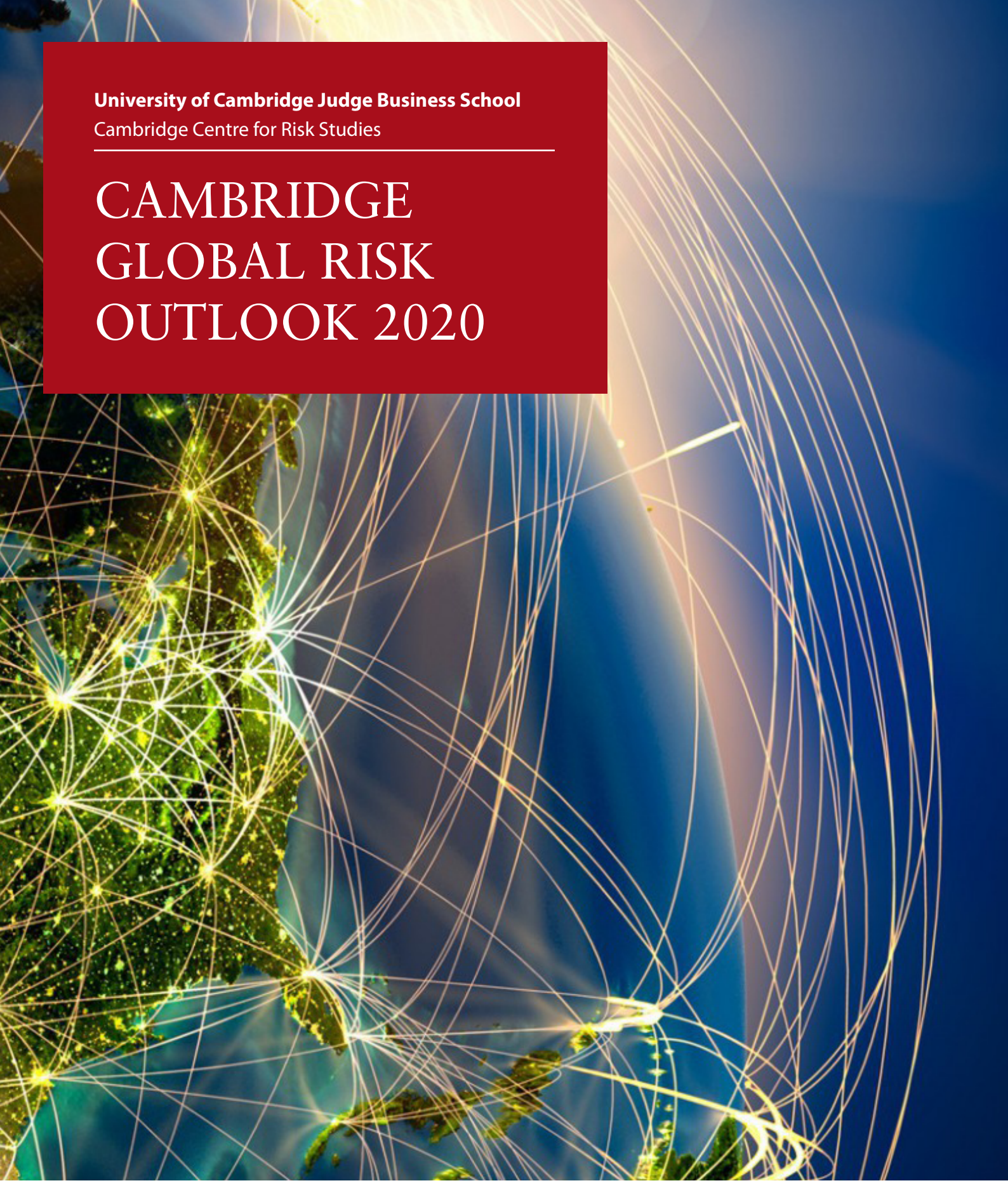

University of Cambridge Judge Business School
Cambridge Centre for Risk Studies

CAMBRIDGE GLOBAL RISK OUTLOOK 2020

Centre for
Risk Studies

UNIVERSITY OF CAMBRIDGE
Judge Business School

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The 2020 Global Risk Index quantifies the impact of future catastrophe shocks on the world's economy, represented by the most prominent cities accounting for 41% of global GDP. The Index quantifies the risk to economic output from 22 types of threats providing GDP@Risk estimates as a standardised metric for 279 different cities. The highlights of our 2020 update include the continued rise of Cyber Attack risk, the likelihood of continued commodity price volatility, and sustained levels of high risk from geopolitical events.

The overall GDP@Risk for 2020 is $584 bn or 1.55% of the 2020 GDP, an increase of 3% from our 2019 risk index. Drivers of this increase include growth in the economy (there is more output to be lost by these catastrophes), increasing likelihood of loss from emerging threats such as cyber attack, and shifts in the patterns of potential loss to threaten higher growth economic regions. Our 2019 update sees an increase in risk from Cyber Attacks, Social Unrest, Commodity Price Shocks, Heatwave, Freeze and Sovereign Default, while Terrorism and Solar Storm saw a decrease in risk. A more detailed analysis of coastal cities carried out this year results in an increase of our assessment of Flood risk.

Consistent with 2019, the top three classes of threat types in the 2020 Index are Natural Catastrophes (with GDP@Risk of $179bn, 31% of total GDP@Risk), Financial, Economics & Trade (GDP@Risk of $149bn, 26% of total GDP@Risk), and Geopolitics & Security in third place (GDP@Risk of $141bn, 24% of total GDP@Risk).

The top three individual threat types are Market Crash with GDP@Risk at $106.5bn, about a fifth of total GDP@Risk; Interstate Conflict at $83.8bn, 14% of total GDP@Risk; and Tropical Windstorm, $68.3bn or 12% of total risk. Social Unrest rises to fourteenth amongst the threat rankings at $8.3bn, up from three places from last year's rankings. Cyber attack increases from $39.7bn to $41.6bn, constituting 7% of total 2020 GDP@Risk. The capacity for cyber attacks to cause severe economic damage continues to rise. This is a threat to be closely monitored as the increasing number and severity of attacks is countered by capabilities to protect against them. The complete ranking of the 22 threats in the Global Risk Index is shown in Figure 1.

The top 10 cities by risk exposure are Tokyo followed by Istanbul, New York, Manila, Taipei, Osaka, Los Angeles, Shanghai, Seoul, and Mexico City (see Table 1). Their appearance at the top of the risk list of cities indicates two characteristics: a large annual GDP output, hence the potential, even if unlikely, for major losses; and exposure to particular shocks associated with the geography and type of economy of each city.

The resulting GDP@Risk is mediated by each city's ability to limit the impact (or to protect itself against shocks) as well as its ability to recover from them

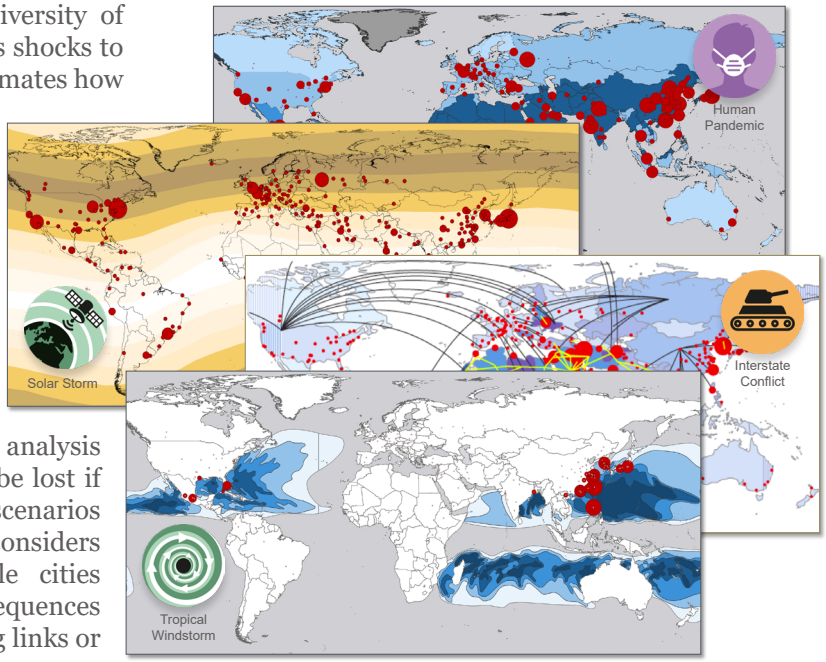
Shocks to the global economy are largely inevitable, resulting in real losses to the economy. Mitigation of losses is an essential consideration in understanding those losses. In the Global Risk Index, risk mitigation is closely related to the rate of recovery of each city, i.e., the time a city's economy takes to recover from a shock. If the rate of recovery of each of the slowest cities - some 46 out of the 279 covered - were improved by just one level then their relative risk exposure would reduce by 11%. If the rate of recovery of all cities having the lowest two levels, 101 cities altogether, were to be increased up to the highest recovery level their relative risk exposure would reduce by 31%. This is an indication of what the insurance industry calls the "protection gap", and the size of earnings from investment in preparedness and resilience ahead of inevitable yet unpredictable shocks. Furthermore, closing this protection gap is crucial given the role played by ex-ante protection measures such as insurance pay-outs in funding the recovery process of cities. The time a city takes to recover also depends on access to funding (including insurance and aid). Consequently, better access would imply a lower protection gap, faster recovery and therefore higher resilience to such shocks.

