University of Cambridge Judge Business School

Cambridge Centre for Risk Studies

CAMBRIDGE GLOBAL RISK INDEX 2019 EXECUTIVE SUMMARY

Centre for
Risk Studies

UNIVERSITY OF CAMBRIDGE
Judge Business School

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The 2019 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 (Figure 1) providing GDP@Risk estimates as a standardised metric for 279 different cities. The highlights of our 2019 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 and financial crises.

The overall GDP@Risk for 2019 is $577 bn or 1.57% of the 2019 GDP, an increase of 5.59% from our 2018 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 to a lesser extent Solar Storms, while Sovereign Default 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 2018, the top three classes of threat types in the 2019 Index are Natural Catastrophes (with GDP@Risk of $174bn, 30% of total GDP@Risk), Financial, Economics & Trade (GDP@Risk of $149bn, 26% of total), and Geopolitics & Security in third place.

The top three individual threat types are Market Crash with GDP@Risk at $109bn, about a fifth of total GDP@Risk; Interstate Conflict at $83bn, 14% of total GDP@Risk; and Tropical Windstorm, $66bn or 11% of total risk. Cyber Attack rises to sixth amongst the threat rankings at $40bn, 7% of total risk GDP@Risk. Cyber Attack has moved up one ranking surpassing Civil Conflict in the 2019 Index. 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 New York, Manila, Istanbul, Taipei, Osaka, Los Angeles, London, Baghdad, and Shanghai (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 – enjoyed by Tokyo, London, Singapore, Zurich, San Jose amongst others – 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**	26.01	Interstate Conflict	36%
2	**New York**	15.69	Market Crash	20%
3	**Manila**	13.87	Tropical Windstorm	56%
4	**Istanbul**	13.35	Market Crash	22%
5	**Taipei**	13.01	Tropical Windstorm	62%
6	**Osaka**	12.29	Interstate Conflict	30%
7	**Los Angeles**	11.68	Earthquake	24%
8	**Baghdad**	9.88	Interstate Conflict	56%
9	**London**	9.15	Market Crash	24%
10	**Shanghai**	9.05	Tropical Windstorm	28%
11	**Mexico City**	8.22	Market Crash	35%
12	**Seoul**	7.53	Tropical Windstorm	36%
13	**Cairo**	7.31	Interstate Conflict	57%
14	**Hangzhou**	7.12	Tropical Windstorm	68%
15	**Jakarta**	6.63	Civil Conflict	30%
16	**Nagoya**	6.53	Interstate Conflict	35%
17	**São Paulo**	6.53	Market Crash	47%
18	**Paris**	6.31	Market Crash	24%
19	**Moscow**	6.19	Market Crash	46%
20	**Chicago**	6.14	Market Crash	21%

Flooding in Texas as a result of Hurricane Harvey, 2017

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 40% 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.
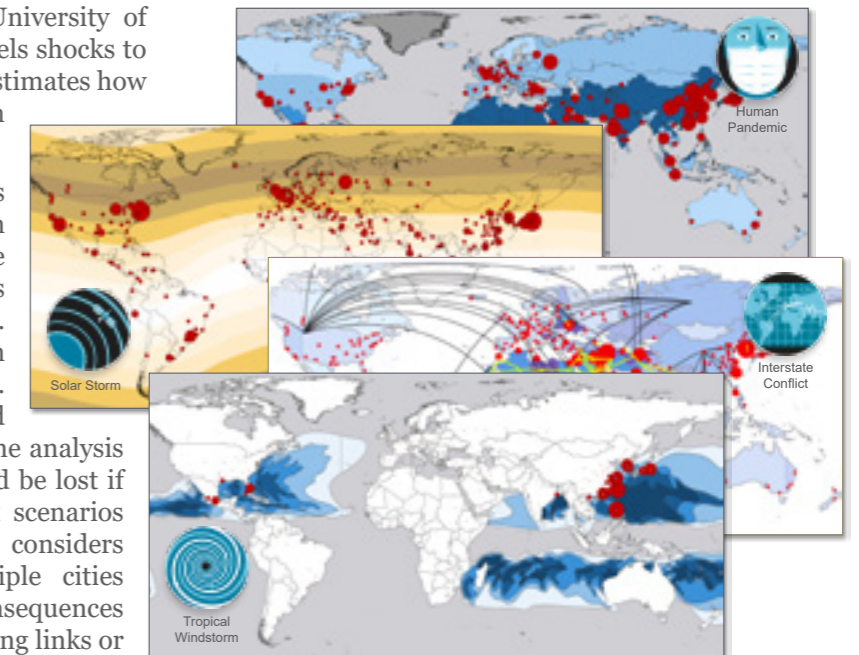
How were the threats selected?

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 from 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.
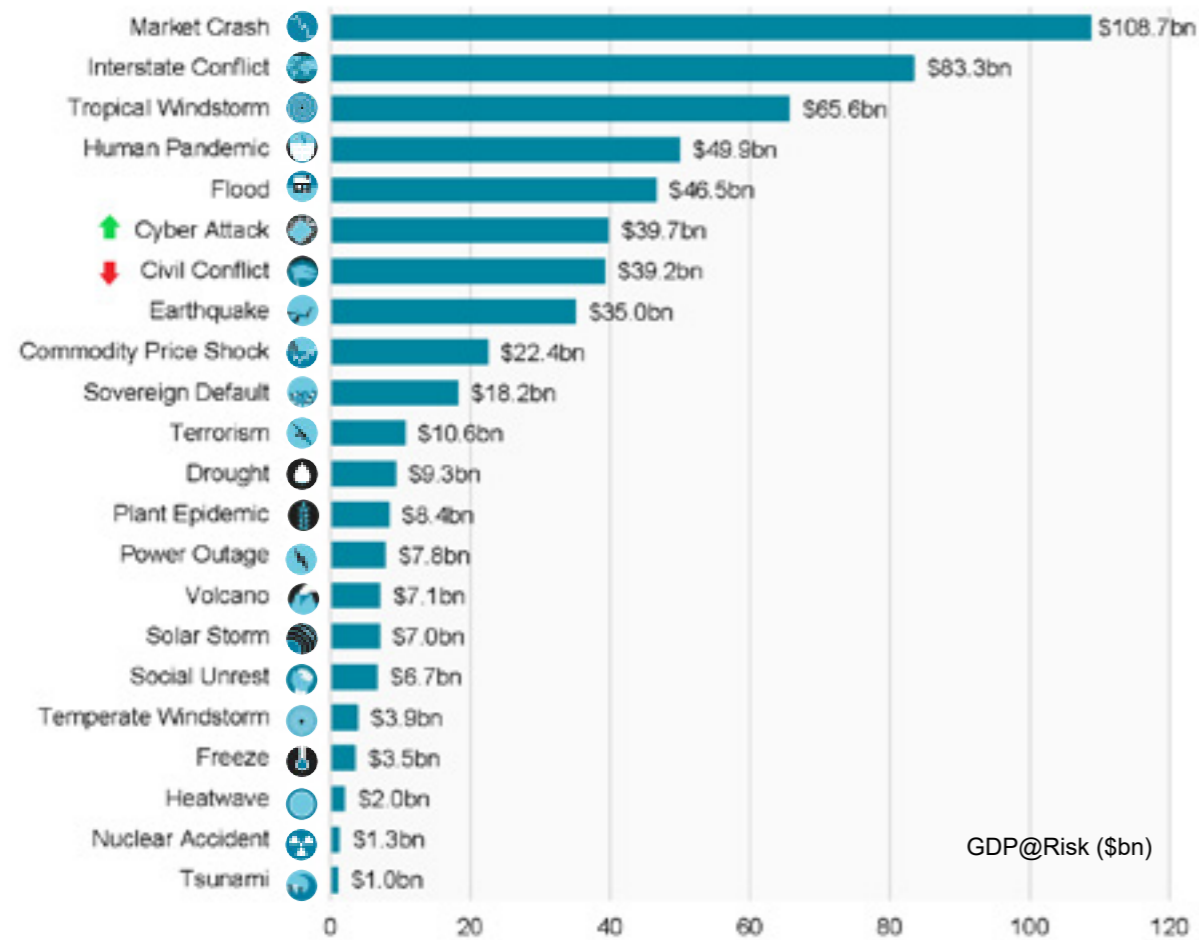
2019 Threat Rankings

Figure 1: Global Risk Index 2019 Threat Rankings

The Global Risk Index 2019 provides a comprehensive threat analysis for 279 cities that represent 41% of global GDP. The economy of each city is analysed by sector, size, and demography to determine the GDP@Risk across different scenarios for 22 threat types.

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.[1] Figure 2 shows the projected changes in GDP from 2018 to 2019.

Tripoli, Libya is projected to be the fastest growing city in terms of the percent change in 2018 GDP to 2019, with GDP change at 14%, while Caracas, Venezuela has the largest percent decrease with a value of -7%. Central and South Asia is the region with the largest percent change at 8%, with Eastern Europe having only a 1% change.

