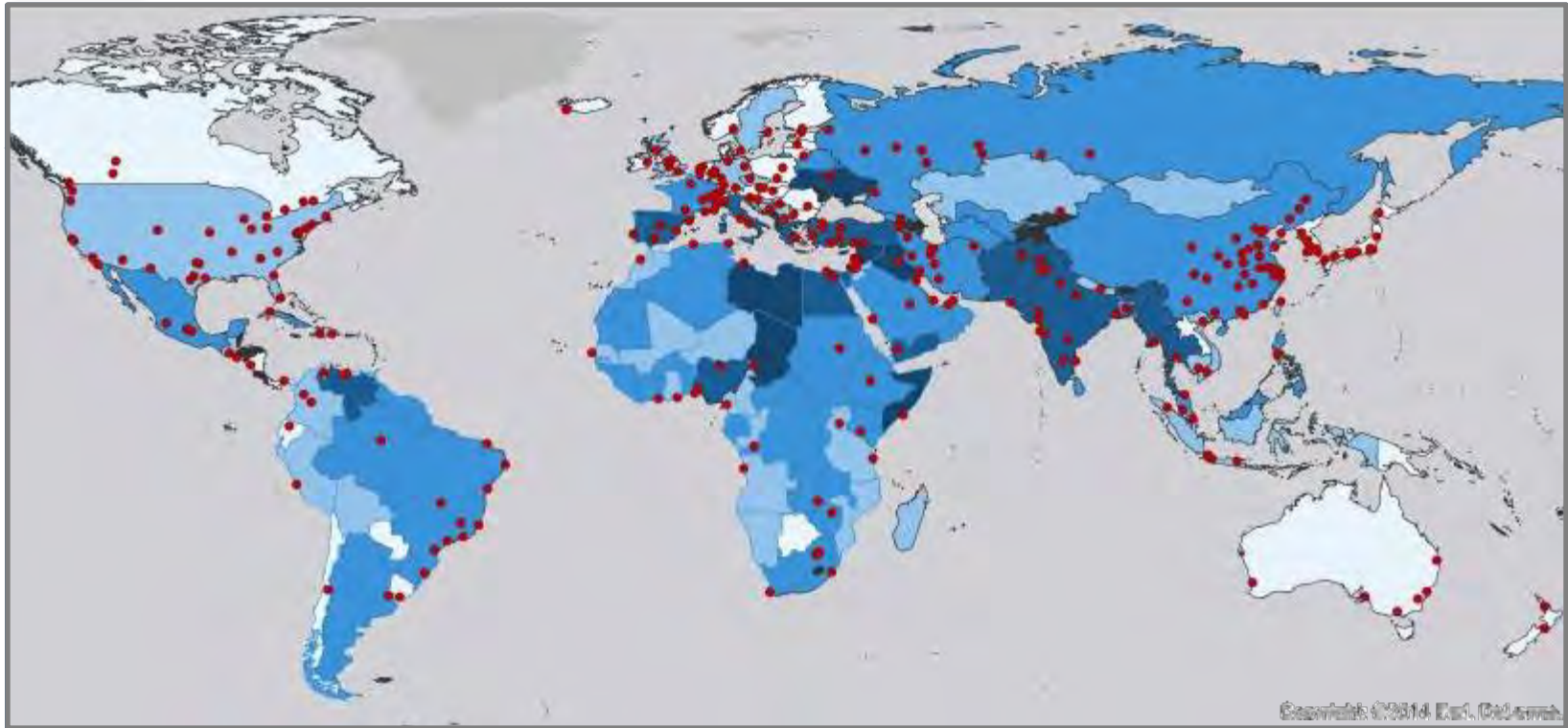
- SP1** Incidents of sectarian fighting between armed gangs and private militias in the streets of the city for multiple years
- SP2** Civil war involves months of street fighting between well-organized and well-equipped armies, using heavy weaponry in sectarian divide in country.





Source:

**Encyclopedia of Modern Separatist Movements**



# Social Unrest



-  A Very High Threat of Social Unrest
-  B High Threat of Social Unrest
-  C Moderate Threat of Social Unrest
-  D Moderately Low Threat of Social Unrest

## Characteristic Scenarios

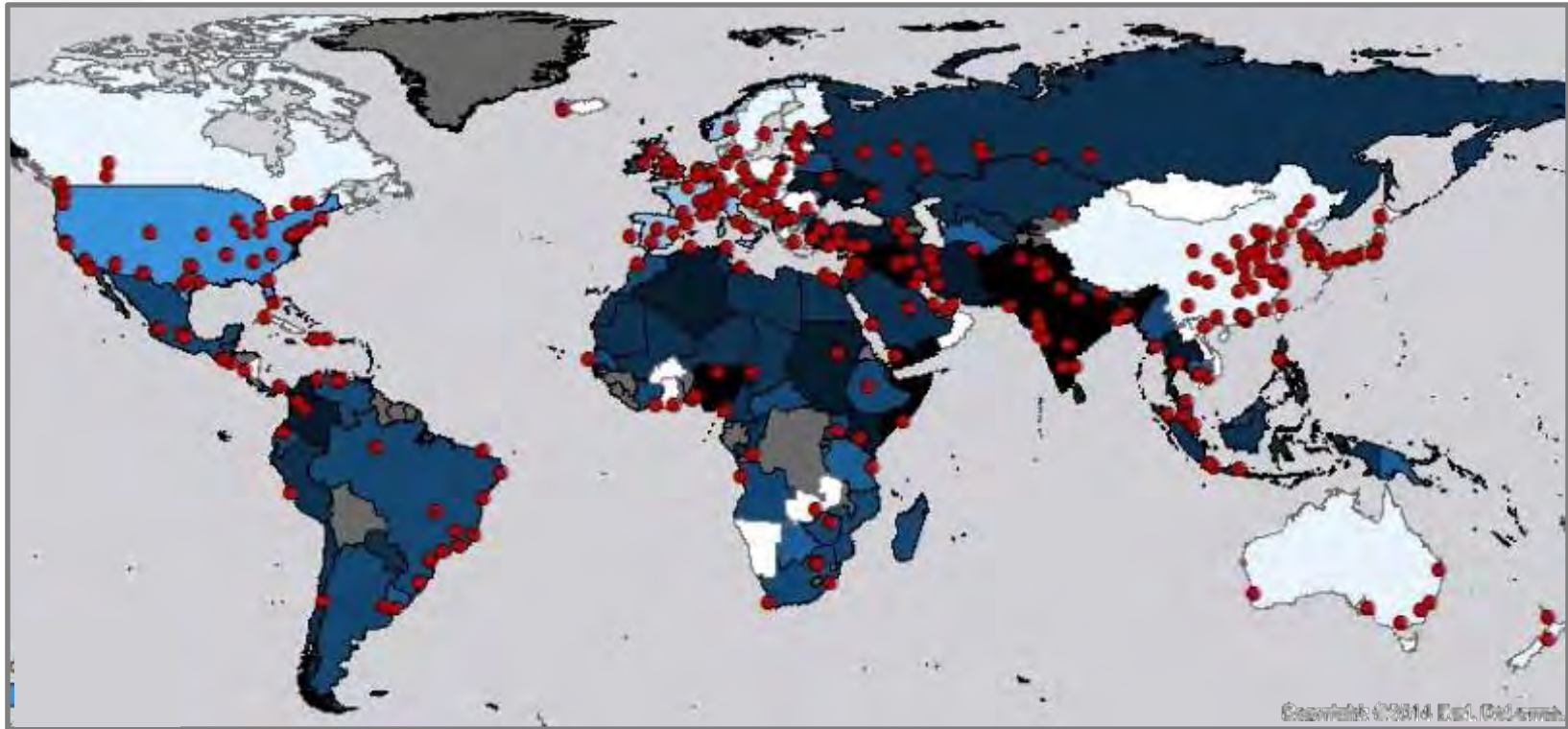
**SU1** Civil Unrest causes riots and protests in the streets for months; violent confrontations with police;

Source:

**Cytora Analysis of Social Unrest Activity** (commissioned by CRS)



# Terrorism



- A Very High Terrorism Activity
- B High Terrorism Activity
- C Campaigns of Large Scale Terrorist Attacks Possible
- D Potential Campaigns of Small Scale Terrorist Attacks
- E Some Possibility of Sustained Campaigns of Small Scale Terrorist Attacks
- F Highest Value Target for Terrorists, Very Highly Defended by Security
- G High Value Target for Terrorists, Highly Defended by Security
- H Strong Counter-Terrorism Interdicts Most Terrorist Plots
- I Low Terrorism Activity

## Characteristic Scenarios

- TR1** Micro-Terror campaign (e.g. individual and mass-attack shootings, poisonings, food chain sabotage etc.) with repeated attacks over a period of many months causes fear and distrust in urban population.
- TR2** Macro-terrorist attack - Coordinated series of simultaneous high profile terrorist attacks (e.g. major truck bombings, airplanes into buildings or other surprise destructive events) causes horrific loss of life and major destruction to property in and around city centre
- TR3** WMD Terrorist Attack - City is attacked by sophisticated terrorist operation using weapons of mass destruction; (e.g. anthrax, air-dispersed bio-weapons, or chemical or radioactive contaminant, or small yield nuclear detonation) kills large numbers of people and contaminates many buildings in Central Business District

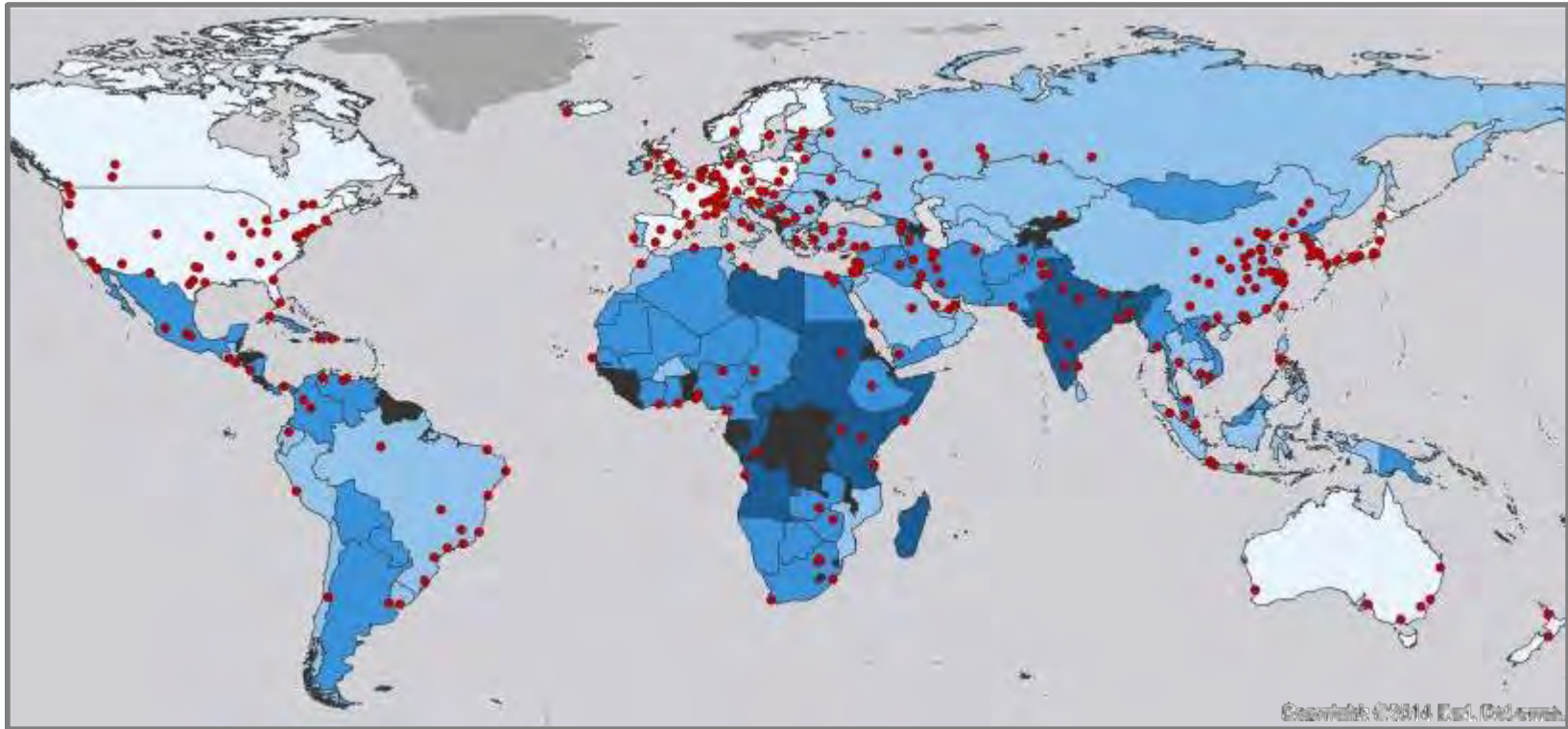
Source:

Global Terrorism Index  
 Analysis of City Risk of Terrorism by Dr. Gordon Woo, RMS (commissioned by CRS)





# Electrical Power Outage



- A Very High Threat of Outages (>50 a year)
- B High Threat of Outages (10-50 a year)
- C Moderate Threat of Outages (1-10 a year)
- D Low Threat of Outages (<1 a year)

## Characteristic Scenarios

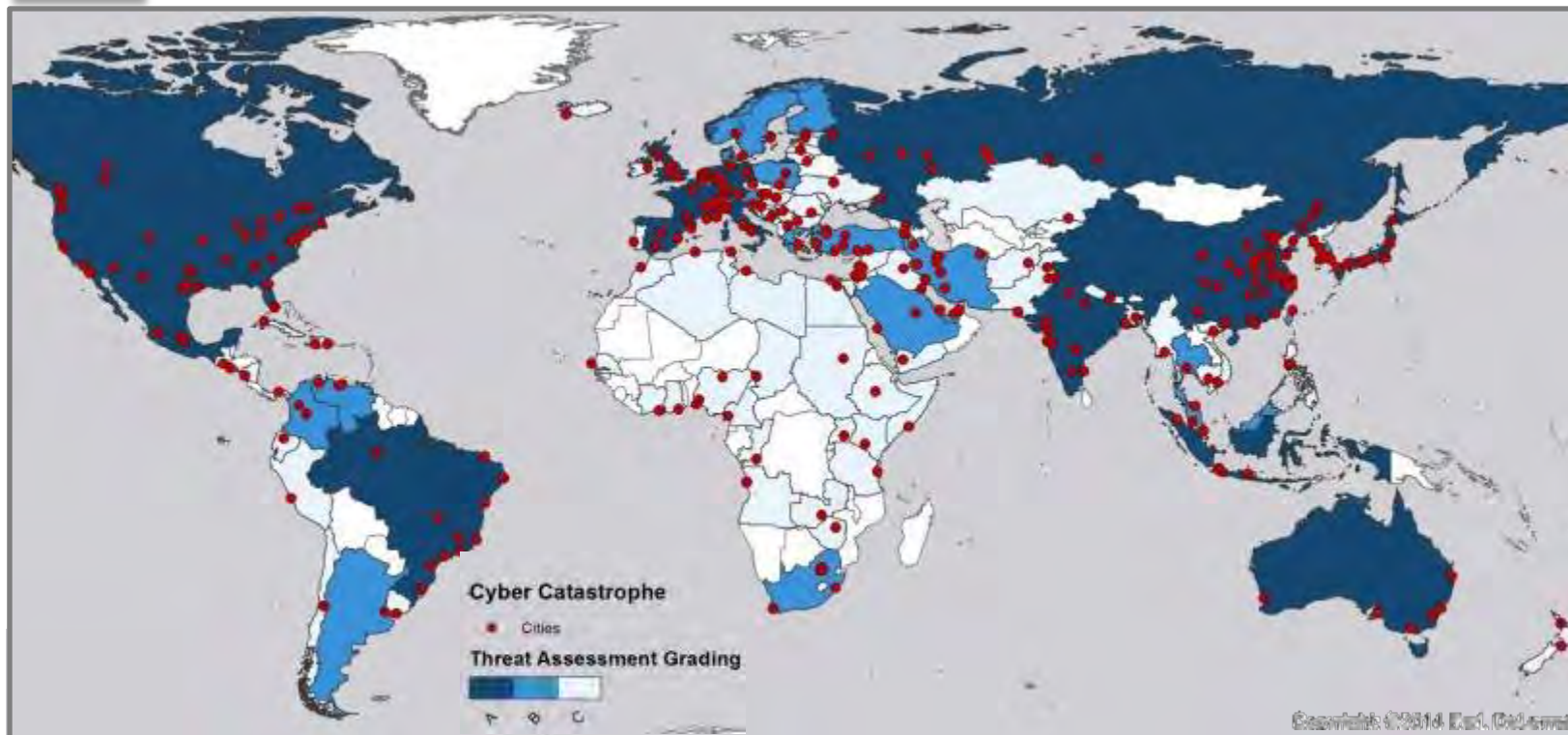
- PO1** One City-Day of Power Loss (100% of city loses power for 1 day or 50% of city loses power for 2 days etc).
- PO2** A 5-City-Day event (100% of city loses power for 5 days, 50% of city loses power for 10 days etc)
- PO3** A 10 City-Day event (100% of city loses power for 10 days)

