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Insight Report

The Global Risks Report 2019
14th Edition

In partnership with Marsh & McLennan Companies and Zurich Insurance Group

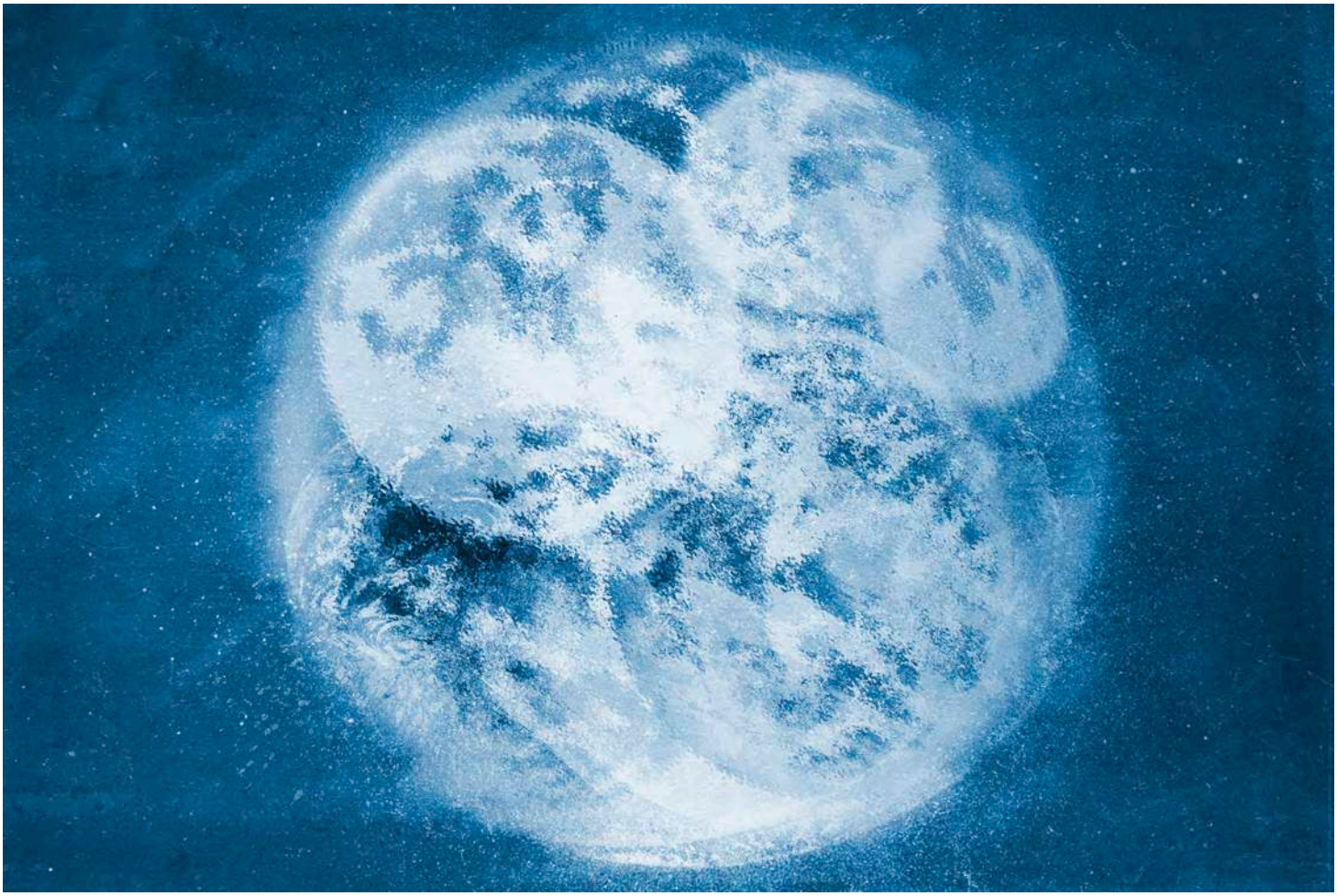

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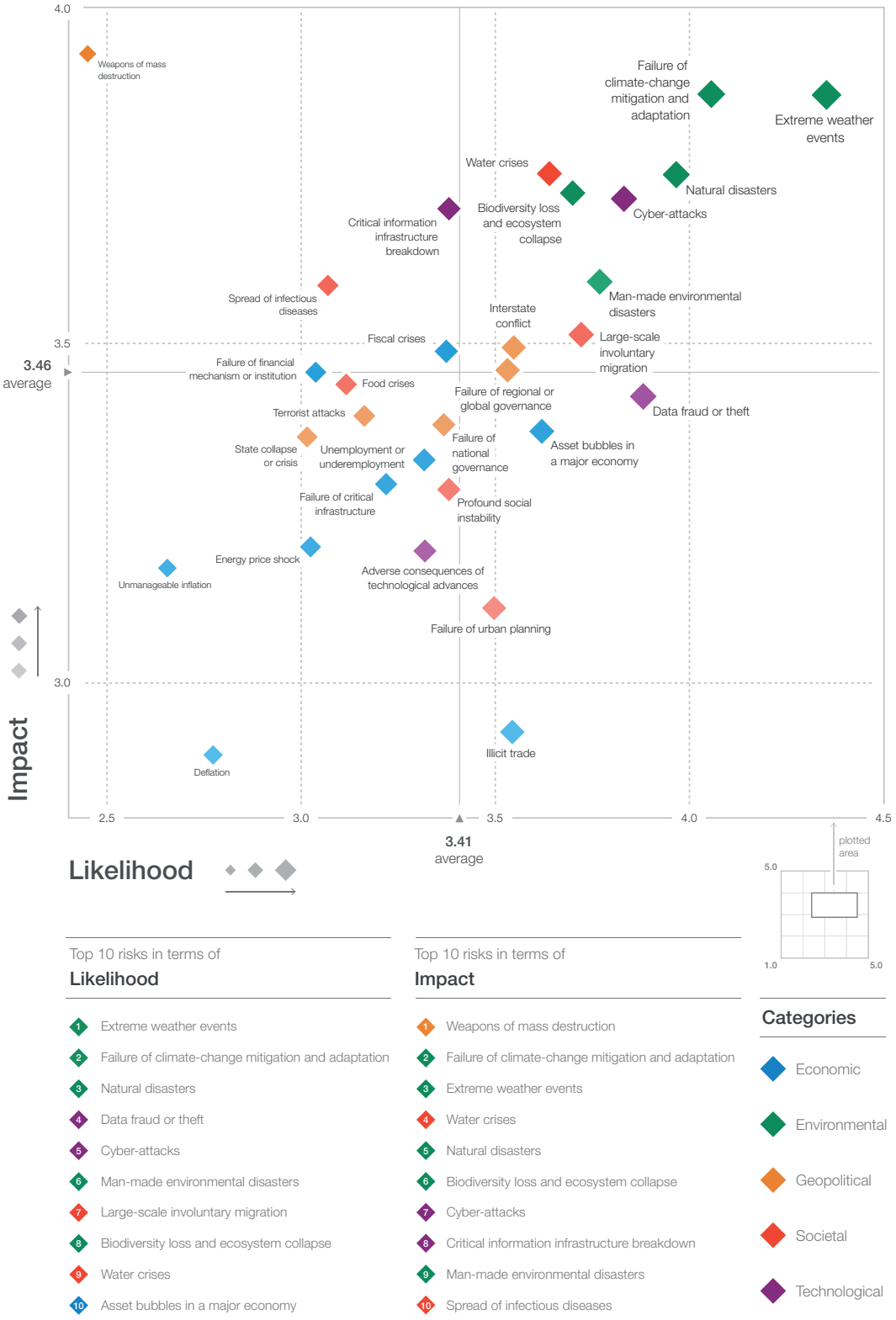
Figure I: The Global Risks Landscape 2019



Top 10 risks in terms of
Likelihood

1. Extreme weather events
2. Failure of climate-change mitigation and adaptation
3. Natural disasters
4. Data fraud or theft
5. Cyber-attacks
6. Man-made environmental disasters
7. Large-scale involuntary migration
8. Biodiversity loss and ecosystem collapse
9. Water crises
10. Asset bubbles in a major economy

Top 10 risks in terms of
Impact

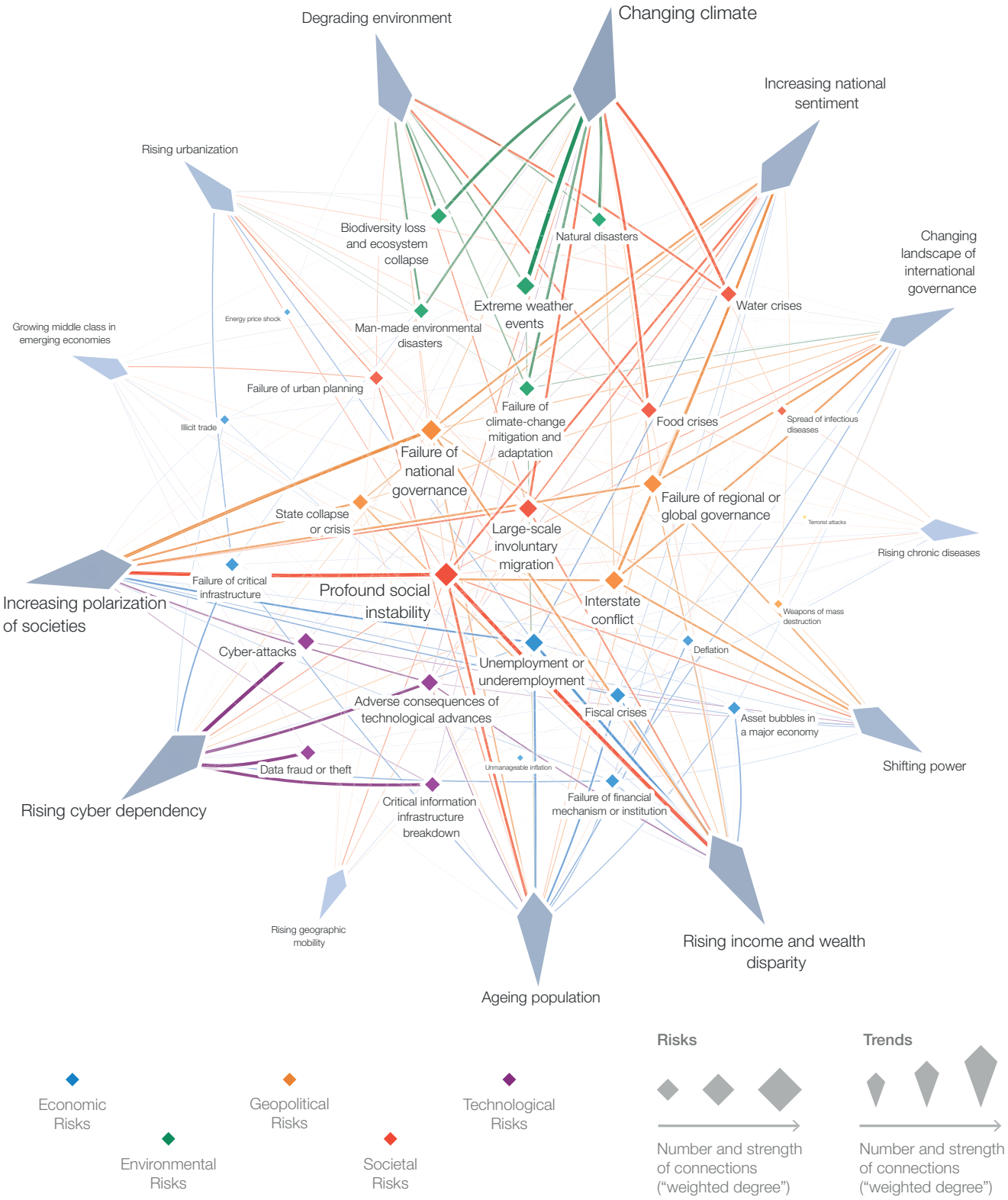
1. Weapons of mass destruction
2. Failure of climate-change mitigation and adaptation
3. Extreme weather events
4. Water crises
5. Natural disasters
6. Biodiversity loss and ecosystem collapse
7. Cyber-attacks
8. Critical information infrastructure breakdown
9. Man-made environmental disasters
10. Spread of infectious diseases

Categories

- Economic
- Environmental
- Geopolitical
- Societal
- Technological

Source: World Economic Forum Global Risks Perception Survey 2018–2019.
Note: Survey respondents were asked to assess the likelihood of the individual global risk on a scale of 1 to 5, 1 representing a risk that is very unlikely to happen and 5 a risk that is very likely to occur. They also assess the impact on each global risk on a scale of 1 to 5 (1: minimal impact, 2: minor impact, 3: moderate impact, 4: severe impact and 5: catastrophic impact). See Appendix B for more details. To ensure legibility, the names of the global risks are abbreviated; see Appendix A for the full name and description.

Figure II: The Risks-Trends Interconnections Map 2019

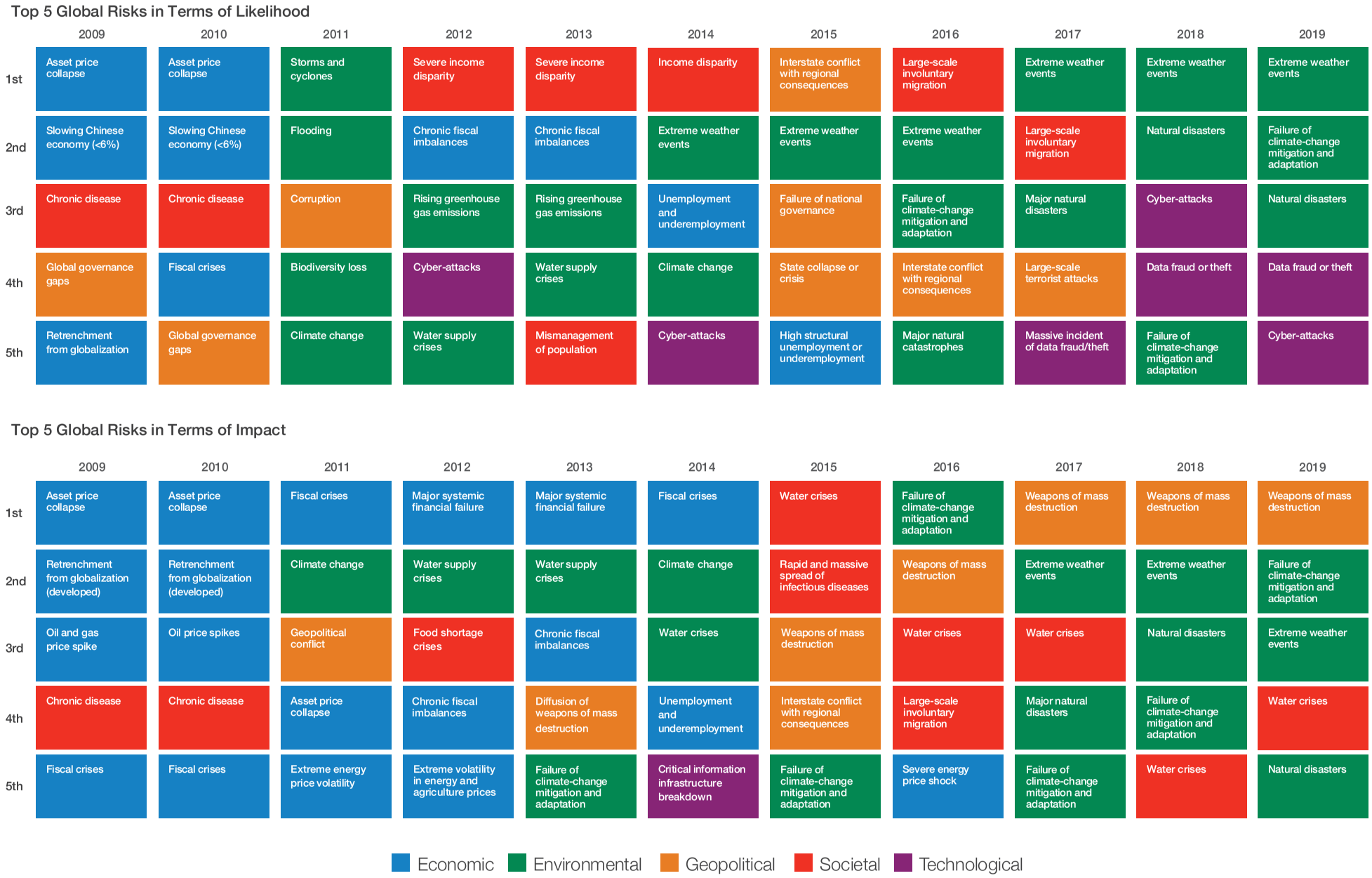


Source: World Economic Forum Global Risks Perception Survey 2018–2019.
Note: Survey respondents were asked to select the three trends that are the most important in shaping global development in the next 10 years. For each of the three trends identified, respondents were asked to select the risks that are most strongly driven by those trends. See Appendix B for more details. To ensure legibility, the names of the global risks are abbreviated; see Appendix A for the full name and description.

Figure III: The Global Risks Interconnections Map 2019

Source: World Economic Forum Global Risks Perception Survey 2018–2019.
Note: Survey respondents were asked to select up to six pairs of global risks they believe to be most interconnected. See Appendix B for more details. To ensure legibility, the names of the global risks are abbreviated; see Appendix A for the full name and description.

Figure IV: The Evolving Risks Landscape, 2009 – 2019



Source: World Economic Forum 2009–2019, Global Risks Reports.
Note: Global risks may not be strictly comparable across years, as definitions and the set of global risks have evolved with new issues emerging on the 10-year horizon. For example, cyberattacks, income disparity and unemployment entered the set of global risks in 2012. Some global risks were reclassified: water crises and rising income disparity were re-categorized first as societal risks and then as a trend in the 2015 and 2016 *Global Risks Reports*, respectively.

The Global Risks Report 2019
14th Edition

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Wharton Risk Management and Decision Processes Center, University of Pennsylvania

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Preface

Børge Brende
President
World Economic Forum

We publish the 2019 edition of the World Economic Forum's *Global Risks Report* at an important moment. The world is facing a growing number of complex and interconnected challenges—from slowing global growth and persistent economic inequality to climate change, geopolitical tensions and the accelerating pace of the Fourth Industrial Revolution. In isolation, these are daunting challenges; faced simultaneously, we will struggle if we do not work together. There has never been a more pressing need for a collaborative and multistakeholder approach to shared global problems.

This is a globalized world, as a result of which historic reductions in global poverty have been achieved. But it is also increasingly clear that change is needed. Polarization is on the rise in many countries. In some cases, the social contracts that hold societies together are fraying. This is an era of unparalleled resources and technological advancement, but for too many people it is also an era of insecurity. We are going to need new ways of doing globalization that respond to this insecurity. In some areas, this may mean redoubling efforts at the international level—implementing new approaches to a range of issues: technology and climate change to trade, taxation, migration and humanitarianism. In other areas renewed commitment and resources will be needed at the national level—tackling inequality, for example, or strengthening social protections and the bonds of political community.

Renewing and improving the architecture of our national and international political and economic systems is this generation's defining task. It will be a monumental undertaking, but an indispensable one. The *Global Risks Report* demonstrates how high the stakes are—my hope is that this year's report will also help to build momentum behind the need to act. It begins with a sweep of the global risks landscape and warns of the danger of sleepwalking into crises. It goes on to consider a number of risks in depth: geopolitical and geo-economic disruptions, rising sea levels, emerging biological threats, and the increasing emotional and psychological strain that many people are experiencing. The Future Shocks section again focuses on potential rapid and dramatic changes in the systems we rely on—topics this year include quantum computing, human rights and economic populism.

The *Global Risks Report* embodies the collaborative and multistakeholder ethos of the World Economic Forum. It sits at the heart of our new Centre for Regional and Geopolitical Affairs, which is responsible for our crucial partnerships with the world's governments and international organizations. But the breadth and depth of its analysis also hinge on constant interaction with the Forum's industry and thematic teams, which shape our systems-based approach to the challenges facing the world. I am grateful for the collaboration of so many colleagues in this endeavour.

I am also particularly grateful for the insight and dedication of the report's Advisory Board. I would like to thank our long-standing strategic partners, Marsh & McLennan Companies and Zurich Insurance Group, as well as our academic advisers at the National University of Singapore, the Oxford Martin School at the University of Oxford and the Wharton Risk Management and Decision Processes Center at the University of Pennsylvania. As in previous years, the *Global Risks Report* draws on our annual Global Risks Perceptions Survey, which is completed by around 1,000 members of our multistakeholder communities. The report has also benefitted greatly from the input of many individuals in the Forum's global expert networks.

Executive Summary

Is the world sleepwalking into a crisis? Global risks are intensifying but the collective will to tackle them appears to be lacking. Instead, divisions are hardening. The world's move into a new phase of strongly state-centred politics, noted in last year's *Global Risks Report*, continued throughout 2018. The idea of "taking back control"—whether domestically from political rivals or externally from multilateral or supranational organizations—resonates across many countries and many issues. The energy now expended on consolidating or recovering national control risks weakening collective responses to emerging global challenges. We are drifting deeper into global problems from which we will struggle to extricate ourselves.

During 2018, **macroeconomic risks** moved into sharper focus. Financial market volatility increased and the headwinds facing the global economy intensified. The rate of global growth appears to have peaked: the latest International Monetary Fund (IMF) forecasts point to a gradual slowdown over the next few years.[1] This is mainly the result of developments in advanced economies, but projections of a slowdown in China—from 6.6% growth in 2018 to 6.2% this year and 5.8% by 2022—are a source of concern. So too is the global debt burden, which is significantly higher than before the global financial crisis, at around 225% of GDP. In addition, a tightening of global financial conditions has placed particular strain on countries that built up dollar-denominated liabilities while interest rates were low.