Our analysis shows that of the 5.6% increase in GDP@Risk from 2018 to 2019, 4.0% is from an increase in GDP, 0.2% is from changes to city rate of recovery levels while 1.3% is solely from changes in risk levels. Even if risk levels remain the same, wealth will continue to grow and distribute itself unevenly between cities and countries.

Note that changes to GDP projections mean that the

Top Cities by % GDP Change

Top 5
1. Tripoli, Libya
2. Bangalore, India
3. Hyderabad, India
4. Surat, India
5. Chennai, India

Bottom 5
1. Caracas, Venezuela
2. Maracay, Venezuela
3. Maracaibo, Venezuela
4. Buenos Aires, Argentina
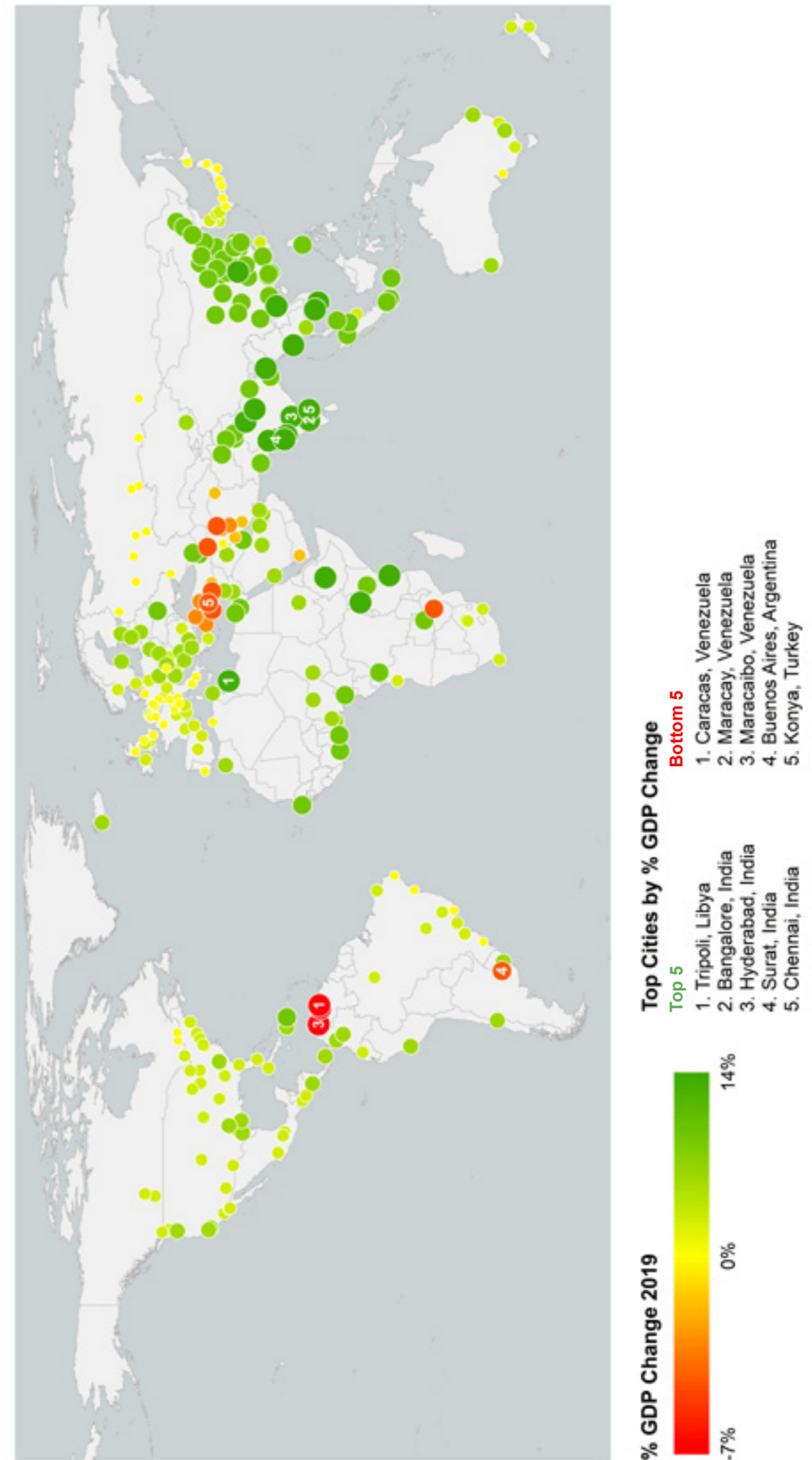5. Konya, Turkey

% GDP Change 2019
14%
0%
-7%

Figure 2: Cambridge Global Risk Index, change in GDP from 2018 to 2019 (Data from Oxford Economics)

Global Risk Index 2018 as published and Global Risk Index 2019 are not directly comparable.

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 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 factors that determine catastrophe recovery are multi-dimensional. The city rate of recovery assessment was refreshed in the 2019 Global Risk Index to incorporate the latest trends in recoverability. It is 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 2019. Moscow and Kiev have both seen an increase in their rate of recovery (meaning they are likely to recover faster following a disaster) due to a reduction in the number of uprooted people in each city. However, due to social and economic vulnerability degradation in Vietnam and Egypt country wide driven by reductions in human development, poverty, gender inequality, and access to public aid, cities within these countries saw their rate of recovery decrease.

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.

Data sources for financial, economic and trade risks include current and historical sovereign debt ratings and outlooks, equity market price indices and commodity price indices. For geopolitical and security risks, major data sources include the Global Terrorism Index from the Institute for Economics and Peace and the Global Conflict Risk Index by the Joint Research Center of the European Commission. For technology and space risks, major sources include nuclear power plant data from the World Nuclear Association, power outage data from the World Bank, and cyber and infrastructure research from the Centre for Risk Studies. For health and humanity risks, sources include surveillance data from World Health Organization, databases of emerging infectious diseases from EcoHealth Alliance, data from ResistanceMap from the Center for Disease Dynamics, Economic & Policy, and CABI Plantwise. For natural catastrophes, sources include the UN Environment Programme's Global Risk Data Platform, the EM-DAT International Disaster Database from the Centre for Research on the Epidemiology of Disasters, and other natural hazard maps.

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 (above), 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 2018 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 2018 events is key to the three year look ahead that is presented in the Index. The 2018 scan 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.

Resilience Terminology

For this years' Index, the terminology for the resilience have been refreshed. The previous 'Resilience' category will now be called 'Rate of Recovery'. This change in definition is meant to better reflect how this parameter is used in the model and to help clear up any confusion as the word resilience tends to be used interchangeably for rate of recovery, impact, preparedness and vulnerability related measures. Resilience in a social science sense focuses on preparedness, both social and economic, which limits the impact of a disaster while in an engineering sense it focuses on increasing the strength of the built environment thus reducing the probability of collapse from disasters. In reality, resilience is the combination of the social science and engineering preceptives, thus creating yet another definition for resilience. "Some analysts define resilience as a system attribute, whilst others use it as an umbrella concept for a range of system attributes deemed desirable."[2] For the CGRI, resilience is made up of two measures: Threat Vulnerability and the Rate of Recovery.

Threat Vulnerability = how significant the initial shock to the city's economy would be in the case of an event. The United Nations Office of Disaster Risk Reduction defines vulnerability as conditions that increase the impacts of hazards on various systems.[3] In the Index, market crash impact is assessed as the reliance on private capital, human pandemic impact is the state of healthcare facilities and for cyber it is the dependency on IT systems. All of these measures reflect how the city's economy will behave following an event.

Rate of Recovery = how much and how quickly a city can recover from the initial shock of the event. The United Nations Office of Disaster Risk Reduction defines resilience as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management."[4] 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 confidence, and re-engages in business activities after an event. In the index, rate of recovery is assessed using three primary factors: the social-economic resilience, lack of coping capacity and the fiscal resilience. The lack of coping capacity dimension measures the institutional and infrastructure capacity – formal, organised activities in response to disasters such as governance and communication systems. Fiscal resilience is a measure of the economic and financial capacity to recover from a disaster including the ability to withdraw funds from reserves to shift fiscal budgets, raise new funds, transfer risk through insurance and distribute funds efficiently. Rate of recovery was called resilience in previous Index releases.

Resilience										
Threat Vulnerability (CRS)	Rate of Recovery									
	Vulnerability (INFORM)				Lack of Coping Capacity (INFORM)				Fiscal Resilience	
	Socio-economic			Vulnerable Groups	Institutional		Infrastructure		Wealth	Insurance
Vulnerability assessment per threat type	Development deprivation	Inequality	Aid dependency	Uprooted people	Other vulnerable groups	Disaster Risk Reduction	Governance	Communication	Physical Infrastructure	Access to health systems	City GDP per capita (OEM)	Non-Life Insurance Penetration (Sigma)

Figure 3: Dimensions of resilience are defined by 'Threat Vulnerability' (assessment per threat type) and 'Rate of Recovery' (compromised of two components 'Vulnerability' and 'Lack of Coping Capacity' from the INFORM Index for Risk Management analysis and further supplemented by 'Fiscal Resilience' using data from Oxford Economics and Swiss Re Sigma).