Source:

**Nation Master Electrical Outage Report**



# Cyber Catastrophe



- A: High Cyber Threat (High Priority Target for Cyber Attackers)
- B: Moderate Cyber Threat (Medium Priority Target for Cyber Attackers)
- C: Low Cyber Threat (Low Priority Target for Cyber Attackers)

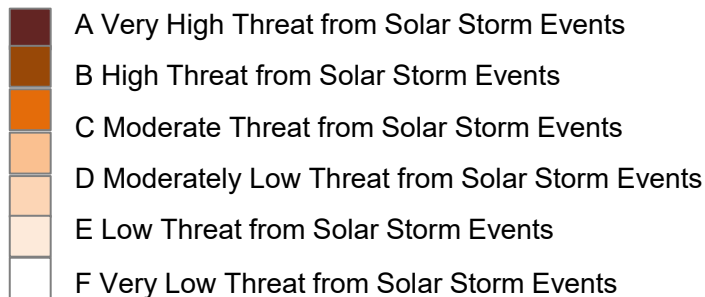
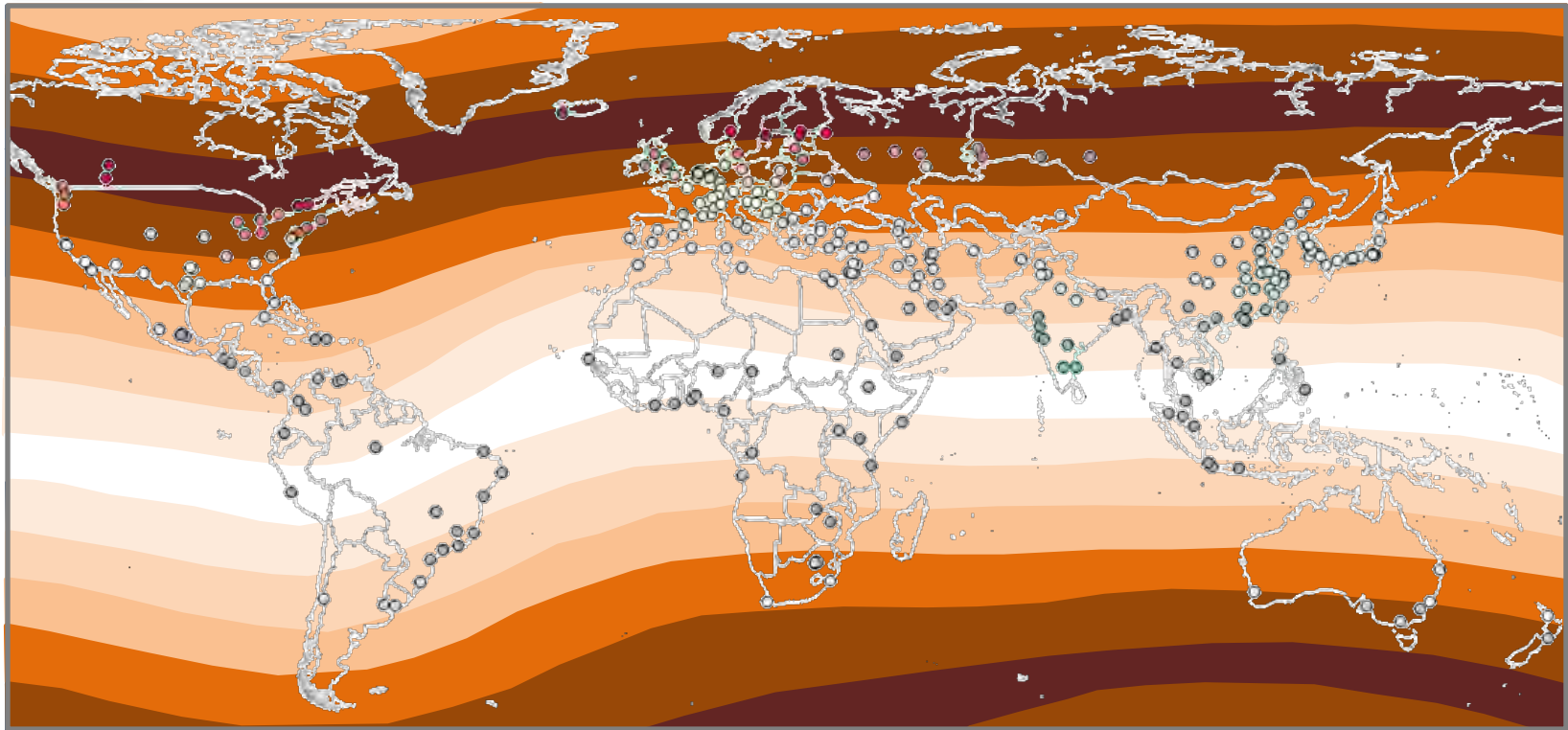
Source:  
**McAfee International Cyber Risk Report**

## Characteristic Scenarios

- CY1** A sporadic set of technology failures (such as GPS outages, accidental technical faults, or cyber attacks on individual organizations) reduces the outputs of companies with high dependence on technology, and consumer confidence is affected.
- CY2** Systemic cyber attack (e.g. Sybil logic bomb) causes heavy losses to many commercial companies operating in that city and undermines confidence of general public in IT systems in general.
- CY3** Cyber attacks on critical infrastructure destroys the power distribution grid and causes power loss in the city for 6 months



# Solar Storm



## Characteristic Scenarios

- SS1** Radiation storm level S4, equivalent to a solar flare of X20.
- SS2** Radiation storm level S5 and equivalent to a solar flare of X40 (Similar to 'Carrington Event')
- SS3** Radiation storm level S6+ (Beyond 5-point NOAA Scale). Estimated effects of a solar flare of X60 - also known as a class Z event.

Source:

**US National Oceanic and Atmospheric Administration**





# Nuclear Power Plant Accident



- A Operational NPP within 50 km and multiple NPPs within 100km
- B Operational NPP within 50 km
- C Multiple NPPs within 100km
- D Operational NPP within 100km
- E Operational NPP within 250km of city
- F No operational NPP within 250km of city
- Nuclear Power Plant Operational 2014-2025
- Area within 250km of a Nuclear Power Plant

## Characteristic Scenarios

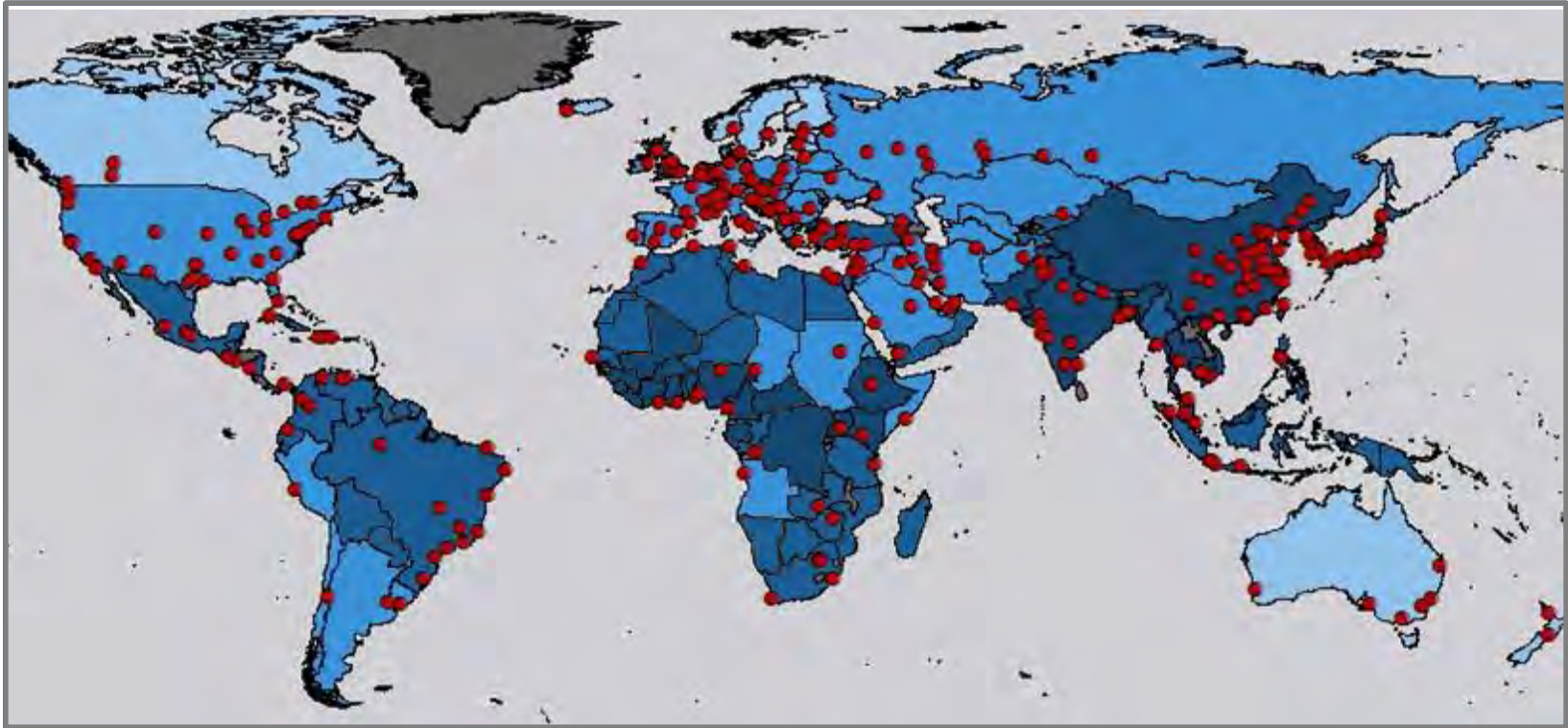
- NP1** City receives radioactive fallout of  $>1\text{Bq}/\text{km}^2$  (30 Curies of C137) similar to within 30km of Chernobyl INES 7 event in 1986
- NP2** City receives radioactive fallout of  $>0.1\text{Bq}/\text{km}^2$  (3 Curies of C137) similar to within 70 km of Chernobyl 1986 or 50km of Fukushima 2011
- NP3** City receives radioactive fallout of  $>0.01\text{Bq}/\text{km}^3$  (0.3 Curies of C137), similar to within 200km of Chernobyl 1986 or 120km of Fukushima 2011

Source:

**World Nuclear Association Information Library**



# Human Epidemic



- A: High Threat of Emerging Infectious Diseases
- B: Moderately High Threat of Emerging Infectious Diseases
- C: Possible Threat of Emerging Infectious Diseases
- D: Low Threat of Emerging Infectious Disease

## Characteristic Scenarios

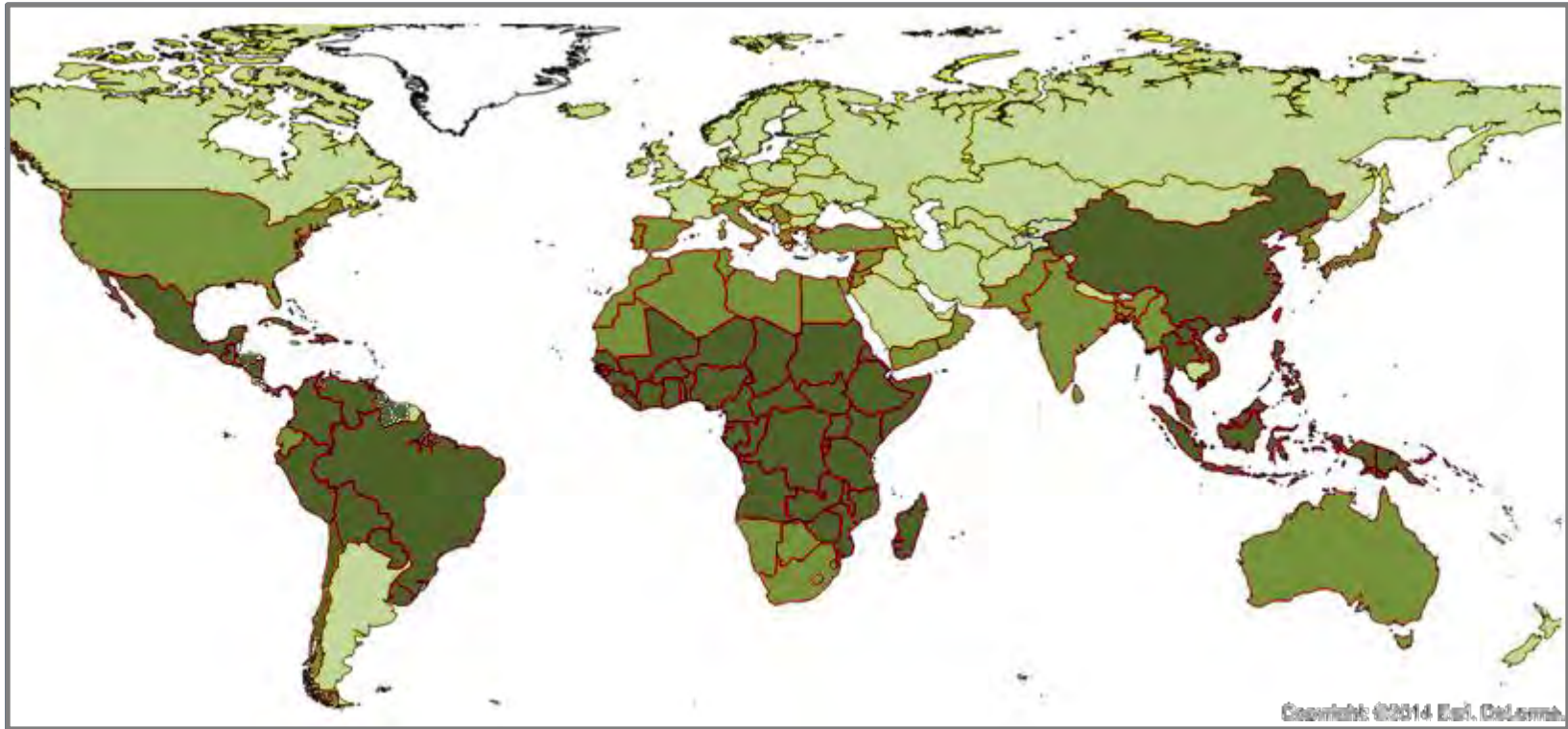
- HE1** Localized epidemic of new emergent disease that has case fatality rate of 10% causes public health emergency and fear in population of catching disease, leads to loss of tourism trade
- HE2** Pandemic influenza virus infects 43% of the population, with a case fatality rate of 0.3%
- HE3** Pandemic of high fatality disease (3% case fatality rate)

Source:

**Global Trends in Emerging Infectious Diseases, Institute of Zoology, UK**



# Plant Epidemic (Crop Failure)



- A High Threat of Plant Epidemic in Local Crops
- B Moderate Risk of Plant Epidemic in Local Crops
- C Low Risk of Plant Epidemic in Local Crops

## Characteristic Scenarios

- PE1** Localized Plant Epidemic affects prices of staple foods in city markets
- PE2** National plant epidemic affects price of staple foods in city markets
- PE3** International Plant Epidemic affects price of stable foods in city markets

Source:  
**Wallingford Distribution Maps of Plant Diseases**



# Overview of Threat Models

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

# IPCC Terminology of Confidence and Uncertainty

Uncertainty	Degree of confidence in being correct
Very High Uncertainty	<i>Less than 1 out of 10 chance</i>
High Uncertainty	<i>About 2 out of 10 chance</i>
Medium Uncertainty	<i>About 5 out of 10 chance</i>
Low Uncertainty	<i>About 8 out of 10 chance</i>
Very Low Uncertainty	<i>At least 9 out of 10 chance of being correct</i>

Confidence	Degree of confidence in being correct
Very High Confidence	<i>At least 9 out of 10 chance of being correct</i>
High Confidence	<i>About 8 out of 10 chance</i>
Medium Confidence	<i>About 5 out of 10 chance</i>
Low Confidence	<i>About 2 out of 10 chance</i>
Very Low Confidence	<i>Less than 1 out of 10 chance</i>



