CRS RISK OUTLOOK: NATURAL HAZARDS AND CLIMATE RISK

Oliver Carpenter
Natural Hazards Risk Research Lead
Cambridge Centre for Risk Studies
Outline

- Natural Hazards: A Growing Risk?
- Climate Change Risk
- Transition Risks
  - e.g. Market Risks
  - e.g. Liability Risks
  - e.g. Reputation & Consumer Change Risks
- Physical Risks
  - Modelling Extreme Weather Disruption
  - Quantifying Disaster Recovery
Natural Hazards: A Growing Risk

Annual Occurrence of Natural Hazard Events Globally and Total Losses; By Event Group

By Decade

<table>
<thead>
<tr>
<th>Year</th>
<th>Damage US$ Bn (2018) (Hydromet.)*</th>
<th>No. of Events (Hydromet.)*</th>
<th>Damage US$ Bn (2018) (Geophys.**)</th>
<th>No. of Events (Geophys.**)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>105</td>
<td>459</td>
<td>39</td>
<td>88</td>
</tr>
<tr>
<td>1970</td>
<td>172</td>
<td>715</td>
<td>77</td>
<td>125</td>
</tr>
<tr>
<td>1980</td>
<td>284</td>
<td>1,410</td>
<td>166</td>
<td>243</td>
</tr>
<tr>
<td>1990</td>
<td>837</td>
<td>2,246</td>
<td>322</td>
<td>330</td>
</tr>
<tr>
<td>2000</td>
<td>925</td>
<td>3,504</td>
<td>216</td>
<td>357</td>
</tr>
<tr>
<td>2010</td>
<td>1,261</td>
<td>2,813</td>
<td>409</td>
<td>273</td>
</tr>
</tbody>
</table>

*Hydrometeorological: incl. storm, extreme temperature, flood, landslide, drought, wildfire
**Geophysical: incl. earthquake, tsunami, volcano

Data Source: EM-DAT 2019
## The Decade in Natural Hazard Risk

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>The Haitian earthquake is the deadliest natural catastrophe of the decade, with more than 222,000 fatalities</td>
</tr>
<tr>
<td>2011</td>
<td>The fourth most powerful earthquake ever recorded strikes Japan’s Tōhoku region, triggering a major tsunami and the meltdown of Fukushima Nuclear Power Plant</td>
</tr>
<tr>
<td>2012</td>
<td>Hurricane Sandy devastates New York and New Jersey, a region rarely affected by windstorms</td>
</tr>
<tr>
<td>2013</td>
<td>Floods in Central Europe are the worst in recent European history and marked a step change in the understanding and management of flood risk</td>
</tr>
<tr>
<td>2013</td>
<td>Typhoon Haiyan is the deadliest storm to ever hit the Philippines and one of the most powerful storms ever recorded, prompting a global response to the disaster</td>
</tr>
<tr>
<td>2015</td>
<td>The Gorkha earthquake devastates Nepal, and gives new insights into Himalayan seismicity, suggesting the densely-populated region is at risk of more extreme mega-earthquakes</td>
</tr>
<tr>
<td>2015-16</td>
<td>Droughts in India affect 330 million people, making it the most widespread natural catastrophe of the decade</td>
</tr>
<tr>
<td>2016</td>
<td>The year is declared the warmest ever on record, with a global average of .94°C over the 20th Century norm</td>
</tr>
<tr>
<td>2017</td>
<td>Atlantic hurricanes Harvey, Irma and Maria contribute to the costliest hurricane season ever, with a $220bn loss overall</td>
</tr>
<tr>
<td>2018</td>
<td>California is affected by unprecedented wildfires, triggering an insurance response equivalent to those reserved for flood, hurricanes and earthquakes</td>
</tr>
</tbody>
</table>

[William Saito/Flickr, NASA/NOAA GOES, Kip Evans/Alamy]
Climate Change Risk

2100 WARMING PROJECTIONS
Emissions and expected warming based on pledges and current policies

Dec 2018 update

Baseline
4.1 – 4.8°C

Current policies
3.1 – 3.5°C

Optimistic policies
3.0°C

Pledges & Targets
2.7 – 3.0°C

2°C consistent
1.6 – 1.7°C

1.5°C consistent
1.3°C

greater Physical Risks

greater Transition Risks
Climate Change Risk

- **Physical Risks** are increasing in response to climate change
- Society’s response towards a low-carbon economy provides opportunities;
- But also presents **Transition Risks** to businesses, assets, and economies