Griffith Park brush wildfire and Woolsey fire in California, 2018

Earthquake

Tropical Windstorm

Temperate Windstorm

Tsunami

Volcano

Flood

Freeze

Drought

Heatwave

Natural Catastrophe and Climate

The 2018 year was characterised by record-breaking natural catastrophes.

Amongst the earthquakes that have occurred this year, the Mw7.5 earthquake and subsequent tsunami in Sulawasi, Indonesia on 28th September was the deadliest, with a current death toll of over 2000[5] and suggestions that this number could reach 5000.[6] Extraordinary liquefaction is likely responsible for a large proportion of the deaths and destruction, with reports of whole villages sinking into the earth.[7] Other notable earthquakes include the Mw.6.6 Hokkaido Eastern Iburi event in September – one of multiple damaging natural disasters Japan has suffered this year – and a Mw7.5 earthquake in Lombok, Indonesia in August that resulted in 563 deaths.[8]

The 2018 tropical cyclone season set various new records as well. Notably, in September there were 21 named tropical cyclones active at some point during the month – just one short of the record 22 in 1966.[9] The Pacific Ocean experienced numerous Category 5-equivalent super typhoons, of which Yutu was the strongest storm of the season, devastating the US territory of the Northern Mariana Islands in late October but drawing little media attention.[10] Super Typhoon Mangkhut caused the greatest human impacts, with at least 150 deaths,[11] hitting the populous and vulnerable northern Philippines before progressing across the South China Sea to affect Hong Kong and coastal south-east China. Hong Kong experienced a record-breaking 2.35 metre storm surge in Hong Kong, although coastal flood defences protected the most exposed areas.[12] Japan also saw its strongest storm in 25 years with Typhoon Jebi causing an estimated $5.5 billion in insured losses.[13] In the Atlantic, Hurricane Florence, was only at CAT1 status when it made landfall in North Carolina on 14th September, and was primarily a flood event. It dumped 1.27 metres of rain on the Carolinas making it the 2nd wettest hurricane

on record and causing a 1-in-1000 year rainfall event in terms of extreme 3-day rainfall amounts.[14] Hurricane Michael made landfall in October 2018 as a CAT4 hurricane devastating the Florida Panhandle with the greatest wind speeds to impact the area in recorded history.[15]

Major flood events occurred in Japan, China, and the Indian Subcontinent. July saw Japan's deadliest freshwater floods since 1892, causing 225 fatalities, and was an exceptional event on account of its severity, producing floods across multiple prefectures.[16] These events highlighted weakness in ageing city infrastructure, with a heavy impact on production, consumption, & tourism.[17] In the southern Indian state of Kerala, above average seasonal rainfall resulted in flooding that killed over 350 people. Kerala's authorities have been criticised for poor forecasting and management of water resources, with suggestions that losses could have been avoided if water had been slowly released from dams before they were full.[18] Severe flooding in Venice, Italy was seen in October 2018 following a string of violent storms.[19] Updates to our coastal storm surge assessment have informed a change in the overall risk from floods.

In South Africa, prolonged drought conditions since 2015 resulted in acute water shortages in Cape Town prompting the city to half consumption. Recent rainfall meant that 'Day Zero' has been narrowly avoided for now. Intense drought conditions in south-east Australia, Argentina, Uruguay and Italy caused impacts to agriculture. Further, drought conditions prevail in the western US with some states seeing little to no rainfall. Intense drought in California is fuelling destructive fires across the state. Although, not a current threat in the Index, wildfires made the headlines this year notably in California, which saw one of the largest wildfires on record occur in 2018.[20] Wildfires are driven by the temperature and atmospheric

humidity. This is a threat category that we are monitoring with the intent to add it to the Index in a future release.

Extreme heatwaves affected much of the northern hemisphere during the 2018 summer. In the UK, the Met Office declared it the joint hottest year on record together with 1976, 2003, and 2006.[21] This event has drawn comparison to the European heatwave of 2002, which resulted in over 70,000 deaths across the continent.[22] Japan also saw an unprecedented heatwave, with 35,000 people hospitalised following record temperatures of 41°C.[23] Karachi, Pakistan saw temperatures soar to 45°C in April.[24] If temperatures continue to rise, parts of South Asia may become uninhabitable by the end of the 21st century. Overall, the next four years are going to be anomalously warm,[25] even on top of regular climate change.[26]

Freeze events also made the headlines this year in Europe, particularly in the UK. Between February and March, a split in the stratospheric polar vortex produced anomalous warm conditions in the Arctic and cold conditions in Europe.[27] In the UK, the resultant "Beast from the East" limited growth in the first 3 months of this year.[28]

Scientific consensus suggests that the severity and impacts of natural catastrophes are increasingly due to climate change. There is evidence that, among catastrophe types modelled in the Global Risk Index, flooding, heatwaves and droughts are all becoming more frequent. Atlantic hurricanes are experiencing rapid growth spurts, meaning that they are growing from tropical depressions to category level storms faster.[29] Further, there is growing evidence that tropical storms are becoming sluggish and lingering over a given area for longer periods, bringing more rain and greater damage. The speed at which tropical storms moved across the planet slowed by about 10% in the last 60 years.[30]

The increased frequency of natural catastrophe events due to climate change 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. Although 2018 was a severe year for natural catastrophes, the uncertainty and long-term nature of climate projections cannot tell us whether short-term trends will escalate.

Ramrod Key in Florida Keys after Hurricane Irma, 2017

Finance, Economics and Trade

Market Crash

Sovereign Crisis

Commodity Prices

Financial, Economics and Trade Risks have remained largely steady since the publication of the 2018 Global Risk Index. Global financial stability is improving due to higher capital requirements under Basel III but risk appetite has also increased due to a positive global growth outlook coupled with a low interest rate environment. Financial vulnerabilities continue to accumulate due to low interests and volatility. Leverage in the non-financial sector has risen in major economies. Canada, China, Sweden and Ireland have credit more than double of their GDP.[31]

As for the banking sector, North American banks are the most resilient by balance sheet metrics. Nonperforming loans have increased in Cyprus, Greece and Portugal.[32] Although regulators in China have taken steps to address systemic risks stemming from the intercorrelation of the banking sector, the shadow banking sectors vulnerabilities remain high.

Trade disputes between the US and China and the US and Europe are causing a disruption to the global supply chains. The introduction of trade tariffs — and the prospect of more — has added to the downward pressure on agricultural commodities such as wheat, corn and soy beans and left them trading at multiyear lows. However, droughts this year in key growing regions, such as Brazil, Argentina and Russia as well as the EU, have adjusted the production forecasts down.[33] Overall, industrial metals have fallen 19% from a peak in April, hinting a bear market ahead, according to the Bloomberg Industrial Metals Index.[34] Copper hit its lowest level since July 2017, while metals including nickel, zinc and aluminium also fell sharply.[35] Escalating trade tensions have led to a clear divide between western countries (US, UK, Japan and Eurozone) and developing countries (China, Asia excluding Japan and Emerging Markets) in terms of equity market performance.

Global equity market correlations have rebounded since the start of the year. Broader correlations across asset classes have increased. Countries with high financing needs such as Malaysia and Turkey are vulnerable to a tightening of global financing condition.[36] Heightened house price synchronisation is observed among 40 countries and 44 major cities with the potential for an asset bubble.[37]

Sovereign debt risks have decreased in some countries following restructuring of their debt and country level credit rating upgrades in Cyprus, El Salvador, Greece, Mongolia, Portugal, Spain, Armenia, Bulgaria, Cambodia, Israel and Tunisia.[38] However, these improvements may be transient in nature as political and economic uncertainties could alter the outlooks for these sovereigns.

The past year also saw a remarkable rise in Brent crude price, driven by both tightening supply from OPEC and Russia and strong demand from a booming global economy. Brent crude oil prices started the year at approximately $67/bbl, reaching $86/bbl before declining again.[39] This was the highest the oil price has been since 2014. This volatility in price increases the likelihood that we will see another rise in price again in the coming years.

Geopolitics and Security

Overall, Geopolitics and Security risks have remained the same as last year. This is driven by the limited movements relating to the geopolitical assessment done for last year. States identified as being involved in conflict or at risk of conflict remains the same as last year. Iran maintains a proxy presence in several conflicts throughout the region, namely in Yemen, Iraq, Israel, Syria and Lebanon. Iran vs. Syria still remains the top concern in terms of interstate conflict. It is now confirmed that Iran through Islamic Revolutionary Guard Corps have increased Hezbollah's strategic rocket arsenal in both Lebanon and Syria from 10k to 15k in 2006 war time to 100k to 150k present.[40] Territorial disputes in the East and South China Seas continue. Statements made by President Trump and Chairman Kim Jong Un suggest that North Korea will denuclearise, however actions speak otherwise.[41]

Violent terrorist activity in the Sahel region driven by localised issues, Islamic extremism and the influence of global Islamic terrorist groups has tripled in the past decade.[42] In November, a rocket barrage lasting over 24hrs saw more than 400 rockets launched into Israeli territory by Hamas and Islamic Jihad from Gaza.[43] Afghanistan experienced record civilian casualties in the first half of 2018 due to an increase in suicide bombings, the influence of the Islamic State and Taliban insurgent activity.[44] The Islamic States territorial defeat has seen a decrease of violent attacks and fatalities in Syria and Iraq.[45] However, a transition from insurgency and territorial acquisition to terrorism could lead to a dispersion of violent threats.