Table 1: Top cities by GDP@Risk and threat

	City	GDP@ Risk ($USbn)	Top Threat	% Contribution
1	**Tokyo**	24.72	Interstate Conflict	32%
2	**Istanbul**	18.80	Interstate Conflict	40%
3	**New York**	16.06	Market Crash	20%
4	**Manila**	14.35	Tropical Windstorm	56%
5	**Taipei**	13.28	Tropical Windstorm	62%
6	**Osaka**	12.26	Interstate Conflict	27%
7	**Los Angeles**	12.09	Earthquake	24%
8	**Shanghai**	8.20	Tropical Windstorm	29%
9	**Seoul**	7.94	Tropical Windstorm	37%
10	**Mexico City**	7.94	Market Crash	34%
11	**London**	7.83	Market Crash	21%
12	**Hangzhou**	7.53	Tropical Windstorm	68%
13	**Cairo**	7.40	Interstate Conflict	51%
14	**Baghdad**	7.02	Interstate Conflict	53%
15	**Jakarta**	6.75	Civil Conflict	30%
16	**São Paulo**	6.61	Market Crash	43%
17	**Tehran**	6.41	Interstate Conflict	61%
18	**Nagoya**	6.37	Interstate Conflict	31%
19	**Suzhou**	6.20	Tropical Windstorm	52%
20	**Paris**	6.16	Market Crash	23%

Extinction Rebellion protestors in Melbourne in October 2019 (Photo: Julian Meehan)

The Centre for Risk Studies (CRS), University of Cambridge Judge Business School models shocks to the major economies of the world and estimates how likely they are to occur and how much output is at stake.



We analyse the risk to 279 of the world's leading cities, responsible for more than 41% of global GDP, and consider a wide range of potential causes of future shocks by modelling around 12,000 scenarios. Economic shock models have been developed for 22 different threats types. The economy of each city is analysed by sector, size, and demography, and the analysis estimates how much GDP output would be lost if each city were to experience different scenarios of shock for each threat. The model considers scenarios of events impacting multiple cities across a region, and propagates the consequences to other unaffected cities that have trading links or economic codependence.

At present we analyse the loss of output as a measure of economic 'flow'. We recognise that these catastrophes also cause loss to infrastructure, assets and other 'stock'. Flow and stock are interrelated, but this Index represents the risk to flow.

Expected loss

We do not predict that crises and shock events will occur. Each event is rare and unlikely. We analyse the small likelihood of each shock occurring and combine the chances of a rare catastrophe with its consequences to estimate the 'expected loss' – the average probability-weighted amount of lost GDP, which produces the Cambridge Global Risk Index that can be used to compare different types of loss in various places and over alternative time horizons. The actual amount of lost economic production that would occur from a shock is many times larger than the probability-weighted expected loss index values that we present in this report.

We do not attempt to forecast which city will be hit by what type of events, but we assume that crises will continue to happen and that the risks of crises can be measured.

Threat analysis

The analysis of each threat consists of a geographical risk map, threat assessments for each of the 279 cities, adoption of standardised metrics for frequency and severity of occurrence, localised impact severity scenarios, and economic impact analyses. CRS gratefully acknowledges the expertise of our external subject matter specialists who have provided insights into each threat.

How were the threats selected?

The 22 threats were identified as the most significant risks to the global economy through an extensive study of the shocks that have impacted society and the economy over the past thousand years, combined with reviews of published catastrophe typologies, emerging risk registers, and scientific conjectures of potential future threats. This was developed into the Cambridge Taxonomy of Threats, published in 2014. Some of these threats have been studied in detail, and published as stress test scenarios in the publication suite of the CRS, available on our website.

Project Pandora

The Pandora global risk research programme at Cambridge Centre for Risk Studies is named after the Greek myth of the first woman created by the gods, who opened a forbidden container and accidentally released all the world's evils upon humanity. The wide range of threat models being incorporated in the risk analysis represents the contents of Pandora's box.

2020 Threat Rankings

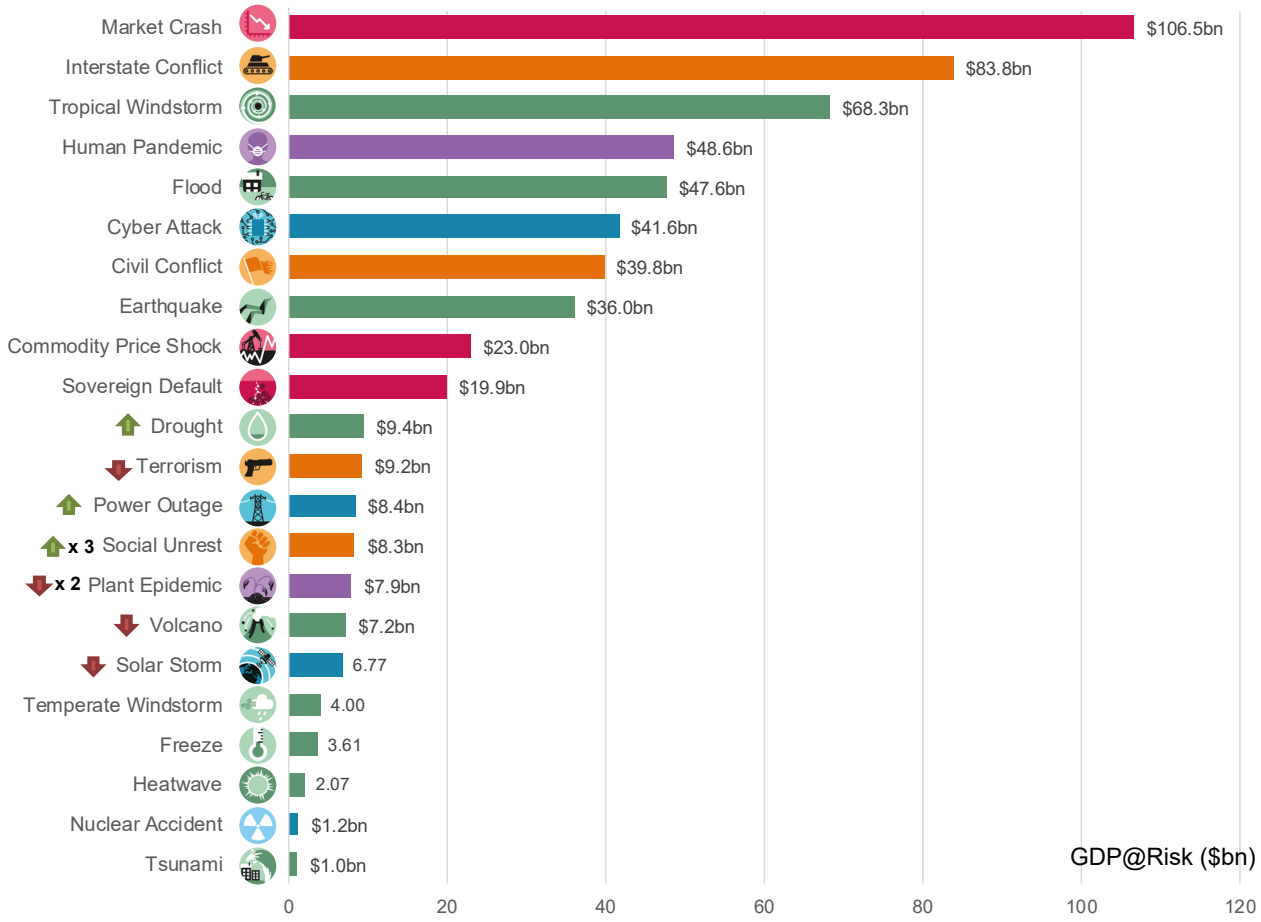


Figure 1: Global Risk Index 2020 Threat Rankings

The definition of a city is critical to measuring the losses that occur in the case of catastrophe. The cities are consistently defined as larger urban agglomerations or official metropolitan areas, where they exist. For example the Tokyo major metropolitan area is an urban agglomeration of five separate cities: Tokyo, Chiba, Kawasaki, Yokohama and Saitama. The Global Risk Index also makes use of Oxford Economics' GDP data and projections. Using a single source of city GDP data allows more credible comparisons between the Risk Index for different years.