Geopolitical and geo-economic tensions are rising among the world's major powers. These tensions represent the most urgent global risks at present. The world is evolving into a period of divergence following a period of globalization that profoundly altered the global political economy. Reconfiguring the relations of deeply integrated countries is fraught with potential risks, and trade and investment relations among many of the world's powers were difficult during 2018. Against this backdrop, it is likely to become more difficult to make collective progress on other global challenges—from protecting the environment to responding to the ethical challenges of the Fourth Industrial Revolution. Deepening fissures in the international system suggest that systemic risks may be building. If another global crisis were to hit, would the necessary levels of cooperation and support be forthcoming? Probably, but the tension between the globalization of the world economy and the growing nationalism of world politics is a deepening risk.

Environmental risks continue to dominate the results of our annual Global Risks Perception Survey (GRPS). This year, they accounted for three of the top five risks by likelihood and four by impact. Extreme weather was the risk of greatest concern, but our survey respondents are increasingly worried about environmental policy failure: having fallen in the rankings after Paris, "failure of climate-change mitigation and adaptation" jumped back to number two in terms of impact this year. The results of climate inaction are becoming increasingly clear. The accelerating pace of biodiversity loss is a particular concern. Species abundance is down by 60% since 1970. In the human food chain, biodiversity loss is affecting health and socioeconomic development, with implications for well-being, productivity, and even regional security.

[1] International Monetary Fund (IMF). 2018. *World Economic Outlook, October 2018: Challenges to Steady Growth.* Washington, DC: IMF. https://www.imf.org/en/publications/weo

Technology continues to play a profound role in shaping the global risks landscape. Concerns about data fraud and cyber-attacks were prominent again in the GRPS, which also highlighted a number of other **technological vulnerabilities**: around two-thirds of respondents expect the risks associated with fake news and identity theft to increase in 2019, while three-fifths said the same about loss of privacy to companies and governments. There were further massive data breaches in 2018, new hardware weaknesses were revealed, and research pointed to the potential uses of artificial intelligence to engineer more potent cyber-attacks. Last year also provided further evidence that cyber-attacks pose risks to critical infrastructure, prompting countries to strengthen their screening of cross-border partnerships on national security grounds.

The importance of the various structural changes that are under way should not distract us from **the human side of global risks**. For many people, this is an increasingly anxious, unhappy and lonely world. Worldwide, mental health problems now affect an estimated 700 million people. Complex transformations—societal, technological and work-related—are having a profound impact on people's lived experiences. A common theme is psychological stress related to a feeling of lack of control in the face of uncertainty. These issues deserve more attention: declining psychological and emotional well-being is a risk in itself—and one that also affects the wider global risks landscape, notably via impacts on social cohesion and politics.

Another set of risks being amplified by global transformations relate to biological pathogens. Changes in how we live have increased the risk of a devastating outbreak occurring naturally, and emerging technologies are making it increasingly easy for new **biological threats** to be manufactured and released either deliberately or by accident. The world is badly under-prepared for even modest biological threats, leaving us vulnerable to potentially huge impacts on individual lives, societal well-being, economic activity and national security. Revolutionary new biotechnologies promise miraculous advances, but also create daunting challenges of oversight and control—as demonstrated by claims in 2018 that the world's first gene-modified babies had been created.

Rapidly growing cities and ongoing effects of climate change are making more people vulnerable to **rising sea levels**. Two-thirds of the global population is expected to live in cities by 2050 and already an estimated 800 million people live in more than 570 coastal cities vulnerable to a sea-level rise of 0.5 metres by 2050. In a vicious circle, urbanization not only concentrates people and property in areas of potential damage and disruption, it also exacerbates those risks—for example by destroying natural sources of resilience such as coastal mangroves and increasing the strain on groundwater reserves. Intensifying impacts will render an increasing amount of land uninhabitable. There are three main strategies for adapting to rising sea-levels: (1) engineering projects to keep water out, (2) nature-based defences, and (3) people-based strategies, such as moving households and businesses to safer ground or investing in social capital to make flood-risk communities more resilient.

In this year's **Future Shocks** section, we focus again on the potential for threshold effects that could trigger dramatic deteriorations and cause cascading risks to crystallize with dizzying speed. Each of the 10 shocks we present is a "what-if" scenario—not a prediction, but a reminder of the need to think creatively about risk and to expect the unexpected. Among the topics covered this year are quantum cryptography, monetary populism, affective computing and the death of human rights. In the **Risk Reassessment** section, experts share their insights about how to manage risks. John Graham writes about weighing the trade-offs between different risks, and András Tilcsik and Chris Clearfield write about how managers can minimize the risk of systemic failures in their organizations. And in the **Hindsight** section, we revisit three of the topics covered in previous reports: food security, civil society and infrastructure investment.

(REUTERS/Lucy Nicholson)

2019 Global Risks

Out of control

Is the world sleepwalking into a crisis? Global risks are intensifying but the collective will to tackle them appears to be lacking. Instead, divisions are hardening. The world's move into a new phase of state-centred politics, noted in last year's *Global Risks Report*, continued throughout 2018. The idea of "taking back control"—whether domestically from political rivals or externally from multilateral or supranational organizations—resonates across many countries and many issues. The energy now being expended on consolidating or recovering national control risks weakening collective responses to emerging global challenges. We are drifting deeper into global problems from which we will struggle to extricate ourselves.

The following sections focus on five areas of concern highlighted in this year's Global Risks Perception Survey (GRPS), which frame much of the analysis in subsequent chapters: (1) economic vulnerabilities, (2) geopolitical tensions, (3) societal and political strains, (4) environmental fragilities, and (5) technological instabilities.

Economic worries

Geo-economic tensions ratcheted up during 2018, as discussed in Chapter 2 (Power and Values). GRPS respondents were concerned in the short term about the deteriorating international economic environment, with the vast majority expecting increasing risks in 2019 related to "economic confrontations between major powers" (91%) and "erosion of multilateral trading rules and agreements" (88%).

Last year's report advised caution about broader macroeconomic fragilities, even at a time of strengthening growth. Economic risks have since moved into sharper focus. Financial market volatility increased in 2018, and the headwinds facing the global economy intensified. The rate of global growth appears to have peaked: the latest International Monetary Fund (IMF) forecasts point to a gradual slowdown over the next few years.[1] This is mainly the result of developments in advanced economies, where the IMF expects real GDP growth to decelerate from 2.4% in 2018 to 2.1% this year and to 1.5% by 2022. However, while developing economies' aggregate growth is expected to remain broadly unchanged, projections of a slowdown in China—from 6.6% in 2018 to 6.2% this year and 5.8% by 2022—are a source of concern.

High levels of global indebtedness were one of the specific financial vulnerabilities we highlighted last year. These concerns have not eased. The total global debt burden is now significantly higher than it was before the global financial crisis, at around 225% of GDP.[2] In its latest *Global Financial Stability Report*, the IMF notes that in countries with systemically significant financial sectors, the debt burden is higher still, at 250% of GDP—this compares with a figure of 210% in 2008.[3] In addition, a tightening of global financial conditions has placed particular strain on countries that built up dollar-denominated liabilities while interest rates were low. By October last year, more than 45% of low-income countries were in or at high risk of debt distress, up from one-third in 2016.[4]

Inequality continues to be seen as an important driver of the global risks landscape. "Rising income and wealth disparity" ranked fourth in GRPS respondents' list of underlying trends. Although global inequality has dipped this millennium, within-country inequality has continued to rise. New research published last year attributes economic inequality largely to widening divergences between public and private levels of capital ownership over the past 40 years: "Since 1980, very large transfers of public to private wealth occurred in nearly all countries, whether rich or emerging. While national wealth has substantially increased, public wealth is now negative or close to zero in rich countries";[5] (see Figure 1.1).

Coupled with political polarization, inequality erodes a country's social fabric in an economically damaging way: as cohesion and trust diminish, economic performance is likely to follow.[6] One study attempts to quantify by how much various countries' per capita income would hypothetically increase if their levels of trust were as high as they are in Sweden.[7] Even in richer developed countries, the estimated gains

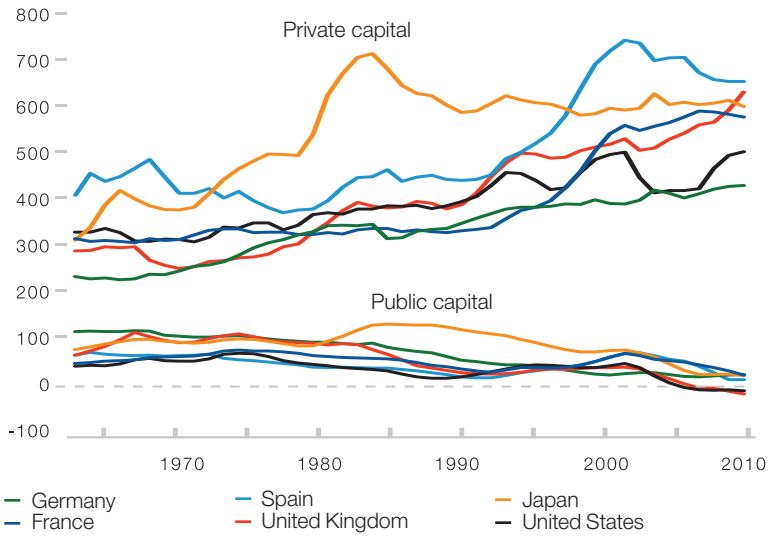
(REUTERS/Damir Sagolj)

would be significant, ranging from 6% in the United Kingdom to 17% in Italy. In some other countries they are much greater: 29% in the Czech Republic, 59% in Mexico and 69% in Russia. Given these results, it is sobering that the 2018 Edelman Trust Barometer categorizes 20 of the 28 countries surveyed as "distrusters".[8] Beyond economic impacts, eroding trust is part of a wider pattern that threatens to corrode the social contract in many countries. This is an era of strong-state politics, but also one of weakening national communities.

Interest is increasing in approaches to economics and finance that draw on moral theory and social psychology to reconcile individual and communitarian goals. For example, more attention is being paid to economist and philosopher Adam Smith and to placing his work on the "invisible hand" of market capitalism in the context of his ideas on moral obligation and community. Some argue that too much emphasis has been placed on "the 'wants' of *The Wealth of Nations*" over "the 'oughts' of *The Theory of Moral Sentiments*."[9] There are no easy remedies: the moral psychology of partisan differences is not conducive to compromise on values,[10] while the geopolitical divergences discussed in Chapter 2 (Power and Values) will complicate any attempt to find consensus on bold attempts to rethink global capitalism. However, that is the new challenge, and it is one to which the World Economic Forum will devote itself at its Annual Meeting 2019 in Davos.

Figure 1.1: Private Gains

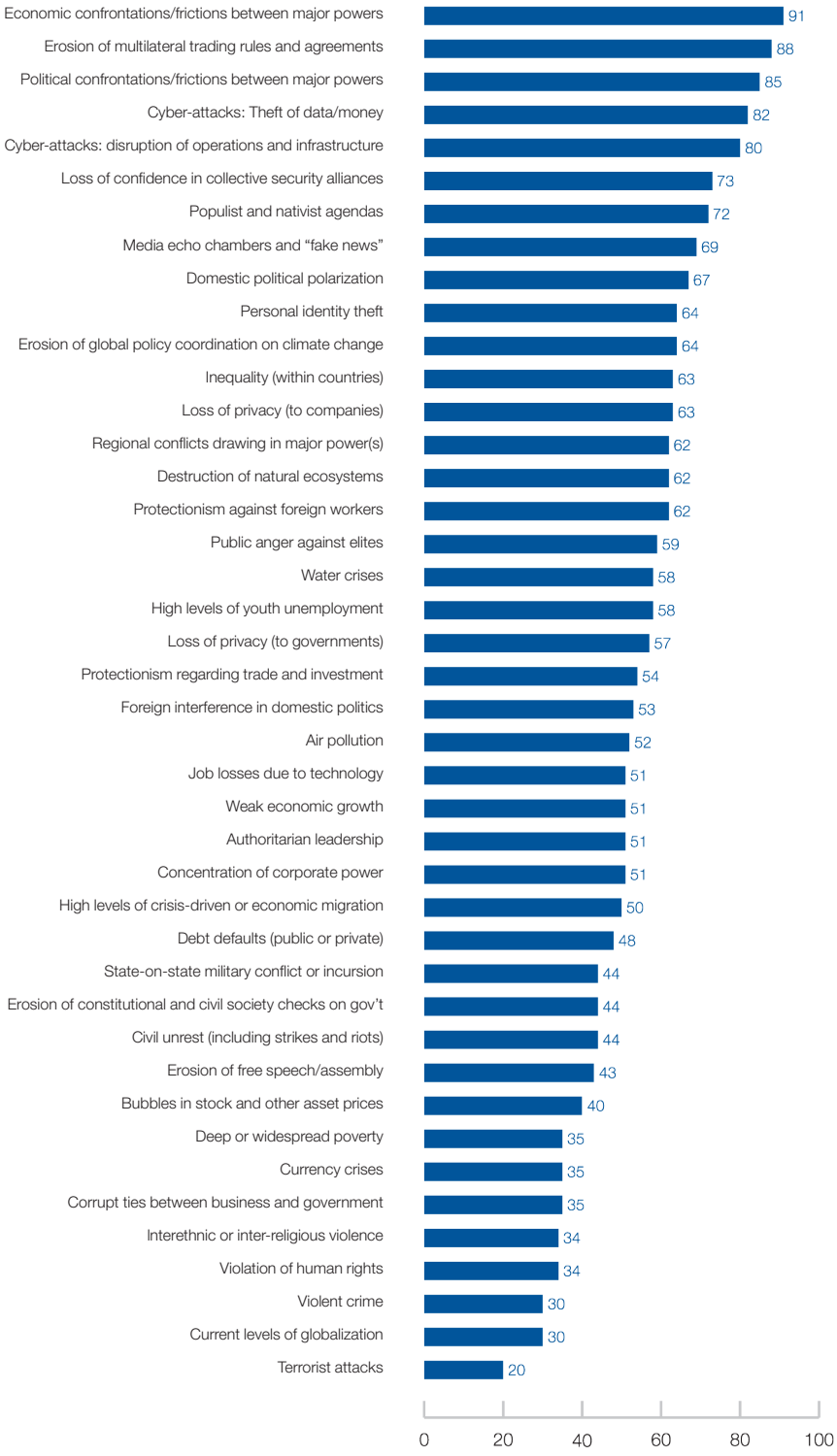
Net private and public wealth 1970–2015 (% of national income)



Source: World Inequality Database. https://wir2018.wid.world

Figure 1.2: Short-Term Risk Outlook

Percentage of respondents expecting risks to increase in 2019



Source: World Economic Forum Global Risks Perception Survey 2018–2019.
Note: For details of the question respondents were asked, see Appendix B.

Major-power tensions

Last year saw rising geopolitical tensions among the world's major powers. These mostly played out in the economic field, as discussed in Chapter 2 (Power and Values), but more fundamental spillovers are possible. The respondents to this year's GRPS are pessimistic: 85% said they expect 2019 to involve increased risks of "political confrontations between major powers" (see Figure 1.2).

Polarization and weak governance raise serious questions about many countries' political health

The evolving China-US relationship is part of the emerging geopolitical landscape described in last year's *Global Risks Report* as "multipolar and multiconceptual". In other words, the instabilities that are developing reflect not just changing power balances, but also the fact that post-Cold War assumptions—particularly in the West—that the

world would converge on Western norms have been shown to be naïvely optimistic. As Chapter 2 (Power and Values) discusses, differences in fundamental norms are likely to play an important role in geopolitical developments in the years and decades ahead. These differences will affect the global risks landscape in significant ways—from weakening security alliances to undermining efforts to protect the global commons.

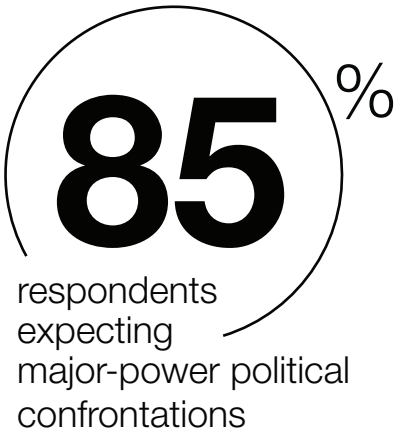
With multilateralism weakening and relations between the world's major powers in flux, the current geopolitical backdrop is inauspicious for resolving the many protracted conflicts that persist around the world. In Afghanistan, for example, civilian deaths in the first six months of 2018 were the highest in 10 years, according to the UN, while the share of districts controlled by the United States–supported Afghan government fell from 72% in 2015 to 56% in 2018.[11] In Syria, multiple states are now embroiled in a civil conflict in which hundreds of thousands have died. And in Yemen, the direct casualties of war are estimated at 10,000 and as many as 13 million people are at risk of starvation as a result of disruptions to food and other supplies, according to a UN warning in October 2018.[12]

One positive geopolitical development since the last edition of this report has been an easing of tensions and volatility related to North Korea's nuclear programme, following increased diplomacy involving the United States, South Korea and North Korea. This may have played a part in a sharp fall—from 79% to 44%—in the proportion of the survey respondents expecting the risk of "state-on-state military conflict or incursion" to increase over the next year. Nonetheless, for the third year running, weapons of mass destruction ranked as the number one global risk in terms of potential impact.

Political strains

Around the world, mounting geopolitical instabilities are matched—and frequently exacerbated—by continuing domestic political strains. GRPS respondents ranked "increasing polarization of societies" second only to climate change as an underlying driver of developments in the global risks landscape. Many Western democracies are still struggling with post-crisis patterns of political fragmentation and polarization that have complicated the process of providing stable and effective governance. But this is a global issue, not just a "first-world problem". In the World Economic Forum's inaugural *Regional Risks for Doing Business* report, published last year, "failure of national governance" ranked second globally and first in Latin America and South Asia, based on a survey of around 12,000 business leaders covering more than 130 countries.[13]

Polarization and weak governance raise serious questions about numerous countries' political health. In many cases, partisan differences are deeper than they have been for a long time. A vicious circle may develop in which diminishing social cohesion places ever-greater strain on political institutions, undermining their ability to anticipate or respond to societal challenges. This problem is even more acute when global challenges require multilateral cooperation or integration: weaker levels of legitimacy and accountability invite an anti-elitist backlash. So too do failures of multilateral policy and institutional design. For example, it is now widely acknowledged that more should have been done to provide protection or remedies to the losers from globalization.[14] It should not have taken a crisis to recognize this. In the GRPS, 59% of respondents said they expect risks associated with "public anger against elites" to increase in 2019.



Chapter 3 (Heads and Hearts) looks at the causes and potential consequences of rising levels of anger, along with other forms of emotional and psychological distress.

Identity politics continue to drive global social and political trends, and immigration and asylum policy raise fundamental questions about control over the composition of political communities. Migration has triggered political disruption in recent years, ranging from Asia and Latin America to Europe and the United States. Global trends—from demographic projections to climate change—practically guarantee further crises, and some leaders are likely to take a tougher line in defence of dominant national cultures. In the GRPS, 72% of respondents said they expect risks associated with "populist and nativist agendas" to increase in 2019.

In some countries, efforts to secure recognition and equality for a widening range of minority social groups—defined by characteristics such as race, ethnicity, religion, gender identity or sexual orientation—have become increasingly electorally significant. In the United States, for example, attitudes towards identity politics mark increasingly bitter divisions between Republican and Democratic voting blocs.[15] November 2018's mid-term Congressional elections saw a record number of women and non-white candidates elected.

There has been a period of renewed politicization around gender, sexism and sexual assault in the United States. The #MeToo movement, which began in October 2017, continued in 2018 and has also drawn attention to—and in some cases amplified—similar campaigns against sexual violence.[16] The increased attention being paid globally to violence against women was also reflected in the Nobel Peace Prize going to Nadia Murad and Denis Mukwege for their work to end the use of sexual violence as a tool of conflict. Beyond being directly targeted with violence and discrimination, women around the world are also disproportionately affected by many of the risks discussed in the *Global Risks Report*, often as a result of experiencing higher levels of poverty and being the primary providers of childcare, food and fuel. For example, climate change means women in many communities must walk farther to fetch water. Women often do not have the same freedom or resourcesas men to reach safety after natural disasters—in parts of Sri Lanka, Indonesia and India, men who survived the 2004 tsunami outnumbered women by almost three to one.[17] According to the International Monetary Fund (IMF),

(REUTERS/Yannis Behrakis)

women are also more likely than men to have their jobs displaced by automation.[18]

Climate catastrophe

Environment-related risks dominate the GRPS for the third year in a row, accounting for three of the top five risks by likelihood and four by impact (see Figure IV). Extreme weather is again out on its own in the top-right (high-likelihood, high-impact) quadrant of the Global Risks Landscape 2019 (see Figure I).

Environment-related risks account for three of the top five risks by likelihood and four by impact

The year 2018 was another one of storms, fires and floods.[19] Of all risks, it is in relation to the environment that the world is most clearly sleepwalking into catastrophe. The Intergovernmental Panel on Climate Change (IPCC) bluntly said in October 2018 that we have at most 12 years to make the drastic and unprecedented changes needed to prevent average global temperatures from rising beyond the Paris Agreement's 1.5ºC target. In the United States, the Fourth National Climate Assessment warned in November that without significant reductions in emissions, average global temperatures could rise by 5ºC by the end of the century.[20] GRPS respondents seem increasingly worried about environmental policy failure: having fallen in the rankings after Paris, "failure of climate-change mitigation and adaptation" jumped back to number two in terms of impact this year. And the most frequently cited risk interconnection was the pairing of "failure of climate-change mitigation and adaptation" and "extreme weather events".