The removal of Mugabe in Zimbabwe signalled a regime shift that has elevated its threat for civil conflict in 2019.[46] Sub-national conflict in Myanmar has been ongoing for decades from a myriad of isolated rural groups with limited aims. The UN is calling for an investigation into possible war crimes, causing mass migration of the Rohingya, committed by Myanmar's top military officials.[47] The conflict in Yemen is considered 2018's worst humanitarian conflict with at least 3 million displaced and issues of malnutrition and food shortages due to price instability leading to an outbreak of cholera.[48] A presidential election in October has caused an uprising of separatists in Cameroon.[49]

A developing economic crisis has fuelled social unrest in Venezuela and Argentina while protests in Nicaragua have led to civilian casualties.[50] Germany continues to see right wing protests, with tensions increasing in Sweden as far right parties vie for power during the elections this year. President Zuma resigned in February following mounting press due to corruption, inequality and government ineffectiveness in South Africa.[51] Over one million Uighur Muslims and other minority groups are being held at internment camps in the Xinjiang Province with potential for unrest as there are signs the people are being held without any lawful charges.[52] There is a general sentiment in China concerning incipient peasant displeasure due to working conditions, status, citizenship, government control and economic hardships within major population centres causing unrest. Further, Turkey, Iraq, Iran, South Africa and Bangladesh all have experienced heightened levels of unrest as well.

Conflict and social disruption in Yemen
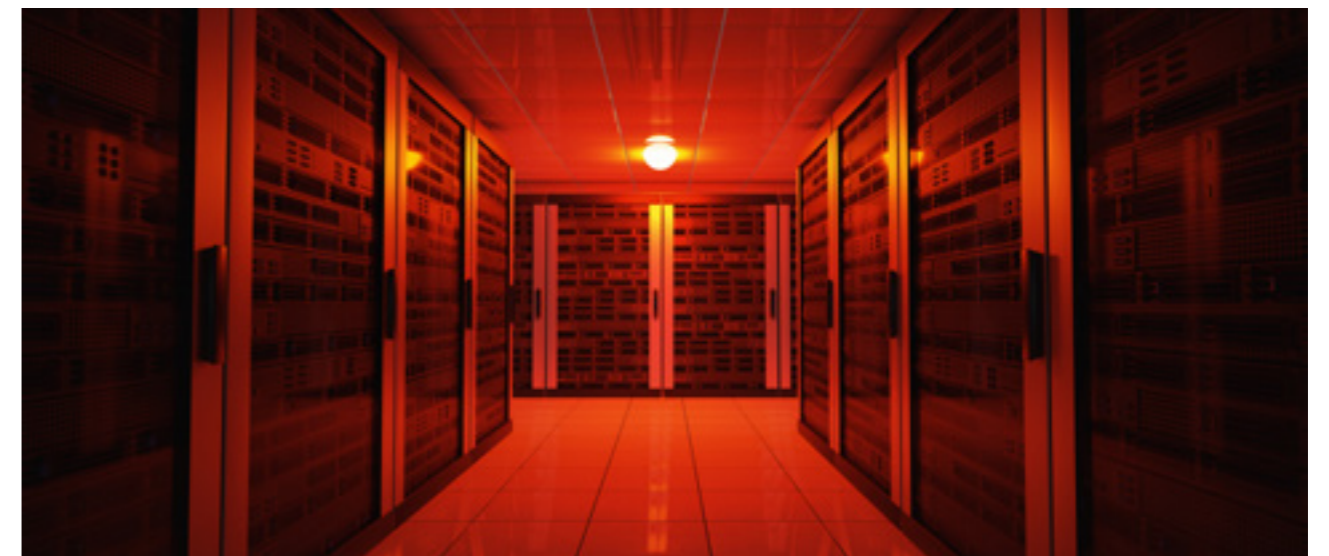
Technology and Space

August and September 2018 were particular active months for geomagnetic storms following increased activity on the sun. The solar cycle is exiting a solar minimum,[53] where we are likely to see an increase in the number of sunspots and consequently raising the risk of solar storms within the next three years. Researchers have developed a new method of providing short-term forecast geomagnetic storms, thus providing more details on the fluctuations expected during the storm.[54] Additionally, NASA just launched the Parker Solar Probe in August 2018, coined "the mission to touch the sun" by entering into the sun's atmosphere attempting to collect data to answer long debated questions about the Sun.[55]

Notable power outages occurred in 2018. Weakened electricity infrastructure by flooding caused outages in early part of the year in Sudan, with one outage coincidentally timed during an address by President Omar al-Bashir.[56] The March Nor'easter in the US took out power for 1 to 2 million while recovery from the 2017 Hurricane Maria continued to be slow in the early part of the year with 4% of households still without power in April 2018 following the September 2017 storm.[57] An equipment failure in Brazil took out 22.5% of capacity turning off the lights for 10 million plus people.[58] A World Cup game between Nigeria and Croatia saw a temporary power outage due to increased demand.[59] Power grid operators continue to upgrade their infrastructure to maintain capacity, balance the demand and protect against outages.

Threat of nuclear accident is also relatively unchanged although, several major facilities are slated to be decommissioned within the next few years in Lithuania, France and the US. There seems to be an emerging trend to move away from nuclear power to renewables, which is worth monitoring. However, new facilities are still being planned in Asia and Russia.

The cyber threat, as in last year's update, continues to develop at a rapid pace. Cyber attack loss severities are increasing with several recent attacks showing the potential for systemic impacts with global reach. Nearly every country in the industrialised world has reported a loss related to cyber risk. Ransomware continues to be the most significant malware threat. WannaCry and NotPetya ransomware were the most prominent examples seen in 2017; with new variants and losses still being seen throughout 2018. Other infection methods are increasing however – e.g. spam botnets, social engineering – and illustrate the evolving nature of this threat.

Data breaches are still making headlines with notable breaches occurring at Exactis, a marketing firm that exposed 340 million records,[60] Under Armor with a leak of 150 million,[61] and Singapore's largest healthcare institution targeted. The largest data breach in 2018 involved the personal information of 1.1 billion Indian citizens including their Aadhaar number and biometric information.[62]

The SWIFT banking system remains vulnerable to hacks, with $13+ millions stolen in May and again in August.[63] Cryptojacking

Interstate Conflict

Terrorism

Civil Conflict

Social Unrest

Cyber Attack

Power Outage

Nuclear Accident

Solar Storm

increased in threat this year - this is where attackers use spare computing resources like cloud servers to mine cryptocurrency without the owner's consent.

DDos attacks were seen targeting political candidates' fundraising websites during the 2018 Mid-term elections and taking the Pyeongchang Olympic Games' official website down for 12 hours as well as disrupting wifi and TVs at the Pyeongchang Olympic stadium.[64]

2018 saw continued negative impacts from cloud outages. Inclement conditions included prolonged periods of high temperatures (Microsoft),[65] the March Nor'easter winds and rain (AWS, Equinix),[66] and lightning strikes (Microsoft).[67] These events highlight the interconnection between Natural Catastrophes and Cyber risk via data centres. Indeed, 2018 has brought us various sophisticated techniques and tools exploited against cloud storage services, such as lauching DDos and malware attacks. In the past year alone, 51% of organisations worldwide have experienced cloud-based attacks due to lack of credentials, including FedEx, Intel, and Honda.[68]

The cost to industries in terms of business interruption and ransom payments is growing due to increased reliance on connected devices. Reports released during 2018 show that the 2017 WannaCry and NotPetya had a much larger impact than originally imagined, with companies reporting losses around greater than $300 million and some still reporting losses into mid-2018.[69] Ransomware attacks are increasingly being used for strategic and political reasons rather than financial gain. The US now formally blames Russia for interference in the 2016 Presidential Election and thus ramped up cyber security for the 2018 Mid-term Elections this year.[70]

The greatest potential for economic loss from cyber attacks is the threat to critical infrastructure. While several ransomware and data infiltration cyber attacks were executed with high profile targets this year, there were few successful or destructive attacks on critical infrastructure. An interesting example of the breadth of disruption that cyber attacks can have on cities is the ransomware attack on Atlanta in March 2018, where the city came to a standstill after all its computers were locked.[71]

The attack surface is growing as more businesses adapt Internet of Things (IoT) devices. Several attempts and advances have been recorded however. The US Department of Homeland Security released a report in March 2018 indicating Russian hackers had launched cyber attacks on critical control systems in several sectors of American infrastructure including energy, nuclear, commercial facilities, water, aviation and manufacturing.[72] Further the indictment of several Russian officials in hacking of Westinghouse, a nuclear energy company, shows the level of espionage attempts critical infrastructure companies are facing.[73]

Global economies are becoming progressively dependent on digital links and this can be seen by the increase in internet penetration and e-commerce activity per country. Countries are trying to combat this increase in risk with offense spending, for example the UK is slated to spend hundreds of millions of pounds on cyber offensive capability.[74] All of this led to an increase in the risk for cyber this year, moving it up one rank in the threat ranking.