### Climate Change Risks

<table>
<thead>
<tr>
<th>Shocks</th>
<th>Trends</th>
<th>Regulation &amp; Liability</th>
<th>Market</th>
<th>Reputation &amp; Consumer Power</th>
<th>Disruptive Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Exacerbated extreme weather events</td>
<td>▪ Changes to average climatic conditions</td>
<td>▪ Carbon pricing &amp; reporting obligations</td>
<td>▪ Market uncertainty or negative outlook</td>
<td>▪ Consumer preference change</td>
<td>▪ Disruptive, low-carbon products &amp; services</td>
</tr>
<tr>
<td>▪ Magnitude</td>
<td>▪ Sea level rise</td>
<td>▪ Asset stranding</td>
<td>▪ Investor sentiment – carbon divestment</td>
<td>▪ Frequency</td>
<td>▪ Raw material costs</td>
</tr>
<tr>
<td>▪ Frequency</td>
<td>▪ Ocean acidification</td>
<td>▪ Regulation of existing products &amp; services</td>
<td>▪ Raw material costs</td>
<td>▪ Geography</td>
<td>▪ Innovation failure</td>
</tr>
<tr>
<td>▪ Geography</td>
<td>▪ Cryosphere change/reduction</td>
<td>▪ Exposure to litigation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Disruption of biogeochemical cycles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Loss of biosphere integrity</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Adapted from TCFD 2017
Market Risk Scenarios

Unhedgeable risk: How Climate Change Sentiment Impacts Investment

- Awareness of climate change transition risks shifts market sentiment
- Economic shock through rapid divestment of carbon intensive assets
- Represent financial tipping points: losses to portfolio value within investor-sensitive timescales
- Changing asset allocations can offset only half of the negative impacts on financial portfolios: climate change thus entails ‘unhedgeable risk’

Impacts of Severe National Catastrophes on Financial Markets

- Few nat cats have impacted global markets, but growing global exposure means more potential loss vectors
- ‘Trillion Dollar Nat-Cat’ scenarios – threshold of loss that would trigger market shocks and economic downturns
- Impacting insurance balance sheets: through losses from property casualty underwriting portfolio and the devaluations to assets in their investment portfolio
### Liability Risks

**Litigation** risk arising from breaches of tort, consumer, corporate & financial risk management laws:

- Claims for failing to **mitigate** impacts of climate change
- Claims for failing to **adapt** to the impacts of climate change
- Claims for failure to **disclose** climate-related risks to shareholders

- Notable cases against energy companies include:
  - Public nuisance claim *City of Oakland v. BP p.l.c.*
  - Attribution claim *Lliuya v. RWE AG*
  - Breach of human rights claim *In re Greenpeace Southeast Asia and Others*
  - Securities fraud class action *Ramirez v. Exxon Mobil Corp.*
e.g. Liability Risks: Insurance Clash Scenarios

CRS Developing insurance clash scenarios

- Assess how an event triggers loss across all types of insurance and their coverages
- Large Nat Cats have potential to trigger losses in many property lines and casualty liability

**Hurricane Kayla**

- Counterfactual Hurricane Katrina: CAT 5 hits Gulf of Mexico
  - Storm surge: 2.4 m
  - Peak sustained wind speed: 305 km/h

- Significant liability & casualty claims due to perceived negligence & failure in duty of care
  - Impacts offshore energy assets, producing oil spill; environmental liability & clean-up costs
  - Medical malpractice lawsuits by injured patients
  - Workers compensation claimed by injured emergency personnel
  - Technical errors & omissions following failures in transmitting evacuation warnings

**Insurance Loss Estimates**

<table>
<thead>
<tr>
<th>Class of Business</th>
<th>US$ Bn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Lines Property</td>
<td>45</td>
</tr>
<tr>
<td>Personal Lines Property</td>
<td>84</td>
</tr>
<tr>
<td>Casualty and Liability</td>
<td>20</td>
</tr>
<tr>
<td>Energy</td>
<td>49</td>
</tr>
<tr>
<td>Marine</td>
<td>10</td>
</tr>
<tr>
<td>Aviation</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>224</strong></td>
</tr>
</tbody>
</table>

**Ranked Liability Loss**

<table>
<thead>
<tr>
<th>Liability Coverage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pollution Liability</td>
</tr>
<tr>
<td>2</td>
<td>Professional Liability</td>
</tr>
<tr>
<td>3</td>
<td>Directors and Officers</td>
</tr>
<tr>
<td>4</td>
<td>Employers Liability</td>
</tr>
<tr>
<td>5</td>
<td>Aggregate Policy</td>
</tr>
<tr>
<td>6</td>
<td>Commercial General Liability</td>
</tr>
<tr>
<td>7</td>
<td>Workers' Compensation</td>
</tr>
<tr>
<td>8</td>
<td>Product Liability</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15.4</strong></td>
</tr>
</tbody>
</table>
Reputation & Consumer Power Risks

61% of consumer say they’re likely to switch to a brand that is more environmentally friendly than their current brand

Global Web Index 2019

Consumer Preference Shift Model

- 5% of Population (Current)
- 50% Sustainable Purchasing
- 100% Traditional Purchasing

Take-Up Time $T_{5\%}$ to $T_{50\%}$

Climate change: Which airline is best for carbon emissions?