# Analyzing the Risk to Cities

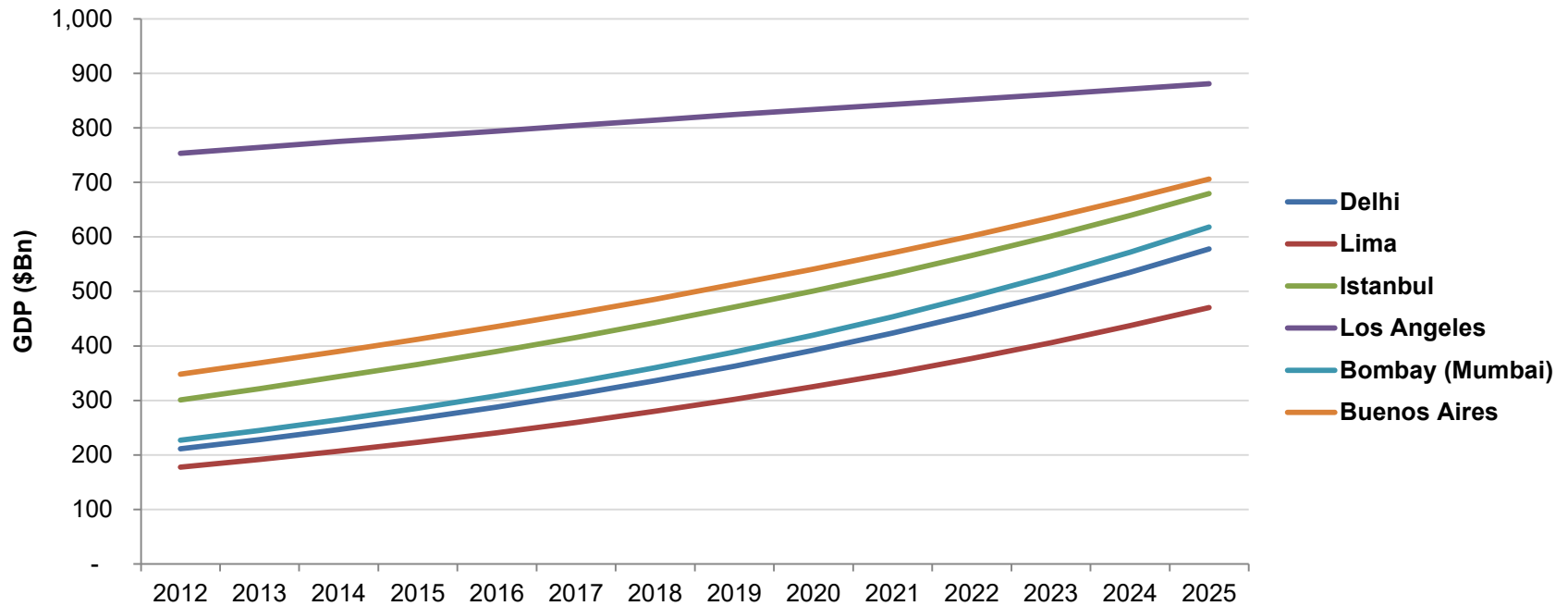
Centre for  
**Risk Studies**



UNIVERSITY OF  
CAMBRIDGE  
Judge Business School

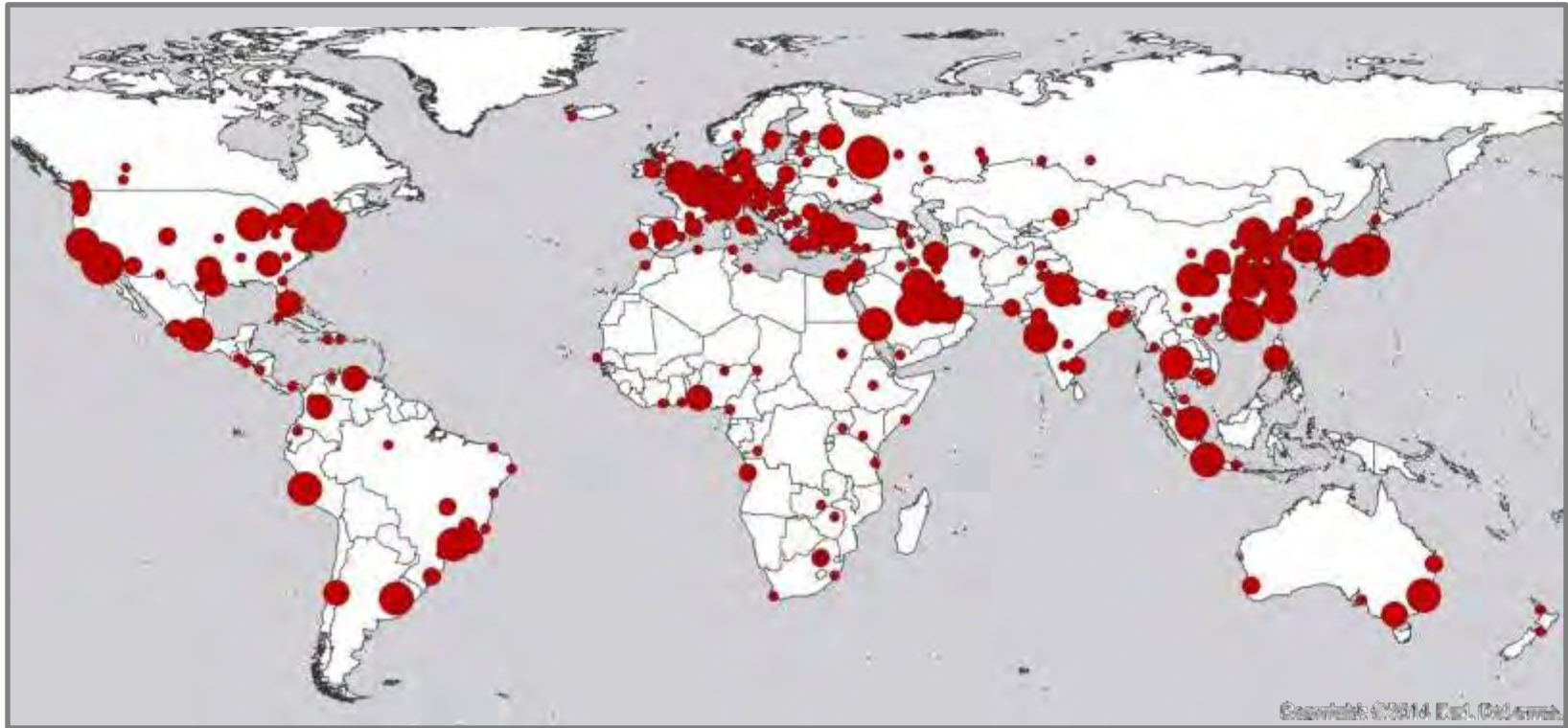


# GDP Projections



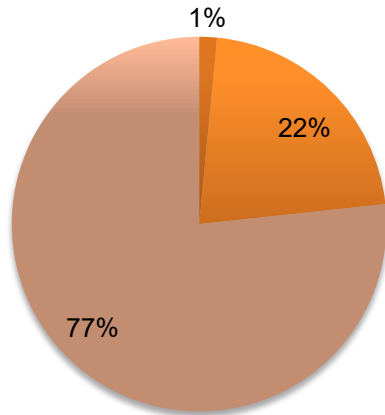
- GDP projections for each year to 2025 have been derived for each of the 300 cities
- These draw on studies from McKinsey, Brookings Institute, and macroeconomic projections by country from Oxford Economics
- Projections take account of trends in GDP per capita, future demographic change, capital investment, and sectoral economic outputs

# GDP 2025

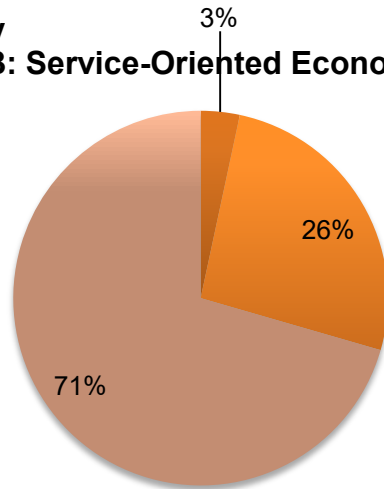


# Economy Mix: Classification of Cities

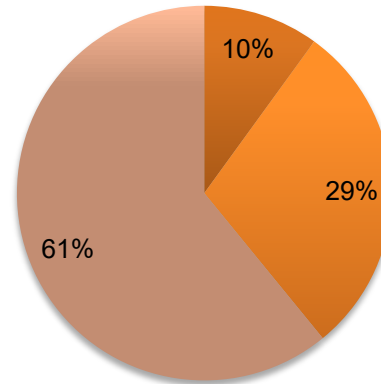
**A: Service-Dominated Economy**



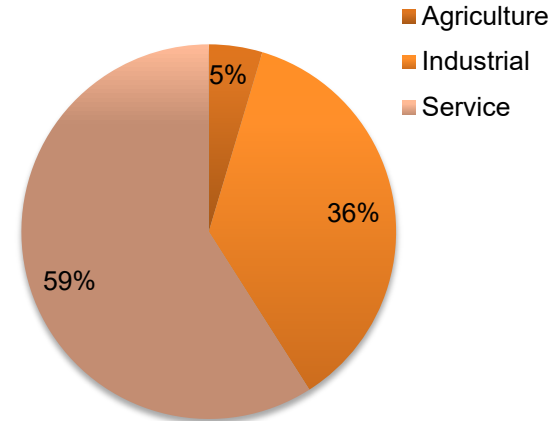
**B: Service-Oriented Economy**



**C: Service with Industrial**

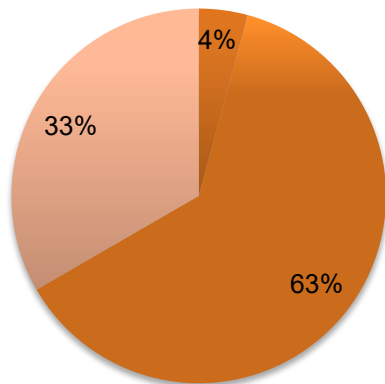


**D: Service-Industrial**

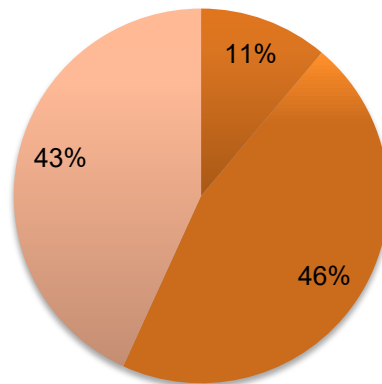


Average mix within cities classified in that category

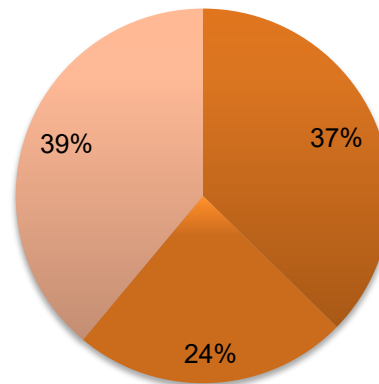
**E: Industrial-Oriented Economy**



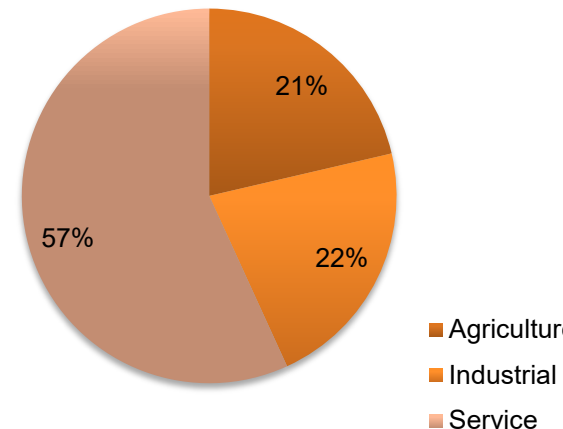
**F: Industrial with Service**



**G: Agriculture with Ind & Service**



**H: Service with Industria/Ag Mix**

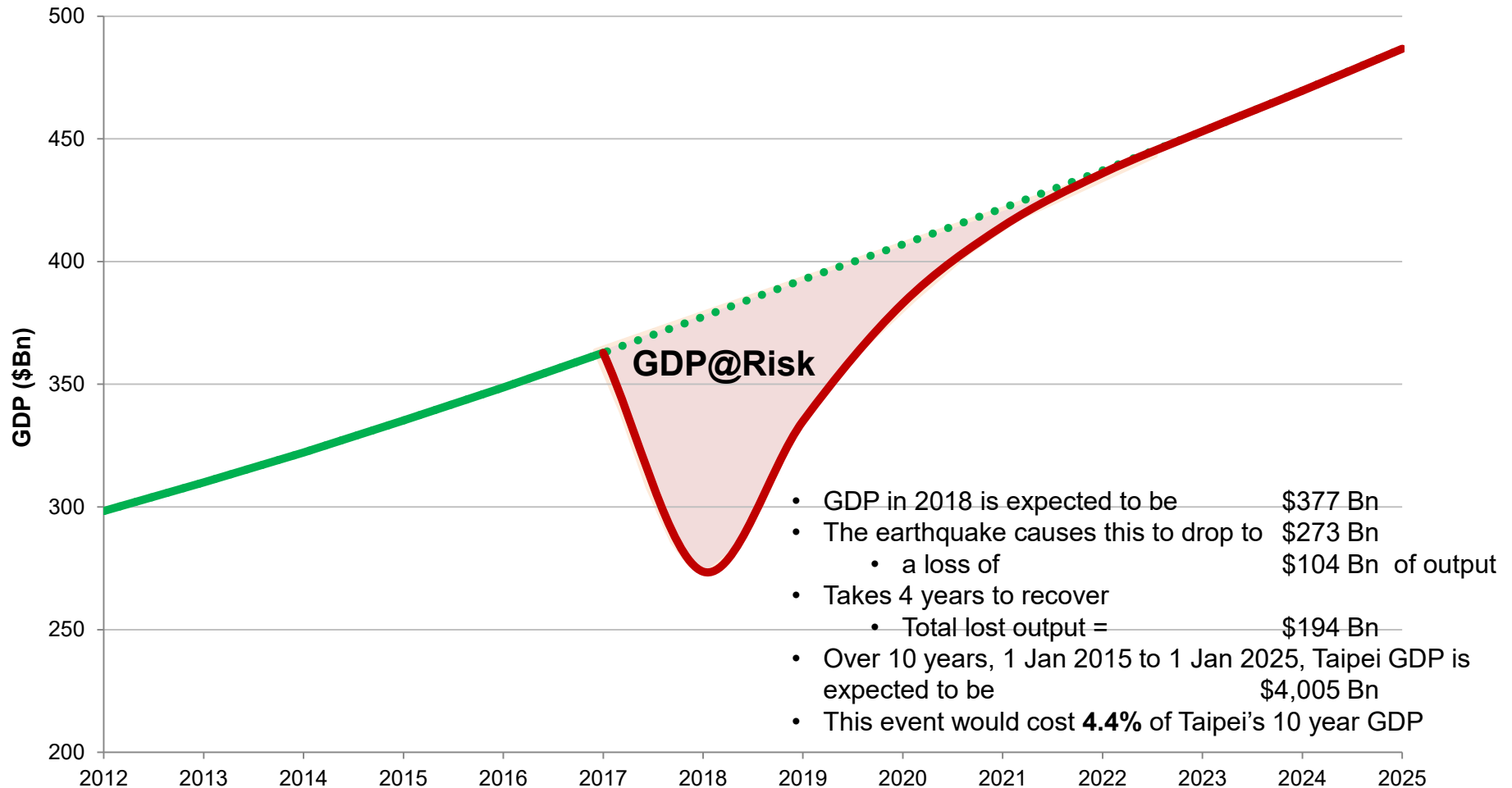




# Analysis of Economic Loss

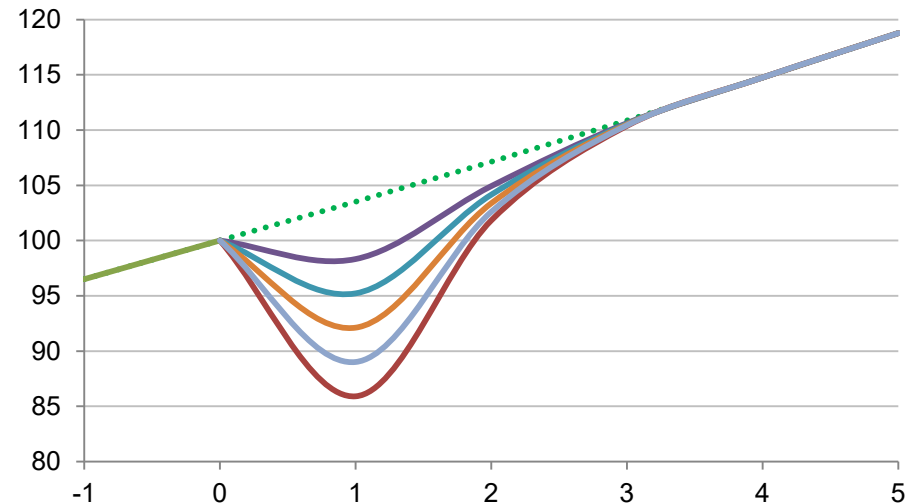
- The GDP reduction analysis takes into account:
  - Supply Shock
    - Destruction of physical infrastructure
    - Disruption to work activity (outout)
    - Flight of capital
    - Loss of ability to supply export markets
  - Demand Shock
    - Public morale and confidence
    - Share price reduction & loss of private capital
    - Import reductions
  - Government emergency response stimuli
  - Inflation and increased cost of inputs