The accelerating pace of biodiversity loss is a particular concern. The Living Planet Index, which tracks more than 4,000 species across the globe, reports a 60% decline in average abundance since 1970.[21] Climate change is exacerbating biodiversity loss and the causality goes both ways: many affected ecosystems—such as oceans and forests—are important for absorbing carbon emissions. Increasingly fragile ecosystems also pose risks to societal and economic stability. For example, 200 million people depend on coastal mangrove ecosystems to protect their livelihoods and food security from storm surges and rising sea levels, as discussed in Chapter 5 (Fight or Flight).[22] One estimate of the notional economic value of "ecosystem services"—benefits to humans, such as drinking water, pollination or protection against floods—puts it at US$125 trillion per year, around two-thirds higher than global GDP.[23]

In the human food chain, loss of biodiversity affects health and socio-economic development, with implications for well-being, productivity and even regional security. Micronutrient malnutrition affects as many as 2 billion people. It is typically caused by a lack of access to food of sufficient variety and quality.[24] Nearly half the world's plant-based calories are provided by just three crops: rice, wheat and maize.[25] Climate change compounds the risks. In 2017, climate-related disasters caused acute food insecurity for approximately 39 million people across 23 countries.[26] Less obviously, increased levels of carbon dioxide in the atmosphere are affecting the nutritional composition of staples such as rice and wheat. Research suggests that by 2050 this could lead to zinc deficiencies for 175 million people, protein deficiencies for 122 million, and loss of dietary iron for 1 billion.[27]

As environmental risks crystallize with increasing frequency and severity, the impact on global value chains is likely to intensify, weakening overall resilience. Disruptions to the production and delivery of goods and services due to environmental disasters are up by 29% since 2012.[28] North America was the region worst affected by environment-related supply-chain disruptions in 2017; these disruptions were due notably to hurricanes and wildfires.[29] For example, in the US automotive industry, only factory fires and company mergers caused more supply-chain disruptions than hurricanes.[30] When the disruptions are measured by the number of suppliers affected rather than the number of individual events, the four most significant triggers in 2017 were hurricanes, extreme weather, earthquakes and floods.[31]

Upheavals in the global waste disposal and recycling supply chain during 2018 may be a foretaste. China banned the import of foreign waste, including almost 9 million tons of plastic scrap, to reduce pollution and strain on its national environmental systems.[32] This ban exposed weaknesses in the domestic recycling capacity of many Western countries. Plastic waste built up in the United Kingdom, Canada and several European states. In the first half of 2018 the United States sent 30% of the plastic that would previously have gone to China to landfill,[33] and the rest to other countries including Thailand, Malaysia and Vietnam. However, all three of those countries have since announced their own new restrictions or bans on plastic imports. In sum, as the impact of environmental risks increases, it will become increasingly difficult to treat those risks as externalities that can be ignored or shipped out. Domestic and coordinated international action will be needed to internalize and mitigate the impact of human activity on natural systems.

Technological instabilities

Technology continues to play a profound role in shaping the global risks landscape for individuals, governments and businesses. In the GRPS, "massive data fraud and theft" was ranked the number four global risk by likelihood over a 10-year horizon, with "cyber-attacks" at number five. This sustains a pattern recorded last year, with cyber-risks consolidating their position alongside environmental risks in the high-impact, high-likelihood quadrant of the Global Risks Landscape (Figure I). A large majority of respondents expected increased risks in 2019 of cyber-attacks leading to theft of money and data (82%) and disruption of operations (80%). The survey reflects how new instabilities are being caused by the deepening integration of digital technologies into every aspect of life. Around two-thirds of respondents expect the risks associated with fake news and identity theft to increase in 2019, while three-fifths said the same about loss of privacy to companies and governments. The potential psychological effects of the increasing digital intermediation of people's lives is discussed in Chapter 3 (Heads and Hearts).

Malicious cyber-attacks and lax cybersecurity protocols again led to massive breaches of personal information in 2018. The largest was in India, where the government ID database, Aadhaar, reportedly suffered multiple breaches that potentially compromised the records of all 1.1 billion registered citizens. It was reported in January that criminals were selling access to the database at a rate of 500 rupees for 10 minutes, while in March a leak at a state-owned utility company allowed anyone to download names and ID numbers.[34] Elsewhere, personal data breaches affected around 150 million users of the MyFitnessPal application,[35] and around 50 million Facebook users.[36]

Cyber vulnerabilities can come from unexpected directions, as shown in 2018 by the Meltdown and Spectre threats, which involved weaknesses in computer hardware rather than software. They potentially affected every Intel processor produced in the last 10 years.[37] Last year also saw continuing evidence that cyber-

The vulnerability of critical technological infrastructure is a growing national security concern

attacks pose risks to critical infrastructure. In July the US government stated that hackers had gained access to the control rooms of US utility companies.[38] The potential vulnerability of critical technological infrastructure has increasingly become a national security concern. The second most frequently cited risk interconnection in this year's GPRS was the pairing of cyber-attacks with critical information infrastructure breakdown.

Machine learning or artificial intelligence (AI) is becoming more sophisticated and prevalent, with growing potential to amplify existing risks or create new ones, particularly as the Internet of Things connects billions of devices. In a survey conducted last year by Brookings, 32% of respondents said they view AI as a threat to humanity, while only 24% do not.[39] IBM last year revealed targeted AI malware that can "hide" a well-known threat—WannaCry—in a video-conferencing application, activating only when it recognizes the face of the intended target.[40] Similar innovations are likely to occur in other fields. For example, Chapter 4 (Going Viral) highlights the potential for malicious actors in synthetic biology to use AI to create new pathogens. One of this year's Future Shocks (Chapter 6) considers the potential consequences of "affective computing"—referring to AI that can recognize, respond to and manipulate human emotions.

Among the most widespread and disruptive impacts of AI in recent years has been its role in the rise of "media echo chambers and fake news", a risk that 69% of GRPS respondents expect to increase in 2019. Researchers last year studied the trajectories of 126,000 tweets and found that those containing fake news consistently outperformed those containing true information, on average reaching 1,500 people six times more quickly. One possible reason cited by researchers is that fake news tends to evoke potent emotions: "Fake tweets tended to elicit words associated with surprise and disgust, while accurate tweets summoned words associated with sadness and trust."[41] The interplay between emotions and technology is likely to become an ever more disruptive force.

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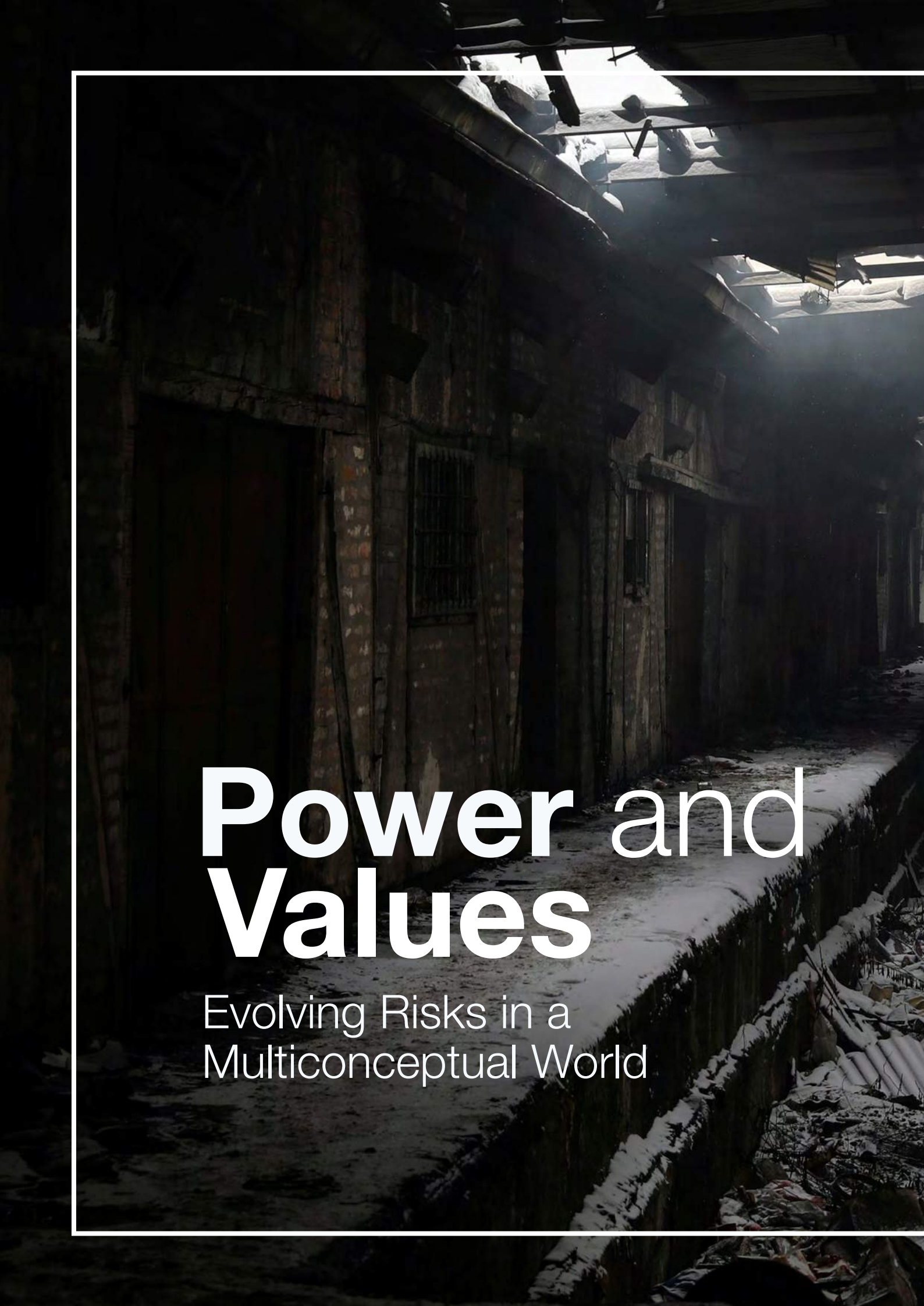


Power and **Values**

Evolving Risks in a Multiconceptual World

REUTERS/Marko Djurica

A period of change in the international system is destabilizing assumptions about global order. Last year's *Global Risks Report* argued that the world is becoming not just multipolar, but also "multiconceptual". This chapter further examines how changing power dynamics and diverging norms and values are affecting global politics and the global economy.

The chapter begins by outlining how normative differences increasingly shape domestic and international politics. It then highlights three trends with the potential to trigger disruptive change: (1) the difficulty of sustaining global consensus on ethically charged issues such as human rights; (2) intensifying pressure on multilateralism and dispute-settlement mechanisms; and (3) states' increasingly frequent use of geo-economic policy interventions.

No room for nostalgia

It should be no surprise that a multipolar world is also more multiconceptual: as global power is diffused, there is more room for divergent values to shape geopolitics than there has been since the end of World War II. After the bipolar Cold War gave way to unipolar US power, some argued that the battle of ideas was over and Western liberal democratic norms would, in time, prevail globally. That was a bold claim then and it looks like hubris now. In today's world, narratives of gradual convergence on any set of overarching values look unconvincing. Values seem to be a source of division rather than unity, not just globally but also within regions and countries.

Nostalgia is an inadequate response, especially as previous decades were hardly risk-free. The imperative now is to understand the changes that are happening and learn how to safely navigate the challenges they entail. After a period of globalization that has deeply integrated many countries, reconfiguring relationships is unlikely to be easy.

States, individuals and markets

Values-based tensions are manifesting in different ways in different places, creating new fault lines within and between countries and regions. But they have common features: control, and the role of the state. Many political leaders and communities feel they have lost control—whether to internal divisions, external rivals or multilateral organizations—and, in response, they look to strengthen the state. Because notions of power, security and self-determination are so politically fundamental, clashes may have less scope for compromise than when differences involve more technical issues.

Domestically, key tensions include the following:

- *States and individuals.* The balance has tilted from individuals towards states.[1] In this context, the idea of "illiberal democracy" has gained currency.[2]

- *States and minorities*. Politically, rising majoritarianism means voting is increasingly a winner-takes-all contest between polarized groupings. Culturally, identity politics have become increasingly contentious, with national majorities in many countries seeking greater assimilation (or exclusion) of minorities.

- *States and markets.* The scale and power of multinational businesses has fuelled growing opposition to globalization in many countries. Elsewhere, states are taking a stronger economic role: almost a quarter of the world's largest firms are now state-controlled, the highest level in decades.[3]

REUTERS/Jean-Paul Pelissier

- *The role of technology.* New technological capabilities have amplified existing tensions over values—for example, by weakening individual privacy or deepening polarization—while differences in values are shaping the pace and direction of technological advances in different countries.[4]

Globally, key pressures relate to how states interact and tackle cross-border challenges:

- *Multilateral rules and institutions.* Strong-state politics makes it harder to sustain multilateralism. As further explored below, this has been most evident so far in the shift in trade policy from global frameworks overseen by the World Trade Organization to state-led regional initiatives and bilateral deals.[5]

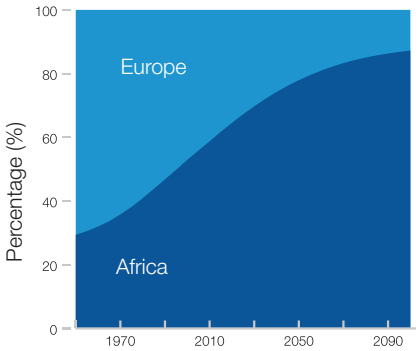
- *Sovereignty and non-interference.* The protections for state sovereignty in the UN Charter appear more resilient than the interventionist norms of the 2005 Responsibility to Protect principle. In the digital era, efforts to promote (or disrupt) political values in other countries have become increasingly contentious.

- *Migration and asylum.* The international movement of people has emerged in recent years as a fault-line issue in many countries. Demographic trends—such as those illustrated in Figure 2.1, which projects changes in the relative populations of Africa and Europe—will drive inter-regional migration in the decades ahead.

- *Protection of the global commons.* Climate change, outer space, cyber space and the polar regions are aspects of the global commons that are already or could increasingly become a source of international tensions.

Figure 2.1: Wave of Change

Relative shares of combined Europe/Africa population



Source: World Population Prospects 2017. https://population.un.org/wpp/

In the context of rising geopolitical competition and weakening multilateral institutions, debates revolving around these pressures have the potential to be destabilizing and even to foment conflict. A more hopeful prospect is that the current flux in the international system instead will lead in pragmatic, open and pluralist directions, but even then a difficult and risky transition lies ahead.

Shared goals amid divergent values

In a world of disparate powers and divergent values, it is likely to be more difficult to make progress on shared global goals. Such progress requires two things: aligning on substantive priorities for action, and then sustaining coordination and collaboration. The example of climate change shows that, even when the first is possible, the second can be challenging: broad consensus was built up over decades, culminating in the signing of the Paris Agreement in 2015—but evidence on implementation is mixed, and even full implementation will not be enough to prevent damaging levels of global warming.

Challenges related to the Fourth Industrial Revolution will evolve rapidly and coordinating a response may be complicated when they touch on fundamental values. Chapter 4 (Going Viral) discusses how emerging bio-technologies are blurring the lines between humanity and technology: for example, it was claimed in late 2018 that gene-editing tools had been used to create genetically modified babies. Whether countries each chart their own course on such research or instead align around shared ethical principles to craft international restrictions could have important implications for the future of humanity.

Migration and cross-border tax policy are among other global issues that are both ethically charged and subject to divergent state interests. However, the most acute challenge may be posed by human rights, which have become a litmus test for the changing role of values in the international system.

As geopolitical tensions and competition have intensified, human rights have been increasingly politicized.[6] The complex global picture that is emerging in that area—nominal alignment on shared values, marked differences in interpretation and implementation, fragmented approaches to multilateral institutions—is a microcosm of the wider role of values in the international system. An optimistic scenario sees the kind of flux that is evident around human rights as an opening for states and other stakeholders to find better ways of doing things. However, values divergence means that it will be difficult even to align on what "better" means in this context. As sketched out in one of our Future Shocks (see page 74), it is possible to imagine a tipping point is reached where states simply abandon ideas—and institutions—that limit their autonomy.

Multilateralism under threat

Political leaders have increasingly asserted the primacy of the nation-state in the international system and sought to weaken the constraints placed on national autonomy by international agreements and multilateral institutions. Defenders of multilateralism point out that this fragmentation risks creating blind spots, undermining global stability, and limiting the capacity to respond to cross-border challenges.

The current multilateral architecture has been criticized in rising and legacy powers alike. In some rising powers, critics argue that the international architecture is too firmly shaped by the post-World War II balance of power and values, and has failed to evolve to reflect subsequent global transformations.[7] In economic terms, for example, in 1950 the United States had 27.2% of global GDP and China 4.6% (on a purchasing power parity basis); in 2017 those figures were 15.3% and 18.2%, respectively.[8] Such shifts in the economic centre of gravity create demands for institutional change. Meanwhile, in some legacy powers, critics argue that multilateralism is a costly drag on their freedom to manoeuvre.

Multilateralism can be weakened in numerous ways. States can withdraw from agreements and institutions; they can intervene to block consensus; and they can adopt a selective approach to upholding norms and rules. Multilateral institutions can also experience a gradual process of disuse or disregard. Arguably, the cohesiveness of the multilateral

REUTERS/Edgar Su

Fragmentation risks creating blind spots, undermining global stability, and limiting the capacity to respond

system could be weakened by the creation of new parallel structures, but it is also possible that increased institutional density could bolster the resilience of the system.

International dispute resolution is an area of particular concern, so far manifesting especially in relation to trade. For example, if the appointment of new judges to the WTO's Appellate Body continues to be blocked, a key dispute-settlement panel could cease to function in December 2019, when there will no longer be enough judges on the panel to issue valid rulings.[9]

Dispute resolution is a crucial part of the architecture of international commerce, and the system is already changing—its centre of gravity is shifting from the West to Asia. For example, in late 2017 the China International Economic and Trade Arbitration Commission (CIETAC) introduced its first international arbitration rules, and in mid-2018 China established two new international courts to handle commercial disputes related to the Belt and Road Initiative.[10] Controversy has escalated in many countries over investor-state dispute settlement (ISDS) procedures, which allow foreign investors to rely on international arbitration processes rather than the local legal frameworks of countries in which they have invested.[11] If cross-border trust is eroded by geopolitical competition and diverging values, creating mutually accepted dispute-settlement mechanisms may become increasingly complicated.

Worsening trade relations

Trade is the arena in which the broader implications of a more multipolar, multiconceptual world have so far played out most clearly. Trade relations between China and the United States rapidly worsened during 2018. There were positive signs in the final months of the year, raising hopes that a normalization of relations will follow, but the pace of the earlier deterioration highlights how quickly risks can crystallize and intensify in this area.

The US Department of Commerce's strategic plan states that "economic security is national security"

In early 2018, on the recommendation of the US International Trade Commission,[12] President Trump announced "global safeguard tariffs"—the first time this provision had been used since 2001—totalling US$8.5 billion on solar panel imports and US$1.8 billion on washing machine imports. The United States later cited national security when imposing tariffs on steel and aluminium imports, and on three occasions it increased China-specific tariffs related to intellectual property and technology disputes.[13] These US steps drew counter-measures from China, and the stand-off soon threatened to cover all goods trade between the two countries.[14]

The potential costs of deepening trade tensions were highlighted in October 2018 when the International Monetary Fund (IMF) revised down its global growth projections for 2018 and 2019 by 0.2 percentage points. The IMF expects growth to slow in the United States from 2.9% last year to 2.4% in 2019, and in China from 6.6% to 6.2%. Any slowdown in global growth will add to the headwinds for developing countries, which already face rising interest rates and, in some cases, domestic political stresses as well: in September, as US bond yields picked up, investor nervousness had pushed emerging market equities into bear-market territory.[15]

Economic policy—long seen as a means of mitigating geopolitical risk by embedding powers in mutually beneficial relationships—is now frequently seen as a tool of strategic competition. For example, the US Department of Commerce's strategic plan for 2018–22 states that "economic security is national security."[16] Each side in the worsening stand-off between the United States and China last year blamed the other for eroding bilateral relations,[17] [18] and domestic political factors have not always been conducive to compromise between the two countries. Their current relationship is such that a rapid unwinding of protectionist measures cannot be ruled out, but some analysts have warned about more fundamental challenges.

It was not only among rivals that global trade conditions worsened in 2018. US trade relations with its allies also saw unexpected volatility. Ahead of the meeting of G7 leaders in June, the United States imposed tariffs on steel and aluminium imports from the European Union, Canada, Mexico and others.[19] Threat and counter-threat followed, between the United States and the European Union in particular: President Trump talked of imposing a 20% tariff on vehicle imports from the European Union; the European Commission hinted at global countermeasures totalling US$294 billion, around one-fifth of total goods exports.[20] The uncertainty put strain on European car makers, some of which were already under pressure from US-China trade tensions.[21] In a rapprochement of sorts, President Trump and European Commission President Jean-Claude Juncker agreed in July to work towards reducing tariffs on both sides. And in October, a revised trade deal between the United States, Mexico and Canada was announced to replace NAFTA: the


REUTERS/Yannis Behrakis

USMCA (the United States-Mexico-Canada Agreement).[22]

Almost all of the high-profile trade disruptions that were threatened or imposed in 2018 relate to exports and imports of physical goods. But a growing proportion of global trade consists of services—digital services in particular. As digital flows have increased in economic importance, so too have data localization provisions that require businesses to store data in the country where they are collected rather than on company servers located elsewhere.[23] Localization rules have been justified on numerous grounds, from privacy and intellectual property to national security, policing and tax. Critics argue, however, that governments' expressed reasons for restricting data flows are often a pretext for what amounts to protectionism designed to inhibit cross-border digital trade.[24]

Investment tensions

The past year's developments in foreign direct investment (FDI) are arguably even more significant than trade tensions. As discussed in the 2018 *Global Risks Report*, outward investment has become more associated with geopolitical positioning. As a result, caution towards inward investment is growing. Because FDI creates economic facts on the ground in a way that trade flows do not, this is an area where increasing geo-economic competition could sow seeds of tensions that take years to grow and years more to resolve. Western countries in particular have been sharpening their power to block investments in strategic sectors, particularly emerging technologies—raising the prospect of a partial unwinding of globalization in investment, as in trade.