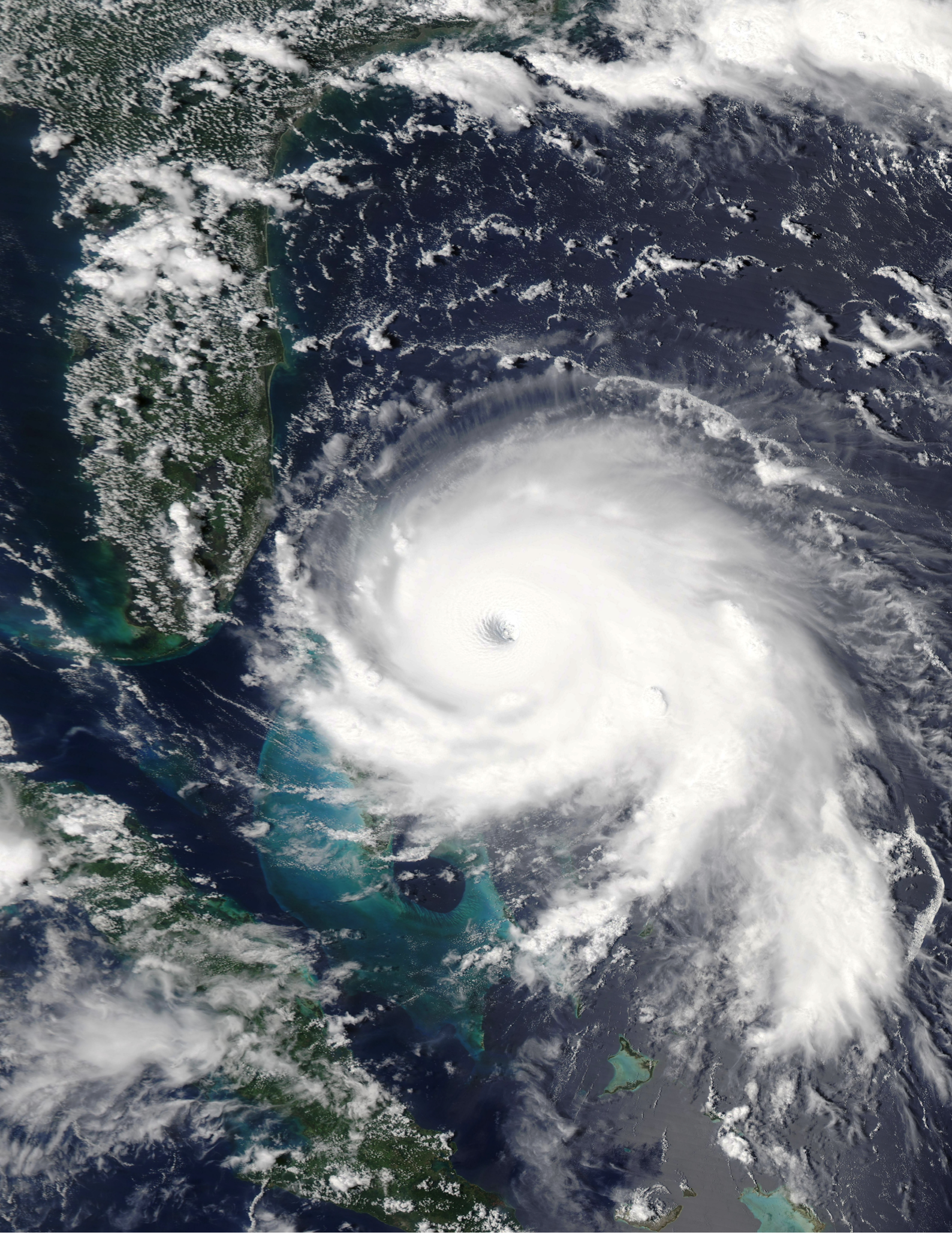
As city clusters drive growth, particularly in developing economies like India and China that show high urbanisation rates relative to more advanced economies, future GDP and therefore GDP@Risk will inevitably show geographic shifts over time. These changes are relevant even in the short term: World Bank projections of 2019 GDP growth for the emerging economies is more than double that of the advanced economies. Figure 1 shows the changes in risk threat rankings from 2019 to 2020.

Dhaka in Bangladesh is projected to be the fastest growing city in terms of the percent change in 2019 GDP to 2020, with GDP change at 10%, while Caracas, Venezuela has the largest percent decrease with a value of -17% for the second year in a row. This continued decrease is linked to the ongoing social unrest, corruptions, and shortages in the country, which is stifling Venezuela's economic recovery from the drop in oil prices in 2015.

Our analysis shows that of the 3% increase in GDP@Risk from 2019 to 2020 is smaller than in previous years. Risk is growing slowly, but the growth rate for global GDP is also slower than in previous years. Africa is the region with the largest percent increase at 1.5%, compared to Eastern Europe which saw a 20% decrease in GDP@Risk.

City recoverability

An economy's ability to recover from a catastrophe is demonstrated by the speed and extent to which it reconstructs factories and homes, repairs damaged infrastructure, regains consumer and market



Hurricane Dorian is the most intense tropical cyclone to hit the Bahamas, in September 2019

confidence, and re-engages in business activities after an event. The Global Risk Index uses a level-based rate of recovery metric to determine each city's pace of recovery after a catastrophic shock.

The city rate of recovery assessment was refreshed in 2019's Index and now incorporates the latest trends in recoverability, modelled as a composite of socio-economic factors such as deprivation and inequality, institutional factors such as governance and physical infrastructure, and wealth-related factors such as GDP per capita and the insurance penetration.

Refreshing the rate of recovery levels for each city yielded some interesting insights for 2020. Key cities which have seen an increase in their rate of recovery include St Petersburg, Kazan, Tallin, Kraków, and Medellin. Iran, meanwhile, has seen a decrease in the rate of recovery for its major cities. This is due to the impact to its national GDP as a result of imposed sanctions by the United States which began in 2018 and continue to the present.

If the rate of recovery of the slowest cities in the study were improved by just one level, their relative risk exposure would reduce by 11%. If the rate of recovery of all cities having the lowest two levels were to be increased up to the highest level, their relative risk exposure would reduce by 31%. Further, if all the rate of recovery levels were increased to the highest level, the overall GDP@Risk would reduce by 14%. Shocks to the global economy are largely inevitable, resulting in real losses to the economy, but this loss level is not pre-determined: the Global Risk Index demonstrates the value of investing in recoverability.

How the Index is constructed

The Centre for Risk Studies generates the Global Risk Index by combining standardised data sets and expert judgement to determine the average impact of 22 threats on the global economy in the next three years. This requires consolidating disparate data sets from multiple sources, deep dive analyses of individual threats ranging from natural disasters to wars and other geopolitical catastrophes to technology shocks like power outage. The Global Risk Index provides a platform to compare these analyses across the world economy through a single metric: GDP@Risk.

For each threat type, we conduct a horizon-scanning exercise to bring the catalogue of threat events up to date. We use this catalogue to validate external threat assessments appearing in the data collection (see Appendix), and/or determine whether the risk from that threat is expected to increase or decrease from its baseline within the three-year outlook. Lastly, this analysis is complemented by solicitation of expert judgement from a team of subject matter specialists.

The following sections review significant events that occurred in 2019 and highlight trends and future projections for each threat. While the Cambridge Global Risk Index reflects long term processes and historical events, the scan of 2019 events is key to the three year look ahead that is presented in the Index. The review of the year 2019 showed that events mostly reflect the risk as determined by the threat assessments in line with the previous year's Index. The one exception is the raised risk of Cyber Attack as the frequency and scale of cyber events is growing year on year.

The Cambridge Taxonomy of Business Risks

In 2019, the Centre for Risk Studies applied the past five years study of the Cambridge Global Risk Index to determine a taxonomy for analysing corporate risks. This taxonomy describes the entire business landscape corporates face, enabling identification of emerging risks and creating a common language for communicating risks.

Identifying these risks involved an extensive historical review of causes of social and economic disruption over the past thousand years, collating other academic and industry risk taxonomies, analysing annual reports, risk registers and corporate fillings, and developing a distress catalouge of corporate failures and near misses. This was augmented with a review of catastrophe catalogues and databases, a precedent review, a study of counter-factual theories.

These risks are generally recognised by risk managers and analysts but they are not well understood. The field currently suffers from confusion of definition. This report summarises the wide range of terminology in use and proposes a standardisation of risk terminology in the field.

The Cambridge Taxonomy of Business Risks is organised in a hierarchy of causal similarity, into six Primary Classes - Financial, Geopolitical, Technology, Environmental, Social, and Governance. Of these six classes, five are drawn directly from and strongly reference the risk types found in the Cambridge Global Risk Index. The Taxonomy of Business Risks features a further 37 Families, and 170 Risk Types. The structure can be further subdivided into more granular types as required. A breakdown of the taxonomy is shown on the next page.

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Cambridge Taxonomy of Business Risks

CTBR v2.0
04/11/2019

Financial

Economic Outlook
- Recession
- Stagnation
- Contraction
- Credit Crisis
- Steady Growth
- Expansion
- Acceleration
- Peak

Economic Variables
- Commodity Price Fluctuation
- Inflation
- Interest Rates

Market Crisis
- Asset Bubble
- Bank Run
- Sovereign Debt Crisis
- Flash Crash
- Fraudulent Market Manipulation
- Cryptocurrency Failure
- Reserve Currency Shift

Trading Environment
- Tari Dispute
- Cartel Manipulates Market
- Organised Crime

Company Outlook
- Hostile Takeover
- Credit Rating Downgrade
- Investor Negative Outlook

Competition
- Disruptive Competitor
- Aggressive Competitor
- Fraudulent Competitor
- Intellectual Property Theft

Counterparty
- Supplier Failure
- Customer Failure
- Government Failure
- Creditor Failure
- Counterparty Fraud

Geopolitical

Business Environment (Country Risk)
- Talent Availability
- Industrial Action
- Minimum Wage Hike
- Sanctions
- Territorial Disputes
- Logistics Restrictions

Corruption & Crime
- Corruption Deterioration
- Crime Wave/Piracy Increase
- Slavery Practices

Government Business Policy
- Emerging Regulation
- Corporation Tax Rate Hike
- Diverted Profits Tax
- Nationalisation
- Confiscation of Assets
- Privatisation
- License Revocation

Change in Government
- Nationalism/ Protectionism
- Left-Wing Radicalism
- Right-Wing Radicalism
- Populism
- Environmentalism

Political Violence
- Social Unrest
- Terrorism
- Subnational Conflict & Civil War
- Coup d'État

Interstate Conflict
- Conventional Military War
- Asymmetric War
- Nuclear War
- Cold War

Technology

Disruptive Technology
- E-Commerce
- Gig Economy
- Artificial Intelligence
- 5G Technology
- Blockchain
- Robotics & Automation
- Augmented/Virtual Reality
- Cryptocurrency
- Autonomous Vehicles
- Drones
- Medical Advances

Cyber
- Data Exfiltration
- Contagious Malware
- Cloud Outage
- Financial Theft
- Distributed Denial of Service
- Internet of Things
- Industrial Control Systems
- Internet Failure