# Example: Characteristic Scenario 'B' Earthquake Hits Taipei in 2018



# Vulnerability of the City influences Shock Severity

	Small	Medium	Large
1 Very Strong	97.0%	95.0%	80.0%
2 Strong	95.0%	85.0%	70.0%
3 Moderate	90.0%	75.0%	60.0%
4 Weak	80.0%	68.0%	50.0%
5 Very Weak	75.0%	50.0%	40.0%

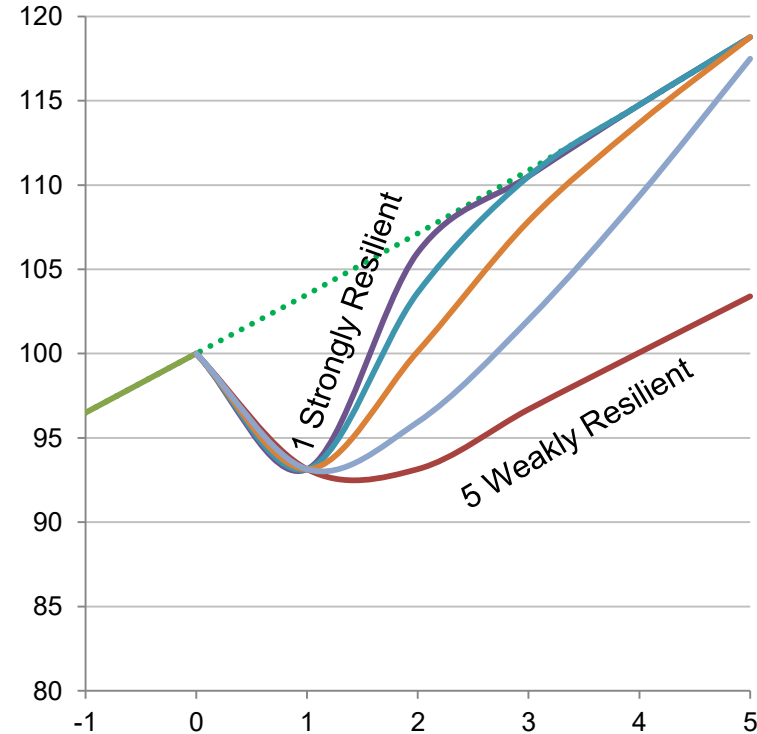


- Physical Vulnerability includes assessment of the quality of buildings and compliance to construction codes, such as seismic
- Flood Vulnerability considers water damage loss by economic sector
- Cyber Vulnerability considers the reliance on IT and its criticality for the city's economic output
- Financial Vulnerability considers connectivity and impact from a financial crisis
- Pandemic Vulnerability includes healthcare index assessment by World Health Organization



# Resilience: Recovery Speed

- The speed of recovery of the city is influenced by its social and economic resilience
- We have developed a Resilience classification (1-5) for cities based on four factors (adaptation of an accepted technique ND-GAIN)
  - Governance; Social coherence; Economic strength; Infrastructure
- Resilience' of the city determines how long the recovery process takes
- Recovery is calibrated from precedent studies of economic recovery after disaster



# Sample City Data (Selected Threats)

City Name	Delhi	Lima	Istanbul	Los Angeles
Country	India	Peru	Turkey	United States
CRS Index	IND_DEL	PER_LIM	TUR_IST	USA_CAL
GDP 2014	246.6	207.2	343.6	774.8
GDP 2025	578.0	470.6	679.4	880.7
Economic Resilience	5 Very Weak	3 Moderate	3 Moderate	1 Very Strong
Economic Sectoral Type	C: Service with Industry (service >50% and Industry >25%)	D: Service-Industrial (Service >50%, Industrial >33%)	C: Service with Industry (service >50% and Industry >25%)	A: Service-Dominated Economy (more than 75% of economy based on services)
Earthquake Threat	D Some Hazard; large earthquakes could occur in vicinity, small localized earthquakes nearby	A Very High Hazard; Great magnitude earthquakes can occur within or close to city with return periods of a few centuries	B High Hazard; Large magnitude earthquakes can occur near to the city with long return periods	A Very High Hazard; Great magnitude earthquakes can occur within or close to city with return periods of a few centuries
Volcano Threat	F No recent volcanic activity in region	E Distant volcanos with historical activity of large eruptions	F No recent volcanic activity in region	F No recent volcanic activity in region
Flood Threat	A High Threat from Flood	A High Threat from Flood	F No Information on Flood	B Moderately High Threat of Flood
Market Crash Threat	C: Integral part of International Financial System - Stable, interlinked markets	A: Peripheral to International Financial System but Highly Affected	B: Local Markets Volatile - Influenced by International Financial System	C: Integral part of International Financial System - Stable, interlinked markets
Sovereign Default Threat	C - Moderate Chance of Sovereign Default	C - Moderate Chance of Sovereign Default	B - Significant Chance of Sovereign Default	D - Low Chance of Sovereign Default
Interstate Conflict Threat	D Low Threat of Interstate Conflict Impacting Cities in Homeland	D Low Threat of Interstate Conflict Impacting Cities in Homeland	D Low Threat of Interstate Conflict Impacting Cities in Homeland	F Major Power with Very Low Threat of Interstate Conflict Impacting Cities in Homeland
Separatism Threat	C Moderate Threat of Separatist Activity in Some Cities	F No Known Separatist Movements	D Moderately Low Threat or Localized Separatist Activity in Some Cities	F No Known Separatist Movements
Terrorism Threat	M City With Some Possibility of Large Scale Acts of Terrorism	C Campaigns of Large Scale Terrorist Attacks Possible	M City With Some Possibility of Large Scale Acts of Terrorism	F Highest Value Target for Terrorists, Very Highly Defended by Security
Cyber Threat	A High Cyber Threat (High Priority Target for Cyber Attackers)	C Low Cyber Threat (Low Priority Target for Cyber Attackers)	B Moderate Cyber Threat (Medium Priority Target for Cyber Attackers)	A High Cyber Threat (High Priority Target for Cyber Attackers)
Pandemic Threat	A High Threat of Emerging Infectious Diseases	C Possible Threat of Emerging Infectious Diseases	B Moderately High Threat of Emerging Infectious Diseases	C Possible Threat of Emerging Infectious Diseases
Physical Vulnerability	4 Weak	3 Moderate	3 Moderate	1 Very Strong
Flood Vulnerability	4 Economy Highly Vulnerable to Flood Disruption	4 Economy Highly Vulnerable to Flood Disruption	4 Economy Highly Vulnerable to Flood Disruption	5: Economy Very Highly Vulnerable to Flood Disruption
Financial Vulnerability	3 Moderate Reliance on Private Capital	3 Moderate Reliance on Private Capital	2 Low Reliance on Private Capital	5 High Reliance on Private Capital
Cyber Vulnerability	4 High Vulnerability to Cyber Attack (High dependence on IT for economic productivity)	4 High Vulnerability to Cyber Attack (High dependence on IT for economic productivity)	4 High Vulnerability to Cyber Attack (High dependence on IT for economic productivity)	5 Very High Vulnerability to Cyber Attack (Very High dependence on IT for economic productivity)
Pandemic Vulnerability	3 Moderate Healthcare System	3 Moderate Healthcare System	3 Moderate Healthcare System	1 Very Strong Healthcare System



# Results

Centre for  
**Risk Studies**

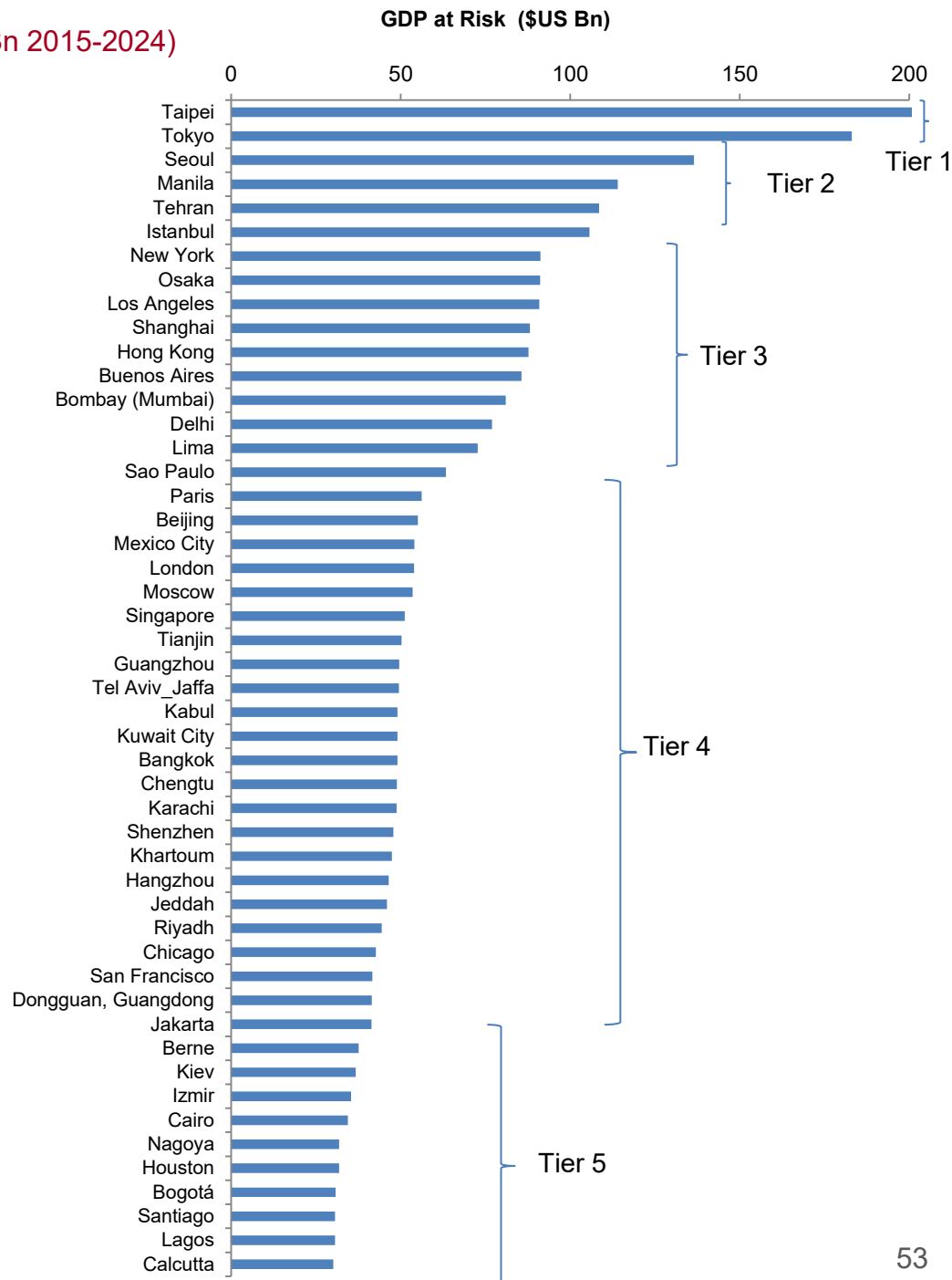


UNIVERSITY OF  
CAMBRIDGE  
Judge Business School



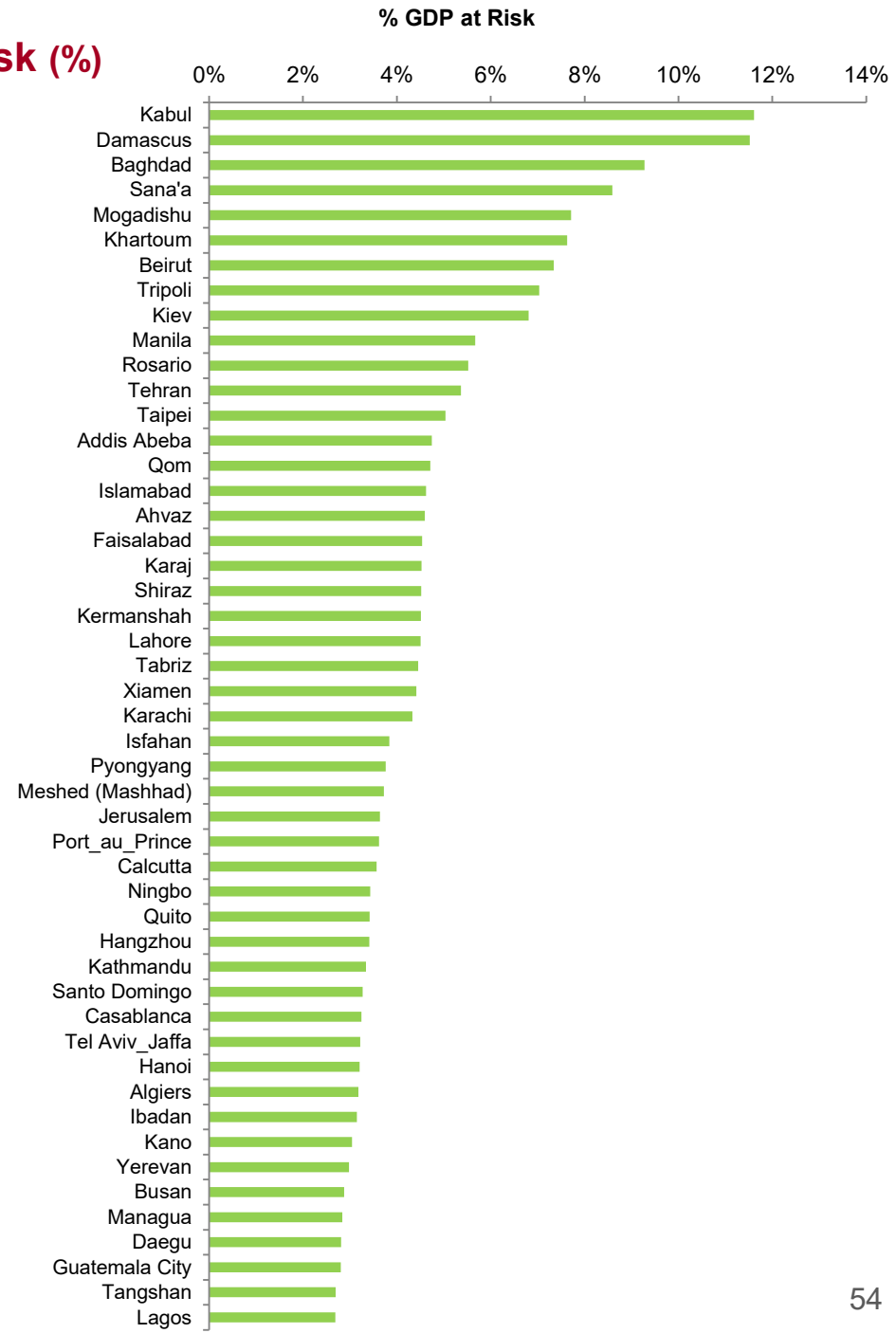
# Top 50 Cities by GDP at Risk (\$Bn 2015-2024)