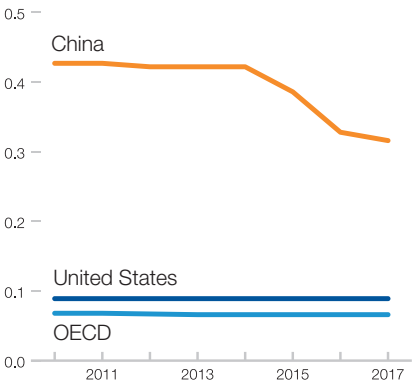
In August 2018 the German government announced a reduction in the threshold at which foreign investments can be blocked.[25] It had earlier instructed a state-owned bank to acquire a 20% stake in an energy infrastructure company to prevent its acquisition.[26] This is not the first time that a European government has sought to restrict inward investment. In 2005 France notoriously fended off PepsiCo's mooted acquisition of dairy producer Danone.[27] Then-Prime Minister Dominique de Villepin lauded "economic patriotism" as the foundation of global competitiveness.[28] That language prompted a backlash at the time, but it resonates today—though European wariness now focuses on Chinese rather than US takeovers.

This wariness has intensified since the cutting-edge German technology firm Kuka was acquired by a Chinese company in 2016. In 2018 the United Kingdom released a 120-page policy proposal that would increase government power to block foreign acquisitions,[29] while France published draft legislation increasing the number of sectors in which foreign acquisitions must receive prior ministerial approval.[30] Technology firms are a particular focus for investment screening because their significance goes beyond the economic: the dual-use nature of many new technologies means their acquisition could have national security implications.[31]

In December 2017 the European Commission proposed EU-wide measures to control non-EU investment into EU companies, as only 12 of the 28 member states have screening mechanisms. One reason for EU concern is that many decisions need member-state unanimity, creating vulnerability to foreign leverage in individual member states. In September 2018 European Commission President Jean-Claude Juncker called for more foreign-policy decisions in the European Union to be made by qualified majority voting instead.[32]

Figure 2.2: Opening Up?

OECD FDI Restrictiveness Index (0=open; 1=closed)



Source: Organisation for Economic Co-operation and Development (OECD). https://data.oecd.org/fdi/fdi-restrictiveness.htm

Note: The index covers four main types of FDI restriction: foreign equity restrictions, discriminatory screening or approval mechanisms, restrictions on key foreign personnel, and operational restrictions.

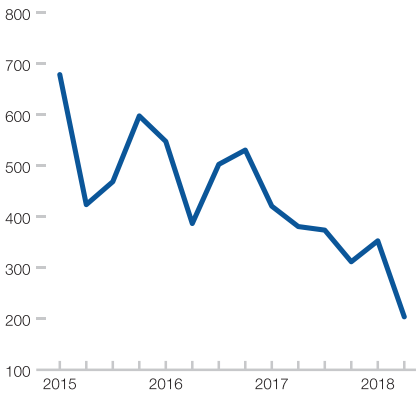
The United States also introduced legislation in 2018 to improve the screening of investment into 27 sectors, including semiconductors and telecommunications.[33] In 2017 India tightened the rules for foreign businesses operating in power transmission.[34] Australia has repeatedly tightened its inward investment rules in recent years, and in 2018 announced further restrictions on investment in electricity infrastructure and agricultural land.[35]

China is travelling in the other direction, albeit from a very different starting point. According to Organisation for Economic Co-operation and Development (OECD) data, China has significantly

reduced its restrictiveness to FDI in recent years, but nevertheless it remains among the world's most restrictive countries (see Figure 2.2).[36] While in 2018 China announced further cuts to its "negative list"—of sectors into which foreign businesses are prohibited from investing, or in which they can operate only as part of a joint venture with Chinese entities[37]—many sectors that would generate interest from foreign investors remain on the list.[38] As with trade, if the climate for cross-border investment flows continues to worsen it will hamper global economic growth and risk creating a vicious circle in which economic and geopolitical tensions aggravate each other. The data already point to a sharp fall-off in FDI in 2017, despite other macroeconomic indicators being solid. This trend continued in the first half of 2018 (see Figure 2.3).[39] If this were to be sustained, it would leave many states—particularly smaller or weaker ones—having to make painful choices between securing investment for growth and maintaining fiscal control and strategic independence.

Figure 2.3: Going Down

Global FDI inward flows (US$ billions)



Source: Organisation for Economic Co-operation and Development (OECD). http://www.oecd.org/investment/statistics.htm

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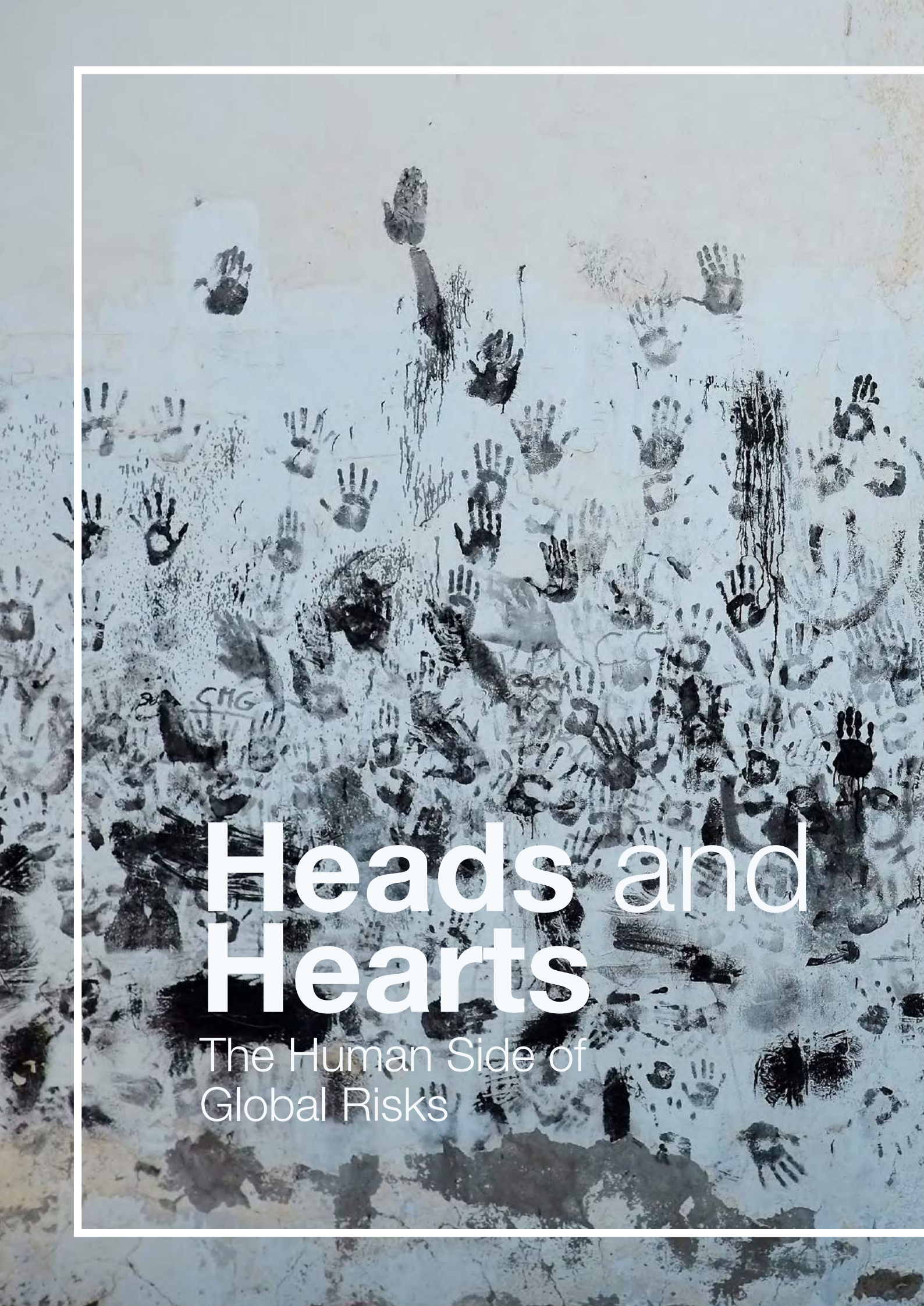


Heads and Hearts

The Human Side of Global Risks

REUTERS/Jon Nazca

The *Global Risks Report* tends to deal with structural issues: systems under stress, institutions that no longer match the challenges facing the world, adverse impacts of policies and practices. All these issues entail widespread human costs in terms of psychological and emotional strain.

This is usually left implicit but it deserves more attention—and not only because declining psychological and emotional well-being is a risk in itself. It also affects the wider global risks landscape, notably via impacts on social cohesion and politics.

This chapter focuses explicitly on this human side of global risks. For many people, as explored in the first two sections, this is an increasingly anxious, unhappy and lonely world. Anger is increasing and empathy appears to be in decline. The chapter examines the ramifications of complex transformations in three areas—societal, technological and work-related. A common theme is that psychological stress is related to a feeling of lack of control in the face of uncertainty.[1]

The age of anger

Every year Gallup takes a large-scale snapshot of the world's emotional state. It asks respondents—154,000 across more than 145 countries in 2017—whether they had various positive and negative experiences on the preceding day. Overall, the positive experiences (such as smiling, respect and learning) comfortably outstrip the negative (which include pain, worry and sadness)—but the trend lines are worrying.

As illustrated by the graphs in Figure 3.1, the positive experience index (a composite measure of five positive experiences) has been relatively steady since the survey began in 2006. Meanwhile, the negative experience index has broken upwards over the past five years. In 2017, almost four in ten people said they had experienced a lot of worry or stress the day before; three in ten experienced a lot of physical pain; and two in ten experienced a lot of anger.[2]

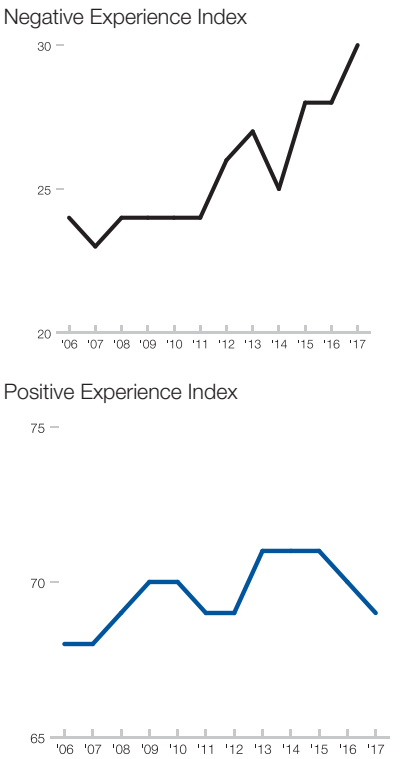
Although still the least prevalent of Gallup's negative experiences, anger is commonly referenced as the defining emotion of the zeitgeist. Some suggest this is an "age of anger", noting a "tremendous increase in mutual hatred."[3] And while it is conceivable that public anger can be a unifying and catalysing force—a hope often expressed at the start of the decade in relation to the Arab Spring[4]—it has since come to be seen more as politically divisive and societally corrosive.

In the United States, public opinion researchers note that where opposing political groups previously expressed frustration with each other, they now express fear and anger.[5] In one survey, almost a third of respondents reported having stopped talking to a family member or friend over the 2016 presidential election.[6] In another, 68% of Americans said they were angry at least once a day; women reported themselves more angry than men, as did the middle class relative to their richer and poorer peers.[7]

Anger has long been associated with loss of status.[8] Recent research also suggests a strong link with group identity.[9] The risk is that this combination generates angry polarization—an increasingly

700 million
people are estimated to have a mental disorder

Figure 3.1: Emotional Downturn



Source: *Gallup 2018 Global Emotions Report.* https://www.gallup.com/analytics/241961/gallup-global-emotions-report-2018.aspx

Note: Scores on the two indices range from 1 to 100. Higher scores on the Positive Experience Index indicate more positive experiences; on the Negative Experience Index they indicate more negative experiences.

prevalent feature of politics in many countries. And as further explored in the technology section below, in recent years group identities have been hardened by a process of "social sorting" that has eroded traditional, cross-cutting societal ties.[10]

Global trends in mental health

Gallup's finding that negative experiences are on the rise chimes with World Health Organization data suggesting that depression and anxiety disorders increased by 54% and 42%, respectively, between 1990 and 2013.[11] They rank second and seventh, respectively, in the global burden of disease; five of the top 20 are mental illnesses.[12] Worldwide, 700 million people are estimated to have a mental disorder.[13]

Not all data confirm the finding that the prevalence of mental health problems is rising, but there are indications that the current generation of young people in particular are experiencing significant increases. In the United States, for example, the proportion of the total population with depression increased from 6.6% in 2005 to 7.3% in 2015, but the rise was much sharper for individuals aged between 12 and 17, where prevalence increased from 5.7% to 12.7%.[14] One study found that between five and eight times as many US students in 2007 reported psychopathological symptoms on a standardized survey than their counterparts in 1938. These trends are particularly pronounced for American girls—in 2016 one in five had experienced a major depressive episode in the previous year.[15] Concerns have been raised about a loosening of diagnostic criteria, but behavioural evidence points in the same direction. The rate of self-harm for girls aged between 10 and 14 nearly tripled between 2009 and 2015 and the suicide rate for 15- to 19-year-olds increased by 59% over the same period.[16]

Recorded rates of mental health disorders are higher in the West—the lifetime prevalence rate for anxiety ranges from 4.8% in China to 31% in the United States. Suggested explanations for this have included reporting bias, methodological factors and the possibility that in poorer circumstances mental suffering is more likely to be seen as an expected part of life than a diagnosable condition.[17] Nonetheless, people with mental health conditions in lower-income countries can face profound difficulties: one study across 28 countries found treatment gaps of up to 85%.[18]

Within affluent countries, wealth affects well-being in complex ways. The prevalence of anxiety disorders is higher among lower-income groups. But attitudes towards money matter too—researchers have linked reduced well-being to societal shifts away from intrinsic motivations (related to community feeling and affiliation) and towards extrinsic motivations (related to financial success and social status).[19] This is generationally significant: in one US study, 81% of 18- to 25-year-olds said that getting rich was their generation's top or second goal, compared to 62% of 26- to 39-year-olds.[20] Another important generational pattern relates to expectations of increasing quality of life. As illustrated by Figure 3.2, there is significant variation across countries in terms of young people's

Where opposing political groups previously expressed frustration with each other, they now express fear and anger

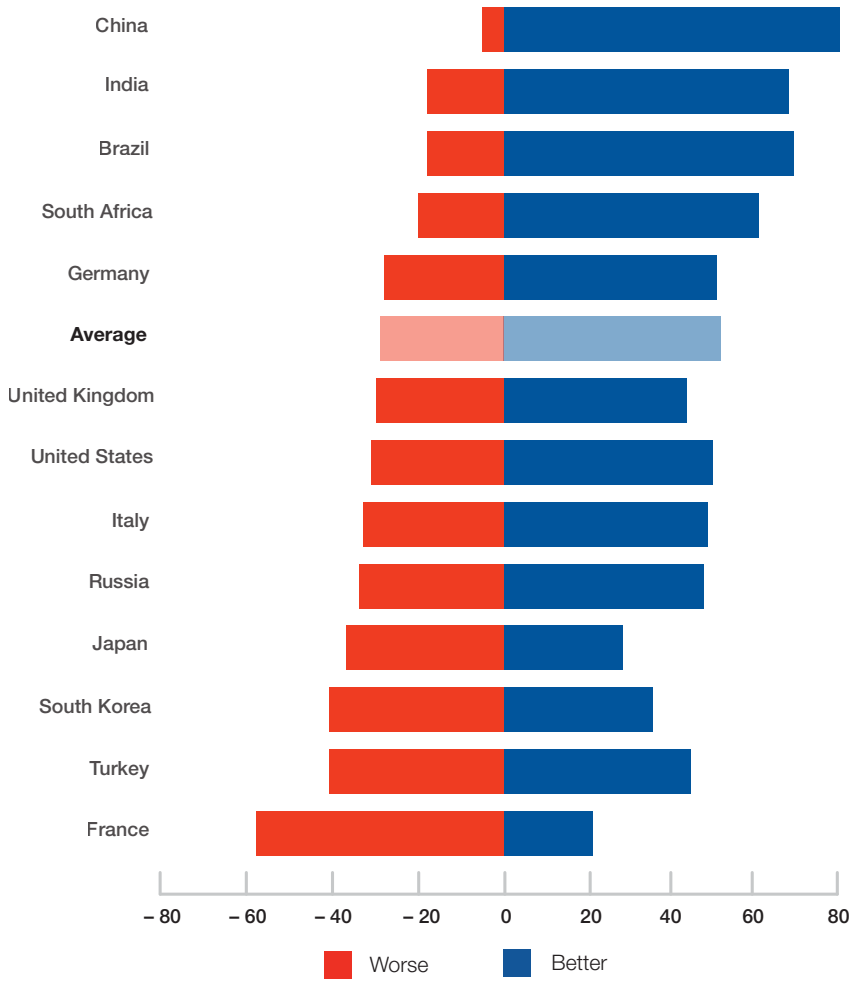
perceptions of how their lives will compare to those of their parents. Only 5% of survey respondents in China expect to live a worse life than their parents, compared with 30% in the United States and the United Kingdom and almost 60% in France.[21]

Violence, poverty and loneliness

What is contributing to these patterns of increased negative experience? Societal stressors are the first potential driver considered. Violent conflict remains one of the most potent causes of emotional and psychological distress. There is a danger of complacency here, because conflict-related deaths have fallen sharply since the middle of the 20th century, as shown in Figure 3.3. However, as the figure illustrates, the overall number of conflicts is close to the highs of the early 1990s and has risen in recent years.[22] While not mass death conflicts, these are clearly a source of emotional and psychological distress for huge numbers of people, particularly in Africa, the Middle East and South Asia.[23]

Figure 3.2: Life Prospects

"Will you have had a better or worse life than your parents' generation?" (% of respondents)



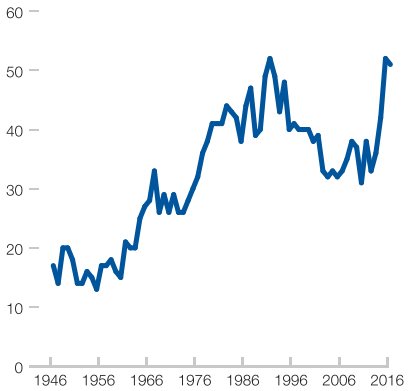
Source: Ipsos Global Trends, 2016. https://www.ipsosglobaltrends.com/life-better-or-worse-than_parents/

The same is true for violence of other sorts. The prevalence of homicide is particularly important, because it influences overall perceptions of security.[24] Although the global rate fell for a decade before a marginal uptick in 2016,[25] regions are affected very differently: Latin America accounts for 8% of the world's population but 33% of its murders.[26] Similar trendlines are not available for "intimate partner violence", but the World Health Organization estimates that around 30% of women globally experience it during their lives, and that it doubles the risk of depression.[27] In 2017, 137 women were killed every day by intimate partners or family members.[28]

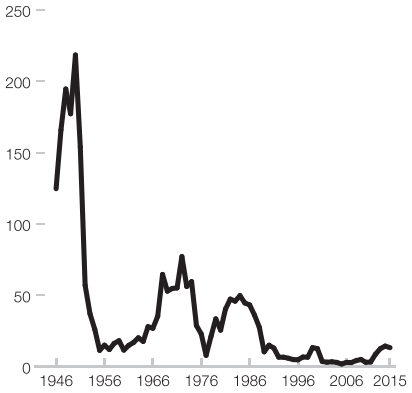
The proportion of the world's population living in poverty has dropped significantly in recent decades, alleviating one of the key threats to physical and mental well-being,[29] but increases in the global population mean the absolute numbers are still extremely high. In 2015 there were 736 million people

Figure 3.3:
Conflict and Death

Number of conflicts, 1946–2016



Battle deaths per 1,000,000 people, 1946–2016



Source: Uppsala Conflict Data Program. http://ucdp.uu.se/; Max Roser, "War and Peace", 2018. https://ourworldindata.org/war-and-peace.

living on less than US$1.90 a day, and numbers were increasing in Sub-Saharan Africa, the Middle East and North Africa.[30] And even in high-income countries, income and wealth disparities—ranked fourth as a driver of the global risks landscape in our survey this year—have been linked to increasing mental health problems.[31]

A third societal stressor is loneliness. This is on the rise, in the West in particular, where household structures have been undergoing a profound shift.

Researchers call the current share of people living alone "wholly unprecedented historically".[32] In the United Kingdom, the average proportion of single-person households has increased from around 5% in pre-industrial communities to 17% by the 1960s and 31% in 2011. Similar figures are recorded in Germany, Japan, the Netherlands and the United States.

Many capital cities have even higher proportions of so-called "solitaries"—for example, 50% in Paris and 60% in Stockholm. In midtown Manhattan 94% of households are single-person. Researchers argue that urbanization can weaken family and other bonds relative to smaller, rural communities;[33] this may help to explain high-income countries' apparently higher prevalence of mental health problems.[34] Evidence of psychological strains related to urbanization also comes from emerging economies: in China, where the rural population plunged from 80.6% to 45.2% between 1980 and 2014,[35] research finds increased levels of loneliness both among migrants moving to cities and in the rural communities they have left.[36]

The latest official data in the United Kingdom point to an increase to 22% in 2017 in the proportion of people feeling lonely either sometimes, often or always, up from an average of 17% in 2014–16.[37] The proportion of people never feeling lonely decreased from 33% to 23% over the same period. A US study looked at how many close friends people have: the average fell from 2.9 in 1985 to 2.1 in 2004, and the proportion of people responding that they had no close friends tripled over that period to become the modal response.[38]

Research suggests that people who describe themselves as lonely have as much social capital as their non-lonely peers.[39] One of the behavioural patterns linked to loneliness is poorer sleep quality, which has knock-on effects on individuals' wider resilience.[40] There are early signs that the potential societal impacts of rising loneliness are beginning to be recognized as a problem requiring attention—in early 2018, the United Kingdom added loneliness to the remit of one of its government ministers.

30%

women who experience "intimate partner violence" during their lives

Technology, addiction and empathy

In one recent study, technology was cited as a major cause of loneliness and social isolation by 58% of survey respondents in the United States and 50% in the United Kingdom.[41] However, the same survey found that social media was viewed as making it easier for people to "connect with others in a meaningful way", and respondents who reported feeling lonely were no more likely than others to use social media. These findings exemplify the uncertainty around how technological changes impact individual well-being. Technological change is always a source of stress, but the current wave of change—the Fourth Industrial Revolution—is defined by the blurring of the line between the human and the technological.