Health and Humanity

Human Pandemic

Plant Epidemic

Major epidemics were mostly contained to specific regions in 2018. The places affected are typically suffering from climate and geopolitical crises which exacerbate hygiene and public health issues. These epidemics highlight the intersection of threats as events of one type can trigger or exacerbate the effects of another. Whether it is due to the global nature of supply chains, urbanisation or climate change, we see that the potential for epidemics to extend their reach is increasing. Increased travel and mobility aid in the spread of viruses.[75]

Considering the emerging influenza variants, the 2017 outbreak in China of Influenza A(H7N9) was a resurgent bird flu strain. It has been flagged as it can transmit easily among animals and can cause lethal disease. The H7N9 virus has been circulating in China since 2013, causing severe disease in people exposed to infected poultry. Last year, human cases spiked, and the virus split into two distinct strains that are unique enough to no longer succumb to existing vaccines. It also has the potential to kill birds, affecting the poultry industry. The World Health Organisation is also monitoring a new subtype of Avian Influenza A(H7N4).[76] A discover of a new flu vaccine could reduce this risk in the future.[77]

A challenge in the health and humanity outlook is the effect of anti-microbial resistance (AMR). 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. A resistant strain of tuberculosis is also of note.[78]

AMR is a serious threat in all parts of the world, including the developed parts with otherwise strong healthcare systems. Anti-microbial infections kill 55,000 people each year in Europe and the US, with global deaths estimated to be 700,000.[79] 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.[80] While drug resistance is not new, this is an important risk in health that is worsening and will need to be monitored. 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 lags behind the rise of drug resistance.[81]

There is little doubt that a pandemic is due to occur again, with high profile people like Bill Gates calling for better development of vaccines,[82] but how it will unfold remains highly variable and dependent upon emergency planners and the insurance community.

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.[83] A potential solution to the impact of plant diseases is crop heterogeneity, as the growth in industrial farming has reduced biodiversity.[84]

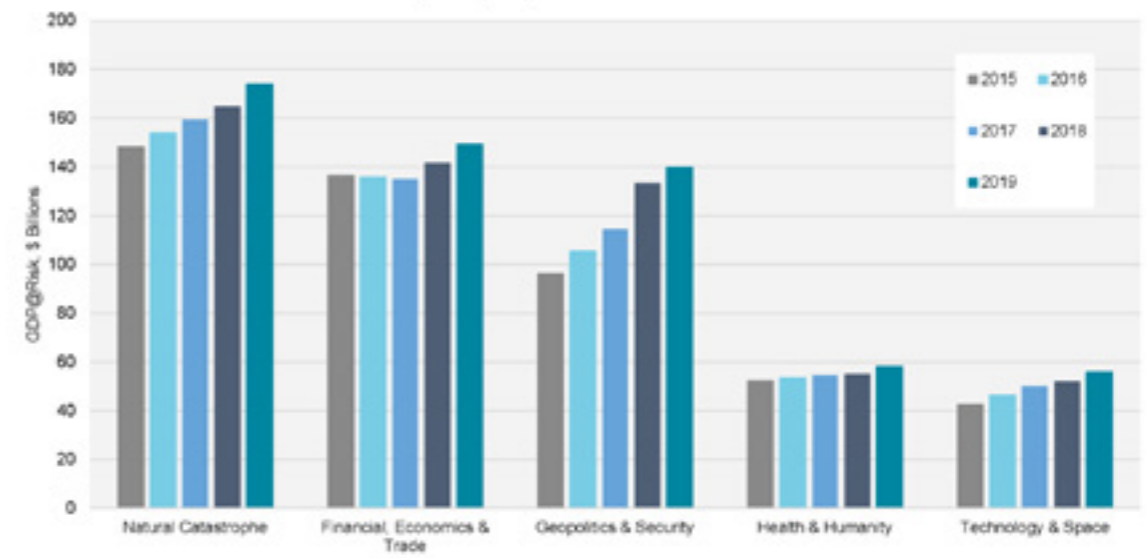Global Risk Index Growth: Threat categories ($bn)

Figure 4: Global Risk Index 2019 Growth by Sub-Category ($, bn)

Changes in Threat Risks

In comparison to the 2018 Global Risk Index, the 2019 outlook has not changed significantly. The most significant threats to the global economy are consistent with last year's risk outlook: Financial, Economics & Trade risks are becoming more volatile compared to the long-term trend as baseline commodity prices were trending up to record levels this year before they collapsed again and severe financial shocks are likely to be contained as banking liquidity returns and capital buffers continue to be put in place. Market Crash risk remains the top threat overall. While there has been no notable increase in this risk year-over-year, on the 10 year anniversary of the Great Financial Crisis of 2008 we should be reminded of the severity of a financial crisis on GDP, especially as these crises happen with relatively high frequency throughout history.

Cyber attacks also remain top of mind and saw an increase in the threat ranking. All sub-categories within cyber saw an increase in frequency with reports published early in the year of the scale of impact of the 2017 WannaCry and NotPetya ransomware attacks had on individual companies, illustrate this elevated threat. Cyber protection capabilities are slowly improving in response to the proliferation of cyber criminals, providing a steady but relatively high level of risk, coming in 6th overall out of the 22 threat categories, a one rank ascension from last year.

Natural catastrophe risks together inflict the most 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 second-most costly threat for Tokyo ($3.48bn) and Flood is the second-most costly threat for New York ($2.54bn). 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. Freeze and Heatwave saw moderate increases in risk due to the increased impact seen following past events. A modelling change in how we classify coastal cities provided an increase for the Flood risk.

Minor increases in risk from Geopolitics and Security risk is driven by the growing social unrest in several countries including Yemen, Nicaragua, Argentina, Iraq and South Africa. The total expected loss from this category is close that of Financial, Economic & Trade risk – another category of man-made risks. Man-made risks have shorter time scales compared to Natural Catastrophes and can escalate (and de-escalate) quickly.

The overall GDP@Risk value is up to $577.03 bn for the 2019 Index from $546.50 for the 2018 Index. Natural Catastrophe risk makes up 40% of the total loss with man-made risks accounting for the remaining 60%.
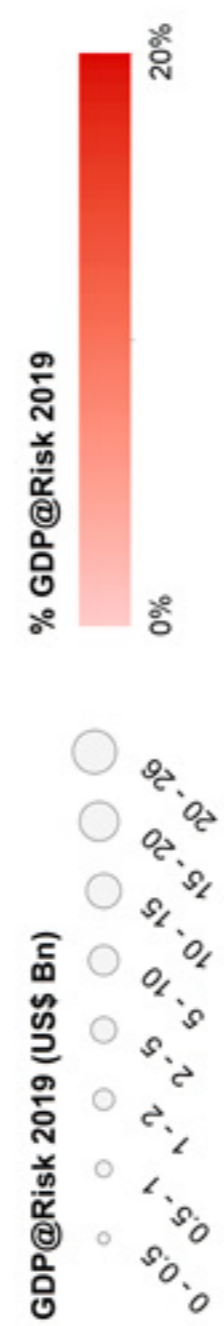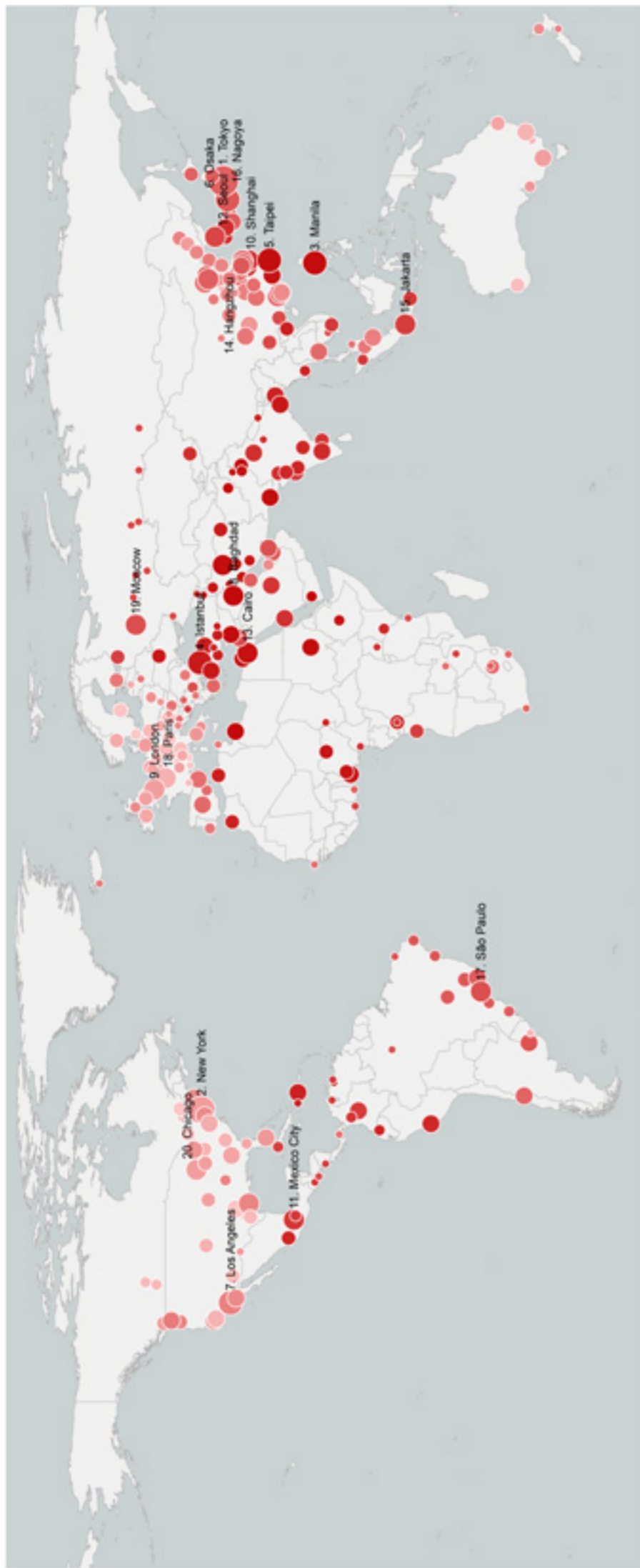
Shelters for Rohingya refugees at Jamtoli camp, Bangladesh