Amazon accused of lack of transparency on climate impact

Time’s up for a golden age of corporate greenwashing

Just 100 companies responsible for 71% of global emissions, study says

ExxonMobil boss extends olive branch to investors on climate change
Modelling Extreme Weather Occurrence

- Climate change models forecast that changes will occur in long-term average climatic conditions
  - Course-resolution models are still poor at predicting volatility
- However, it is **short-term extreme weather events** that will be disruptive to businesses & economies **in the next decade**
  - Already departed historic baseline: exacerbating event impacts
- Growth of attribution science linking climate change to individual events:
  
  **European Heatwaves**
  “Across the Euro-Mediterranean the likelihood of a heat wave at least as hot as summer 2017 is now on the order of 10%. Anthropogenic climate change has increased the odds at least threefold since 1950.”
  Kew et al. 2018

  **Bangladesh Floods**
  “Anthropogenic climate change doubled the likelihood of the 2017 pre-monsoon extreme 6-day rainfall event at northeast Bangladesh.”
  Rimi et al. 2018

  **North Atlantic Hurricanes**
  “Relative to pre-industrial conditions, climate change so far has enhanced the average and extreme rainfall of hurricanes Katrina, Irma and Maria, but did not change tropical cyclone wind-speed intensity.”
  Patricola & Wehner 2018

  **Australia Wildfire**
  “Extreme vapor pressure deficits (VPD) have been associated with enhanced wildfire risk. Using one model, we found for 2015/16 that human influences quintupled the risk of extreme VPD for western North America and increased the risk for extratropical Australia.”
  Tett et al. 2018

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**GISS Surface Temperature Analysis**

August 2017

L-OTI (°C) Anomaly vs 1951-1980

0.86

2017 S. Europe Heatwave

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**GISTEMP 2019. NASA Goddard Institute for Space Studies**

**GISS Surface Temperature Analysis**

August 2017

L-OTI (°C) Anomaly vs 1951-1980

0.86

2017 S. Europe Heatwave
Modelling Extreme Weather Disruption

- CRS approach to compile a short-term outlook of stress test for potential disruption
- Focus on vulnerability of economic productivity to extreme events
- Vulnerable economic sectors include:
  - Agriculture
  - Construction
  - Energy & Utilities
  - Finance
  - Healthcare
  - Leisure & Retail
  - Online Continuity
  - Tourism
  - Transportation
- We analyse the number of weather disruption days per year, i.e.:
  - When transport networks are unable to function
  - When retail footfall drops as customers deterred or restricted
  - When the productivity of business operations is reduced
Business Productivity Reduction

Store Footfall with Cold Weather

- Highway Traffic (Source 2)
- Footfall Reduction Non-Food Stores (Source 1)
- Food Stores Town Centres (Source 1)
- Colder

Source 1: IPSOS Retail Traffic Index
Source 2: Roh 2016

The Beast from the East engulfs London, 2018

City of London

Freezing weather costs UK economy £1bn a day

Financial impact of the 'beast from the east' and storm Emma worst since Christmas 2010

Lorries stuck on the M80 during 2018 Beast from the East
## Extreme Weather Operational Thresholds