Debate, for example, surrounds the claimed addictiveness of digital technologies.[42] UK research in mid-2018 found that people spend an average of 24 hours per week online—more than twice as much as in 2011.[43] At least one prominent endocrinologist has likened digital technologies to addictive substances—in that they stimulate dopamine, which produces pleasure, but also require increasing use to get the same effect.[44] Many business models rely on the efficiency with which new technologies can attract and retain users' attention; some companies have even marketed their ability to leverage the behavioural impact of dopamine.[45] However, others argue that claims of addictiveness are alarmist or overblown:[46] the UK research found people still spend less time online than they do watching television.

Researchers looking at early child development are worried less by addiction than risks of "functional impairment"—that digital technologies could crowd out interpersonal interactions that provide the building blocks for subsequent development, such as the ability to "concentrate, prioritize, and learn to control passing impulses".[47] The American Academy of Pediatrics now recommends that children up to 18 months old use screens only for video chats, and a limit for children up to 5 years old of one hour of "high quality" programming, watched with a parent.[48]

Among adolescents, a study of more than 500,000 US school students found those who spent more time on digital media—relative to non-digital activities such as sports, in-person interactions, homework, printed media or religious services—were more likely to report mental health issues.[49] Critics contest these findings, particularly for moderate levels of screen time. They also note that even with high levels of screen time the effects remain small compared to, for example, missing breakfast or not getting enough sleep.[50]

REUTERS/Juan Medina

Another potential concern is that technology is leading to a decline in empathy, the ability to put oneself in the shoes of another. One study of students in the United States found that levels of empathy had fallen by 48% between 1979 and 2009;[51] however, possible explanations for this other than the greater use of personal technologies include increasing materialism and changes in parenting practices. Debate often centres on how digital echo-chambers can weaken cross-society empathy by anchoring individuals in tight-knit sub-groups.

Other technologies also play a role—such as online dating platforms leading to sorting and matching processes that researchers find are reducing cross-cutting societal bonds.[52]

The relationship between technology and empathy seems to be nuanced: online connections can be empathetic, but research suggests the effect is six times weaker than for real-world interactions.[53] Some believe virtual reality (VR) technologies will become an "engine for empathy".[54] Others note, for example, that current online gaming is negatively correlated with empathy,[55] which might suggest that more immersive VR versions of similar games would strengthen the negative effect. Some suggest that emotionally responsive robots could tackle loneliness, particularly in care-related settings. But this is not without potential risks—we consider potential dangers in Future Shocks, on page 73.[56]

Automation, monitoring and workplace stress

Technological and societal change is linked to rapid transformations in the workplace—and what happens at work has the potential to affect emotional and psychological well-being.[57] According to a survey of full-time employees in 155 countries, just 15% feel "highly involved in and enthusiastic about their work".[58] This "engagement" rate varies from 33% in the United States to just 6% across East Asia, a result the researchers attribute to overwork. Globally, a higher proportion of employees—18%—were found to be actively disengaged, defined as "resentful and acting out their unhappiness".[59]

For many workers, a pronounced recent change has been a blurring of the line dividing work from the rest of life.[60] Work-related emails often begin long before the start of nominal working hours and finish long afterwards. Many families juggle multiple jobs with childcare, stressful commuting logistics and caring for elderly parents. In growing numbers, employees cite the ability to manage work/life balance as the most important thing for thriving at work.[61] According to one study, 50% of American workers say they are

No amount of law or regulation will overcome a lack of empathy

"often or always exhausted due to work", up by almost a third in 20 years.[62] In another study, when UK workers were asked to identify the main workplace causes of stress, half cited unrealistic time pressure and demands. The same study noted employees' concern about lack of consultation on workplace changes (31%) and lack of control over the work they do (27%).[63]

Automation has long been a source of disruption in the workplace. It has allowed huge numbers of employees to move up the value chain and escape monotonous and dangerous tasks, but as far back as 1959 the World Health Organization was noting adverse psychological impacts not just of automation but even of the prospect of automation.[64] Research published in 2018 suggests that, in the United States, a 10% increase in the likelihood of being affected by automation is associated with decreases in physical and mental health of 0.8% and 0.6%, respectively.[65]

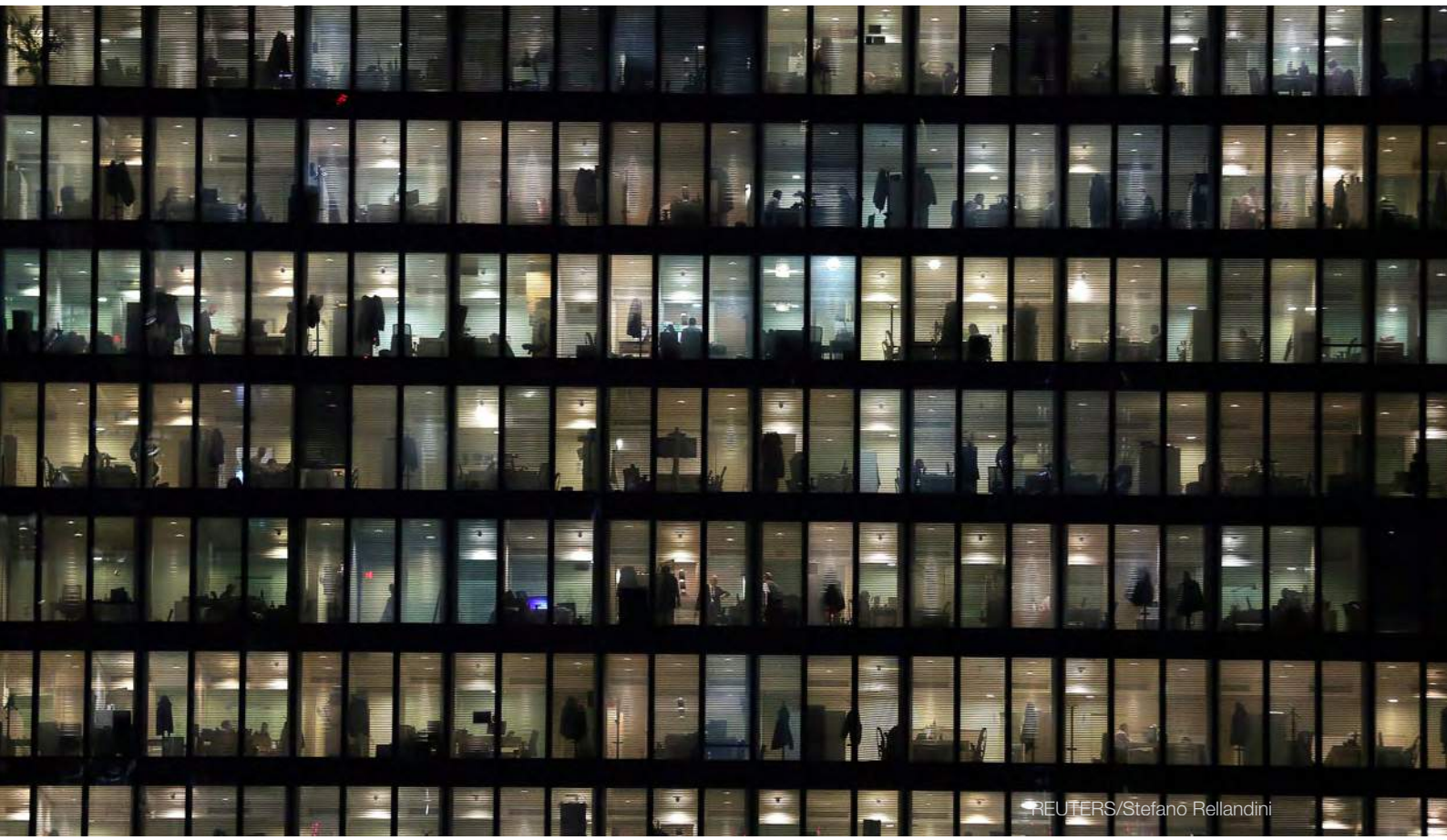
Technology is also making it easier for employers to monitor workers; some suggest the level of "anticipatory conformity" this can encourage amounts to a surrogate form of automation.[66]

One of the sectors in which concerns about automation and monitoring have become most prominent is online retailing, where the level of efficiency with which warehouses in particular can now operate has led to numerous reports of productivity targets causing physical and psychological strain among workers. However, workplace monitoring can actually reduce output if workers perceive it as an indication of distrust.[67] Loss of privacy due to monitoring may have a similar effect: a study in a Chinese factory found that workers shielded from monitoring by a curtain were 10–15% more productive than their peers.[68] Conversely, in a study of US restaurants where monitoring was being used to deter employee theft, large increases in weekly revenues were recorded—the result of unexpected improvements in levels customer service.[69]

Wider changes in the structure of work and in its place in society are a further source of potential stress. Job security and stability are in decline in many advanced economies, with real earnings growth sluggish or stagnating and less predictable "gig economy" work expanding. In many low-income countries, meanwhile, secure and stable employment has always been the exception: for example, 70% of employment in Sub-Saharan Africa is classified as "vulnerable" by the International Labour Organization.[70]

Evidence from the workplace reinforces concerns about growing problems with mental health. In the United Kingdom, an independent review found that while sickness-related absences overall fell by more than 15% between 2009 and 2017, absences related to mental health problems increased by 5%.[71] Of course, not all mental health problems recorded in the workplace are caused in the workplace—but employers and regulators ought to ensure that workplace conditions are not triggering or exacerbating problems. The UK review recommended revising health and safety provisions to take greater account of mental as well as physical well-being.

In the 19th century, physical health and safety rules and practices reshaped work in many industrializing economies. In the 21st century, mental health and safety rules and practices could play an analogous role by ensuring that workplace conditions are appropriate for an increasingly knowledge-based economy.



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Why well-being matters

This chapter has focused on some of the drivers leading to increased individual harm and distress. The chapter considered societal, technological and workplace trends, but could equally have examined how other transformations are linked to declining well-being, from political uncertainty to demographic change and environmental disruption.

Individual harms matter in themselves, but they can also feed into wider systemic risks and challenges. For example, there are huge economic costs. Research by the World Economic Forum and the Harvard School of Public Health suggests that the global economic impact of mental disorders in 2010 was US$2.5 trillion, with indirect costs (lost productivity, early retirement and so on) outstripping direct costs (diagnosis and treatment) by a ratio of around 2:1.[72]

Beyond the economic risks, there are potential political and societal implications. For example, a world of increasingly angry people would be likely to generate volatile electoral results and to increase the risk of social unrest. If empathy were to continue to decline the risks might be even starker, in some societies at any rate: "empathy underwrites all political systems that aspire to the liberal condition . . . and no amount of law or regulation will overcome a lack of empathy."[73]

Internationally, repeated accusations have been made in recent years of rival states using technology to foment angry fragmentation and polarization. It is not difficult to imagine such emotional and psychological disruptions having serious diplomatic—and perhaps even military—consequences.

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Going Viral

The Transformation of Biological Risks

REUTERS/Yves Herman

The previous chapter looked at the emotional and psychological impact of the multiple transformations the world is undergoing. This chapter considers another set of threats being shaped by global transformations: biological pathogens. Changes in how we live have increased the risk of a devastating outbreak occurring naturally, while emerging technologies make it increasingly easy for new biological threats to be manufactured and released—either deliberately or by accident.

REUTERS/Brian Snyder

The world is badly under-prepared for even modest biological threats. We are vulnerable to potentially huge impacts on individual lives, societal well-being, economic activity and national security. Revolutionary new biotechnologies promise miraculous advances, but they also create daunting challenges of oversight and control. Progress has made us complacent about conventional threats, but nature remains capable of "innovating" a pandemic that would cause untold damage.

The sections that follow examine the way biological risks are evolving both in nature and in laboratories. We are at a critical juncture. If there is one area in which a turn inward by societies could be needlessly destructive, it is global health security. Yet, as new risks emerge, there are early signs that important governance systems and protocols are eroding.

Outbreaks are increasing

In the past, naturally emerging infectious diseases have caused extraordinary health, economic and security impacts—often assisted by propitious conditions created by changing patterns of human behavior. Many years of global headlines have made various threats familiar: Ebola, MERS, SARS, Zika, yellow fever and each year's strains of influenza.

The frequency of disease outbreaks has been rising steadily. Between 1980 and 2013 there were 12,012 recorded outbreaks, comprising 44 million individual cases and affecting every country in the world.[1] Each month the World Health Organization (WHO) tracks 7,000 new signals of potential outbreaks, generating 300 follow-ups, 30 investigations, and 10 full risk assessments. In June 2018 there were—for the first time ever—outbreaks of six of the eight categories of disease in the WHO's "priority diseases" list. If any had spread widely, it would have had the potential to kill thousands and create major global disruption.[2]

Five main trends have been driving this increase in the frequency of outbreaks. First, surging levels of travel, trade and connectivity mean an outbreak can move from a remote village to cities around the world in less than 36 hours. Second, high-density living, often in unhygienic conditions, makes it easier for infectious disease to spread in cities—and 55% of the world's population today lives in urban areas, a proportion expected to reach 68% by 2050.[3]

Third, increasing deforestation is problematic: tree-cover loss has been rising steadily over the past two decades, and is linked to 31% of outbreaks such as Ebola, Zika and Nipah virus.[4] Fourth, the WHO has pointed to the potential of

climate change to alter and accelerate the transmission patterns of infectious diseases such as Zika, malaria and dengue fever.[5]

Finally, human displacement is a critical factor in this regard. Whether due to poverty, conflict, persecution or emergencies, the movement of large groups to new locations—often under poor conditions—increases displaced populations' vulnerability to biological threats. Among refugees, measles, malaria, diarrheal diseases and acute respiratory infections together account for between 60 and 80% of deaths for which a cause is reported.[6]

Fewer deaths, higher costs

Globalization has made the world more vulnerable to societal and economic impacts from infectious-disease outbreaks, even though impacts of those outbreaks on human health are declining because medical breakthroughs and advances in public health systems have enabled us to contain the effects on morbidity and mortality.[7] The 2003 SARS outbreak—which infected about 8,000 people and killed 774—cost the global economy an estimated US$50 billion.[8] The 2015 MERS outbreak in South Korea infected only 200 people and killed 38, but led to estimated costs of US$8.5 billion.[9]

Revolutionary new biotechnologies promise miraculous advances, but also daunting challenges of oversight and control

One estimate of potential pandemics through the 21st century puts the annualized economic costs at US$60 billion.[10] Including the imputed value of life-years lost, another estimate puts the cost of pandemic influenza alone at US$570 billion per year—the same order of magnitude as climate change.[11]

Given that many outbreaks occur in comparatively poor countries, even economic costs that may appear low in absolute terms can have a severe impact on the countries concerned. The World Bank has estimated that the three countries most badly impacted by Ebola in 2014–15—Guinea, Liberia and Sierra Leone—suffered combined GDP losses of $2.2 billion.[12] However, including the cost of associated social burdens—direct impacts on health as well as indirect effects on food security and employment—that figure jumps to US$53 billion.[13]

The relatively low recent death toll of infectious outbreaks—for comparison, in 1918 Spanish Influenza killed more than 50 million people—can be seen as evidence of the success of counter-measures: vaccines, antivirals and antibiotics greatly reduce the risk of massive loss of life. But another way of looking at the outbreaks since 2000 is as a "roll call of near-miss catastrophes", which should be prompting increased vigilance but is instead lulling us into complacency.[14]

Preparedness gaps

The WHO has begun to caution against such complacency. In 2015 it introduced a "priority diseases" list, reviewed annually. The purpose of the list is not to forecast which pathogen is most likely to cause the next outbreak, but to highlight where increased research and development is most warranted. In 2018 the WHO included "Disease X" in its list to focus researchers' attention on pandemic risks posed by diseases that cannot currently be transmitted to humans, or transmitted only inefficiently.

The priority diseases exercise builds on work that saw the first

effective vaccine against Ebola developed in 12 months, rather than the normal development cycle of 5–10 years. The estimated costs of developing vaccines for other key diseases greatly exceeds the resources currently devoted to such work. One 2018 study assessed the minimum cost of developing a vaccine for each of 11 infectious diseases previously highlighted by the WHO at between US$2.8 and 3.7 billion.[15] By contrast, the Coalition for Epidemic Preparedness Innovations (CEPI), set up in 2017 to coordinate and finance vaccine development, has committed to invest just US$1 billion by 2021.[16]

The weakness of basic preparedness in individual countries is an important obstacle to pandemic responses. Progress has been made, particularly since the 2014–16 Ebola epidemic, but most countries have not yet reached minimum international standards of capacity to detect, assess, report and respond to acute public health threats as set out in binding regulations that took effect in 2007.[17] Thus when an outbreak hits, appropriate responses may be absent or delayed, and resources will be stretched to deal with other epidemic events that may emerge.

A pattern of panic and neglect tends to affect pandemic preparedness. During and after every major outbreak, leaders are quick to call for increased investment in preparedness. Real progress often follows these calls—but as the effects of the outbreak fade, neglect sets in again until a new outbreak erupts; this prompts a new burst of panic, in which time and energy may be wasted on unnecessary and potentially costly measures. For example, throughout the 2014–16 Ebola epidemic, the WHO advised that general travel restrictions were unnecessary but still registered 41 instances of restrictions being placed on international travel.[18]

Our ability to respond to biological risks is also being hampered by carelessness. Misuse and overuse of antibiotics continues to undermine the efficacy of one of the most important medical countermeasures ever discovered. Similarly, an erosion of vaccine norms is leading to a resurgence of older biological threats that were thought to have been defeated: for example, incidents of measles—which pose a serious threat for babies, toddlers and young people—are increasing across Europe because vaccination coverage rates are falling as a result of unfounded safety concerns.[19]

Synthetic biology is amplifying risks

Synthetic biology technologies have the potential to transform the risk landscape. The possible gains are profound—they include new ways of producing chemicals, pharmaceuticals, fuels and electronics—but so is the risk of things going badly wrong. The skills and equipment required to replicate and alter the building blocks of life are proliferating rapidly. Driven by scientific advances and market forces, the cost of DNA synthesis has decreased at a rate faster than Moore's Law: more and more people around the world have access to powerful biotechnologies that were once accessible only to well-established and well-funded scientists.[20] A state-of-the-art DNA synthesis facility can already be built in a space the size of a shipping container, and miniaturization is advancing rapidly—enzymatic DNA synthesis can now be accomplished with a desktop device.[21] Carrying out this kind of work does not create any external "signature" that would distinguish a facility synthesizing

Outbreaks since 2000 have been described as a "roll call of near-miss catastrophes"

DNA from one performing other biological work.

It is possible now for a small research team to conduct experiments with potentially profound global consequences. For example, in 2018 a group of researchers in Canada demonstrated that a budget of US$100,000 is enough to synthesize horsepox virus. Horsepox is benign to humans, but a close relative is *Variola major*, which causes smallpox—a disease that was eradicated in 1980, having killed 300 million people since 1900. Live samples of smallpox virus now exist in just two highly secure facilities, one in the United States and one in Russia.

By publishing the synthesis process for horsepox virus, the Canadian research team sharply lowered the barriers to smallpox synthesis and increased the risk of smallpox being released into the world, either accidentally or intentionally. The researchers argue that these risks of their work are outweighed by the potential benefits of creating a new vaccine.[22]

This is not an isolated dilemma. The H5N1 strain of influenza, for example, has a staggering case fatality rate of above 50%; by comparison, the fatality rate for Spanish Influenza in 1918 was under 2.5%, and for seasonal influenza it is less than 0.1%. Human cases of H5N1 are rare, in part because the virus is inefficient at transmitting from person to person. If that were to change, a pandemic risk greater than any previously encountered could result. In 2011, researchers studied H5N1 transmissibility with the aim of enabling more rapid responses to new variants. The research was controversial—biosecurity experts worried that it could lead to a highly transmissible virus being released into human populations, by accident or as a deliberately deployed bio-weapon.[23]

Deliberate attacks

Received wisdom is that biological agents are an unattractive weapon, in part because of the perceived risks involved in their production, and also because of the difficulty of targeting particular groups or populations. But this is not an area for complacency. A report commissioned last year by the US Department of Defense highlights the "almost limitless list of malicious activities that could potentially be pursued with biology" and draws parallels with the importance of advances in physics and chemistry during the Cold War.[24]

State-sponsored development of biological weapons has broadly ceased since the Biological Weapons Convention (BWC) entered into force in 1975. However, the BWC has weaknesses. First, it is plagued by financial woes, struggling even to sustain a modest meeting programme.[25] Second, the only mechanism for demonstrating compliance is a system of annual "confidence-building measures"—but no more than half the signatories submit such measures in any given year, and a third have never done so. Third, the BWC has limited application to cutting-edge research—a growing problem, given revolutionary biological advances.[26]

Even if restraint on the part of state actors could be guaranteed, biological weapons still have attractions for malicious non-state actors. The current state of microbial forensics would make it difficult to reliably attribute a biological attack, and the impact could be incalculable: the direct effects—fatalities and injuries—would be compounded by potentially grave societal and political disruption.

In contrast to other types of terrorist attack, which require resources that are difficult to scale and replenish, the technical knowledge required to launch a catastrophic biological attack can be deployed repeatedly once it is mastered. This potential to "reload" creates the potential for successive high-impact attacks. According to one expert, this means that the national security vulnerabilities revealed by the 9/11 terrorist attacks in the United States were smaller than those revealed by the series of "anthrax letters" that killed five people in the weeks that followed.[27] In June 2018, German police intercepted a potential

REUTERS/Ueslei Marcelino

biological attack when an arrest led to the discovery of 84 milligrams of the poison ricin.[28]

Responses that would work against a natural pandemic might not be as effective against a deliberate attack, given such an attack's military and political dimensions and the lack of reliable governing frameworks.[29] For example, states might be reticent about sending resources and personnel to assist other countries if they perceive a risk of being affected themselves by any subsequent attacks.