Figure 5: Cambridge Global Risk Index 2019, overall GDP@Risk per city

% GDP@Risk 2019

20%

0%

GDP@Risk 2019 (US$ Bn)

- 20 - 26
- 15 - 20
- 10 - 15
- 5 - 10
- 2 - 5
- 1 - 2
- 0.5 - 1
- 0.05 - 0.5
- 0 - 0.05

Conclusion

The risk landscape is changing. The Index provides guidance on where future disruptions to revenues and economic activity are most likely to occur. It provides 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 Figure 4. 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 2019 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.

Taxonomy of Threats

Geopolitical Conflict
Emerging Risk Scenario

Pandemic
Emerging Risk Scenario

Cyber Catastrophe
Emerging Risk Scenario

Social Unrest
Emerging Risk Scenario

Ebola
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

2017 Cyber Risk Landscape
Co-branded with RMS, Inc.

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

Disaster Recovery Case Studies

Health and Disease

- **Cambridge Infectious Disease Interdisciplinary Research Centre**, Dr Colin Russell, *Royal Society Research Fellow, Department of Veterinary Medicine*

- **Department of Plant Sciences**, University of Cambridge, Dr Matt Castle, *Senior Research Fellow*

1   The World Bank, "Global Economic Prospects," Text/HTML, Global Economic Prospects, 2018, http://www.worldbank.org/en/publication/global-economic-prospects

2   Richard J. T. Klein, Robert J. Nicholls, and Frank Thomalla, "Resilience to Natural Hazards: How Useful Is This Concept?," Global Environmental Change Part B: Environmental Hazards 5, no. 1 (January 1, 2003): 35–45, https://doi.org/10.1016/j.hazards.2004.02.001

3   United Nations Office of Disaster Risk Reduction, "Terminology," February 2, 2017, https://www.unisdr.org/we/inform/terminology

4   United Nations Office of Disaster Risk Reduction. "Terminology," February 2, 2017. https://www.unisdr.org/we/inform/terminology

5   Reliefweb, "Logistics Cluster: Indonesia, Sulawesi Earthquake and Tsunami Situation Update - 12 November 2018 - Indonesia," ReliefWeb, 2018, https://reliefweb.int/report/indonesia/logistics-cluster-indonesia-sulawesi-earthquake-and-tsunami-situation-update-12

6   Hannah Ellis-Petersen and Kate Lamb, "Indonesia Earthquake Death Toll Could Reach 5,000 as Officials Count Missing," The Guardian, October 8, 2018, sec. World news, https://www.theguardian.com/world/2018/oct/08/indonesia-earthquake-death-toll-could-reach-5000-as-officials-count-missing

7   Robert Muir-Wood, "Ultra-Liquefaction Changes Everything | The RMS Blog," 2018, https://www.rms.com/blog/2018/10/12/ultra-liquefaction-changes-everything/

8   Wikipedia, "5 August 2018 Lombok Earthquake," Wikipedia, November 13, 2018, https://en.wikipedia.org/w/index.php?title=5_August_2018_Lombok_earthquake&oldid=868691204

9   Met Office, "An Active September for Tropical Cyclones," Official Blog of the Met Office News Team (blog), October 1, 2018, https://blog.metoffice.gov.uk/2018/10/01/an-active-september-for-tropical-cyclones/

10 Lenika Cruz and Alia Wong, "The Media Barely Covered One of the Worst Storms to Hit U.S. Soil," The Atlantic, November 14, 2018, https://www.theatlantic.com/science/archive/2018/11/super-typhoon-yutu-mainstream-media-missed-northern-mariana-islands/575692/

11 Reliefweb, "Philippines: Latest Typhoon-Induced Landslide Death Toll Climbs - Philippines," ReliefWeb, May 11, 2018, https://reliefweb.int/report/philippines/philippines-latest-typhoon-induced-landslide-death-toll-climbs

12 Simon Athawes and James Cosgrove, "Typhoon Mangkhut: A Weekend of Destruction | The RMS Blog," accessed September 24, 2018, http://www.rms.com/blog/2018/09/18/typhoon-mangkhut-a-weekend-of-destruction/

13 Simon Athawes and James Cosgrove, "Typhoon Mangkhut: A Weekend of Destruction | The RMS Blog," accessed September 24, 2018, http://www.rms.com/blog/2018/09/18/typhoon-mangkhut-a-weekend-of-destruction/

14 Umair Irfan, "Hurricane Florence's '1,000-Year' Rainfall, Explained," Vox, September 20, 2018, https://www.vox.com/2018/9/20/17883492/hurricane-florence-rain-1000-yea

15 Richard Luscombe, "Hurricane Michael: Everything You Need to Know on the Record-Breaking Storm," The Guardian, 10 2018, https://www.theguardian.com/us-news/2018/oct/11/hurricane-michael-explained-biggest-florida-storm-all-you-need-to-know-extreme-weather

16 Hemant Nagpal, Manabu Masuda, and Junichi Sakai, "Japan: Waking Up to Flood Risk | The RMS Blog," 2018, https://www.rms.com/blog/2018/08/03/japan-waking-up-to-flood-risk/#more-5116

17 Lauren Hubbard, "Poor Land Management Is Fuelling Dangerous Wildfires," Lloyd's City Risk Index, 2018, https://cityriskindex.lloyds.com/2018/09/11/poor-land-management-is-fuelling-dangerous-wildfires/.

18 BBC, "Japan Floods and Landslides Kills Scores," BBC News, July 8, 2018, sec. Asia, https://www.bbc.com/news/world-asia-44749847

19 Reuters in Rome, "Italy Storms Kill 11 and Floods Inundate St Mark's Basilica, Venice," The Guardian, 10 2018, https://www.theguardian.com/weather/2018/oct/30/water-rises-to-three-feet-in-st-marks-basilica-after-venice-floods

20 Hubbard, "Poor Land Management Is Fuelling Dangerous Wildfires."

21 "Was Summer 2018 the Hottest on Record?," Met Office, accessed September 21, 2018, https://www.metoffice.gov.uk/news/releases/2018/end-of-summer-stats.

22 Robine, Jean-Marie, Siu Lan K. Cheung, Sophie Le Roy, Herman Van Oyen, Clare Griffiths, Jean-Pierre Michel, and François Richard Herrmann. 2008. "Death Toll Exceeded 70,000 in Europe during the Summer of 2003." Comptes Rendus Biologies, Dossier : Nouveautés en cancérogenèse / New developments in carcinogenesis, 331 (2): 171–78. doi:10.1016/j.crvi.2007.12.001.