<table>
<thead>
<tr>
<th>Event</th>
<th>Operational Thresholds</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Cyclone or Temperate Windstorm</td>
<td>Wind speed on land; lighting &amp; hail</td>
<td>Wind speed on land; lighting &amp; hail &gt;72 km/h Key ports affected; unsafe to operate cranes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wind speed on land; lighting &amp; hail &gt;75 km/h Road &amp; rail traffic disrupted; infrastructure damage &amp; debris, incl. power outages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wind speed on land; lighting &amp; hail &gt;83 km/h Key airports closed; aircraft cannot taxi</td>
</tr>
<tr>
<td></td>
<td>Wind speed at sea</td>
<td>Wind speed at sea &gt;62 km/h; gale force 8 Cargo ships halted; shipping traffic disrupted</td>
</tr>
<tr>
<td>Flash Flood</td>
<td>Precipitation &gt;10 cm in 3 hours</td>
<td>Loss of economic activity; infrastructural damage</td>
</tr>
<tr>
<td>Coastal Flood</td>
<td>Storm surge 1 m height (high tides coincident with low pressure storm systems &gt;990 mb central pressure &amp; high wind-driven waves &gt;75 km/h)</td>
<td>Loss of economic activity; infrastructural damage</td>
</tr>
<tr>
<td>River Flood</td>
<td>Precipitation &gt;20 cm/d in catchment; or, rapid snow melt in catchment (winter temperature rise &gt;5°C/d)</td>
<td>Loss of economic activity; infrastructural damage</td>
</tr>
<tr>
<td>Freeze</td>
<td>Temperature &lt; -10°C; Snowfall &gt;5 cm</td>
<td>Reduced air, rail &amp; road traffic</td>
</tr>
<tr>
<td>Heat Wave</td>
<td>Prolonged temperature deviation (e.g. &gt;1SD from 1-month mean); includes drought</td>
<td>Consumer demand drop &amp; unpredicted purchasing patterns</td>
</tr>
<tr>
<td>Drought</td>
<td>Extreme soil moisture deficit (prolonged reduced rainfall &amp; high temperatures (e.g. below 1SD from 1-month mean))</td>
<td>Agricultural productivity loss in key growing areas (to Tesco); Loss of economic activity; particularly in water-intensive industries</td>
</tr>
<tr>
<td>Wildfire</td>
<td>Extreme fuel moisture deficit (prolonged reduced rainfall &amp; high temperatures); Wind speed</td>
<td>Agricultural productivity loss; infrastructural damage</td>
</tr>
</tbody>
</table>
Quantifying Natural Disaster Recovery

If physical climate change risks are increasing, what can we do about it?

CRS research addresses:

- What are the key controls on socioeconomic recovery from disasters?
- What can be learnt about recovery dynamics from previous disasters?
- How can insurance improve recovery speed and quality and enhance resilience?
Disaster Recovery: The Relationship between GDP and Economic Loss

Non-Life Insurance Penetration vs GDP per capita (log-log scale) – 100 Natural Hazard Events 1990-2015

GDP Per Capita ($bn) vs Non-Life Insurance Penetration (%)

Economic Damage:
- $1bn
- $10bn
- $50bn
- $210bn
Disaster Recovery: Case Study Narratives

Germany Floods 2013
- Adequately financed & effectively managed
- Coordinated FRM strategies at catchment level, but questionable across state/national borders
- Reliance on flood protection & significant residual risk ('levee effect')

UK Floods 2007
- Marked a step change in UK FRM (motivated by Pitt review)
- Developed (subsidised) flood insurance market (90% penetration)
- But improved resilience has had limited impact on recovery speed/quality

Hurricane Sandy USA 2012
- FEMA generally commended for immediate management effort (especially compared to Katrina)
- But disparate recovery – exacerbated existing socioeconomic inequality
- NYC adaptation pathways represent shift in thinking towards resilience

Typhoon Damrey Vietnam 2017
- Communal self help & finance
- Little international attention & involvement
- Rapid development of economy provides opportunity but challenges existing resilience mechanisms

Typhoon Haiyan Philippines 2013
- Extreme magnitude event impacted huge swath of central PHP islands
- Exposed structure of management & governance – national vs regional
- Dependence on external aid
- Coordinated efforts to build back better

India-Pak. Floods 2014
- Poor regional risk management, no early warning systems
- Cross-border tension & Kashmiris reject Indian rule – media further eroded gov. trust
- Reliance on external aid, but failure of state to provide timely relief
Building Resilience Through Disaster Recovery

- Antecedent resilience
- Disaster load
- Window of Opportunity
- Response
- Recovery
- Reformatory Recovery
- Restorative Recovery
- Impaired Recovery
- No Recovery

Δ QUALITY: 
Δ SPEED: 

Adapted from Lallemant, 2013; Hsiang & Jina, 2014
Conclusions

- Next decade will see climate change risks increasing
  - As society transitions towards a low-carbon economy
  - As extreme weather is exacerbated
- Balance of these risks dependent on global response
  - Transition risks greater in the near-term
  - Short-term extreme weather events will disrupt businesses & economies
- Low probability, high-impact scenarios offer stress tests to assess vulnerability & management/mitigation options

Climate Change Risks

Physical Risks

Shocks
- Exacerbated extreme weather events
  - Magnitude
  - Frequency
  - Geography

Trends
- Changes to average climatic conditions
- Sea level rise
- Ocean acidification
- Cryosphere change/reduction
- Disruption of biogeochemical cycles
- Loss of biosphere integrity

Transition Risks

Regulation & Liability
- Carbon pricing & reporting obligations
- Asset stranding
- Regulation of existing products & services
- Exposure to litigation

Market
- Market uncertainty or negative outlook
- Investor sentiment – Carbon Divestment
- Raw material costs

Reputation & Consumer Power
- Consumer preference change
- Sector stigmatisation

Disruptive Technology
- Disruptive, low-carbon products & services
- Innovation failure

Adapted from TCFD 2017