The potential impact of a deliberate attack was highlighted last year by a pandemic preparedness exercise in the United States. This involved a war-gaming scenario in which a terrorist group released a virus that had been modified to combine a high case fatality rate with ease of transmission.[30] The results? A failed vaccine, tens of millions of deaths, incapacitated governments, over-whelmed healthcare systems and stock markets down by 90%.[31] This may have been a hypothetical scenario, but it is not in the realm of science fiction.

Governance challenges

Current governance systems risk creating the conditions for bioterrorism. Scientists often take the lead, developing self-governance frameworks to define acceptable limits for synthetic biology research. For example, DNA synthesis companies have developed new systems to screen orders for synthesized DNA to look for potential indications of malicious intent. However, screening is voluntary; it does

not apply in many countries; and screening standards, technologies and incentives have not kept pace with the rapid evolution of DNA synthesis technologies and business models. More rigorous transparency and oversight requirements are needed, as well as stronger norms applying to work that might increase pandemic risks.

In another example of self-governance, in 2015 the National Academy of Sciences of the United States, the Institute of Medicine, the Chinese Academy of Sciences and the Royal Society of London convened scientists to consider the future of germline editing, which changes the DNA that is passed on from generation to generation. The group issued a recommendation against performing germline editing on human embryos.[32] However, this kind of recommendation is difficult to enforce and researchers in China subsequently used CRISPR to correct a mutation in nonviable human embryos.[33] Some top-tier journals refused to publish this research, in part on ethical grounds, but that has not prevented further work in this area. In November last year the dividing line between technology and humanity was further blurred when a researcher in China claimed to have created the first gene-modified babies, twin girls whose genomes had been altered to make them resistant to HIV.[34]

The challenges of regulating synthetic biology will intensify as mutually reinforcing advances are made across the various technologies that make up the Fourth Industrial Revolution. For example, machine learning can identify which influenza mutations would prove most deadly.[35] The rationale for this research was to enable more efficient outbreak responses, but machine learning could equally be deployed to help a hostile actor build a better biological weapon. Work is also being done at the intersection of artificial intelligence and gene editing, with consequences that are uncertain—not only practically but ethically too.[36] While continued innovation must be encouraged, too little attention has so far been paid to emerging risks of high-impact events.

The challenge of establishing norms that can be enforced globally is exacerbated by geo-economic competition across advanced technologies, as discussed in Chapter 2 (Power and Values). But the field of synthetic biology is still young enough for norms and practices to be put in place that will steer its development in the years and decades ahead. There is an analogy with the internet: with hindsight, a much stronger security focus could have been incorporated in its building blocks at an early stage. Cybersecurity experts see a similar opportunity in synthetic biology today.

Governance challenges also exist in relation to "conventional" pandemic preparedness, despite advances such as the establishment of a Global Preparedness Monitoring Board and a Pandemic Emergency Financing Facility.[37] The WHO's Contingency Fund for Emergencies, established in 2015 to enable rapid responses to disease outbreaks and health crises, is funded at only one-third of its annual US$100 million target. The international system for sharing biological samples, vital for disease surveillance and response, appears to have been weakened since the introduction of the Nagoya Protocol. This is an agreement on "access and benefit sharing" that has been interpreted to give states greater rights over virus samples collected on their territory.[38] It has revived concerns in some countries about samples being used to create vaccines generating benefits that are not fairly shared.[39]

Negotiations around access and benefits have already delayed responses to novel outbreaks and even started to complicate the exchange of seasonal influenza samples. It would be dangerous if differences between countries were not swiftly and equitably resolved: in few areas is apolitical commitment to open and collaborative exchange as crucial as in global health security.

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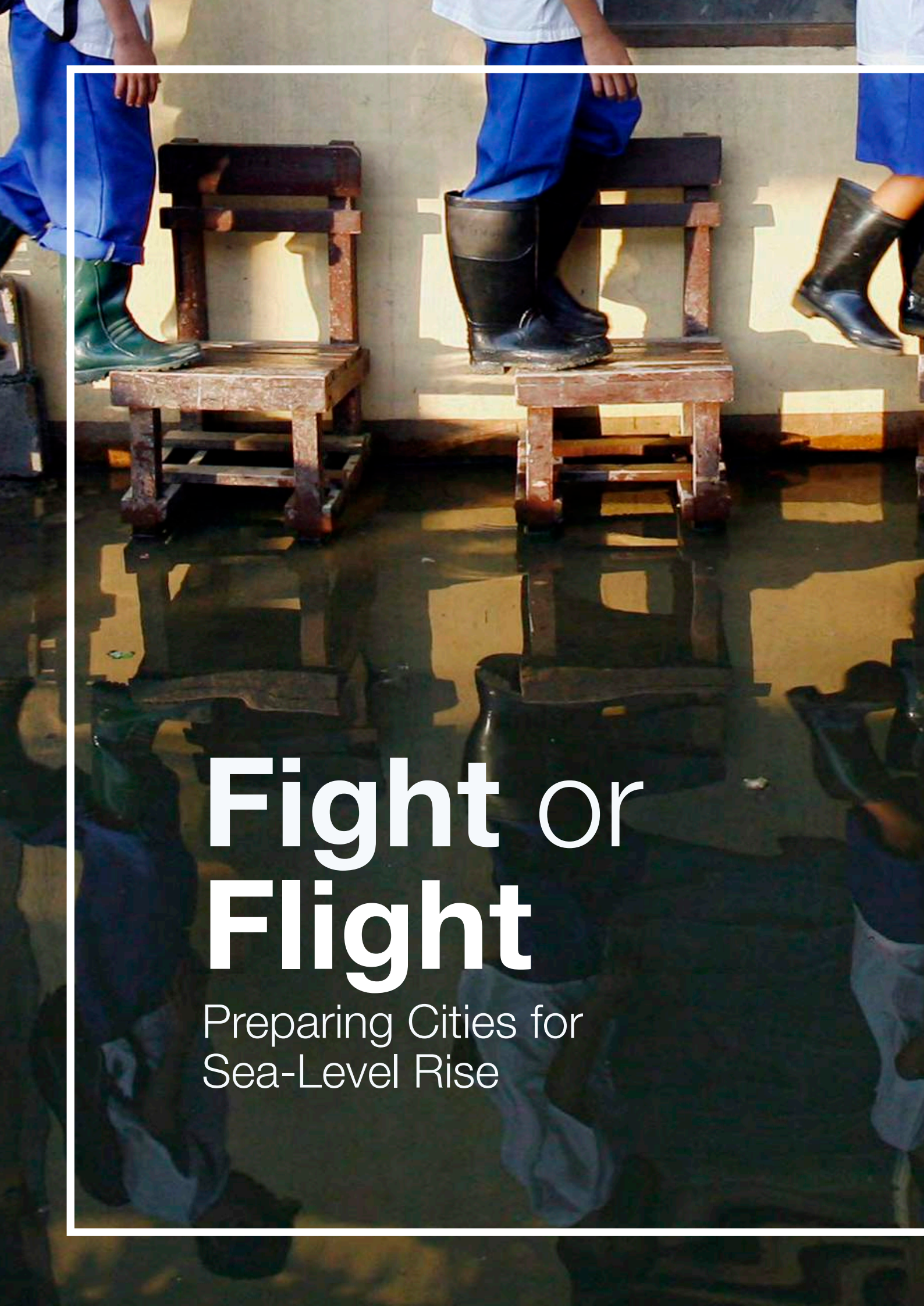

Fight or **Flight**

Preparing Cities for Sea-Level Rise

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Rapidly growing cities are making more people vulnerable to rising sea levels. Two-thirds of the global population is expected to live in cities by 2050. Already an estimated 800 million people in more than 570 coastal cities are vulnerable to a sea-level rise of 0.5 metres by 2050.[1]

In a vicious circle, urbanization not only concentrates people and property in areas of potential damage and disruption, but it also exacerbates those risks—for example, by destroying natural sources of resilience such as coastal mangroves and increasing the strain on groundwater reserves. The risks of rising sea levels are often compounded by storm surges and increased rainfall intensity.

Some cities and countries started decades ago to put strategies in place to deal with accelerating sea-level rise. In the last 20 years, approaches have shifted notably towards supplementing "hard" engineering strategies with greater promotion of more "soft" nature-based approaches. In many cities, however, preparations are lagging and the need to take action is increasingly urgent.

The following sections set out the latest projections for sea-level rise, assess which parts of the world are likely to be hardest hit, and look at the potential impacts on human populations and urban infrastructure. The chapter then considers the adaptation strategies being pursued in a number of cities, highlighting the growing prevalence of holistic approaches to flood resilience.

Rising sea levels

If global warming continues at its current rate, the Intergovernmental Panel on Climate Change (IPCC) considers it likely that the rise in atmospheric temperature will reach 1.5°C degrees within the next 35 years.[2] Forestalling this will require unprecedented action to drive decarbonization of agriculture, energy, industry and transport.[3] It appears increasingly unlikely that the world will meet even the 2°C upper limit identified by the Paris Climate Agreement.[4] The current trajectory is towards a rise of around 3.2°C.[5]

As global temperatures have increased, so sea levels have risen at an accelerating rate. According to the IPCC, the mean sea-level rise between 1901 and 2010 was 1.7 millimetres per year (mm/y). Between 1993 and 2010 it was 3.2 mm/y. Global sea levels will continue to rise through the 21st century and beyond, owing to increased oceanic warming and loss of glaciers and ice sheets. According to the IPCC, a 2°C increase will cause sea levels to rise between 0.30 metres and 0.93 metres by 2100.[6] Other research suggests this rise could be as much as 2 metres even with warming below 2°C.[7] Beyond 2100, it could eventually reach 6 metres.[8] The uncertainty is due to the complex nature of the interaction of atmospheric warming, oceanic warming and ice-sheet responses: for example, the collapse of the West Antarctic Ice Sheet could push up sea levels by 3.3 metres.[9]

Global averages tell only part of the story. Sea-level rise will also vary regionally and locally: ice loss in the Antarctic, for example, is expected to have a disproportionate impact in the northern hemisphere, where most of the world's coastal cities are located.[10] Estimates suggest that 90% of coastal areas will experience above-average rise,[11] with differentials of up to 30% relative to the mean.[12]

Relative sea-level rise will be even higher in the many cities that are sinking because of factors that include groundwater extraction and the growing weight of urban sprawl. Some cites are sinking faster than sea levels are rising: in parts of Jakarta, for example, ground level has sunk by 2.5 metres in the past decade.[13] In addition, sea-level rise amplifies the impact of storm surges, as it takes a smaller surge to produce the same extreme water level.

Estimates suggest that 90% of coastal areas will experience above-average rise

Uncertainties surround the precise interactions of regional sea-level rise and patterns of urban demography and development. However, it is clear that Asia will be the worst-affected region as a result of a combination of hydrology, population density and asset concentration.[14] Asia is home to four-fifths of the people who are expected to be flooded if there is a 3°C rise in global temperatures.[15] China alone has more than 78 million people in low-elevation

cities, a number increasing by 3% each year.[16]

The World Bank notes that 70% of the largest cities in Europe have areas vulnerable to rising sea levels.[17] Africa has at least 19 vulnerable coastal cities with a population of more than 1 million, including Abidjan, Accra, Alexandria, Algiers, Casablanca, Dakar, Dar es Salaam, Douala, Durban, Lagos, Luanda, Maputo, Port Elizabeth and Tunis.[18] In the United States, East Coast cities including Norfolk, Baltimore, Charleston, and Miami have already experienced "sunny day" flooding due to the rising sea levels.[19] One study suggests that a sea-level rise of 0.9 metres by 2100 would expose 4.2 million people to flooding, while a rise of 1.8 metres over the same period would affect 13.1 million people—equivalent to 4% of the current population.[20]

Deltas are home to more than two-thirds of the world's largest cities and 340 million people.[21] These delta cities are particularly vulnerable to land subsidence. Relative sea-level rise poses the highest risks for the Krishna (India), Ganges-Brahmaputra (Bangladesh) and Brahmani (India) deltas.[22] In Bangladesh, a rise of 0.5 metres would result in a loss of about 11% of the country's land, displacing approximately 15 million people.[23]

Potential damage

Sea-level rise threatens significant damage to property—not only homes and businesses but also public assets and critical infrastructure, which adds significant contingent liabilities to the taxpayer. Research suggests that economic impacts are highly concentrated geographically, where sea-level vulnerabilities interact with high-value property and infrastructure. Just four cities account for 43% of average annual losses: Guangzhou, Miami, New Orleans and New York.[24] The researchers note that because "coastal flood risks are highly concentrated, flood reduction actions in a few locations could be very cost-effective."[25]

Existing protection already reduces these losses significantly. The same research compares cities' recorded average annual losses with their expected exposure to a 100-year flood event—that is, a flood with a severity that would be statistically expected once every century. The results vary hugely. For example, Amsterdam's exposure to a 100-year flood event is more than double that of Guangzhou—an estimated US$83 billion versus US$38.5 billion. But the strength of Amsterdam's protection means its average annual losses to date are just US$3 million, compared with US$687 million for Guangzhou.[26]

In the United States, a study found that between 2005 and 2017 sea-level rise wiped US$14.1 billion off home values in Connecticut, Florida, Georgia, New Jersey, New York, North Carolina, South Carolina and Virginia.[27] In developing countries, the threat to property is often exacerbated by coastal erosion as rising sea levels, sand-mining and built infrastructure disrupt the flow of coastal sediment. Some coastal communities in Sub-Saharan Africa are already being washed away, losing up to 30–35 metres of land each year, with thousands more at risk.[28]

A study by the UK National Oceanographic Centre projects the global cost of rising sea levels at US$14 trillion per year in 2100.[29] It found that China would face the biggest costs in absolute terms, while as a percentage of GDP the impacts will be highest for Kuwait (24%), Bahrain (11%), the United Arab Emirates (9%) and Viet Nam (7%).[30]

More people will be crammed into shrinking tracts of habitable urban space

Various forms of infrastructure and economic activity are at risk from rising sea levels:

- *Roads:* A study of coastal roads on the US East Coast estimates that high tide flooding already causes 100 million vehicle-hours of delay every year, which could rise to 3.4 billion hours by 2100.[31]

- *Railways:* Researchers predict that a 4.5 kilometre stretch of coastal railway in the United Kingdom would be disrupted on 84 days each year with a 0.55 metre sea-level rise, and the line would cost hundreds of millions of pounds to divert.[32]

- *Ports:* The World Bank has identified 24 port cities in the Middle East and 19 in North Africa at particular risk of sea-level rise.[33] Rising sea levels will lead to a greater frequency of disruptive events such as Hurricane Florence, which closed North Carolina's port to trucks for 10 days in September 2018.[34]

- *Internet:* In the United States, more than 4,000 miles of underground fibre optic cable and 1,100 nodes are projected to be underwater within 15 years, with New York, Miami and Seattle at greatest risk.[35] Unlike submarine internet cables, these are not designed to be waterproof.

- *Sanitation:* A 2018 study found that in the United States, a sea-level rise of just 30 centimetres will expose 60 wastewater treatment plants, which serve more than 4.1 million people.[36] Water treatment facilities in Benin and other countries in West Africa are already threatened by the sea.[37]

- *Drinking water:* Pollution of aquifers will be exacerbated by declines in streamflow: by the 2050s, more than 650 million people in 500 cities are projected to face declines in freshwater availability of at least 10%.[38] As rivers and streams contain some groundwater, salination could also affect surface-level fresh water.

- *Energy:* The C40 Cities initiative has identified 270 power plants that are vulnerable to a sea-level rise of 0.5 metres; these plants provide power to 450 million people mostly in Asia, Europe, and the east coast of North America.[39]

- *Tourism:* In many cities, coastal areas are a source of revenue from tourism and business. In Egypt, for example, the IPCC has estimated that a 0.5 metre rise in sea levels would destroy Alexandria's beaches, leading to losses of US$32.5 billion.[40]

- *Agriculture:* Sea-level rise can lead to increased salination of soil and of water sources used for irrigation, particularly in delta regions. In Bangladesh, the World Bank estimates salination could cause a 15.6% decline in rice yield.[41]

In 2017, 18.8 million people were newly displaced by weather-related causes, including floods and coastal storms.[42] The intensifying impact of sea-level rise on coastal cities and plains will render an increasing amount of land uninhabitable or economically unviable.

This is likely to lead to population movement within and from large cities. More people will be crammed into shrinking tracts of habitable urban space, and more are likely to move to other cities, either domestically or in other countries. These movements have the potential to cause spillover risks—for example, they could result in heightened strain on food and water supplies and in increased societal, economic and even security pressures. According to the World Bank, climate change could force 86 million people in Sub-Saharan Africa, 40 million in South Asia and 17 million in Latin America to permanently relocate internally by 2050.[43]

Coastal adaptation

Cities faced with the risk of damage from rising sea levels can adapt either by trying to keep water out or learning to live with water at higher levels. Some strategies and technologies are new, but the

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basic idea is not: "[C]oastal societies have a long history of adapting to environmental change and local sea-level rise because coasts are amongst the most dynamic environments on Earth. For example, a number of coastal megacities in river deltas have experienced, and adapted to, relative sea-level rise of several metres caused by land subsidence during the twentieth century."[44]

There are three main strategies. The first involves "hard" engineering projects to keep water out of cities, such as sea walls, storm-surge barriers, water pumps and overflow chambers. The second involves nature-based defences—for example, conserving or restoring mangroves and salt marshes—or seeking to shape how floods will affect cities, rather than always trying to prevent them. The third strategy involves people—for example, moving households and businesses to safer ground, or investing in social capital to make flood-risk communities more resilient. An appropriate mix of coastal adaptation measures can potentially "reduce some coastal impacts by several orders of magnitude."[45]

The Netherlands is at the forefront of coastal adaptation because of its existential exposure to rising sea levels—two-thirds of the country is vulnerable to flooding. The importance of water management is recognized in the country's administrative structures—regional water boards levy their own taxes for flood protection rather than depending on government.[46] The Netherlands pursues a mix of the three strategies. Its highly developed hard infrastructure includes an extensive system of dikes and the world's largest storm-surge barrier. However, inland floods in the early 1990s, in which 200,000 people were evacuated, led to a shift of approach. Instead of continuing to build ever-higher dikes—which means greater damage is done if they are breached—the "room for the river" programme lowered some dikes to allow farmland to be inundated in flood events to protect towns. Farmhouses in affected areas were demolished

Spending on disaster recovery is almost nine times higher than on prevention

and families moved to new homes built on artificially created mounds, 8 metres high.[47]

In Rotterdam—where 90% of land is beneath sea level—a programme called "the Sand Engine" involved dredging sediment from the North Sea and depositing it off the city's shore to prevent waves from eroding the coastline.[48] Rotterdam is also home to numerous urban water innovations, such as floating houses and city squares designed to collect millions of litres of water in flood conditions.

Managed retreat

Like the Netherlands, China's approach to flood management changed in the 1990s in response to major flooding. The 1998 Yangtze River Basin floods killed 4,000 people and prompted a shift away from reliance on hard infrastructure projects. Nature-based measures were prioritized and more than 2 million people were relocated to higher ground.[49] However, the rapid pace of urbanization has continued to increase flooding risks in many coastal areas by destroying natural flood defences: in Shenzhen, for example, around 70% of mangrove coverage has been destroyed.[50] In 2015 a new "sponge city" initiative was launched to offset this process by introducing urban features such as permeable pavements, new wetland areas and green roofs; the 30 cities in the programme include Shanghai, which is particularly vulnerable to sea-level rise. The target is for 80% of urban land to be able to absorb or re-use 70% of stormwater by 2030.[51]

Many cities and countries have struggled to cope with the mounting challenges posed by rising sea levels. In Indonesia, Jakarta is building a massive sea wall—with Dutch help—and has also launched a five-year project to relocate around 400,000 people away from riverbanks and reservoirs under threat from rising sea levels.[52] However, some critics argue that the authorities should also be doing more to prevent the city from sinking.[53] This debate over the right course of action highlights the institutional complexity of getting flood management right: often success depends on legacy infrastructure issues that are hugely expensive to resolve. Jakarta's system of water pipes reaches only one-third of residents, leaving two-thirds reliant on the groundwater extraction that is weakening the city's foundations.[54]

In Thailand, Bangkok is low lying and sinking, its natural coastal defences have been eroded, and the nearby Gulf of Thailand is rising faster than the global average.[55] Bangkok's surface area is also one of the world's most impervious—it averages just 3.3 square metres of green space per resident, compared with 66 square metres in Singapore.[56] Extreme weather patterns are intensifying, leaving the city vulnerable to rising sea levels from the south and increasingly severe monsoon rains from the north.[57] The government's response includes constructing a 2,600 kilometre canal network, as well as a central park that can drain 4 million litres into underground containers.[58]

In 2011, severe flooding in Bangkok prompted some authorities to suggest moving the capital city.[59] The idea of "managed retreat" is likely to become an increasingly familiar feature of adaptation plans as sea levels rise and extreme weather intensifies. One study identifies 27 cases across 22 countries that have already occurred.[60] Elsewhere, plans are in preparation. The Maldives intends to build artificial islands, fortified with 3 metre high sea walls and financed by renting out islands and boosting tourism.[61] In the Pacific Ocean, Kiribati has purchased land in Fiji as a potential new home for its citizens. And in the United States, US$48 million has been allocated to relocate the entire community of the Isle de Jean Charles in Louisiana, which has lost 98% of its land since 1955.[62] The complex task of resettling these residents while keeping their sense of community will serve as a test case for the future.

No time to waste

As sea levels rise and urban vulnerabilities increase, the urgency of the need to respond to these changes is going to intensify. Beyond adaptation measures, addressing urban vulnerability to sea-level rise will require households, businesses and governments to avoid exacerbating dangers. There is little point putting new flood defences in place, for example, if existing defences are undermined through continued development of homes and businesses in coastal areas and on floodplains.

The affordability of flood resilience is set to become an increasingly important issue. Robust risk financing strategies will be required, both to fund investment

REUTERS/Lucas Jackson

in adaptation and to pay for recovery when floods occur. At present, spending on recovery is almost nine times higher than on prevention.[63] Turning that around will not be easy: building support for pre-emptive spending and action—particularly if it involves major disruptions such as relocation—can take many years of dialogue and planning. There is no time to waste.