Critical Infrastructure
- Power
- Transport
- Telecommunications
- Satellite Systems
- Water & Waste
- Fuel
- Gas

Industrial Accident
- Fire
- Explosion
- Pollution
- Structural Failure
- Nuclear

Environmental

Extreme Weather
- Flood
- Tropical Windstorm
- Temperate Windstorm
- Drought
- Freeze
- Heatwave
- Wildfire

Geophysical
- Earthquake
- Volcanic Eruption
- Tsunami

Space
- Solar Storm
- Astronomical Impact Event

Climate Change
- Physical
- Liability
- Transition
- Increase in Extreme Weather
- Sea Level Rise
- Ocean Acidification
- Lower Carbon Economy

Environmental Degradation
- Waste & Pollution
- Biodiversity Loss
- Ecosystem Collapse
- Deforestation
- Soil Degradation

Natural Resource Deficiency
- Fossil Fuels
- Biogeochemicals
- Raw Materials
- Water

Food Security
- Animal Epidemic
- Plant Epidemic
- Famine

Social

Socioeconomic Trends
- Ageing Population
- Gender Imbalance
- Wealth Inequality
- Poor Educational Standards
- Migration

Human Capital
- Failure To Attract Talent
- Gender & Diversity
- Labour Disputes & Strikes
- Loss of Key Personnel
- Employee Misconduct

Brand Perception
- Fake News
- Negative Media Coverage
- Key Influencer Disruption
- Negative Customer Experience

Sustainable Living
- Consumer Activism
- Sustainable Purchasing
- Supply Chain Provenance
- Diet

Health Trends
- Obesity
- Longevity
- Antimicrobial Resistance
- Medical Breakthroughs
- Healthcare
- Social Care

Infectious Disease
- Influenza Pandemics
- Coronavirus-like Epidemics
- Viral Hemorrhagic Fevers
- Preventable Disease Outbreaks
- Unknown Emergent Diseases

Governance

Non-Compliance
- Emerging Regulation
- Internal Corruption & Fraud
- Negligence
- Revised Accounting Standards
- Occupational Health & Safety

Litigation
- Private Lawsuit
- Mass Tort
- Class Action

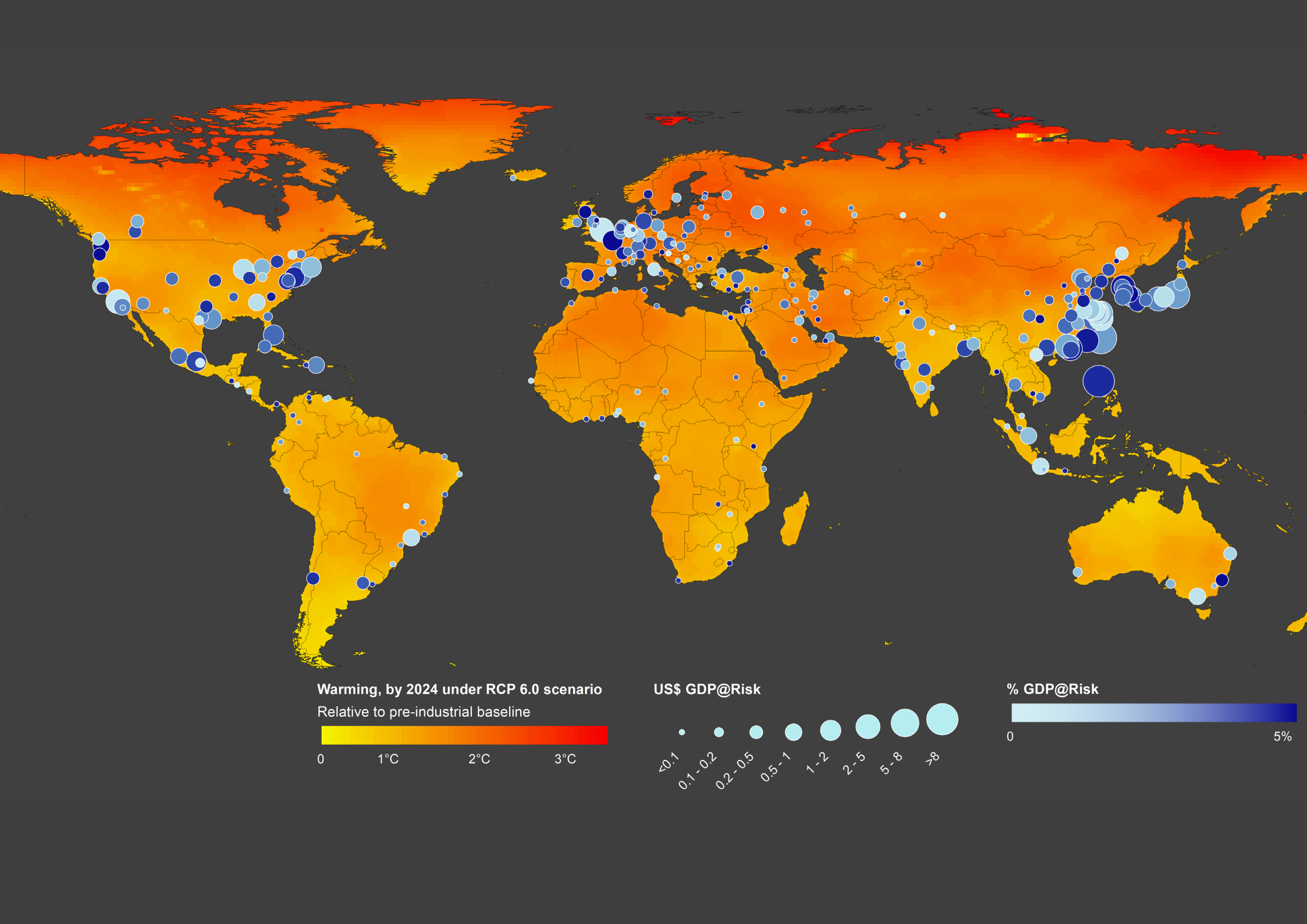
Strategic Performance
- Divestitures
- Joint Ventures
- Mergers & Acquisitions
- Restructuring
- Poor Investment

Management Performance
- Executive Mismanagement
- Ine ective Board
- Management Execution Failure

Business Model Deficiencies
- Technology
- Customer Preference Change

Pension Management
- Contribution Management
- Fund Management

Products & Services
- Product Defect/Failure
- Innovation (R&D) Failure


Warming, by 2024 under RCP 6.0 scenario
Relative to pre-industrial baseline
0
1°C
2°C
3°C
US$ GDP@Risk
<0.1
0.1 - 0.2
0.2 - 0.5
0.5 - 1
1 - 2
2 - 5
5 - 8
>8
% GDP@Risk
0
5%


Earthquake


Tropical Windstorm


Temperate Windstorm


Tsunami


Flood


Volcano


Drought


Freeze


Heatwave

The Decade in Natural Catastrophe and Climate

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

The occurrence of natural disasters and their associated losses in 2019 have been below average relative to the 21st Century baseline. Nevertheless, the year has seen a number of global events make headlines, and the majority of catastrophes causing significant impacts have resulted from extreme weather events (including extreme temperatures, drought, floods, storms, and wildfire) in all global regions.

Geophysical hazards, including earthquakes, tsunamis, and volcanoes, have the potential to cause the most devastating impacts across large regions, with the greatest magnitude events producing death tolls in the range of thousands or further orders of magnitude. For example, in September 2018 a M7.5 earthquake in Sulawasi, Indonesia caused nearly 5,000 fatalities and required major international response efforts. 2019 has seen comparatively minimal geophysical catastrophes. Of the earthquakes that have occurred this year, China's Sichuan province experienced the most impactful. A M6.0 earthquake and several powerful aftershocks caused 13 deaths and economic losses of about $1 billion.

The reinsurance industry has benefited from a year of below-average insurance losses. As a result of major insurance loses in 2017 and 2018, especially in lines of business such as property that suffered in a spate of natural catastrophes, reinsurers are able to command higher prices, but remain wary of events capable of generating colossal ($10s of billions) insured losses – such as those caused by multiple Atlantic hurricanes in 2017 making it a record breaking year.

Hurricane Dorian, the first major storm of 2019, threatened to cause such damages. Initially forecast to hit the coastal southern US states, it instead struck the Bahamas as the strongest Atlantic hurricane ever to make landfall, before skirting the US East Coast. While not as expensive as expected, record windspeeds of over 300km/h and a six metre storm surge left widespread devastation in the Bahamas, with 43 dead and over 70% of buildings destroyed in the worst affected areas. It was the fifth Atlantic hurricane to reach Category 5 magnitude in the last four years; the Bahamas had not previously experienced damages of such magnitude.

Elsewhere, Typhoon Hagibis hit Tokyo as Japan's most powerful storm in decades, temporarily bringing the city to a halt and leaving 425,000 homes without power. Japan's authorities had issued warnings in

unusually strong language, comparing Hagabis to the 1958 typhoon that killed over 1,200 people in the Tokyo region. Despite the damage, activity in the city resumed the morning after, amid global attention on the Rugby World Cup, while major response efforts began in other areas.

Detectable changes in tropical windstorm can be attributed to climate change, and while the frequency of storms is likely to be decreasing in certain regions, they are growing more intense, lingering over land and dumping extreme rainfall to cause severe impacts from flooding – such as in Texas during Hurricane Harvey in 2017.

July 2019 was the warmest moth ever recorded worldwide. Nearly 400 all-time high temperatures were recorded at weather stations in the northern hemisphere summer; national records were broken in 29 countries between May and August, including in Belgium, France, Germany, the Netherlands, and the UK.