23 Our Foreign Staff, "'Unprecedented' Japan Heatwave Kills 65 in One Week and Leaves 23,000 in Hospital," The Telegraph, July 24, 2018, https://www.telegraph.co.uk/news/2018/07/24/unprecedented-japan-heatwave-kills-65-one-week-leaves-23000/

24 Joanna Ruck, "Karachi Residents Cool off in Pakistan Heatwave – in Pictures," The Guardian, May 30, 2018, sec. World news, https://www.theguardian.com/world/gallery/2018/may/30/karachi-residents-cool-off-pakistan-heatwave-in-pictures

25 Eun-Soon Im, Jeremy S. Pal, and Elfatih A. B. Eltahir, "Deadly Heat Waves Projected in the Densely Populated Agricultural Regions of South Asia," Science Advances 3, no. 8 (August 1, 2017): e1603322, https://doi.org/10.1126/sciadv.1603322

26 Florian Sévellec and Sybren S. Drijfhout, "A Novel Probabilistic Forecast System Predicting Anomalously Warm 2018-2022 Reinforcing the Long-Term Global Warming Trend," Nature Communications 9, no. 1 (August 14, 2018): 3024, https://doi.org/10.1038/s41467-018-05442-8

27 James E. Overland and Muyin Wang, "Recent Extreme Arctic Temperatures Are Due to a Split Polar Vortex," Journal of Climate 29, no. 15 (June 17, 2016): 5609–16, https://doi.org/10.1175/JCLI-D-16-0320.1

28 Tom Knowles, "Economy Fails to Weather Winter Storm as Construction Crumbles," The Times, Winter 2018, Print edition

29 Alexandra Witze, "Atlantic Hurricanes' Rapid Growth Spurts Are Intensifying," News, Nature, December 14, 2017, https://doi.org/10.1038/d41586-017-08719-y

30 James P. Kossin, "A Global Slowdown of Tropical-Cyclone Translation Speed," Nature 558, no. 7708 (June 2018): 104–7, https://doi.org/10.1038/s41586-018-0158-3

31 IMF, "Global Financial Stability Report April 2018: A Bumpy Road Ahead," April 2018, https://www.imf.org/en/Publications/GFSR/Issues/2018/04/02/Global-Financial-Stability-Report-April-2018

32 IMF, "Global Financial Stability Report April 2018: A Bumpy Road Ahead," April 2018, https://www.imf.org/en/Publications/GFSR/Issues/2018/04/02/Global-Financial-Stability-Report-April-2018

33 Emiko Terazono, "Key Food Commodities Face Risk of Price Spike," Financial Times, July 16, 2018, https://www.ft.com/content/bd0900a6-8690-11e8-96dd-fa565ec55929

34 John Dizard, "A Copper-Bottomed Sign: Why the Metal Is Telling Us to Panic," Financial Times, August 3, 2018, https://www.ft.com/content/a8e3a258-9648-11e8-b747-fb1e803ee64e

35 David Sheppard and Henry Sanderson, "Commodity Prices Suffer as Emerging Markets Tumble," Financial Times, August 19, 2018, https://www.ft.com/content/f6b11d9c-a158-11e8-85da-eeb7a9ce36e4

36 Investment Communications Team, "Quarterly Markets Review - Q2 2018" (Schroders, 2018), https://www.schroders.com/en/insights/economics/quarterly-markets-review---q2-2018/

37 IMF, "Global Financial Stability Report April 2018."

38 "Credit Rating - Countries - List," accessed September 21, 2018, https://tradingeconomics.com/country-list/rating.;

"Moody's Upgrades Cyprus's Ratings to Ba2, Changes Outlook to Stable from Positive," Moodys.com, July 27, 2018, https://www.moodys.com/research/Moodys-upgrades-Cypruss-ratings-to-Ba2-changes-outlook-to-stable--PR_386479.;

Mamta Badkar, "Fitch Upgrades Greece Rating to BB-," Financial Times, August 10, 2018, https://www.ft.com/content/f2ed611a-9cdb-11e8-ab77-f854c65a4465.;

Cat Rutter Pooley, "Fitch Upgrades Mongolia Debt Rating as Commodities Cycle Lifts Income," Financial Times, July 10, 2018, https://www.ft.com/content/36830544-8448-11e8-96dd-fa565ec55929.;

Peter Wells, "Moody's Upgrades Spain's Credit Rating," Financial Times, April 13, 2018, https://www.ft.com/content/9c8e7e54-3f5b-11e8-b7e0-52972418fec4.

39 David Sheppard and Anjli Raval, "Nervous Oil: Five Factors Driving Price Swings," Financial Times, November 6, 2018, https://www.ft.com/content/220f55f2-e0f7-11e8-a6e5-792428919cee

40 "Hezbollah 'Getting Precision Rockets,'" BBC News, September 20, 2018, sec. Middle East, https://www.bbc.com/news/world-middle-east-45587633

41 "Joint Statement of President Donald J. Trump of the United States of America and Chairman Kim Jong Un of the Democratic People's Republic of Korea at the Singapore Summit," The White House, accessed September 11, 2018, https://www.whitehouse.gov/briefings-statements/joint-statement-president-donald-j-trump-united-states-america-chairman-kim-jong-un-democratic-peoples-republic-korea-singapore-summit/;

Ankit Panda and Vipin Narang, "North Korea's Nuclear Program Isn't Going Anywhere," Foreign Affairs, August 13, 2018, https://www.foreignaffairs.com/articles/north-korea/2018-08-13/north-koreas-nuclear-program-isnt-going-anywhere;

"North Korea 'Continuing Nuclear Programme,'" BBC News, August 4, 2018, sec. Asia, https://www.bbc.com/news/world-asia-45067681.

42 Maiduguri, and Naimey. 2018. "The Fight against Islamic State Is Moving to Africa - Jihad's next Battleground." The Economist, July 14. https://www.economist.com/middle-east-and-africa/2018/07/14/the-fight-against-islamic-state-is-moving-to-africa

Oliver Holmes and Hazem Balousha, "Israel Faces Outcry over Gaza Killings during Jerusalem Embassy Protests," May 15, 2018, https://www.theguardian.com/world/2018/may/14/israel-tells-palestinians-they-are-risking-lives-in-us-embassy-protests

43 Oliver Holmes, and Hazem Balousha. "Israel and Hamas Agree to Gaza Ceasefire after Intense Violence." The Guardian, November 13, 2018, sec. World news. https://www.theguardian.com/world/2018/nov/13/relentless-reprisal-attacks-as-israel-and-hamas-ignore-ceasefire-pleas-gaza

44 Reuters. "Civilian Deaths in Afghanistan at Record High, UN Says." The Guardian, July 15, 2018, sec. World news. https://www.theguardian.com/world/2018/jul/15/civilian-deaths-afghanistan-record-high-un-says

45 Amanda Erickson and Laris Karklis, "Analysis | Every 2017 Terrorist Attack, Mapped," Washington Post, January 2018, https://www.washingtonpost.com/news/worldviews/wp/2018/01/18/every-2017-terrorist-attack-mapped/

46 Peta Thornycroft, "I Was Illegally Removed from Power, Says Robert Mugabe," The Telegraph, March 15, 2018, https://www.telegraph.co.uk/news/2018/03/15/illegally-removed-power-says-robert-mugabe/

47 OHCHR, "Myanmar: Tatmadaw Leaders Must Be Investigated for Genocide, Crimes against Humanity, War Crimes," United Nations, August 27, 2018, https://www.ohchr.org/EN/NewsEvents/Pages/DisplayNews.aspx?NewsID=23475&LangID=E

48 Tom Miles, "WHO Warns of New Yemen Cholera Surge, Asks for Ceasefire to Vaccinate," Reuters, August 3, 2018, https://www.reuters.com/article/us-yemen-security-cholera-idUSKBN1KO18R;

BBC, "'A Million More' Yemen Children Face Famine," BBC News, September 19, 2018, sec. Middle East, https://www.bbc.com/news/world-middle-east-45568669;

"Key Facts about the War in Yemen," Al Jazeera News, March 25, 2018, https://www.aljazeera.com/news/2016/06/key-facts-war-yemen-160607112342462.html

49 Francois Essomba and Dionne Searcey, "Thousands Flee in Cameroon as Separatists Battle for New Nation," The New York Times, October 15, 2018, sec. World, https://www.nytimes.com/2018/09/24/world/africa/cameroon-ambazonia-secession.html

50 Mariana Zuniga and Harriet Alexander, "Venezuela Rocked by Deadly Protests during Controversial Election for 'super Power' Assembly," The Telegraph, July 30, 2017, https://www.telegraph.co.uk/news/2017/07/30/venezuela-votes-controversial-election-super-power-assembly/;

Natalie Gallón, "At Least 317 Killed in Ongoing Protests in Nicaragua, Rights Group Says," CNN, August 5, 2018, https://www.cnn.com/2018/08/05/americas/nicaragua-violent-protests/index.html;

Hugh Bronstein, "Argentine Austerity Protests Mount over Macri's IMF-Backed Measures," Reuters, 12 2018, https://uk.reuters.com/article/uk-argentina-economy/argentine-austerity-protests-mount-over-macris-imf-backed-measures-idUKKCN1LS312

51 Ed Stoddard, "South Africa's East Platinum Belt Hit by over 400 Social Unrest Incidents since 2016," Reuters, April 10, 2018, https://www.reuters.com/article/us-safrica-mining-unrest/south-africas-east-platinum-belt-hit-by-over-400-social-unrest-incidents-since-2016-idUSKBN1HH20R

52 BBC, "China Defends Uighur 'Education Centres,'" October 16, 2018, sec. China, https://www.bbc.com/news/world-asia-china-45872356

53 NOAA, "Solar Cycle Progression," NWS Space Weather Prediction Center, August 2018, https://www.swpc.noaa.gov/products/solar-cycle-progression.