As adaptation becomes more costly, questions of burden-sharing will arise—for example, between the public and private sectors, and between municipal and national authorities. Burden-sharing may also be needed between countries. Failure to prepare for sea-level rise will create cross-border spillovers, and some of the cities most at risk are in countries that may struggle to find the resources to adapt. Innovative and collaborative approaches may be needed to ensure that action is taken globally before it is too late.

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FUTURE SHOCKS

As the world becomes more complex and interconnected, incremental change is giving way to the instability of feedback loops, threshold effects and cascading disruptions. Sudden and dramatic breakdowns—future shocks—become more likely. In this section, we present 10 such potential future shocks. Some are more speculative than others; some build on risks that have already begun to crystallize. These are not predictions. They are food for thought and action—what are the possible future shocks that could fundamentally disrupt or destabilize your world, and what can you do to prevent them?

Illustrations: **Patrik Svensson**

WEATHER **WARS**

USE OF WEATHER MANIPULATION TOOLS STOKES GEOPOLITICAL TENSIONS

Weather manipulation tools—such as cloud seeding to induce or suppress rain—are not new, but deploying them at scale is becoming easier and more affordable. As the impacts of climate-related changes in weather patterns intensify, the incentives to turn to technological fixes will increase in affected areas. Think of governments trying to manage simultaneous declines in rainfall and increases in water demand.

Aside from the potential environmental consequences, at a time of increasing geopolitical tensions even well-intentioned weather manipulation might be viewed as hostile. Perceptions would be paramount: a neighbouring state might see large-scale cloud-seeding as theft of rain or the reason for a drought. Cloud-seeding planes might be viewed as dual-use tools for espionage. Hostile uses are prohibited, but cannot be ruled out—for example, weather manipulation tools could be used to disrupt a neighbour's agriculture or military planning. And if states decided unilaterally to use more radical geo-engineering technologies it could trigger dramatic climatic disruptions.

As technologies evolve and deployment increases, increased transparency—about who is using what, and why—would help limit destabilizing ambiguity. So too would active discussion and collaboration on environmental vulnerabilities, both bilaterally between bordering states and on wider regional and global multilateral platforms.

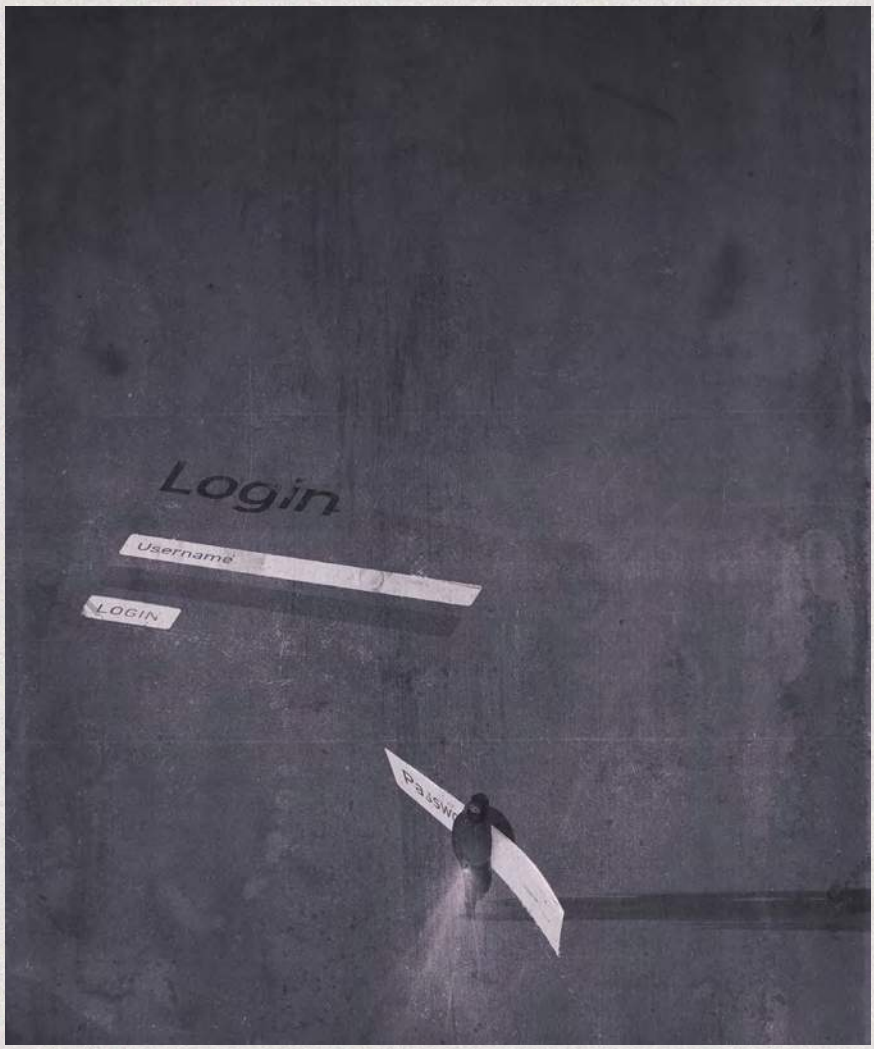
OPEN **SECRETS**

QUANTUM COMPUTING RENDERS CURRENT CRYPTOGRAPHY OBSOLETE

When the huge resources being devoted to quantum research lead to large-scale quantum computing, many of the tools that form the basis of current digital cryptography will be rendered obsolete. Public key algorithms, in particular, will be effortlessly crackable. Quantum also promises new modes of encryption, but by the time new protections have been put in place many secrets may already have been lost to prying criminals, states and competitors.

A collapse of cryptography would take with it much of the scaffolding of digital life. These technologies are at the root of online authentication, trust and even personal identity. They keep secrets—from sensitive personal information to confidential corporate and state data—safe. And they keep fundamental services running, from email communication to banking and commerce. If all this breaks down, the disruption and the cost could be massive.

As the prospect of quantum code-breaking looms closer, a transition to new alternatives—such as lattice-based and hash-based cryptography—will gather pace. Some may even revert to low-tech solutions, taking sensitive information offline and relying on in-person exchanges. But historical data will be vulnerable too. If I steal your conventionally encrypted data now, I can bide my time until quantum advances help me to access it, regardless of any stronger precautions you subsequently put in place.



CITY **LIMITS**

WIDENING GULF BETWEEN URBAN AND RURAL AREAS REACHES A TIPPING POINT

The world's political geography is being transformed by surging migration from rural to urban areas, straining the web of connections between the two. Divergences are widening on numerous dimensions, such as values, age, education, power and prosperity. What if a tipping point is reached at which the urban-rural divide becomes so sharp that the unity of states begins to erode?

Domestically, divergent values between urban and rural areas are already fuelling polarization and electoral volatility in many countries. Greater bitterness and rivalry could lead to localized nativism and even violent clashes. Separatist movements might break through in wealthy city-regions that resent diverting revenues to poorer rural areas with which they feel diminishing affinity. Leading cities might look to bypass national structures and play an international role directly. Economically, accelerating urban migration could lead to rural depopulation and the decline of local economies, with potential food security implications in some countries.

Better long-term planning—for both expanding cities and rural areas at risk of decline—might help to mitigate these dangers. Stronger transport and communications links could help to soften the urban-rural divide. Resources will be needed, which might require more fiscal creativity, such as finding ways to decentralize revenue-raising powers or more widely redistribute the productivity gains that urbanization generates.

AGAINST **THE GRAIN**

FOOD SUPPLY DISRUPTION EMERGES AS A TOOL AS GEO-ECONOMIC TENSIONS INTENSIFY

With climate change placing growing strain on the global food system, and with international tensions already heightened, the risk of geopolitically motivated food-supply disruptions increases. Worsening trade wars might spill over into high-stakes threats to disrupt food or agricultural supplies. Conflict affecting supply-chain chokepoints could lead to disruption of domestic and cross-border flows of food. At the extreme, state or non-state actors could target the crops of an adversary state, for example with a clandestine biological attack.

In these circumstances, retaliatory dynamics could swiftly take hold. Domestically, rationing might be needed. Hoarding and theft could undermine the social order. Widespread famine risk in recent years suggests that greater hunger and more deaths—in least-developed countries, at any rate—might not trigger a major international reaction. If similar suffering were inflicted on more powerful countries, the responses would be swift and severe.

More resilient trade and humanitarian networks would help to limit the impact of food supply disruption. But if trade wars were a contributing factor, then countries might seek greater self-sufficiency in food production and agriculture. In some advanced economies, this might require rebuilding skills that have been allowed to fade in recent decades. Agricultural diversification and the development of more-resilient crop variants could bolster national security by reducing countries' vulnerability.

DIGITAL **PANOPTICON**

ADVANCED AND PERVASIVE BIOMETRIC SURVEILLANCE ALLOWS NEW FORMS OF SOCIAL CONTROL

Biometrics are already making exponential advances—technologies that were recently in the realm of science fiction now shape the reality of billions of people's lives. Facial recognition, gait analysis, digital assistants, affective computing, microchipping, digital lip reading, fingerprint sensors—as these and other technologies proliferate, we move into a world in which everything about us is captured, stored and subjected to artificial intelligence (AI) algorithms.

This makes possible increasingly individualized public and private services, but also new forms of conformity and micro-targeted persuasion. If humans are increasingly replaced by machines in crucial decision loops, the result may lead not only to greater efficiency but also to greater societal rigidity. Global politics will be affected: authoritarianism is easier in a world of total visibility and traceability, while democracy may turn out to be more difficult—many societies are already struggling to balance threats to privacy, trust and autonomy against promises of increased security, efficiency and novelty. Geopolitically, the future may hinge in part on how societies with different values treat new reservoirs of data.

Strong systems of accountability for governments and companies using these technologies could help to mitigate the risks to individuals from biometric surveillance. This will be possible in some domestic contexts, but developing wider global norms with any traction will be a struggle.

TAPPED **OUT**

MAJOR CITIES STRUGGLE TO COPE IN THE FACE OF THE EVER-PRESENT RISK OF WATER RUNNING OUT

A range of compounding factors risk pushing more megacities towards a "water day zero" that sees the taps run dry. These include population growth, migration, industrialization, climate change, drought, groundwater depletion, weak infrastructure and poor urban planning. Short-termist and polarized politics at both municipal and national levels in many countries further heighten these dangers.

The societal shock of running out of water could lead in sharply differing directions depending on the context. It could exacerbate divisions. Conflict might erupt over access to whatever water was still available, or wealthier residents might start to import private supplies. But a water shock could also galvanize communities in the face of a shared existential challenge. Either way, damage would be done. Hygiene would suffer, increasing strains on healthcare systems. And governments blamed for the failure might be tempted to scapegoat weaker communities, such as those in informal dwellings with unofficial connections to the water system.

Getting governance and planning right during times of plentiful water would reduce the risk of day zero arising, including public information campaigns and basic maintenance of existing infrastructure, as well as regulations limiting the amount of water that households, businesses and government can use. New water sources could be identified, subject to careful risk assessment. And smart technologies could be deployed to reduce water use and improve water reclamation.

CONTESTED **SPACE**

LOW EARTH ORBIT BECOMES A VENUE FOR GEOPOLITICAL CONFLICT

With satellites now central to the smooth functioning of civil and military technologies, the amount of commercial and government activity in space has been increasing. This is a legally ambiguous realm, creating the potential for confusion, accident and even wilful disruption. Space debris is proliferating too—half a million pieces are now moving at the speed of a bullet in low orbit.

Even accidental debris collisions could cause significant disruption to internet connectivity and all that relies on it. But at a time of intensifying geopolitical competition, space could also become an arena for active conflict. Even defensive moves to protect critical space assets might trigger a destabilizing arms race. Precision weapons and military early-warning systems rely on high-orbit satellites—militarizing space might be seen as necessary to deter a crippling attack on them. In the future, as space becomes more affordably accessible, new threats of space-based terrorism could emerge.

New rules or updated protocols would provide greater clarity—particularly on the rapid expansion of commercial activity, but also on military activity. Even simple measures could help—such as ensuring transparency on debris-removal activities to prevent the misinterpretation of intentions. At a time of fraying global cooperation, space might be an area where multilateral advances could be signed up to by all.

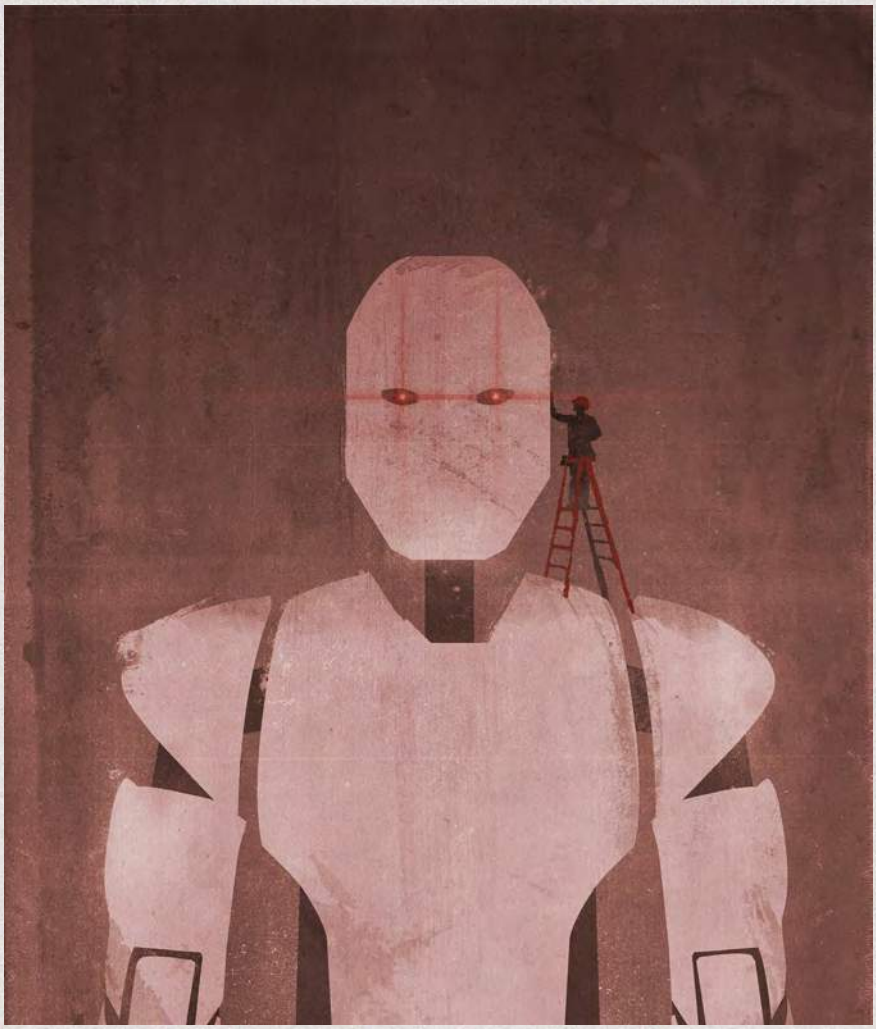
EMOTIONAL **DISRUPTION**

AI THAT CAN RECOGNIZE AND RESPOND TO EMOTIONS CREATES NEW POSSIBILITIES FOR HARM

As the intertwining of technology with human life deepens, "affective computing"—the use of algorithms that can read human emotions or predict our emotional responses—is likely to become increasingly prevalent. In time, the advent of artificial intelligence (AI) "woebots" and similar tools could transform the delivery of emotional and psychological care—analogous to heart monitors and step counters. But the adverse consequences, either accidental or intentional, of emotionally "intelligent" code could be profound.

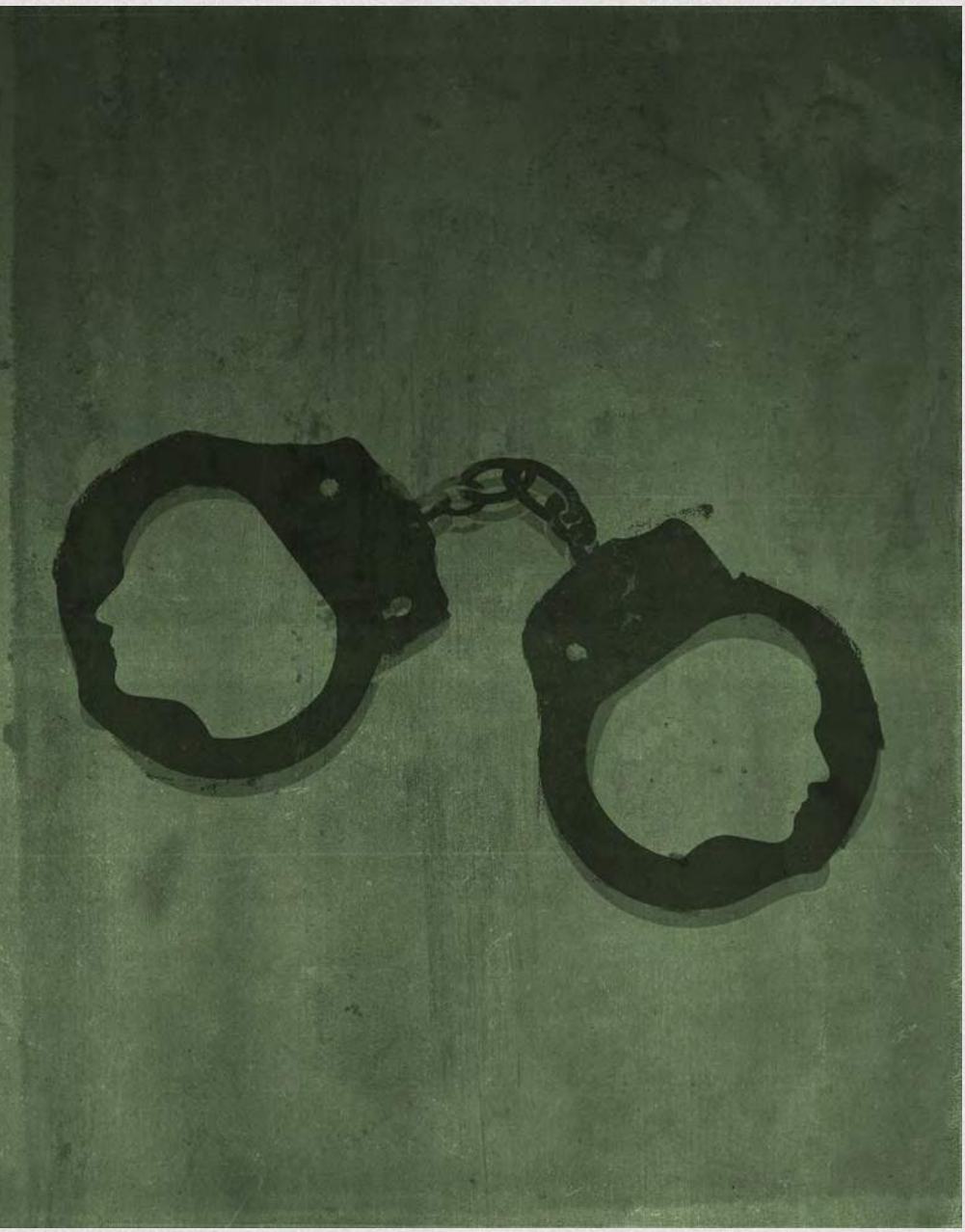
Consider the various disruptions the digital revolution has already triggered—what would be the affective-computing equivalent of echo chambers or fake news? Of electoral interference or the micro-targeting of advertisements? New possibilities for radicalization would also open up, with machine learning used to identify emotionally receptive individuals and the specific triggers that might push them toward violence. Oppressive governments could deploy affective computing to exert control or whip up angry divisions.

To help mitigate these risks, research into potential direct and indirect impacts of these technologies could be encouraged. Mandatory standards could be introduced, placing ethical limits on research and development. Developers could be required to provide individuals with "opt-out" rights. And greater education about potential risks—both for people working in this field and for the general population—would also help.



NO **RIGHTS** LEFT

IN A WORLD OF DIVERGING VALUES, HUMAN RIGHTS ARE OPENLY BREACHED WITHOUT CONSEQUENCE



Amid a new phase of strong-state politics and deepening domestic polarization, it becomes easier for governments to sacrifice individual protections to collective stability. This already happens widely: lip service is paid to human rights that are breached at home or abroad when it suits states' interests. What if even lip service goes by the wayside, and human rights are dismissed as anachronisms that weaken the state at a time of growing threats?

In authoritarian countries with weak human rights records, the impact of such a tipping point might be one of degree—more rights breached. In some democratic countries, qualitative change would be more likely—a jolt towards an illiberalism in which power-holders determine whose rights get protected, and in which individuals on the losing side of elections risk censorship, detention or violence as "enemies of the people".

Battles are already under way among major powers at the UN over the future of the human rights system. In a multipolar world of divergent fundamental values, building far-reaching consensus in this area may be close to impossible. "Universal" rights are likely to be interpreted locally, and those interpretations then fought over globally. Even superficial changes might be of modest help, such as new language that is less politicized than "human rights".

MONETARY **POPULISM**

What if the protectionist wave expanded to engulf the central banks at the heart of the global financial system? Against a backdrop of geo-economic escalation, calls could rise to "take back control" of independent monetary policy and to use it as a weapon in tit-for-tat confrontations between the world's economies. Prudent and coordinated central bank policies might be attacked by populist politicians as a globalist affront to national democracy.

A direct political challenge to the independence of major central banks would unsettle financial markets. Investors might question the solidity of the global financial system's institutional foundations. As unease deepened, markets might start to tremble, currencies to swing. Uncertainty would spread to the real economy. Polarization would hamper domestic political response, with mounting problems blamed on enemies within and without. Internationally, there might be no actors with the legitimacy to force a coordinated de-escalation. The risk of a populist attack on the world's financial architecture could be mitigated by deepened efforts to maximize the popular legitimacy of central bank independence.

This could be done by bringing the public in—perhaps through formal consultative assemblies—to decisions on independence, accountability and stability. The greater the public understanding of and support for monetary policy mandates and tools, the less vulnerable they will be in times of crisis.