Analysis following two record heatwaves in June and July concluded that human-induced climate change made the events up to ten times more likely. Europe is acutely aware of the hazard extreme heat presents; when the previous national record temperature was set during the 2003 summer heatwave, 70,000 additional fatalities were attributed to the event, including 15,000 in France. That event prompted radical measures to adapt and better prepare for heat, and so the death toll this year was significantly lower. Nevertheless, heatwaves such as this have the potential to cause major disruption to business productivity, and some vulnerable sectors, such as agriculture, suffered this year even as others profited.

Wildfire is a growing risk, notably in populated areas of California, eastern Australia, and southern Europe where the potential for economic loss is significant. Further, vast areas of vegetation burn in Brazil and Siberia, attracting global attention as a shocking visual manifestation of climate change. Wildfires occur naturally during hot, dry weather where the presence of vegetation provides fuel. These conditions have strong links to climate change, and studies of Australia, California, and the Arctic have found that human influences have dramatically increased the wildfire risk – lengthening the wildfire season, increasing the frequency of events, and exacerbating the burn severity.

This year, utility company Pacific Gas & Electric was deemed to be responsible for California's Camp Fire in late 2018, the state's deadliest and most destructive fire. The fire was ignited by electrical transmission lines owned and operated by PG&E. Anticipating culpability, the company filed for bankruptcy protection at the end of January, facing around $8.4 billion in potential liabilities from 30,000 plaintiffs. This year, PG&E alleviated its wildfire risk by cutting off the electricity supply of 2.4 million residents. Estimates suggest that the economic impact of the outages could range from $65 million to $2.5 billion, depending on the duration of the outage. The decision to use forced blackouts as a fire-prevention tactic places a heavy economic burden on numerous private businesses, citizens, and pubic services, prompting outrage in part because of the company's perceived long-term failure to protect its infrastructure. The reality is that Californians must now change their attitudes towards the risk – 90 percent of homes destroyed by wildfire are rebuilt within ten years, and the value of exposed assets continues to grow.

The growing research field of 'extreme event attribution' addresses the influence of human activity on individual hazard events, and today there is overwhelming evidence that the likelihood and severity of extremes has been affected by anthropogenic climate change – including those discussed here. To date, scientists have published attribution studies for over 260 global events, of which 68% were more severe or more likely to occur because of a human influence. Climate change forcing is embedded in the risk assessment of the Global Risk Index. The Index demonstrates the economic impact of asset destruction and economic disruption due to these disasters. However, the uncertainty and long-term nature of climate projections mean that short-term trends in extremes are complex and difficult to predict.

Market Crash

Sovereign Crisis

Commodity Prices

The Decade in Finance, Economics and Trade

- **2008:** In the wake of the Great Recession, the global economy, particularly in developed markets, takes a dent in output and growth
- **2009**: Bitcoin, the first decentralised cryptocurrency based on blockchains is released as open-source software
- **2009-2010**: The European debt crisis erupts, leading to a wide contagion across Eurozone countries
- **2010**: The Basel III regulatory framework is agreed upon by the members of the Basel Committee on Banking Supervision, seeking to mitigate the risk of bank runs following the subprime crisis
- **2014**: Oil prices crash for the second time since the Great Recession due to slow growth and alternative production
- **2018**: Amazon, the leading transformer in the digital age, reaches a $1 trillion market cap for the first time since its founding in 1994
- **2018-present**: Trade tensions between the US and China rise to an unprecedented level, weighing on global investment sentiment

Financial, Economics and Trade Risks have remained overall steady since 2019. The total expected loss of GDP from this category has reduced by 0.06% to $149 bn. Variations within the category, however, tell a different story. GDP@Risk from Market Crash has decreased by 1.97%, while that from Sovereign Default has increased by 9.16%. Due to baseline GDP and methodology updates by Oxford Economics, Commodity Price Shock has its expected loss elevated by 2.5%.

Trade disputes continue this year, primarily between the US and China, and risk plunging the global economy into recession. Volatility was escalated by increasing bilateral tariffs on the already levied and untaxed imports, with China raising tariffs on almost all its imports from the US. A dim prospect of truce or any substantial trade agreement was further complicated by the blacklisting of Chinese tech giants including Huawei by the US Department of Commerce who cited espionage or human rights issues.

Elsewhere, geopolitical influence exhibited strong presence in financial markets, including the US-Turkey row over Russian missile system, Brexit turbulence, Hong Kong pre-democracy protest etc. Partly attributed to these events, equity markets

performed better in the first half of 2019 than the second half of 2018, where developed markets outcompeted developing markets in general. In face of global economic slowdown, monetary policies were more patient and flexible in an accommodative realm. Medium-term vulnerabilities continued to build up in both corporate and sovereign-financial sectors along with excessive housing credits, all of which could be triggered by sharper-than-expected slowdown, political and policy risks.

Threat from Sovereign Default is tied closely with fluctuating macroeconomic growth and fundamentals. Stronger growth, lower public debt, balancing budget contributed to a decrease in this threat in Croatia and Slovenia. Structural macroeconomic problems, compounded with elevated policy uncertainty, severe tightening of financing conditions worsened sovereign-financial status of countries such as Argentina and Zambia. Overall, there have been more credit improvements than deteriorations globally, with positive outlooks clustered in Eastern Europe, negative ones in Americas.

Oil and gas prices have presented heightened instability in the past year. After prices jumped above $70 per barrel in 2018 due to the US re-imposing sanctions on Iran and disruptions to Venezuelan production, they dropped owing to OPEC and Russia production, sanction waivers and rising US shale production. Underlying the downward trend was also a slowing global economy and weakening energy demand, before the alleged Iran attacks on Saudi oil facilities spiked up prices again in September 2019.

The high correlation between industrial commodities and economic conditions has been evidenced by a sharp fall in prices of iron ore, copper and lithium, with copper having the worst performance out of all base metals. Nickel, which is a key component in the battery packs powering electric vehicles, saw its price up due to better than expected stainless production in China. Palladium price hit a record high in 2019 also because of a Chinese transition to greener transportation ahead of the introduction of a nationwide emissions standard in 2020. Other precious metals such as gold and silver were increasingly demanded as safe haven assets in the context of slowing global economy.

Planet Labs satellite image of the attack on Aqaiq Oil Refinery on 14 September, 2019


Interstate Conflict


Civil Conflict


Terrorism


Social Unrest

Geopolitical and security risks remain some of the most potent and changeable threat categories in the index. The potential disruption of interstate conflict rose slightly this year and continues to pose a great threat to modern businesses, ranking number two overall, with more than $80 billion GDP@ Risk worldwide.

The world encountered several heated moments in 2019 when international disputes, or regional violence, threatened to boil over into large-scale wars, drawing in multiple players. On 14 September, a missile attack against the Abqaia and Khurais oil processing plants in Saudi Arabia triggered a few weeks of sabre-rattling between Iran and the United States. Relations between the US and Iran have been fraying through 2019, following imposed sanctions and an alleged attack on US oil tankers in the Strait of Hormuz in June. Since then, the US has been seen as permitting Turkey to begin a new offensive into Northern Syria after the Trump Administration approved the withdrawal of troops from vulnerable Kurdish territory.

A series of airstrikes which affected Indian-Administered Jammu and Kashmir in February 2019 briefly brought India and Pakistan to the brink of hostilities. An Indian pilot was allegedly captured by Pakistani forces. India has since begun to move significant numbers of troops around the disputed valley of Kashmir, suggesting that more border clashes and greater tensions are likely.

In Europe and the Asia-Pacific, long held interstate competition remains persistent. Russia continues to escalate its espionage practices and defensive posturing, particularly after Ukraine's 2019 elections. North Korea continues to test its rocket power, while trade sanctions by the US against China erode long standing post-war alliances in the area.

In the decades to come, 2019 will likely be remembered as a turning point for global protest, social unrest, and civil disobedience. In the early summer, protests began in Hong Kong over a proposed extradition bill which would have seen criminal suspects transported to mainland

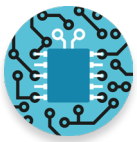
The Decade in Geopolitics and Security

- **2010**: A series of anti-government protests across the Middle East and North Africa nicknamed 'The Arab Spring' ousts presidents and triggers constitutional reforms and civil uprisings across the region
- **2011**: Multiple countries intervene in the Syrian Civil War, setting up a proxy battlefield
- **2013**: The Islamic State of Iraq and the Levant emerges onto the world stage, carrying out deadly terror attacks from the US to Australia
- **2014**: In the aftermath of the Ukrainian Revolution, Russia annexes the Crimean Peninsula, threatening other areas of Eastern Europe
- **2016**: The outcomes of the United Kingdom European Union Membership referendum and US Presidential Election occur amidst a new context of right-wing political movements, social unrest, and distrust in established global institutions
- **2017**: North Korea claims to have successfully tested weapons of mass destruction
- **2019**: Skirmishes on the border of Pakistan and India raise tensions worldwide
- **2019**: The *gilet jaunes* protests spark violence in France, while extradition riots in Hong Kong and uprisings in Venezuela demonstrate global unrest over issues of economic and political equality

China for trial. The bill was scraped in late October, yet demonstrations and rioting continue in the city, predominantly led by young, digitally savvy students, who broadcast meeting places, safety tips, and advice on protective measures over messaging apps. The issue of dispute now is China's continued influence over Hong Kong, which has only some degree of political representation and autonomy in the 'one country, two systems' arrangement. As such, it seems unlikely that the chaos in Hong Kong will end anytime soon. The methods pursued by Hong Kong protestors have arguably galvanised other dissenting groups worldwide. Catalan separatists have cited the movement in Hong Kong as an inspiration, as have Extinction Rebellion, who, through 2019, occupied five key locations in Central London and held global days of protest in 60 international cities to bring attention to the irrevocable levels of climate change caused by major corporations.