54 "Researchers Develop a New Technique to Forecast Geomagnetic Storms," accessed September 25, 2018, https://phys.org/news/2018-08-technique-geomagnetic-storms.html

55 BBC, "Nasa Gets Lift-off in Sun Mission," August 12, 2018, sec. Science & Environment, https://www.bbc.com/news/science-environment-45160722

56 "Power Outage Said to Hit Sudan during President's Speech | News24," accessed September 25, 2018, https://www.news24.com/Africa/News/power-outage-said-to-hit-sudan-during-presidents-speech-20180110

57 Doug Criss, "Puerto Rico's Power Outage Is Now the Second-Largest Blackout in History," CNN, April 16, 2018, https://www.cnn.com/2018/04/16/us/puerto-rico-blackout-second-largest-globally-trnd/index.html;

"Nearly 1 Million without Power as Third Winter Storm Brews for Northeast," usatoday, accessed September 25, 2018, https://www.usatoday.com/story/news/nation/2018/03/08/brutal-noreaster-cuts-power-1-m-homes-businesses/406128002/

58 "Tens of Millions in Northern Brazil Hit by Massive Power Outage," US News & World Report, accessed September 25, 2018, https://www.usnews.com/news/world/articles/2018-03-21/tens-of-millions-in-northern-brazil-hit-by-massive-power-outage

59 James Cox, "Nigeria Suffers Major Power Cut across Country as Nation Kicked off at World Cup," The Sun, June 16, 2018, https://www.thesun.co.uk/world-cup-2018/6551013/nigerias-power-grid-meltdown-world-cup/

60 Greenberg, Andy. "Marketing Firm Exactis Leaked a Personal Info Database with 340 Million Records." WIRED, June 27, 2018. https://www.wired.com/story/exactis-database-leak-340-million-records

61 Chloe Aiello. "Under Armour Says Data Breach Affected about 150 Million MyFitnessPal Accounts." CNBC, March 29, 2018. https://www.cnbc.com/2018/03/29/under-armour-stock-falls-after-company-admits-data-breach.html

62 David Bisson, "The 10 Biggest Data Breaches of 2018... So Far," accessed November 16, 2018, https://blog.barkly.com/biggest-data-breaches-2018-so-far

63 Charlie Osborne. "How Hackers Managed to Steal $13.5 Million in Cosmos Bank Heist." ZDNet, August 27, 2018. https://www.zdnet.com/article/how-hackers-managed-to-steal-13-5-million-in-cosmos-bank-heist/

64 Simon Sharwood. "Winter Olympics Website Downed by Cyber Attack." The Register, February 11, 2018. https://www.theregister.co.uk/2018/02/11/winter_olympics_website_downed_by_cyber_attack/

65 Kurt Mackie. "Microsoft Cloud Services Stumble After Outage Hits Texas Datacenter -." Redmond Channel Partner, September 4, 2018. https://rcpmag.com/articles/2018/09/04/microsoft-cloud-outage-datacenter.aspx

66 Tsidulko, Joseph. "The 10 Biggest Cloud Outages Of 2018 (So Far)." CRN, August 1, 2018. https://www.crn.com/slide-shows/security/300107391/the-10-biggest-cloud-outages-of-2018-so-far.htm/11

67 Tsidulko, Joseph. "The 10 Biggest Cloud Outages Of 2018 (So Far)." CRN, August 1, 2018. https://www.crn.com/slide-shows/security/300107391/the-10-biggest-cloud-outages-of-2018-so-far.htm/11

68 Check Point Research. "Cyber Attack Trends | 2018 Mid-Year Report." Check Point Research, 2018. https://research.checkpoint.com/wp-content/uploads/2018/07/Cyber-Attack-Trends-2018-Mid-Year-Report.pdf

Bibliography

69 Danny Palmer, "NotPetya Cyber Attack on TNT Express Cost FedEx $300m," ZDNet, September 20, 2017, https://www.zdnet.com/article/notpetya-cyber-attack-on-tnt-express-cost-fedex-300m/;

Richard Chirgwin, "IT 'heroes' Saved Maersk from NotPetya with Ten-Day Reinstallation Bliz," The Register, January 25, 2018, https://www.theregister.co.uk/2018/01/25/after_notpetya_maersk_replaced_everything/

70 Newman, Lily Hay. "The Unprecedented Effort to Secure Election Day." WIRED, November 6, 2018. https://www.wired.com/story/midterms-2018-secure-election-day/

71 Alan Blinder and Nicole Perlroth. "A Cyberattack Hobbles Atlanta, and Security Experts Shudder." The New York Times, September 26, 2018, sec. U.S. https://www.nytimes.com/2018/03/27/us/cyberattack-atlanta-ransomware.html

72 Volz, Dustin, and Timothy Gardner. "In a First, U.S. Blames Russia for Cyber Attacks on Energy Grid." Reuters, March 15, 2018. https://www.reuters.com/article/us-usa-russia-sanctions-energygrid/in-a-first-u-s-blames-russia-for-cyber-attacks-on-energy-grid-idUSKCN1GR2G3

73 Sarah Lynch, Lisa Lambert, and Christopher Bing, "U.S. Indicts Russians in Hacking of Nuclear Company Westinghouse," Reuters, October 4, 2018, https://www.reuters.com/article/us-usa-russia-cyber/u-s-indicts-russians-in-hacking-of-nuclear-company-westinghouse-idUSKCN1ME1U6

74 Bond, David. "Britain Preparing to Launch New Cyber Warfare Unit." The Financial Times, September 21, 2018. https://www.ft.com/content/eef717f2-bb6e-11e8-8274-55b72926558f

75 Christian Nordqvist, "Pandemics: Past, Present, and Future," Medical News Today, May 22, 2018, https://www.medicalnewstoday.com/articles/148945.php

76 Lisa Schnirring, "WHO Changes 2 Strains for 2018-19 Flu Vaccine," CIDRAP, February 22, 2018, http://www.cidrap.umn.edu/news-perspective/2018/02/who-changes-2-strains-2018-19-flu-vaccine.

77 Lisa Marshall, "Flu Researchers Discover New Mechanism for Battling Influenza," CU Boulder Today, November 2, 2017, https://www.colorado.edu/today/2017/11/02/flu-researchers-discover-new-mechanism-battling-influenza

78 Christian Nordqvist. "Pandemics: Past, Present, and Future." Medical News Today, May 22, 2018. https://www.medicalnewstoday.com/articles/148945.php

79 O'Neill, Jim. 2014. "Antimicrobial Resistance: Tackling a Crisis for the Health and Wealth of Nations." The Review of Antimicrobial Resistance. https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf

80 European Commission, "EU Action on Antimicrobial Resistance - Antimicrobial Resistance," Antimicrobial Resistance, accessed November 16, 2018, /health/amr/antimicrobial-resistance_en;

CDC, "The Biggest Antibiotic-Resistant Threats in the U.S.," Centers for Disease Control and Prevention, September 10, 2018, https://www.cdc.gov/drugresistance/biggest_threats.html;

Jim O'Neill, "Antimicrobial Resistance: Tackling a Crisis for the Health and Wealth of Nations," The Review of Antimicrobial Resistance, December 2014, https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf

81 Wise, Jacqui. "Global Project to Map Drug Resistance and Tackle 'Superbugs' Is Launched." The BMJ, October 13, 2017. http://archive.is/hClqf. https://www.bmj.com/content/359/bmj.j4769

82 Lena Sun, "Bill Gates Calls on U.S. to Lead Fight against a Pandemic That Could Kill 33 Million," Washington Post, April 27, 2018, https://www.washingtonpost.com/news/to-your-health/wp/2018/04/27/bill-gates-calls-on-u-s-to-lead-fight-against-a-pandemic-that-could-kill-millions/

83 Rodrigo P. P. Almeida, "Emerging Plant Disease Epidemics: Biological Research Is Key but Not Enough," PLOS Biology 16, no. 8 (August 22, 2018): e2007020, https://doi.org/10.1371/journal.pbio.2007020;

Si-Jun Zheng et al., "New Geographical Insights of the Latest Expansion of Fusarium Oxysporum f.Sp. Cubense Tropical Race 4 Into the Greater Mekong Subregion," Frontiers in Plant Science 9 (April 9, 2018), https://doi.org/10.3389/fpls.2018.00457;

Talib Visram, "Colombia and Honduras Lead the Way in Tackling Devastating Coffee Rust Disease," CNN, August 8, 2018, https://money.cnn.com/2018/08/08/news/world/coffee-rust-honduras-colombia/index.html;

"Wheat Rust Diseases," Bayer Crop Science, April 2, 2018, https://www.cropscience.bayer.us/learning-center/articles/wheat-rust-diseases

84 Youyong Zhu et al., "Genetic Diversity and Disease Control in Rice," Nature 406, no. 6797 (August 2000): 718–22, https://doi.org/10.1038/35021046

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