Rank	City Name	GDP@Risk (\$US Bn)
1	Taipei	201.62
2	Tokyo	183.07
3	Seoul	136.52
4	Manila	114.02
5	Tehran	108.50
6	Istanbul	105.65
7	New York	91.25
8	Osaka	91.11
9	Los Angeles	90.84
10	Shanghai	88.15
11	Hong Kong	87.72
12	Buenos Aires	85.60
13	Bombay (Mumbai)	80.99
14	Delhi	76.96
15	Lima	72.69
16	Sao Paulo	63.36
17	Paris	56.23
18	Beijing	55.10
19	Mexico City	54.04
20	London	53.92
21	Moscow	53.52
22	Singapore	51.18
23	Tianjin	50.24
24	Guangzhou	49.56
25	Tel Aviv_Jaffa	49.48
26	Kabul	49.05
27	Kuwait City	49.04
28	Bangkok	49.04
29	Chengtu	48.86
30	Karachi	48.79
31	Shenzhen	47.83
32	Khartoum	47.43
33	Hangzhou	46.46
34	Jeddah	45.93
36	Riyadh	44.43
37	Chicago	42.67
38	San Francisco	41.63
39	Dongguan, Guangdong	41.51
40	Jakarta	41.42
41	Berne	37.59
42	Kiev	36.73
43	Izmir	35.40
44	Cairo	34.42
45	Nagoya	31.84
46	Houston	31.83
47	Bogotá	30.77
48	Santiago	30.66
49	Lagos	30.64
50	Calcutta	30.12

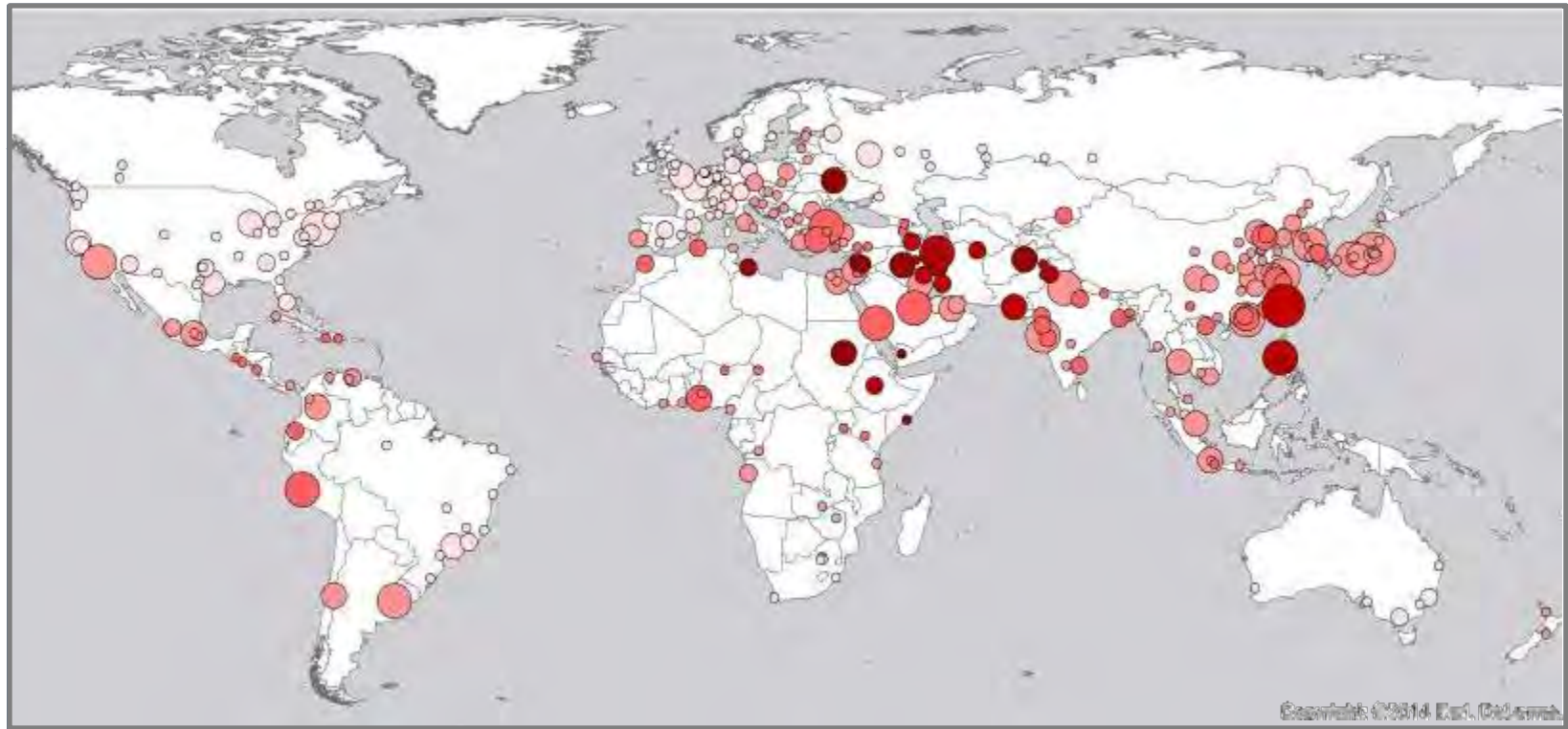


# Top 50 Cities by Highest Proportion of their GDP at Risk (%)

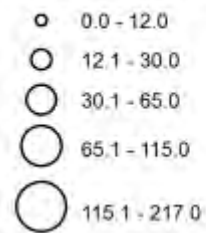
Rank	City Name	% GDP at Risk
1	Kabul	11.6%
2	Damascus	11.5%
3	Baghdad	9.3%
4	Sana'a	8.6%
5	Mogadishu	7.7%
6	Khartoum	7.6%
7	Beirut	7.3%
8	Tripoli	7.0%
9	Kiev	6.8%
10	Manila	5.7%
11	Rosario	5.5%
12	Tehran	5.4%
13	Taipei	5.0%
14	Addis Abeba	4.7%
15	Qom	4.7%
16	Islamabad	4.6%
17	Ahvaz	4.6%
18	Faisalabad	4.5%
19	Karaj	4.5%
20	Shiraz	4.5%
21	Kermanshah	4.5%
22	Lahore	4.5%
23	Tabriz	4.5%
24	Xiamen	4.4%
25	Karachi	4.3%
26	Isfahan	3.8%
27	Pyongyang	3.8%
28	Meshed (Mashhad)	3.7%
29	Jerusalem	3.6%
30	Port_au_Prince	3.6%
31	Calcutta	3.6%
32	Ningbo	3.4%
33	Quito	3.4%
34	Hangzhou	3.4%
36	Kathmandu	3.3%
37	Santo Domingo	3.3%
38	Casablanca	3.2%
39	Tel Aviv_Jaffa	3.2%
40	Hanoi	3.2%
41	Algiers	3.2%
42	Ibadan	3.1%
43	Kano	3.0%
44	Yerevan	3.0%
45	Busan	2.9%
46	Managua	2.8%
47	Daegu	2.8%
48	Guatemala City	2.8%
49	Tangshan	2.7%
50	Lagos	2.7%



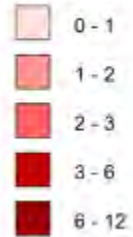
# GDP@Risk



Cities - GDP at Risk - Total US\$ (Bn)



Cities - GDP at Risk - Total %





# What is Driving the GDP@Risk of Highest Risk Cities?

Tiers 1 and 2

Rank [Total GDP at Risk]	1	2	3	4	5	6
CRS City ID	TWN_5155	JPN_KNT	KOR_SJK	PHL_NCR	IRN_TER	TUR_IST
City Name	Taipei	Tokyo	Seoul	Manila	Tehran	Istanbul
CRS Country ID	TWN	JPN	KOR	PHL	IRN	TUR
Country Name	Taiwan, Province of C	Japan	Korea, Republic of	Philippines	Iran, Islamic Republic	Turkey
Earthquake	14.72%	10.28%	0.00%	11.66%	31.85%	28.43%
Volcano	3.49%	4.94%	0.62%	5.09%	0.00%	0.00%
Wind Storm	40.25%	15.87%	32.73%	53.21%	0.00%	0.00%
Temperate Wind Storm	0.00%	0.00%	0.00%	0.00%	0.23%	0.00%
Flooding	5.33%	9.64%	7.20%	4.79%	2.37%	5.17%
Tsunami	0.00%	2.05%	0.00%	0.45%	0.00%	0.00%
Drought	0.39%	1.57%	4.46%	1.63%	1.73%	1.82%
Freeze	0.00%	0.72%	1.04%	0.00%	0.00%	0.00%
Heatwave	0.00%	0.36%	0.00%	0.00%	0.00%	0.21%
Market Crash	14.18%	12.51%	9.25%	4.20%	5.49%	8.07%
Sovereign Default	0.11%	0.41%	1.48%	0.63%	8.98%	10.22%
Oil Price	3.85%	11.68%	9.32%	2.09%	-3.78%	9.03%
Interstate War	10.05%	16.16%	24.12%	11.08%	37.93%	12.78%
Separatism	0.00%	0.00%	0.00%	0.00%	6.47%	5.83%
Terrorism	0.00%	0.12%	0.14%	0.67%	2.39%	1.94%
Social Unrest	0.07%	0.11%	0.07%	0.25%	0.26%	3.31%
Electrical power outage	0.61%	1.24%	0.74%	0.41%	0.58%	1.08%
Cyber	2.55%	3.33%	1.98%	0.25%	0.46%	2.18%
Solar Storm	0.30%	1.32%	0.79%	0.27%	0.31%	0.77%
Nuclear Power Plant Accident	0.28%	0.16%	0.00%	0.00%	0.00%	0.00%
Pandemic	3.52%	6.72%	5.58%	3.06%	4.32%	8.68%
Plant Epidemic	0.29%	0.81%	0.48%	0.25%	0.42%	0.47%
Total GDP at Risk (\$US Bn)	201.62	183.07	136.52	114.02	108.50	105.65

# What is Driving the GDP@Risk of Highest Risk Cities? (1-20)

Rank [Total GDP at Risk]	1	2	3	4	5	6	7	8	9	10
CRS City ID	TWN_5155	JPN_KNT	KOR_SJK	PHL_NCR	IRN_TER	TUR_IST	USA_NYO	JPN_KIN	USA_CAL	CHN_SHN
City Name	Taipei	Tokyo	Seoul	Manila	Tehran	Istanbul	New York	Osaka	Los Angeles	Shanghai
CRS Country ID	TWN	JPN	KOR	PHL	IRN	TUR	USA	JPN	USA	CHN
Country Name	Taiwan, Province of C	Japan	Korea, Republic of	Philippines	Iran, Islamic Republic	Turkey	United States	Japan	United States	China
Earthquake	14.72%	10.28%	0.00%	11.66%	31.85%	28.43%	0.05%	8.22%	20.09%	0.00%
Volcano	3.49%	4.94%	0.62%	5.09%	0.00%	0.00%	0.00%	3.95%	0.00%	0.98%
Wind Storm	40.25%	15.87%	32.73%	53.21%	0.00%	0.00%	0.00%	20.25%	0.00%	30.41%
Temperate Wind Storm	0.00%	0.00%	0.00%	0.00%	0.23%	0.00%	3.26%	0.00%	1.67%	0.00%
Flooding	5.33%	9.64%	7.20%	4.79%	2.37%	5.17%	14.32%	15.18%	14.63%	11.17%
Tsunami	0.00%	2.05%	0.00%	0.45%	0.00%	0.00%	0.00%	1.64%	0.59%	0.00%
Drought	0.39%	1.57%	4.46%	1.63%	1.73%	1.82%	0.00%	1.26%	4.22%	2.10%
Freeze	0.00%	0.72%	1.04%	0.00%	0.00%	0.00%	2.57%	0.00%	0.00%	0.00%
Heatwave	0.00%	0.36%	0.00%	0.00%	0.00%	0.21%	1.30%	0.29%	0.41%	0.59%
Market Crash	14.18%	12.51%	9.25%	4.20%	5.49%	8.07%	27.55%	10.00%	21.21%	12.24%
Sovereign Default	0.11%	0.41%	1.48%	0.63%	8.98%	10.22%	0.60%	0.33%	0.46%	0.39%
Oil Price	3.85%	11.68%	9.32%	2.09%	-3.78%	9.03%	17.24%	9.34%	13.28%	6.37%
Interstate War	10.05%	16.16%	24.12%	11.08%	37.93%	12.78%	0.54%	12.92%	0.41%	1.26%
Separatism	0.00%	0.00%	0.00%	0.00%	6.47%	5.83%	0.00%	0.00%	0.00%	9.86%
Terrorism	0.00%	0.12%	0.14%	0.67%	2.39%	1.94%	0.65%	0.09%	0.06%	0.08%
Social Unrest	0.07%	0.11%	0.07%	0.25%	0.26%	3.31%	0.44%	0.02%	0.15%	0.17%
Electrical power outage	0.61%	1.24%	0.74%	0.41%	0.58%	1.08%	1.83%	0.99%	1.41%	1.24%
Cyber	2.55%	3.33%	1.98%	0.25%	0.46%	2.18%	15.43%	8.30%	11.88%	2.43%
Solar Storm	0.30%	1.32%	0.79%	0.27%	0.31%	0.77%	2.48%	1.06%	1.64%	0.89%
Nuclear Power Plant Accident	0.28%	0.16%	0.00%	0.00%	0.00%	0.00%	1.56%	0.13%	0.00%	0.11%
Pandemic	3.52%	6.72%	5.58%	3.06%	4.32%	8.68%	9.00%	5.38%	6.96%	16.45%
Plant Epidemic	0.29%	0.81%	0.48%	0.25%	0.42%	0.47%	1.19%	0.64%	0.92%	3.28%
Total GDP at Risk (\$US Bn)	201.62	183.07	136.52	114.02	108.50	105.65	91.25	91.11	90.84	88.15

Rank [Total GDP at Risk]	11	12	13	14	15	16	17	18	19	20
CRS City ID	HKG_HKG	ARG_DFD	IND_BOM	IND_DEL	PER_LIM	BRA_SEP	FRA_IDF	CHN_BJN	MEX_DTD	GBR_LON
City Name	Hong Kong	Buenos Aires	Bombay (Mumbai)	Delhi	Lima	Sao Paulo	Paris	Beijing	Mexico City	London
CRS Country ID	CHN	ARG	IND	IND	PER	BRA	FRA	CHN	MEX	GBR
Country Name	Hong Kong	Argentina	India	India	Peru	Brazil	France	China	Mexico	United Kingdom
Earthquake	0.00%	0.00%	0.22%	0.22%	48.88%	0.00%	0.00%	13.91%	10.97%	0.00%
Volcano	0.00%	0.00%	0.00%	0.00%	0.62%	0.00%	0.00%	0.00%	21.56%	0.00%
Wind Storm	17.75%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	30.24%	0.00%
Temperate Wind Storm	0.00%	0.00%	1.41%	0.62%	0.00%	0.00%	1.50%	1.30%	0.00%	2.06%
Flooding	7.48%	8.57%	7.54%	14.65%	4.83%	18.36%	14.74%	7.43%	10.35%	18.01%
Tsunami	0.05%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Drought	2.80%	2.43%	0.00%	0.00%	0.00%	0.00%	0.00%	2.77%	0.00%	5.20%
Freeze	0.00%	0.00%	0.00%	0.45%	0.00%	0.00%	1.10%	1.54%	0.68%	1.00%
Heatwave	0.00%	0.00%	0.23%	0.23%	0.20%	0.00%	1.35%	0.00%	0.34%	0.51%
Market Crash	16.36%	7.18%	7.57%	7.44%	24.39%	24.14%	28.35%	16.16%	11.79%	26.12%
Sovereign Default	0.51%	14.53%	2.03%	1.99%	1.51%	3.40%	0.63%	0.51%	2.65%	0.51%
Oil Price	8.49%	7.38%	7.45%	7.32%	-7.84%	12.08%	17.85%	8.41%	-13.47%	16.34%
Interstate War	1.65%	40.34%	19.20%	18.88%	12.25%	0.00%	0.56%	1.66%	0.00%	0.51%
Separatism	12.95%	0.00%	20.69%	20.35%	0.00%	0.00%	0.00%	13.04%	0.00%	0.00%
Terrorism	0.10%	0.35%	9.81%	2.90%	3.50%	1.39%	1.18%	0.10%	1.04%	1.08%
Social Unrest	0.45%	0.88%	1.61%	3.57%	0.16%	0.64%	1.74%	1.00%	1.07%	0.41%
Electrical power outage	1.66%	1.92%	2.37%	2.33%	1.02%	2.36%	1.89%	1.64%	2.33%	1.73%
Cyber	1.72%	2.52%	3.78%	3.71%	0.72%	14.41%	15.88%	3.21%	5.88%	14.63%
Solar Storm	1.10%	1.03%	0.79%	0.83%	0.68%	1.56%	2.21%	1.17%	1.16%	2.19%
Nuclear Power Plant Accident	0.94%	0.13%	0.67%	0.10%	0.00%	0.21%	0.25%	0.07%	0.00%	0.23%
Pandemic	21.61%	12.29%	14.12%	13.90%	8.45%	20.00%	9.88%	21.76%	12.32%	8.66%
Plant Epidemic	4.37%	0.46%	0.51%	0.50%	0.64%	1.47%	0.90%	4.33%	1.09%	0.82%
Total GDP at Risk (\$US Bn)	87.72	85.60	80.99	76.96	72.69	63.36	56.23	55.10	54.04	53.92