Other major social unrest has swept developing nations, where issues like kleptocracy, inequality, and failing infrastructure, have sown mass distrust in institutions. In Iraq, protests began through the autumn, largely staffed by working class Shiite Muslims against the levels of corruption in government and Iran's influence over the nation's economy. A similar situation has spread in Lebanon, where poor economic conditions combined with an authoritarian bill taxing WhatsApp useage caused protests in October. As in Hong Kong, the offending legislation has been scrapped, but unrest continues, powered by a disenfranchised young population. Violence has engulfed unrest in Sudan, where, after the position of al-Bashir, the military took control of the supposed new democracy, leading to a massacre in Khartoum on 3 June. In September, the military transitioned power back to the Sovereignty Council and Prime Minister Abdalla Hamdok was instated. It is likely that the unrest in these developing nations will give way to a degree of sectarianism and insurgency in the years to come, as governments lack clear pathways and economic resources to reach democratic solutions.

For now, at least, the risk of Terrorism is down from outlooks in 2019, largely due to increased advances in counterterrorism and insurgency, as well as the continuing crackdown on Islamic State infrastructure in the Middle East. The pendulum may swing back rapidly in the future, however. Meanwhile, the rate of right-wing extremism is growing in the West. On 15 March, the murder of 51 worshipers in two mosques in Christchurch, New Zealand, refocused international scrutiny on extremist websites and forums such as 8chan as breeding grounds for a community of violence hate speech and crime. Since 2016, one-third of attacks and one-quarter of disrupted terror plots have been attributed to right-wing extremists. In the US, more than 75% of domestic extremist-killings are carried out by white supremacists. Social media platforms have made some strides to limit extremist speech and propaganda on their services, but rates of success are minimal, and public pressure persists. The role of the internet as a powerful tool in global terror is a challenge that governments and businesses must continue to challenge.


Cyber


Power Outage


Nuclear Accident


Solar Storm

The current solar cycle - Cycle 24 - which bring us to 2020 has been the weakest cycle the Earth has seen in this century with fewer sunspots recorded than predicted. Cycle 25 is predicted to be similar, with a solar maximum likely to occur between 2023 and 2026, lessening the rating for this threat. The United Kingdom has recently invested £20 million to further weather prediction technology and the US has developed real time modelling of the Earth's magnetic field to aid electrical power grid operators in the event of a storm.

The threat of a catastrophic power outage is increasing with notable outages in 2019 occurring from both man-made and natural catalysts. The increased rate and severity of high impact weather events has increased the number of power outages from climate disruption. Millions of US residents lost power for several days in 2019 due to severe thunderstorms, tornados, flooding, and high winds. Similar outcomes were seen in England and Wales where power was downed for several days due to a lightning strike. The rising cost of litigation for damages caused by downed power lines, as in the case of wildfires, has led power companies to enforce blackouts on communities at risk. Elective power cuts affected more than 900,000 California customers of P&E due to 'extreme fire weather conditions'.

The threat of nuclear accident continues to slightly decrease. More major nuclear operation facilities have been decommissioned as companies make a concerted effort to shift toward renewables percieved as "cleaner" and lower-risk. 2019 saw the close of Three-Mile Island in the US which was licensed to operate until 2034, but could not compete with natural gas and renewables. Europe also decommissioned plants in France and Lithuania in September 2019. The threat assessment is only slightly decreasing as some developing countries continue to expand on their nuclear efforts. Two new 1,750-MW reactors began commercial operation in China in 2019, along with the commercial operation of Shin Kori 4 nuclear reactor in Busan and the construction of Unit 2 at Novovoronezh power plant in Oblast, Russia.

Similar to previous years, the cyber threat continues to increase as the cyber attack surface increases at a rapid pace, outstripping the ability to adequately protect it. By the end of this year, there around 3.6 billion devices will be actively connected to the Internet. Attackers are increasingly taking advantage of the growing digital supply chain of companies of all sizes, particularly in the financial, manufacturing, and retail sectors. In over 50% of recorded attacks, cyber criminals are 'island hopping', using the access rights of smaller, potentially more easily penetrated third-party companies or operators such as HR, marketing, or healthcare firms, to gain access to more heavily protected organisations. Fileless malware attacks, such as "reverse business email compromise," in which attackers gain access and manipulate a victim company's mail server to gain access over its mail server, are also becoming more common. Cloud service providers are not exempt from these indirect attacks as more than 70 million records were stolen or leaked in 2019 as a result of poor configuration on the part of the client in AWS S3 buckets.

The Decade in Technology and Space

- **2010**: The Stuxnet worm causes substantial damage to Iran's burgeoning nuclear program
- **2013**: Hackers steal credit and debit information from 41 million shoppers after reaching Target's databases through its HVAC vendor
- **2015**: A cyber attack successfully hits Ukraine's power grid, causing hours of blackout for 230,000 people
- **2016**: Domain name system provider Dyn suffers that largest distributed denial-of-service attack in history, taking down services in Europe and the United States
- **2017**: Equifax announces a massive data breach of 145 million US consumers' private information
- **2017**: The ransomware WannaCry locks vulnerable computers across 150 countries and causes $4 billion in economic damage
- **2017**: The destructive malware NotPetya affects the Ukraine and spreads across Europe and the world, causes $10 billion in economic damage - the costliest cyber attack to date
- **2018**: It is announced that malicious malware has been discovered in industrial plants in Saudi Arabia, affecting Triconex safety systems

Human Pandemic

Plant Pandemic

The Decade in Health and Humanity

- **2009-2010**: The H1N1 pandemic spreads rapidly around the world
- **2013**: The first EU case of the bacterial Xylella fastidiosa plant disease is detected in southern Italy
- **2013**: A new H7N9 influenza virus is reported in China
- **2013-16**: A widespread Ebola Virus occurs in Western Africa, becoming the deadliest occurrence of the disease, with 11,310 deaths reported
- **2015**: A large measles outbreak affects 147 in the United States, linked to an index case among visitors at Disneyland, California
- **2016**: Zika Virus is declared a Public Health Emergency of International Concern by the World Health Organization
- **2016**: An outbreak of cholera begins in Yemen, leading to 1.2 million cases, becoming the world's worst humanitarian crisis
- **2018**: A new ebola epidemic begins in the Democratic Republic of Congo, the second deadliest occurence of the disease
- **2019**: Following the trial of four potential Ebola vaccines at four research centeres in the Congo, WHO prequalifies two effective vaccines for use in at-risk populations

No major Human Pandemic events were recorded in 2019, though regional infectious disease outbreaks have had significant impact in developing nations.

Most notably, the continued outbreak of Ebola in the Democratic Republic of Congo which began in August 2018 reached 3,619 recorded cases and spread into the neighbouring nation of Uganda. In November 2019, following a drug trial in four DRC towns, the World Health Organization (WHO) prequalified an Ebola vaccine proven to significantly reduce the deadliness of the disease for 90% of patients. The vaccine will come into far wider effect by mid-2020, rendering Ebola effectively curable for the first time in its history.

More concerning is the growing trend in vaccine hesitancy and scepticism in developed economies, which has led to a sharp increase in cases of measles, mumps and rubella (MMR). The reasons for the growth in vaccine complacency are complicated and only partly understood. Worldwide, the rate of vaccine confidence is around 79%, and statistically far lower in wealthier economies. Vaccine hesitancy overwhelmingly affects children, who are more susceptible to infectious diseases and have little to no control over their own medical care. On December 21, 2018, an outbreak of the measles began in the Pacific Northwest, leading the state of Washington to declare a state of emergency. In 2019, there were 1234 confirmed cases of measles

in the United States alone. On August 29, 2019, Albania, Czech Republic, Green and the United Kingdom all lost measles-elimination status for the first time in decades. As a result of the resurgence of measles, communities have introduced travel bans on unvaccinated individuals, and schools may refuse admission to students who are not vaccinated.

The threat of growing anti-microbial resistant continues to present a challenge in the health and humanity outlook. Along the Cambodia-Thailand border, a strain of malaria is becoming resistant to almost all available anti-malarial medicines. There is a risk that multi-drug resistance will develop in other parts of the sub-region as well, jeopardising the significant gains made against malaria.

AMR is a serious global threat. Anti-microbial infections kill 55,000 people each year in Europe and the US, with global deaths estimated to be 700,000. According to the Review on Antimicrobial Resistance, 300 million people are expected to die prematurely because of drug resistance over the next 35 years and the world's GDP will be 2 to 3.5% lower than it otherwise would be in 2050. Drug resistance is not new, but AMR remains a significant threat to current longevity and health standards and requires monitoring. The UN has recognised that drug resistance is one of the greatest threats to humanity and the World Health Organisation has warned that the world is running out of antibiotics as drug development moves as a slower rate than drug resistance.

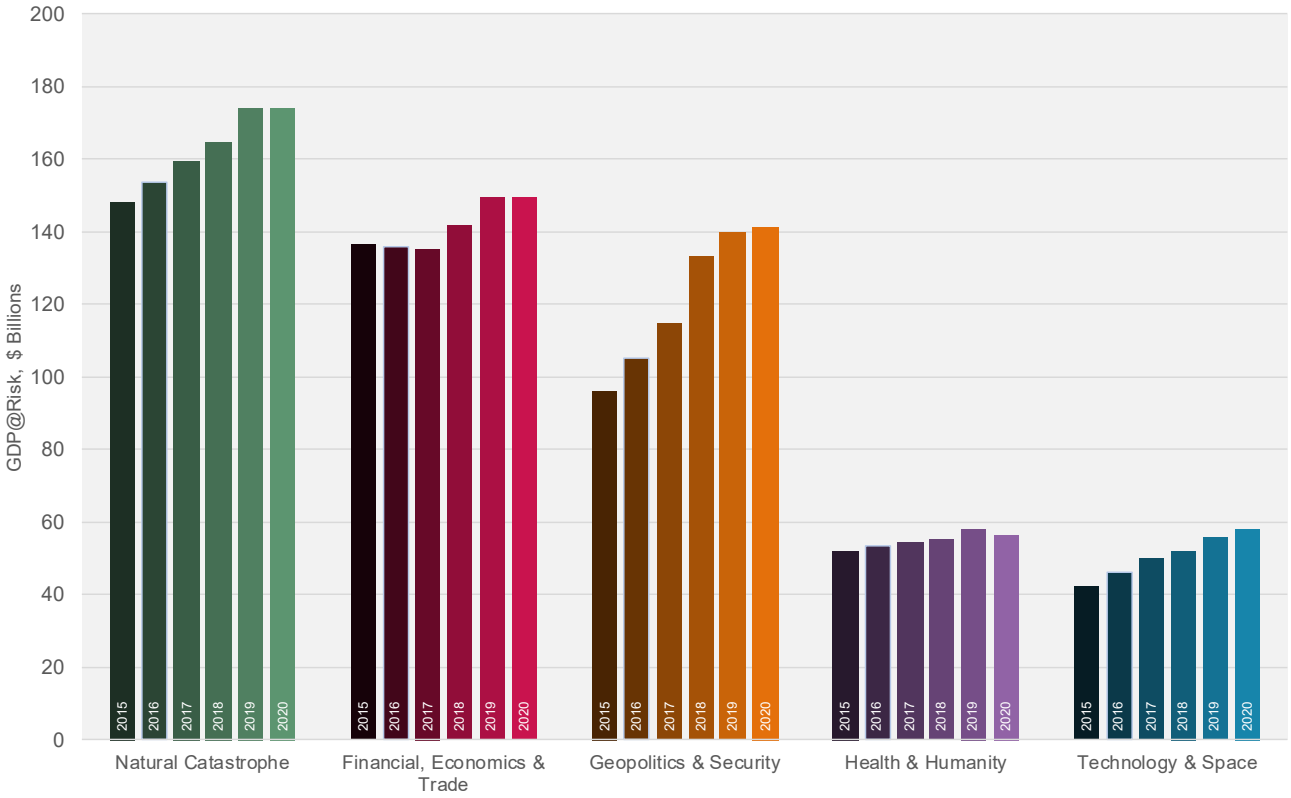
Climate change undoubtedly presents a growing infection vector to the world's more vulnerable populations. Waterborne and airborne diseases have become more prevalent in areas feeling the physical effects of global warming and rising sea levels. This trend will only continue as increased flooding, greater air pollution, and the further migration of people from affected areas add to the mobility and virulence of diseases. These regional epidemics demonstrate the intersection of threats in high-risk areas: disease may lead to geopolitical tensions, or the effects of a natural disaster may impact medical resources such that stockpiles are severely diminished as an epidemic emerges.

The understanding of this risk-relationship, however, has led to better education about disease and infection, and increased control measures when incidents do occur. This year, a second strain of the polio virus was eradicated worldwide.

Plant Epidemic risk has remained the same year on year. Panama disease in bananas, coffee and wheat rust all remain ongoing problems with *xylella fastidiosa* continuing to impact primarily olive plants in Europe. A potential solution to the impact of plant diseases is crop heterogeneity, as the growth in industrial farming has reduced biodiversity.

Xylella fastidiosa affects an olive grove

A anti-expatriation bill march in Hong Kong in July 2019



In comparison to the previous years, the 2020 Global Risk Index does not show any seismic changes in the risk landscape. The most significant threats to the global economy are consistent with last year's risk outlook: Market Crash risk remains the top threat overall. While there has been no notable increase in this risk year-over-year, ten years following the Great Financial Crisis of 2008, there have been multiple warnings of an oncoming financial crisis, which has so far yet to materialise. We should be reminded of the severity of a financial crisis on GDP, especially as these crises happen with relatively high frequency throughout history.

Social unrest is the risk which has advanced the most in rankings through 2019. Considering last year's decade-warning of another global financial crisis, does 2020 signal the re-emergence of a global protest movement, akin to the Arab Spring and Occupy movements? With a summer of demonstrations and rioting amongst young people in Hong Kong, affecting tourism, business continuity, and air travel, a new era of unrest does appear to be in the making. Subsequent protest action by groups like Extinction Rebellion have made disruption and global days of action commonplace in the West again. Protest movements in developing nations, such as Iraq, Lebanon, and Bolivia, trended, as they always have, towards anti-corruption and economic frustrations in 2019, whereas disruption in the West continues to cite the behaviour of major corporations as its key grievance. Compared with the Occupy movement of the 2010s, the target of these protests is governments and the major polluting and climate changing corporations they have failed to penalise.

The changing climate continues to affect the placement of natural catastrophe risks in our ranking. Altogether, environmental risks pose the greatest damage to the global economy, with tropical windstorms (3rd), floods (5th) and earthquakes (8th) as the most financially damaging types. The increase year-over-year is mostly due to the growth in GDP of the cities exposed to natural catastrophes. Many wealthy city economies are vulnerable to these threats, although their relative wealth allows them to be more resilient: Tropical Windstorm is the most costly threat for three of the ten cities most at risk in 2020. With the exception of cities in Japan and Iraq, all Asian cities in the top 20 ranking have a natural catastrophe risk as its top threat. The risk of Drought is also up from 2019, following a record-breaking summer which left environments desiccated and at great risk from fire. Although Power Outage is classed as a Technological and Digital Risk, its movement up the ranking is in part attributed to the impact of wildfires on energy infrastructures.

The overall GDP@Risk value is up 3% since last year to $584bn, or 1.55% of all global GDP. Of this amount, 31% is at risk from Natural Catastrophes, affecting those cities with the highest change in overall GDP since 2019.

Smoke from wildfires in California is visible from space

Conclusion

Every year, the risk landscape advances. As our understanding of principal and known risk grows more sophisticated, new emerging risks appear on the horizon. The Index provides guidance on where future disruptions to revenues and economic activity are most likely to occur. It delivers a framework for incorporating the frequency and severity of future shocks into resilience planning, inputs into risk registers and formal reporting of risks to shareholders and regulators.

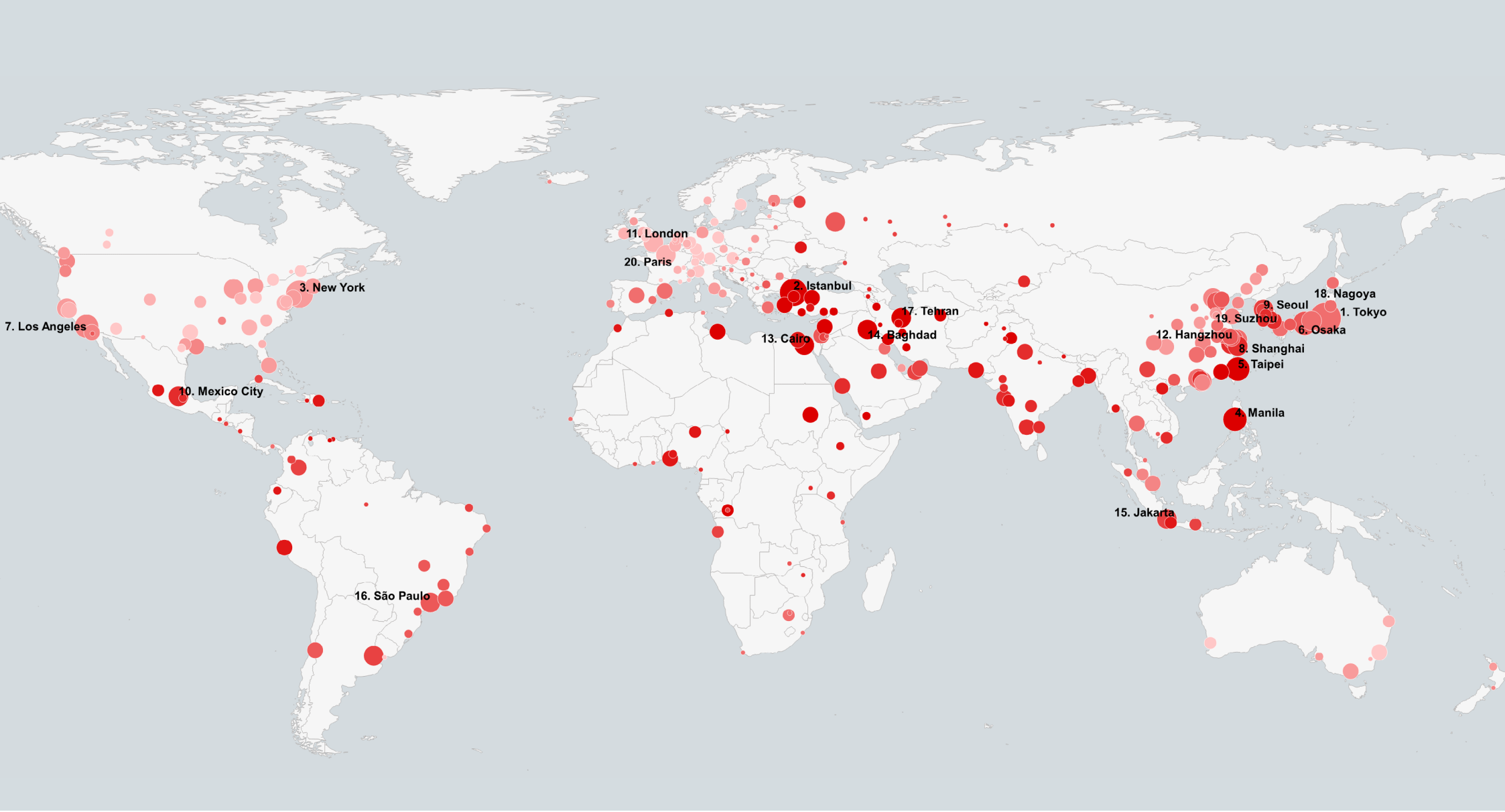
The Index is structured to help with the cost benefit justification of improving resilience. Policy makers can use the Index for civic continuity, economic security, and preparedness, particularly city administrations in identifying the key drivers of risk to the economic prosperity of their metropolis.