# What is Driving the GDP@Risk of Highest Risk Cities? (21-40)

Rank [Total GDP at Risk]	21	22	23	24	25	26	27	28	29	30
CRS City ID	RUS_MSC	SGP_SGP	CHN_TJ	CHN_GUZ	ISR_TAV	AFG_KAB	KWT_KUW	THA_KTH	CHN_SCH	PAK_KAR
City Name	Moscow	Singapore	Tianjin	Guangzhou	Tel Aviv_Jaffa	Kabul	Kuwait City	Bangkok	Chengtu	Karachi
CRS Country ID	RUS	SGP	CHN	CHN	ISR	AFG	KWT	THA	CHN	PAK
Country Name	Russian Federation	Singapore	China	China	Israel	Afghanistan	Kuwait	Thailand	China	Pakistan
Earthquake	0.00%	0.00%	41.41%	0.00%	3.02%	8.43%	7.24%	0.00%	13.80%	5.72%
Volcano	0.00%	7.17%	0.00%	0.00%	0.00%	0.17%	0.00%	1.13%	0.00%	0.44%
Wind Storm	0.00%	0.00%	0.00%	31.91%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Temperate Wind Storm	0.00%	1.20%	0.89%	0.00%	0.00%	0.11%	0.00%	1.36%	1.28%	0.64%
Flooding	3.50%	11.49%	5.10%	7.83%	3.52%	0.60%	7.46%	10.63%	9.77%	0.14%
Tsunami	0.00%	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Drought	0.00%	1.92%	1.90%	2.19%	1.22%	0.34%	2.69%	2.90%	2.74%	0.00%
Freeze	3.14%	0.00%	1.05%	0.50%	0.00%	0.19%	0.00%	0.00%	0.63%	0.00%
Heatwave	0.66%	0.00%	0.00%	0.25%	0.00%	0.00%	0.31%	0.00%	0.32%	0.10%
Market Crash	33.32%	34.55%	11.07%	12.80%	22.43%	2.28%	46.46%	42.28%	15.93%	10.00%
Sovereign Default	4.95%	0.46%	0.35%	0.40%	0.95%	4.68%	0.40%	2.48%	0.50%	5.71%
Oil Price	-29.35%	19.04%	5.76%	6.66%	6.02%	1.02%	-15.37%	10.80%	8.30%	2.74%
Interstate War	2.22%	0.00%	1.14%	1.32%	45.24%	56.60%	35.66%	0.00%	1.65%	53.40%
Separatism	20.86%	0.00%	8.96%	10.34%	11.78%	7.26%	0.00%	0.00%	12.95%	8.40%
Terrorism	11.25%	0.14%	0.07%	0.08%	0.80%	13.65%	0.19%	1.86%	0.10%	3.62%
Social Unrest	2.05%	0.14%	0.15%	0.18%	0.44%	0.61%	0.98%	5.26%	0.22%	0.73%
Electrical power outage	3.35%	2.27%	1.12%	1.30%	0.72%	0.27%	1.59%	1.72%	1.62%	0.71%
Cyber	12.81%	6.67%	2.20%	2.54%	0.45%	0.00%	0.93%	2.18%	3.16%	0.20%
Solar Storm	3.04%	1.51%	0.80%	0.86%	0.51%	0.14%	1.14%	1.14%	1.15%	0.35%
Nuclear Power Plant Accident	0.00%	0.00%	0.10%	0.11%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
Pandemic	27.12%	12.44%	14.96%	17.26%	2.58%	3.35%	9.82%	11.72%	21.61%	6.22%
Plant Epidemic	1.06%	0.99%	2.97%	3.43%	0.31%	0.31%	0.51%	4.53%	4.27%	0.84%
Total GDP at Risk (\$US Bn)	53.52	51.18	50.24	49.56	49.48	49.05	49.04	49.04	48.86	48.79

Rank [Total GDP at Risk]	31	32	33	34	35	36	37	38	39	40
CRS City ID	CHN_SHE	SDN_AKH	CHN_Hang	SAU_JED	IRQ_BGH	SAU_ARI	USA_ILL	USA_FRA	CHN_82927	IDN_JRA
City Name	Shenzhen	Khartoum	Hangzhou	Jeddah	Baghdad	Riyadh	Chicago	San Francisco	Wenguan, Guangdong	Jakarta
CRS Country ID	CHN	SDN	CHN	SAU	IRQ	SAU	USA	USA	CHN	IDN
Country Name	China	Sudan	China	Saudi Arabia	Iraq	Saudi Arabia	United States	United States	China	Indonesia
Earthquake	0.00%	0.00%	0.00%	9.19%	0.00%	0.00%	0.00%	13.62%	0.00%	13.06%
Volcano	0.00%	0.28%	0.00%	0.92%	0.00%	0.00%	0.00%	0.00%	0.00%	9.87%
Wind Storm	30.96%	0.00%	62.26%	0.00%	0.00%	0.00%	0.00%	0.00%	63.47%	0.00%
Temperate Wind Storm	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.22%	1.33%	0.00%	1.01%
Flooding	7.87%	1.17%	6.11%	0.26%	1.58%	0.17%	14.59%	13.15%	4.18%	7.86%
Tsunami	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.11%
Drought	2.21%	0.00%	1.15%	0.00%	0.00%	0.00%	0.00%	2.13%	1.17%	7.66%
Freeze	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	2.62%	0.00%	0.27%	0.00%
Heatwave	0.26%	0.06%	0.13%	0.30%	0.05%	0.32%	1.33%	0.00%	0.14%	0.00%
Market Crash	12.86%	3.80%	6.67%	44.78%	3.05%	47.65%	28.07%	25.30%	6.74%	14.50%
Sovereign Default	0.41%	6.84%	0.21%	0.41%	5.71%	0.43%	0.61%	0.56%	0.22%	19.28%
Oil Price	6.69%	-2.66%	3.48%	-14.58%	-2.41%	-15.51%	17.57%	15.85%	3.54%	-16.76%
Interstate War	1.32%	75.41%	0.69%	38.63%	64.74%	41.06%	0.55%	0.50%	0.72%	0.00%
Separatism	10.40%	5.76%	5.43%	0.00%	8.82%	0.00%	0.00%	0.00%	5.64%	0.00%
Terrorism	0.08%	3.01%	0.04%	5.22%	12.84%	9.54%	0.07%	0.07%	0.04%	10.31%
Social Unrest	0.18%	0.19%	0.09%	0.41%	1.70%	0.99%	0.20%	0.18%	0.09%	0.30%
Electrical power outage	1.30%	0.61%	0.68%	1.51%	0.33%	1.61%	1.86%	1.68%	0.69%	1.91%
Cyber	2.55%	0.01%	1.33%	0.54%	0.01%	0.57%	15.72%	14.17%	1.34%	3.86%
Solar Storm	0.87%	0.20%	0.48%	1.00%	0.18%	1.07%	2.53%	1.96%	0.46%	1.27%
Nuclear Power Plant Accident	0.74%	0.00%	0.39%	0.00%	0.00%	0.00%	1.59%	0.00%	0.06%	0.00%
Pandemic	17.36%	3.74%	9.06%	10.94%	3.31%	11.61%	9.25%	8.42%	9.42%	18.69%
Plant Epidemic	3.44%	1.59%	1.79%	0.48%	0.08%	0.51%	1.21%	1.09%	1.82%	5.05%
Total GDP at Risk (\$US Bn)	47.83	47.43	46.46	45.93	45.77	44.43	42.67	41.63	41.51	41.42

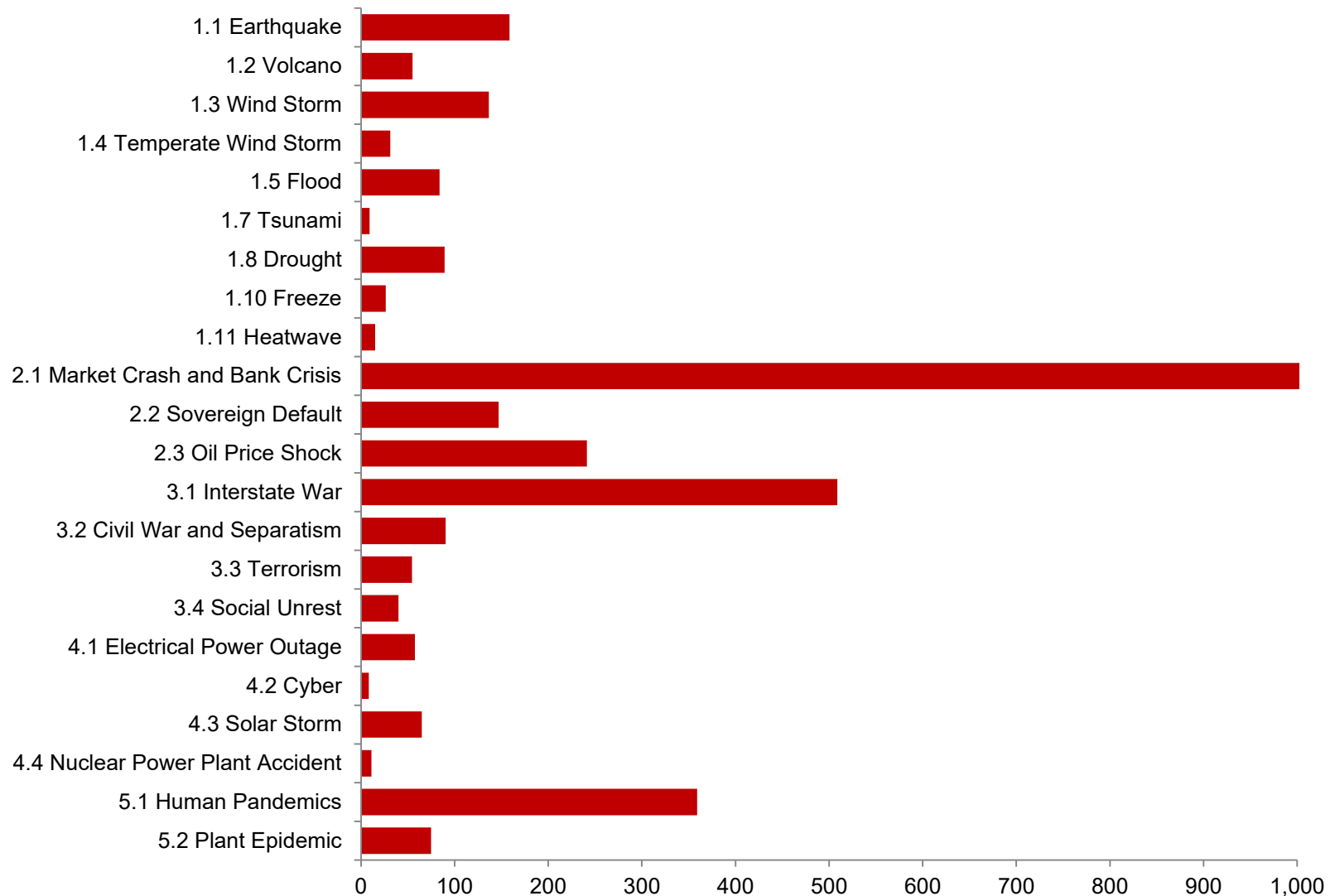


# What is Driving the GDP@Risk of Highest Risk Cities? (31-60)

Rank [Total GDP at Risk]	41	42	43	44	45	46	47	48	49	50
CRS City ID	CHE_14022	UKR_KIE	TUR_IZM	EGY_AQH	JPN_CHB	USA_HOU	COL_BOG	CHL_RMT	NGA_LAG	IND_WBN
City Name	Berne	Kiev	Izmir	Cairo	Nagoya	Houston	Bogotá	Santiago	Lagos	Calcutta
CRS Country ID	CHE	UKR	TUR	EGY	JPN	USA	COL	CHL	NGA	IND
Country Name	Switzerland	Ukraine	Turkey	Egypt	Japan	United States	Colombia	Chile	Nigeria	India
Earthquake	0.08%	0.00%	40.60%	11.20%	9.82%	0.00%	38.52%	16.57%	0.00%	7.40%
Volcano	0.00%	0.00%	0.00%	0.00%	4.72%	0.00%	6.61%	11.54%	0.78%	0.00%
Wind Storm	0.00%	0.00%	0.00%	0.00%	15.16%	3.76%	0.00%	0.00%	0.00%	36.72%
Temperate Wind Storm	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.80%	0.00%	0.00%	0.00%
Flooding	17.88%	2.16%	4.13%	0.32%	9.21%	24.60%	1.62%	8.39%	1.99%	8.17%
Tsunami	0.00%	0.00%	0.00%	0.00%	1.95%	0.00%	0.00%	0.00%	0.00%	0.00%
Drought	2.22%	0.00%	1.46%	0.00%	0.00%	4.79%	2.56%	0.00%	3.45%	1.10%
Freeze	1.01%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Heatwave	0.00%	0.00%	0.17%	0.23%	0.35%	0.47%	0.00%	0.00%	0.00%	0.13%
Market Crash	40.54%	6.25%	6.45%	15.19%	11.95%	24.03%	37.36%	39.79%	14.29%	4.14%
Sovereign Default	0.52%	3.21%	8.20%	24.16%	0.39%	0.53%	2.20%	0.32%	9.88%	1.11%
Oil Price	13.46%	2.85%	7.24%	-9.11%	11.16%	15.06%	-14.63%	11.02%	-7.54%	4.08%
Interstate War	0.00%	59.76%	10.26%	32.51%	15.44%	0.47%	0.00%	0.00%	15.68%	10.52%
Separatism	0.00%	19.77%	4.69%	0.00%	0.00%	0.00%	0.00%	0.00%	34.68%	11.35%
Terrorism	0.17%	0.08%	5.59%	6.13%	0.11%	0.06%	7.96%	1.41%	2.77%	3.03%
Social Unrest	0.04%	2.32%	0.59%	3.63%	0.02%	0.08%	0.24%	0.08%	2.64%	0.44%
Electrical power outage	1.75%	0.34%	0.86%	1.58%	1.18%	1.60%	2.02%	1.32%	1.15%	1.30%
Cyber	7.83%	0.24%	1.75%	0.44%	9.92%	13.46%	3.05%	0.80%	0.02%	2.07%
Solar Storm	2.04%	0.29%	0.62%	0.84%	1.27%	1.86%	1.01%	0.94%	0.57%	0.43%
Nuclear Power Plant Accident	1.61%	0.00%	0.00%	0.00%	0.16%	0.21%	0.00%	0.00%	0.00%	0.00%
Pandemic	10.03%	2.28%	7.00%	11.01%	6.42%	7.98%	9.72%	7.25%	15.14%	7.75%
Plant Epidemic	0.83%	0.11%	0.37%	1.87%	0.77%	1.04%	0.94%	0.57%	4.51%	0.28%
Total GDP at Risk (\$US Bn)	37.59	36.73	35.40	34.42	31.84	31.83	30.77	30.66	30.64	30.12

Rank [Total GDP at Risk]	51	52	53	54	55	56	57	58	59	60
CRS City ID	ARE_5274	CHN_NIN	CHN_ANH	VEN_DFD	TUR_ANK	USA_WAS	PAK_LAH	CHN_XIA	VNM_HNO	KOR_BUS
City Name	Abu Dhabi	Ningbo	Hofei	Caracas	Ankara	Washington	Lahore	Xiamen	Hanoi	Busan
CRS Country ID	ARE	CHN	CHN	VEN	TUR	USA	PAK	CHN	VNM	KOR
Country Name	United Arab Emirates	China	China	Venezuela, Bolivarian Repul	Turkey	United States	Pakistan	China	Vietnam	Korea, Republic of
Earthquake	38.07%	0.00%	0.00%	42.04%	7.89%	0.00%	5.51%	0.06%	30.98%	0.05%
Volcano	0.00%	0.54%	0.00%	0.94%	0.00%	0.00%	0.43%	0.00%	0.00%	3.29%
Wind Storm	0.00%	61.92%	26.60%	0.00%	0.00%	0.00%	0.00%	71.91%	16.75%	46.29%
Temperate Wind Storm	1.10%	0.00%	0.00%	1.21%	0.00%	3.55%	0.27%	0.00%	0.00%	0.00%
Flooding	0.36%	6.08%	8.79%	1.58%	12.57%	4.36%	2.28%	4.73%	3.00%	7.73%
Tsunami	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Drought	0.00%	1.14%	0.00%	0.00%	0.00%	2.52%	2.06%	0.00%	0.00%	3.22%
Freeze	0.00%	0.00%	0.00%	0.00%	0.00%	2.80%	0.00%	0.00%	0.28%	0.00%
Heatwave	0.41%	0.13%	0.29%	0.00%	0.00%	1.42%	0.24%	0.10%	0.00%	0.00%
Market Crash	62.52%	6.63%	14.31%	27.64%	9.95%	29.95%	9.61%	5.16%	13.04%	6.68%
Sovereign Default	0.51%	0.21%	0.45%	14.73%	12.63%	0.66%	5.50%	0.16%	7.45%	1.07%
Oil Price	-20.04%	3.46%	7.46%	-14.79%	11.15%	18.76%	2.64%	2.69%	-5.55%	6.73%
Interstate War	0.00%	0.69%	1.49%	0.00%	15.79%	0.59%	51.46%	0.54%	20.96%	17.42%
Separatism	0.00%	5.41%	11.67%	0.00%	7.22%	0.00%	8.10%	4.20%	0.00%	0.00%
Terrorism	0.25%	0.04%	0.09%	1.60%	2.41%	0.71%	3.50%	0.03%	0.00%	0.10%
Social Unrest	0.57%	0.09%	0.20%	4.70%	4.08%	0.47%	0.35%	0.07%	0.11%	0.01%
Electrical power outage	2.08%	0.67%	1.45%	2.04%	1.33%	1.99%	0.69%	0.52%	0.96%	0.54%
Cyber	0.35%	1.32%	2.84%	3.11%	2.69%	16.78%	0.19%	1.02%	0.26%	1.43%
Solar Storm	1.38%	0.48%	1.04%	1.02%	0.95%	2.51%	0.37%	0.35%	0.48%	0.57%
Nuclear Power Plant Accident	0.18%	0.38%	0.00%	0.00%	0.00%	1.70%	0.00%	0.05%	0.00%	0.49%
Pandemic	11.61%	9.03%	19.49%	13.23%	10.76%	9.95%	6.01%	7.02%	9.38%	4.03%
Plant Epidemic	0.66%	1.78%	3.84%	0.96%	0.58%	1.29%	0.81%	1.38%	1.90%	0.35%
Total GDP at Risk (\$US Bn)	29.99	29.97	29.83	29.11	29.10	26.89	26.18	25.96	25.44	24.77

# Total GDP Loss from Threats for All 300 Cities



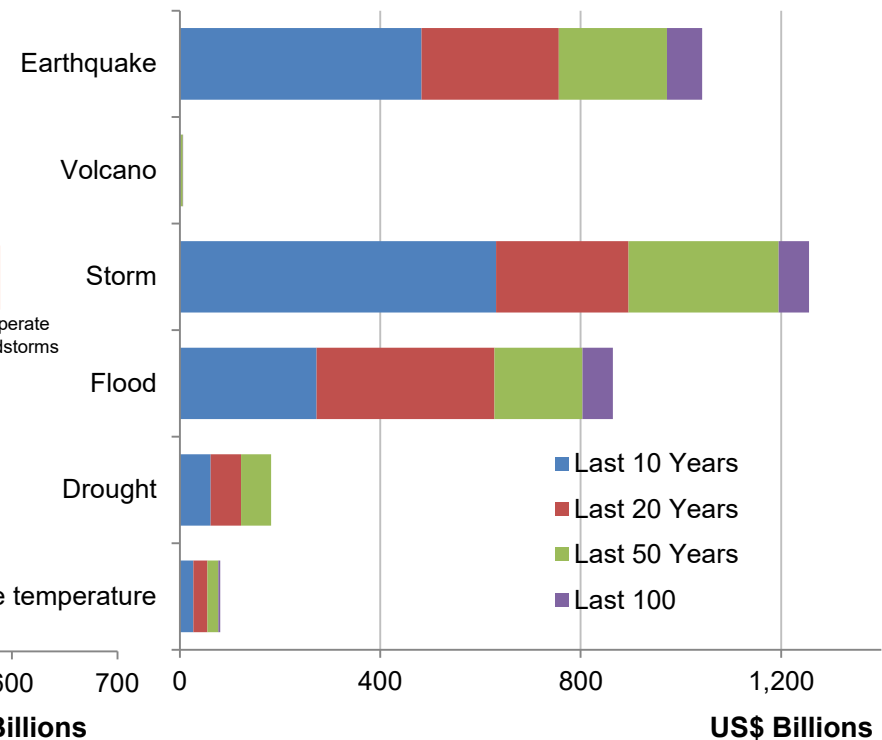
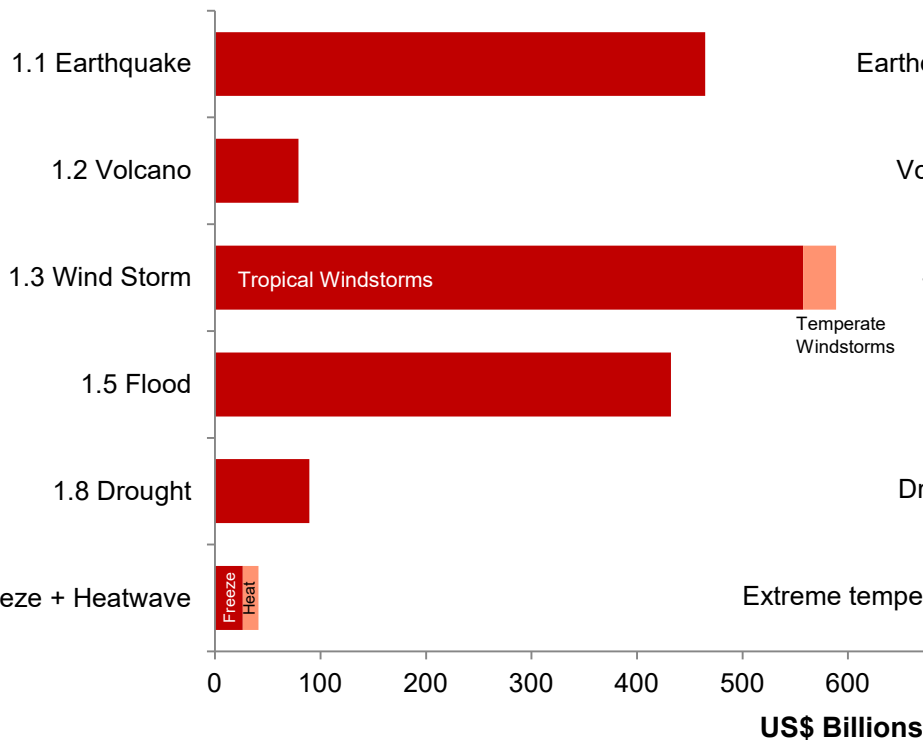
# Comparison with History

## Expected Loss of Economic Output

- Modelled over next 10 years
- 300 cities
- Economic output

## Historical Data Direct Costs of Natural Catastrophe

- Observed Past 100 years
  - Worldwide
  - Repair costs to physical infrastructure
- EM-DAT Database of CRED  
3,806 events since 1900





# How Does Our Study Compare with Other Estimates?

- US National Bureau of Economic Research: Comparison of GDP erosion from cyclones with estimates of other threats

*The Causal Effect of Environmental Catastrophe on Long-Run Economic Growth: Evidence From 6,700 Cyclones*

Solomon M. Hsiang, Amir S. Jina, U.S. National Bureau of Economic Research;  
Pre-Publication Manuscript July 2014

Table 1: Effects of cyclones and other shocks to income per capita

Event Type	Effect on Income	Observed After	In-Sample Probability
Temperature increase (+1°C) <sup>*1</sup>	-1.0%	10 yrs	6.4%
Civil war <sup>2</sup>	-3.0%	10 yrs	6.3%
Tax increase (+1% GDP) <sup>**3</sup>	-3.1%	4 yrs	<sup>1</sup> 16.8%
1 standard deviation cyclone	-3.6%	20 yrs	14.4%
Currency crisis <sup>2</sup>	-4.0%	10 yrs	34.7%
Weakening executive constraints <sup>2</sup>	-4.0%	10 yrs	3.7%
90th percentile cyclone	-7.4%	20 yrs	5.8%
Banking crisis <sup>2</sup>	-7.5%	10 yrs	15.7%
Financial crisis <sup>4</sup>	-9.0%	2 yrs	<0.1%
99th percentile cyclone	-14.9%	20 yrs	0.6%

<sup>\*</sup>Poor countries only; <sup>\*\*</sup>USA only; <sup>1</sup>Number of quarters with any tax change.

<sup>1</sup>Dell, Jones & Olken (AEJ: Macro, 2012); <sup>2</sup>Corra & Saxena (AER, 2008); <sup>3</sup>Romer & Romer (AER, 2010); <sup>4</sup>Reinhart & Rogoff (AER, 2009)

US NBER	National GDP Impact
Cyclone	1.00
Civil War	0.86
Currency Crisis	1.11
Banking Crisis	2.08

Cambridge Model	Global GDP Loss
Tropical Windstorm	1.00
Separatism	0.45
Sovereign Default	0.32
Market Crash	1.88

# How Does Our Study Compare with Swiss Re's Estimates?

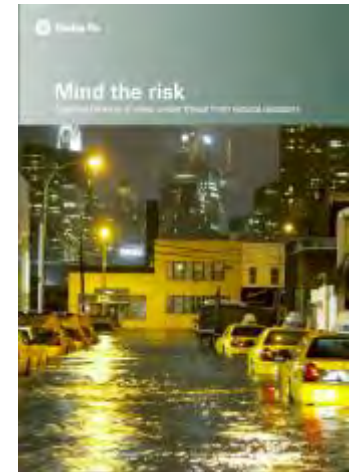
- Swiss Re has developed a system CatNet [www.swissre.com/catnet](http://www.swissre.com/catnet)
- Contains datasets on natural hazards and cities
- Report 'Mind the Risk' assesses 616 cities for 5 perils
  - Earthquake
  - Wind storm
  - River flood
  - Storm surge
  - Tsunami
- Uses 'working days lost' as their metric of GDP loss

Table 3:  
Most people potentially affected, aggregated for all five perils (in million)

Tokyo-Yokohama (JPN)	57.1
Manila (PHL)	34.6
Pearl-River Delta (CHN)	34.5
Osaka-Kobe (JPN)	33.1
Jakarta (IND)	27.7
Nagoya (JPN)	22.9
Kolkata (IND)	17.9
Shanghai (CHN)	16.7
Los Angeles (USA)	16.4
Tehran (IRN)	15.6

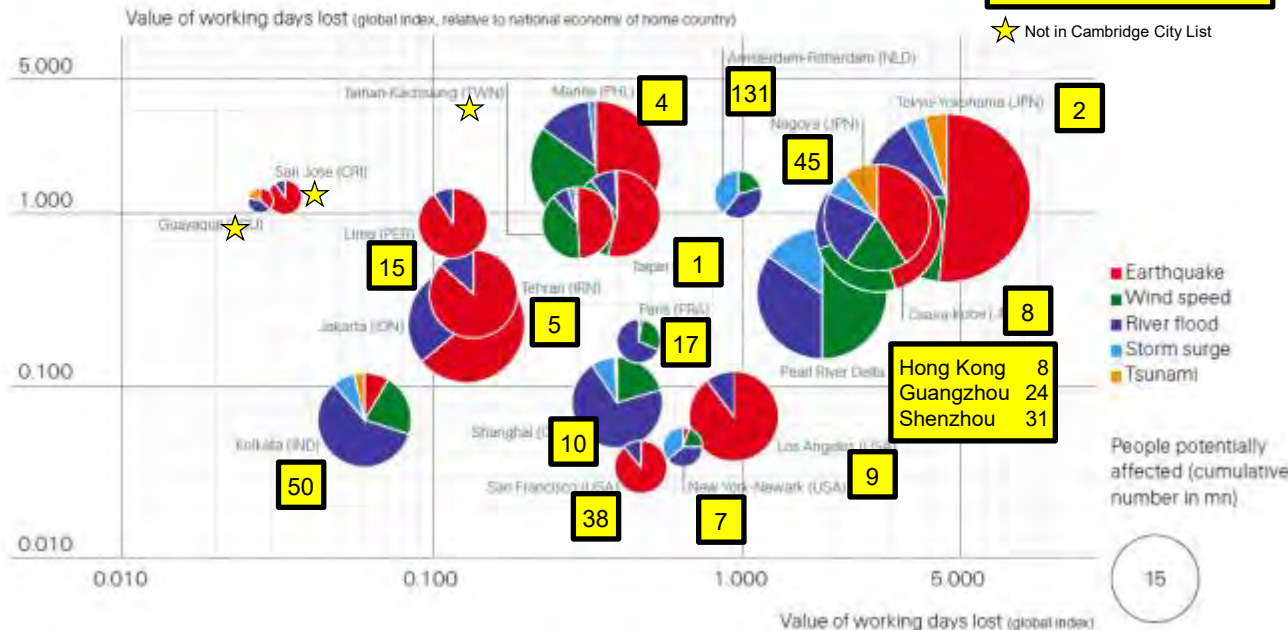
Table 4:  
Cumulative number of people potentially affected in all metropolitan areas - by peril

Peril	People potentially affected globally, in millions
River flood	379
Earthquake	283
Wind storm	157
Storm surge	33
Tsunami	12



**Figure 8: Impact of all perils by metropolitan area - Top 10**

The chart includes the aggregate number of people potentially affected by all relevant perils (bubble size) and global rankings by the value of working days lost, in absolute terms (x-axis) and in relation to the country's national economy (y-axis). Residents are counted multiple times when affected by more than one peril because each peril is accounted for individually.



Swiss Re, Mind the Risk: A global ranking of cities under threat from natural disasters  
[http://media.swissre.com/documents/Swiss\\_Re\\_Mind\\_the\\_risk.pdf](http://media.swissre.com/documents/Swiss_Re_Mind_the_risk.pdf)

- Cambridge Top 10 contains 8 of the Swiss Re 'Top 10' cities
  - Swiss Re does not include Seoul or Istanbul
- Swiss Re prioritization & mix of perils has several differences
- Cambridge analysis does not have as high a loss value for Amsterdam
- Swiss Re has separate model for River flood and Storm surge
  - River flood is their dominant peril

# Results: Key Observations and Insights



	Number of cities in	
	Top 20	Top 50
China	3	9
Japan	2	3
Rest of SE Asia	3	6
SE Asia	8	18
Middle East	2	9
Latin America	4	6
Indian Subcontinent	2	4
North America	2	5
Western Europe	2	3
Africa	0	2
Eastern Europe	0	3
Oceania	0	0

- Geography: the threat to the world's economic growth is most significant in the emerging markets of
  - Southeast Asia
  - Middle East
  - Latin America
  - Indian Subcontinent
- This is a shift from historical patterns of loss, as much of the world's economic growth is expected to be in these markets over the next decade



# **\$5 Trillion of World's GDP will be lost to catastrophes in the next decade**

- The analysis results suggest that the expected loss (probability-weighted losses) will amount to **\$5.4 Trillion** for these 300 cities from 1 Jan 2015 to 1 Jan 2025
- These cities account for around 50% of global GDP today (and an estimated two thirds of global GDP by 2025)
  - So if the rest of the world's GDP is as risky as these 300 cities, it would be reasonable to factor the \$5.4 Tr to estimate that:
  - Losses to the Global Economy from catastrophes: **\$7 Tr to \$10 Trillion**
- The total GDP projected to be generated from the 300 cities 2015-2025 is \$373 Trillion, so
- The expected loss from catastrophes is **1.5% of total GDP output**
- **Catastrophes put a burden of 1.5% on the world's economic output**
  - What would it be worth to society to invest to reduce this loss?