Financial services companies providing risk capital can incorporate this type of analysis into their own techniques and country threat assessments. Some risks included in the analysis are not incorporated in conventional risk management products and standard perils covered in traditional insurance. Better understanding of these risks may provide opportunities for insurers to create new product offerings and address new markets.

A Map of the Future Risk Landscape

The Index provides a map of the risk landscape ahead, see next page. Understanding the patterns of future risk is the key to successful risk management. We provide these analytics to help businesses, policy-makers, financial services providers, insurers, and other professional risk managers gauge their planning decisions, strategies and investments. We estimate that over half of this risk can be mitigated by improvements in resilience and investment in risk management.

Heightened awareness and improved understanding of risks is the key to building resilience. The 2020 Cambridge Global Risk Index is unique in quantifying the GDP impact of unpredictable shocks on 279 of the world's most prominent cities. The Index compiles the impacts of 22 types of threats into a single measurement of economic loss called GDP@Risk. This annual update standardises the tracking of a wide variety of systemic types of shocks to the economy. The underlying analytics provide a methodology to quantify the economic value of improvements in city resilience (both from recoverability and vulnerability improvements); this has significance for governments, infrastructure providers and insurers, and development organisations.



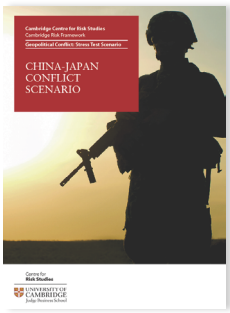
GDP@Risk 2020 (US$ Bn)

0 - 0.5 | 0.5 - 1 | 1 - 2 | 2 - 5 | 5 - 10 | 10 - 15 | 15 - 20 | 20 - 25

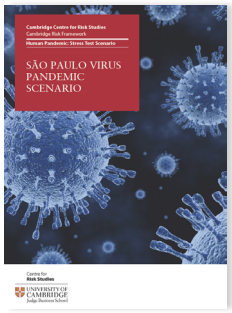
% GDP@Risk 2020

0% — 16%

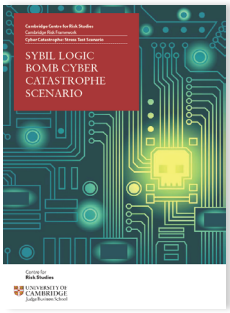
Cambridge Centre for Risk Studies Publications



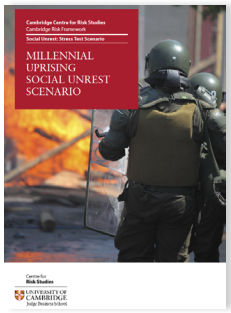
Geopolitical Conflict
Emerging Risk Scenario



Pandemic
Emerging Risk Scenario

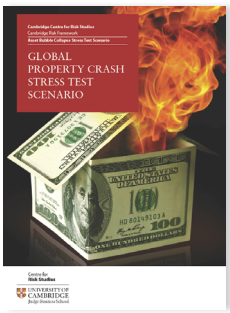


Cyber Catastrophe
Emerging Risk Scenario



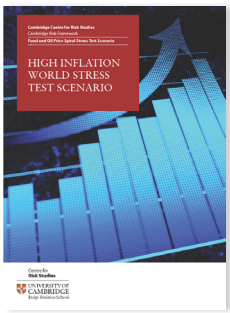
Social Unrest
Emerging Risk Scenario

Climate Change
Investor Sentiment Shock

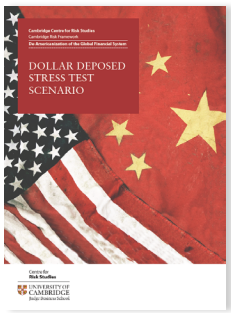


Global Property Crash
Financial Risk Scenario

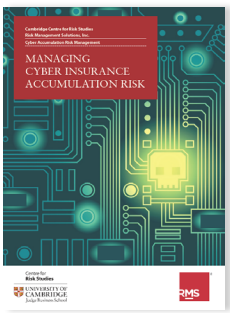
Eurozone Meltdown
Financial Risk Scenario



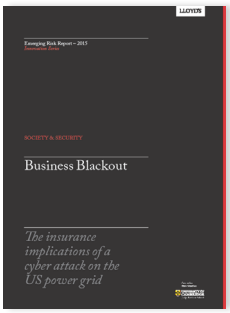
High Inflation World
Financial Risk Scenario



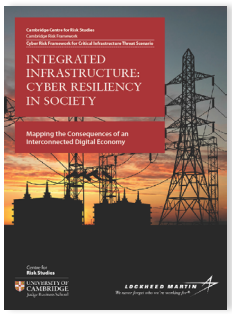
Dollar Deposed
Financial Risk Scenario



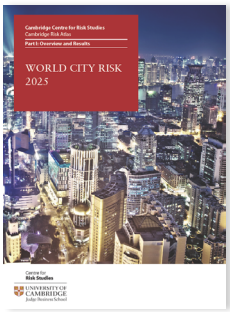
Cyber Accumulation
Insurance Risk Report



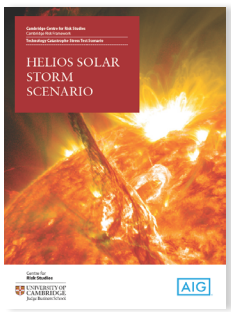
Business Blackout
Lloyd's Emerging Risk Report



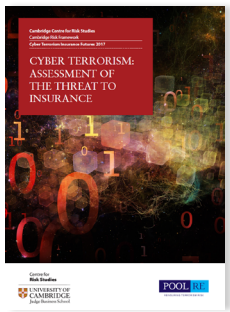
UK Cyber Blackout
Lockheed Martin UK co-branded report



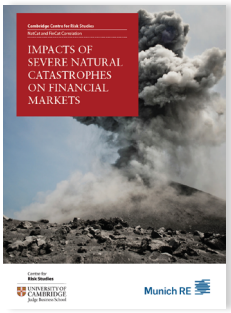
World City Risk 2025
Lloyd's co-branded report



Helios Solar Storm
Emerging Risk Scenario

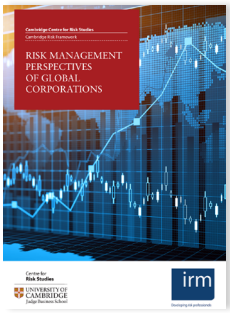


Cyber Terrorism
Pool Re co-branded report



Impacts of Severe NatCats on Markets

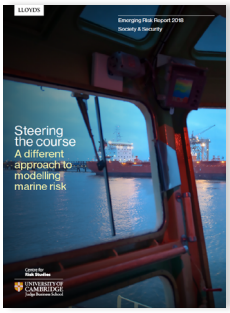
Cyber Risk Outlook 2018
Co-branded with RMS, Inc.



Risk Perspectives of Global Corporations

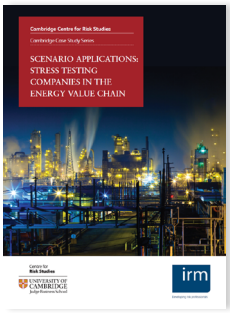
Multi-Threat Risk Analysis and Insurance

Multiline Insurance Exposure Management



Steering the course
New approaches to marine risk

Bashe Malware Attack
In collaboration with Lloyd's and CyRiM



Stress Testing the Energy Value Chain

Risk Management for the Consumer Sector

Shen Port Attack
In collaboration with Lloyd's and CyRiM

Cambridge Centre for Risk Studies gratefully acknowledges the expertise provided for the Global Risk Index research programme by our subject matter specialists. Any misinterpretation in use of the advice provided is entirely the responsibility of Cambridge Centre for Risk Studies.

Finance, Economics and Trade Risks

- **Cambridge Centre for Financial History**, Dr Duncan Needham, *Director*
- **Oxford Economics**
- **Financial Networks Analytics Ltd.**, Dr Kimmo Soramaki, *CEO and Founder*
- **Office of Financial Research, US Federal Reserve**, Dr Mark Flood, *Director*

Geopolitics and Society

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

Terrorism

- **International Centre for Political Violence and Terrorism Research**, S. Rajaratnam School of International Studies (RSIS) at Nanyang Technological University, Singapore, Prof. Rohan Gunaratna, *Director*
- **Risk Management Solutions Inc.**, Dr Gordon Woo, *Catastrophist*

Natural Catastrophe and Climate

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- **Department of Geography,** University of Cambridge, James Pollard, *PhD Student*

Cyber and Technology

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- **University of Cambridge Computer Labs,** Dr Frank Stajano, *Reader in Security and Privacy*, Graham Rymer, *Ethical hacker and penetration tester*
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Infrastructure

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