# The Growing Importance of Man-Made and Emerging Risks

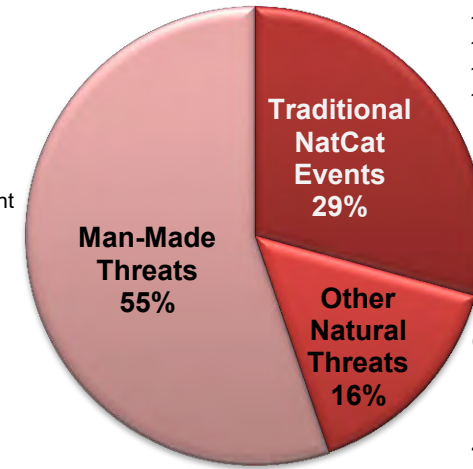
- More than half of the future risk is from man-made threats
- More than a third of future risks is from rapidly changing 'emerging risks'
- This may change the way we think about risk
  - Traditional NatCat threatens the physical 'means of production' (buildings and machinery)
  - Threats to disruption of the social 'means of production' could become more significant in the future

## Man-Made Threats:

2.1 Market Crash and Bank Crisis  
2.2 Sovereign Default  
2.3 Oil Price Shock  
3.1 Interstate War  
3.2 Civil War and Separatism  
3.3 Terrorism  
3.4 Social Unrest  
4.1 Electrical Power Outage  
4.2 Cyber  
4.4 Nuclear Power Plant Accident

## Traditional NatCat:

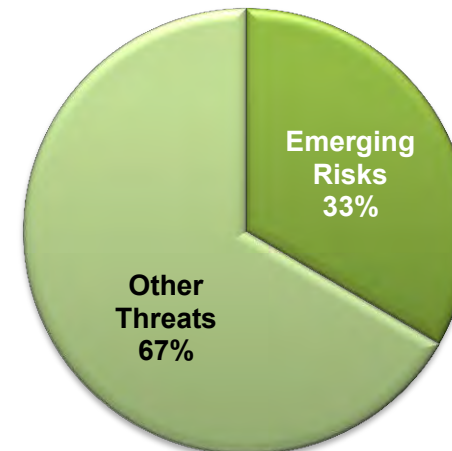
1.1 Earthquake  
1.2 Volcano  
1.3 Tropical Wind Storm  
1.4 Temperate Wind Storm  
1.5 Flood  
1.7 Tsunami



## Other Natural Threats:

1.8 Drought  
1.10 Freeze  
1.11 Heatwave  
4.3 Solar Storm  
5.1 Human Pandemics  
5.2 Plant Epidemic

Distribution by Threats of \$5.4 Trillion GDP@Risk



## Emerging Risks:

4.2 Cyber  
3.4 Social Unrest  
5.1 Human Pandemics  
5.2 Plant Epidemic  
3.1 Interstate War

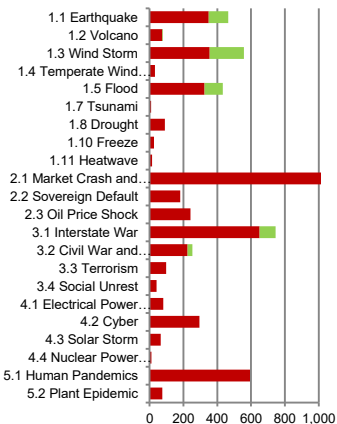
# How Much Could We Reduce the Risk?

Using the model to explore the impact of risk mitigation through investment

All Cities Improve:

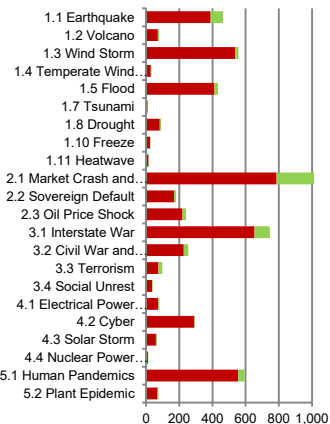
## Physical Vulnerability

1.6a  
Physical Vulnerability  
By One Notch  
1=1; 2=1; 3=2; 4=3; 5=4



Was: \$ 5.43 Tr  
Now: \$ 4.87 Tr  
Saving: \$ 556 Bn  
Reduction 10%

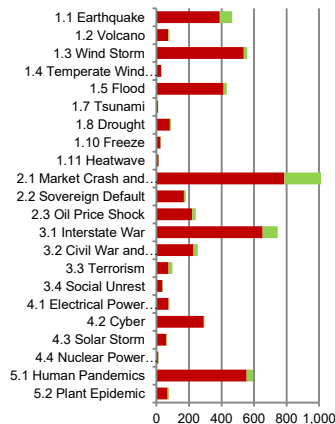
1.6b  
Physical Vulnerability  
To the Max Possible  
1=1; 2=1; 3=1; 4=1; 5=1



Was: \$ 5.43 Tr  
Now: \$ 3.99 Tr  
Saving: \$ 1.44 Tr  
Reduction 26%

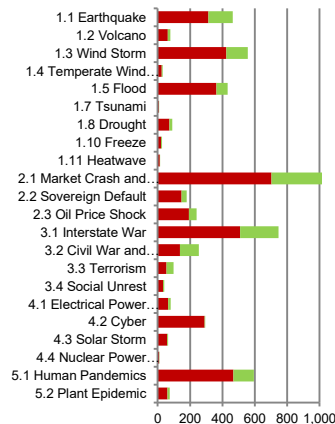
## Social & Economic Resilience

1.6c  
Resilience  
By One Notch  
1=1; 2=1; 3=2; 4=3; 5=4



Was: \$ 5.43 Tr  
Now: \$ 4.78 Tr  
Saving: \$ 646 Bn  
Reduction 12%

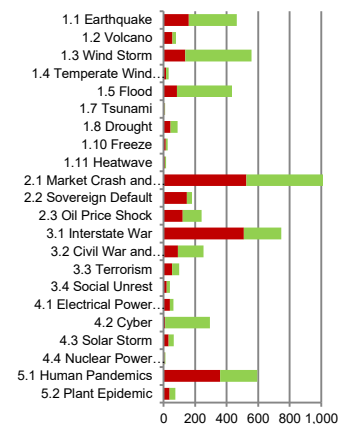
1.6d  
Resilience  
To the Max Possible  
1=1; 2=1; 3=1; 4=1; 5=1



Was: \$ 5.43 Tr  
Now: \$ 4.02 Tr  
Saving: \$ 1.41 Tr  
Reduction 26%

## Physical Vulnerability and Social & Economic Resilience

1.6e  
Vulnerability & Resilience  
To the Max Possible  
1=1; 2=1; 3=1; 4=1; 5=1  
1=1; 2=1; 3=1; 4=1; 5=1



Was: \$ 5.43 Tr  
Now: \$ 2.47 Tr  
Saving: \$ 2.95 Tr  
Reduction 54%

# How Much Might Climate Change Increase the Risk?

## ■ Climate Change is likely to increase the risk of:

- 1.3 Wind Storm
- 1.4 Temperate Wind Storm
- 1.5 Flood
- 1.8 Drought
- 1.10 Freeze
- 1.11 Heatwave

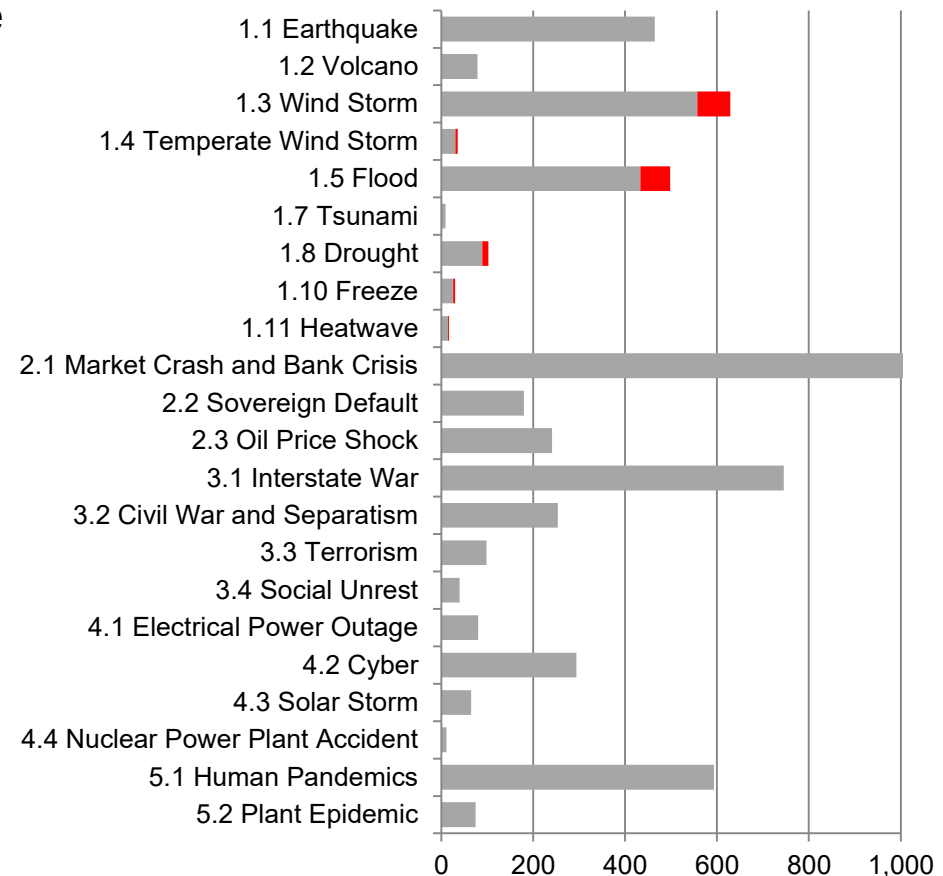
## ■ If:

- All frequencies all these increased by **10%**,
- All event severities increased by **5%**

## ■ Global GDP@Risk **increases by 3%**

## ■ Some studies suggest that climate change could also increase the threat of

- 5.1 Human Pandemics
- 5.2 Plant Epidemic
- 3.4 Social Unrest
- 3.1 Interstate War
- 3.2 Civil War and Separatism

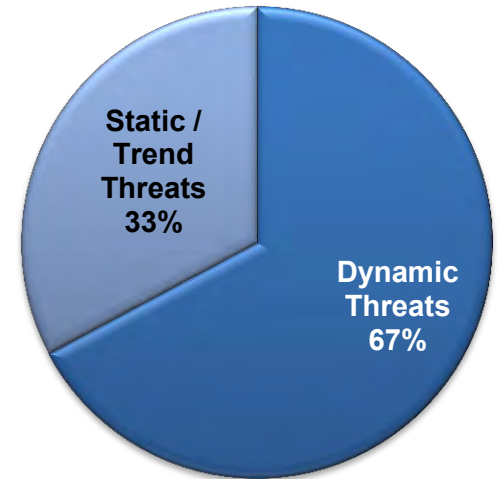


Was: \$ 5.43 Tr  
 Now: \$ 5.59 Tr  
 Increase: **\$ 156 Bn**  
 Increase of: **3%**



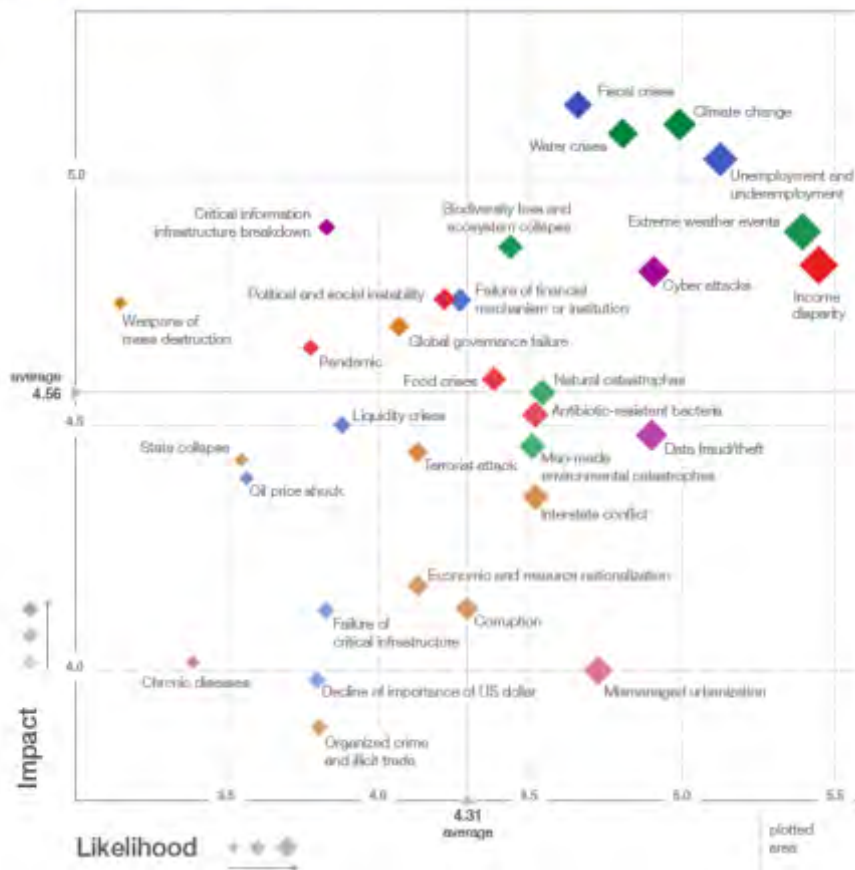
# Most of the Risk is Very Dynamic

- Two-thirds of the risk is from threats that vary a lot from year to year – ‘dynamic threats’
  - We have made our best projection of these for their average rate of occurrence over the next decade
  - However, our view of these risks are likely to be different next year
- It would be possible to update our risk projection each year
- We could provide an annual index and risk report, co-branded with Lloyd’s
- An annual risk report would give an update on
  - This year’s change in ranking of cities
  - Which threats have increased (or decreased)
  - Any mitigation measures that are significant



# WEF publishes an annual Global Risks Perception Survey

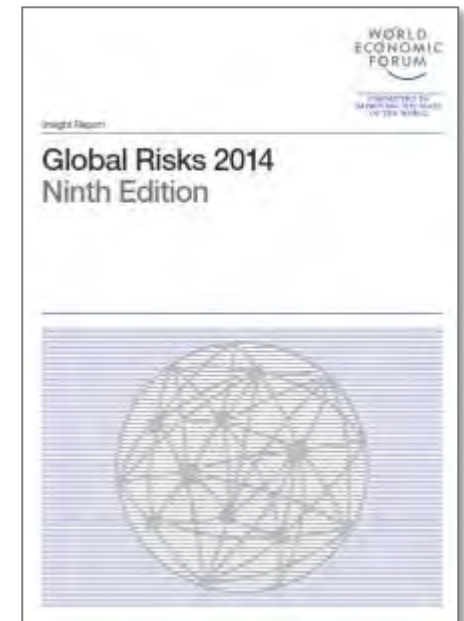
Figure 1.1: The Global Risks Landscape 2014



Source: Global Risks Perception Survey 2013-2014.

Note: Survey respondents were asked to assess the likelihood and impact of the individual risks on a scale of 1 to 7, 1 representing a risk that is not likely to happen or have impact, and 7 a risk very likely to occur and with massive and devastating impacts.

- Economic Risks**
  - Fiscal crises
  - Failure of financial mechanism or institution
  - Liquidity crises
  - Unemployment and underemployment
  - Oil price shock
  - Failure of critical infrastructure
  - Decline of importance of US dollar
- Geopolitical Risks**
  - Global governance failure
  - State collapse
  - Corruption
  - Organized crime and illicit trade
  - Terrorist attack
  - Weapons of mass destruction
  - Interstate conflict
  - Economic and resource nationalization
- Environmental Risks**
  - Extreme weather events
  - Natural catastrophes
  - Man-made environmental catastrophes
  - Biodiversity loss and ecosystem collapse
  - Water crises
  - Climate change
- Societal Risks**
  - Food crises
  - Pandemic
  - Chronic diseases
  - Income disparity
  - Antibiotic-resistant bacteria
  - Mismanaged urbanization
  - Political and social instability
- Technological Risks**
  - Critical information infrastructure breakdown
  - Cyber attacks
  - Data fraud/theft



An analysis based on measured risk metrics would be of more use than a perception survey

# Conclusions

- This study ranks cities by the risk of catastrophic disruption to their economies for the widest range of threats ever analyzed
- The study assesses the scale of economic output at risk for the world's most important cities
  - These cities represent half of the world's output today and will constitute two-thirds of its output by 2025
- It suggests that around half of this risk could be reduced by improved resilience and less vulnerable cities
- It shows how the pattern of risk is shifting from the developed world to the emerging markets
- In the most rapidly growing regions there is significant opportunity to reduce risk through improved infrastructure and risk management resilience

Centre for  
**Risk Studies**

---



UNIVERSITY OF  
CAMBRIDGE  
Judge Business School