ESCALATING PROTECTIONIST IMPULSES CALL INTO QUESTION INDEPENDENCE OF CENTRAL BANKS

Hindsight

Each year the Hindsight section revisits previous editions of the *Global Risks Report* to look again at risks that we have previously covered. The aim is to trace the progress that has been made in the intervening years—how have the risks and the global responses to them evolved? This year the three risks we return to are food security, civil society and investment in infrastructure.

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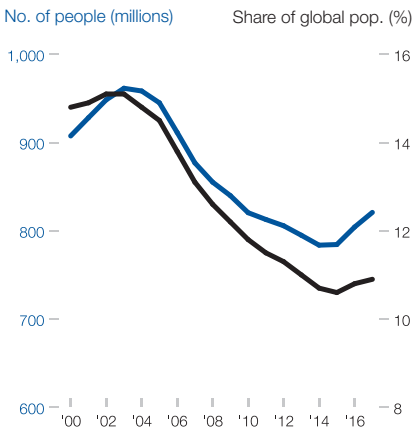
Security of Food Systems

One of the earliest *Global Risks Reports*, in 2008, included a chapter on food security. It asked whether the food-price spikes recorded in 2007 represented familiar short-term volatility or more structural disruptions to the food system, and highlighted drivers of food insecurity including climate change, population growth and changing consumption patterns. In 2016, we looked more closely at the first of these in a chapter entitled "Climate Change and Risks to Food Security", which noted that crop yields were growing more slowly than demand. It highlighted two main ways that climate change is affecting food security: (1) direct impact on agricultural output, through changing temperature and rainfall patterns; and (2) wider systemic disruptions such as market volatility, interruptions to transport networks, and humanitarian emergencies.

Food distress on the rise

The threats to food security have intensified in recent years. In 2017, a state of famine was declared in South Sudan; although it was lifted within months, this was only the second such declaration since the turn of the century. Conditions in South Sudan are still designated as "emergency"—one step below famine on the five-point scale used by the Famine Early Warning Systems Network (FEWS)[1]—as are conditions in Ethiopia, Nigeria and Yemen. More countries are in the next most severe "crisis" category: Afghanistan, Democratic Republic of Congo, Somalia and parts of Southern Africa. According to FEWS, the number of people currently requiring emergency food assistance is "unprecedented in recent decades". In Yemen alone, 15 million people require emergency food assistance each month.[2]

Figure 7.1:
Undernourishment Rises
Prevalence of global undernourishment



Source: United Nations, Department of Economic and Social Affairs, 2018. https://unstats.un.org/sdgs/ indicators/database/?indicator=2.1.1

Undernourishment has increased in both absolute and relative terms since 2015, as shown by Figure 7.1. The proportion of the world's population suffering from undernourishment declined from around 15% in the early 2000s to 10.6% in 2015, but edged back up to 10.9% over the next two years. In absolute terms, that represents an increase of around 40 million people: in 2017 a total of 821 million people were undernourished, the most since 2009. More than 2 billion people lack the micronutrients needed for growth, development and disease prevention.[3]

The role of conflict

Conflict is one important driver of these recent increases in food insecurity. Most of the world's hungry people live in countries affected by conflict,[4] and—as discussed in Chapter 3 (Heads and Hearts)—the number of conflicts around the world has increased in recent years. All 19 of the countries classified in 2017 as experiencing protracted food crises were also affected by violent conflict.[5]

Conflict can trigger the kind of systemic disruptions of food systems discussed in the 2016 *Global Risks Report*, and as noted in the 2017 State of Food Security and Nutrition report: ". . . conflict can lead to economic and price impacts that reduce household food access and may also constrain people's mobility, thereby limiting household

access to food, health services and safe water."[6] In Yemen, the rial depreciated sharply in the second half of 2018, pushing up the price of food and essential commodities; in the capital city Sana'a, food prices increased by 35% between July and October. Conflict also triggers displacement, which creates food security issues. Currently 68.5 million people are displaced worldwide. Providing adequate food for refugees is an ongoing struggle. In 2016, the UN's World Food Programme had to halve rations in Kenyan refugee camps.[7] In 2017, rations were cut three times in Ethiopia's refugee camps because of insufficient funding.[8]

Population growth and waste

Global population growth exacerbates the impact on food systems of conflict and other drivers of food insecurity. To sustain current levels of food availability between now and 2050 will require an estimated 70% increase in food production.[9] The efficiency of efforts to intensify food production will be compromised unless wastage is also addressed: currently, around a third of the world's food is wasted.[10] Levels of food waste vary widely, from 95 kilograms per person each year in the United States to 1 kilogram in Rwanda.[11] Research suggests that food waste could rise by almost 2% per year to 2030.[12] The impacts go beyond food security: according to the Food and Agricultural Organization of the UN (FAO), food waste causes an estimated 8% of annual greenhouse gas emissions.[13]

Climate change and chokepoints

Climate change continues to increase strain on the global food system through "changes in temperature, precipitation and extreme weather events, as well as increasing CO_2 concentrations."[14] The last four years have been the hottest on record.[15] The Intergovernmental Panel on Climate Change (IPCC) has warned about the impacts on food security if global warming exceeds the 1.5°C targeted in the Paris Agreement. For example, while an estimated 35 million people would be exposed to crop yield changes at 1.5°C, this would increase to 1.8 billion at 3°C. Already around one-third of changes in yields are due to climate factors.[16] Drought conditions in Europe during 2018 led to the region's lowest grain production since 2012,[17] contributing to an expected sharp decrease in global grain stocks.[18] The food system also has to compete for water with other users, including urban groundwater extraction, as discussed in Chapter 5 (Fight or Flight).

Researchers also identify climate change as a risk factor affecting food system "chokepoints"—maritime corridors, coastal infrastructure and inland transport networks[19]—which handle a disproportionate volume of global food trade: "Half of all internationally traded grain must pass through at least one of 14 major chokepoints and over 10% depends on a maritime chokepoint to which there is no viable alternative route."[20] The risk posed by these chokepoint vulnerabilities has increased in tandem with the growing role of global food supply chains—between 2000 and 2015, the volume of agricultural commodities traded internationally increased by 127%.[21] The researchers note that climate change increases the risk of multiple chokepoint failures occurring simultaneously: "A worst-case scenario—one in which the Gulf Coast ports in the US were shut down due to a hurricane at the same time as key roads in Brazil were swamped owing to heavy rains—would cut off up to half of global soybean supply in one fell swoop."[22]

The Space for Civil Society

The 2017 *Global Risks Report* included a chapter that discussed the "[c]losing space for civil society". That chapter warned of growing constraints on the operation of civil society organizations around the world, with adverse consequences including declining societal trust and increasing corruption, polarization and unrest. The chapter cited research pointing to serious threats to civic freedoms in 109 countries, notably press freedom. It highlighted the frequent use of security considerations to justify restrictions on civil society groups, and the growing importance of new technologies as a means of limiting freedom of expression and assembly.

Normally we would wait longer than two years to feature a topic in the Hindsight series, but even in this short time these trends have increasingly defined the societal and political risks landscape in many countries. This reflects a general intensification of strong-state politics and a shift to more authoritarian modes of governance in both democratic and non-democratic states.

In its latest annual report, Freedom House stated that global freedom declined in 2017 for the 12th consecutive year, with 113 countries recording a net decrease in freedom over that period compared to 62 recording an improvement. According to the civil society monitoring group CIVICUS, conditions continued to tighten during 2018—between March and November there was a rise in the number of countries categorized as "obstructed" or "repressed" and a decline in those categorized as "open" or "narrowed".

Press under pressure

Globally, the most frequent violations of civic freedoms recorded by CIVICUS relate to freedom of the press. Developments over the past two years have borne out the concerns raised in our 2017 report. There has been a broad-based decline in press freedom around the world. The Economist Intelligence Unit ranks 2017 as the worst year since it began its index of media freedom in 2006.[23]

Conditions have deteriorated significantly even in a number of countries in Europe, the region where protections for journalists are typically strongest, according to Reporters Without Borders. Malta and Slovakia have seen high-profile murders of journalists in the past 18 months.[24]

Conservative groups gain strength

We omitted in 2017 to discuss one development that has since become more important. While most well-established non-governmental organizations (NGOs) are liberal, it is important to note that conservative civil society groups play a prominent role in some countries.

A recent study points to the influence of conservative civil society movements in other countries, including Brazil, India, Thailand, Turkey, Uganda, Ukraine and the United States.[25] These groups pursue a range of causes—rooted in different religious beliefs, community norms and political views—but one commonality is "the search for protection—protection from change, from outside economic pressures, from new kinds of identities and moral codes."[26]

Security concerns continue

Governments restricting civic freedoms continue to cite security as a justification. A 2018 report by the UN Special Rapporteur on the Rights to Freedom of Peaceful Assembly and of Association identifies concerns including "declarations of a state of emergency, sometimes without adequate justification, the use of vague wording to define acts of terrorism and threats to public security, and broad legal provisions that allow for the abusive interpretation of limitations on the rights to freedom of peaceful assembly and of association."[27] The report cites provisions of varying severity in almost 20 countries.

The Special Rapporteur also notes the growing use of restrictive rules and regulations that make it difficult for civil society groups to operate. These can range from onerous administrative requirements to more substantive provisions: "some restrictions require non-governmental organizations (NGOs) to align their activities with government policies, with heavy sanctions for NGOs that fail to do so."[28] Organizations in receipt of foreign funding are at particular risk—a trend we highlighted in 2017, and one that is likely to intensify. Against the backdrop of values-based geopolitical tensions discussed in Chapter 2 (Power and Values), many countries already worry about rivals using "information operations" to sow political instability.[29]

The use of new technologies to monitor or control civil society is also likely to have deepening geopolitical ramifications. Globally, online freedom has declined for eight consecutive years.[30] The Special Rapporteur notes the "utmost importance" of new technologies for freedom of assembly and highlights how some governments have prohibited access to social networking platforms.[31] Some see digital freedom as a key fault line in the evolving multipolar and multi-conceptual world order.[32]

Investment in Infrastructure

Nine years ago, the fifth edition of the *Global Risks Report* drew attention to the need for greater investment in infrastructure. The report was published in 2010, a year after the global economy had contracted at the height of the financial crisis. Against this backdrop of slumping demand and heightened uncertainty, the report cited global infrastructure needs equivalent to an estimated US$35 trillion over 20 years. It pointed to two key trends that would shape the challenge—population growth and climate change—and the need for associated development in the agriculture and energy sectors. It also warned that vulnerabilities in critical infrastructure were a source of wider systemic risk that needed to be assessed and managed.

Since then, estimates of future needs have increased. According to projections from the Global Infrastructure Hub (GIH), a body created by the G20, infrastructure investment totalling US$97 trillion is required by 2040 across 57 countries and seven sectors. That compares with current investment trends of US$79 trillion, leaving a global infrastructure gap of US$18 trillion.[33] Many countries, both emerging and advanced, "have paid insufficient attention to maintaining and expanding their infrastructure assets, creating economic inefficiencies and allowing critical systems to erode."[34]

Spending gaps vary by region

Infrastructure spending has differed sharply by region in recent years, with one estimate ranging from 1.9% of GDP in Sub-Saharan Africa to 6.9% in the Middle East and North Africa.[35] In absolute terms, levels of spending have been particularly high in Asia, specifically China. Asia Pacific accounted for more than half of global infrastructure spending in 2015.[36]

According to GIH projections, China is the country with the most significant infrastructure needs between now and 2040. On current trends, China will fall US$1.9 trillion short of its total spending requirement of US$28 trillion. In the United States, overall investment needs are much lower (US$12 trillion), but the shortfall relative to current trends is twice as large (US$3.8 trillion). In our 2010 report we noted that the American Society of Civil Engineers (ASCE) rated the infrastructure stock of the United States at "D" (where "A" is the best, and anything below "D" is unfit for purpose). The latest ASCE report card is from 2017, when the United States had improved only marginally to a rating of "D+".[37]

Relative to GDP, Africa has the largest infrastructure gap between now and 2040.[38] One reason is that Africa's population is set to double over that period. Meeting the region's infrastructure needs is likely to require significant change: concerns that we cited in 2010 about weak political and governance systems continue to hold back flows of investment finance. The African Development Bank notes that in 2016 commitments of public and private infrastructure funding fell to their lowest level in five years, largely as a consequence of a reported reduction in inflows from China.[39]

Growing risks: FDI and cyber

In recent decades, the profile of development finance in general—and for infrastructure projects in particular—has swung from traditional aid flows to foreign direct investment (FDI).[40] China has been instrumental: its share of global investment flows increased from 4% in 2006 to 17% by 2017.[41] Flows of FDI into developing countries have become increasingly geopolitically charged, as discussed in Chapter 2 (Power and Values). The interdependencies created by a deepening web of international infrastructure projects were not a

pressing concern at the time of our 2010 report, but they are now a growing source of risk in the international system.

Technology has also radically altered risks related to infrastructure development over the past decade. The critical infrastructure risks we noted in 2010 have risen as digitalization and the Internet of Things have deepened connectivity across the world, increasing the potential for malicious actors to mount online attacks and amplifying their potential damage. A successful cyber-attack on a country's electricity system, for example—a current area of focus for the World Economic Forum[42]—could trigger devastating spill-over effects. One estimate suggests that energy utilities spent US$1.7 billion in 2017 on protecting their systems from cyber-attacks.[43]

Low-carbon infrastructure

Climate change has driven significant change in the world's infrastructure needs since our 2010 report. There is now more awareness of the risks it poses and greater consensus on the need for collective policy responses. The low-carbon transition will shape the profile of infrastructure investment in multiple ways. For example, in the energy sector, investment in renewables is likely to accelerate, despite a pause in the shift towards cleaner energy in 2017.[44] Transport infrastructure will need to be adapted to manage increasing shares of electric vehicles, as well as huge projected increases in road, air and sea traffic.[45] And sensor-based technologies are likely to be widely deployed across all kinds of networks and grids, increasing demand for the digital infrastructure on which they rely.[46]

The climate-change imperative will also drive increased investment in "green infrastructure" solutions of the kind discussed in Chapter 5 (Fight or Flight). These work with natural materials and can, for example, lower energy demand, reduce urban temperatures and improve water management.[47]

The rapid roll-out of sustainable infrastructure is likely to lead to continuing financial innovation as more investors move into this market. Already there has been a significant increase in the number of funds investing in infrastructure assets generally, pushing returns down from 14% in 2004 to 10.6% in 2016.[48] According to UN Environment, issuance of "green bonds" jumped from US$11 billion in 2013 to US$155 billion in 2017.[49] There are potential risks associated with the rapid expansion of green finance—including asset bubbles and the temptation to lower capital requirements to encourage sustainable investment[50]—but the costs of managing these risks are likely to be small compared with the benefits of making increased funding available to help meet the world's infrastructure needs sustainably.

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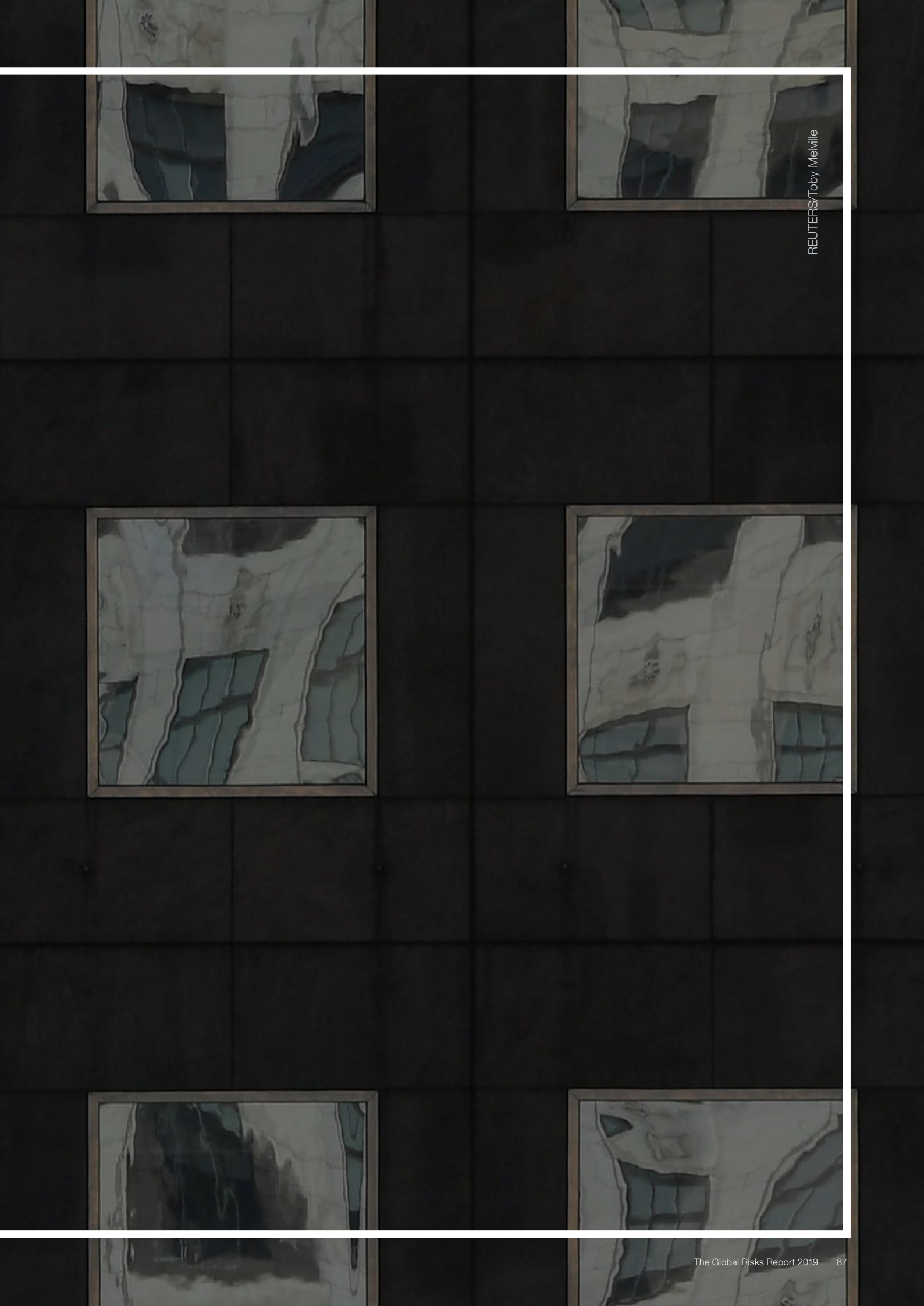
Risk Reassessment

In the Risk Reassessment section of the *Global Risks Report*, we invite selected risk experts to share their insights about risk and risk management. The aim is to encourage fresh thinking about how to navigate a rapidly evolving risks landscape. In this year's report, John D. Graham discusses the importance of considering trade-offs between risks—because efforts to mitigate one risk can often exacerbate others. And András Tilcsik and Chris Clearfield highlight a number of the steps that can be taken to protect organizations from systemic risks.



REUTERS/Toby Melville

Weighing Risks

By John D. Graham

Corporate executives, regulators, physicians and security officials often face a shared dilemma in decision-making: deciding which risks to accept, at least for now. The stark reality is that few decision options in these fields are without any risk. The executive may decide in favour of a promising acquisition, despite knowing that merging with an unfamiliar company is fraught with downside risks. Heart patients often trust cardiologists to help them decide whether the longevity gains from coronary artery bypass surgery are worth its additional surgical dangers compared with the simpler angioplasty procedure. The bold German phase-out of nuclear power is indirectly forcing Germany to incur greater risks from coal-fired electricity, at least until the ambitious path to renewables is accomplished. And measures to counteract terrorism at airports may not reduce overall societal risk if terrorists simply respond by shifting to new vulnerable targets such as sporting events, concerts and subways.

Trade-offs between risks

What might be called the "target risk" is the one of primary concern to decision-makers. The Trump administration sees imports from China as an immediate threat to American businesses because there are plenty of US businesses that have been damaged by government-subsidized Chinese products. The "countervailing risk" is the unintended risk triggered by interventions to reduce the target risk. Slapping tariffs on Chinese imports may bring the Chinese to the negotiating table but, in the interim, the tariffs make some US goods more expensive in global markets, especially those that rely on Chinese inputs. US tariffs also invite a trade war with the Chinese that will create some countervailing risks for US exporters that do business in China.

The challenge of resolving trade-offs between target and countervailing risks is particularly perplexing in the short run. Technological options are fairly fixed, research and development (R&D) solutions are beyond the relevant time horizon, and current legal and organizational arrangements in both government and business are difficult to reform quickly. In the long run, there are more "risk-superior" solutions because the extra time for risk management allows R&D, innovation and organizational change to work against both the target and countervailing risks.

The most promising short-run solution to risk trade-offs is as simple in theory as it is devilishly difficult in practice: identify and carefully weigh the competing risks of decision alternatives. For example, with the global economy in an encouraging recovery, it is tempting for policy-makers to enforce monetary discipline—but that discipline might cause interest rates to rise above the surprisingly low levels that have become familiar throughout much of the world. If interest rates rise too much or too fast, the adverse effects on business activity are predictable. Weighing the risks and benefits of monetary discipline is a crucial responsibility of monetary policy-makers.

Geography and culture

Risk trade-offs are particularly sensitive for decision-makers when the parties suffering from the target risk are different from the parties likely to experience the countervailing risk. In China, electric cars look promising to families in polluted Eastern cities who breathe motor vehicle exhaust on a daily basis, especially those families living close to congested roads and highways. But, when electric cars are recharged by drawing electricity

from the Chinese electrical grid, more pollution is generated at the electric power plants. Those facilities may be located on the perimeter of Chinese cities or in the less prosperous, inner regions of China where electricity plants are easier to site. It requires careful air quality modelling, informed by state-of-the-art atmospheric chemistry and high-resolution geographic information systems, to know precisely who will incur the indirect public health risks of plug-in electric cars. If the countervailing risks are not given the same analytic attention as the target risks, it is impossible for a thoughtful regulator to weigh the ethical aspects of shifting pollution from one population to another. In this setting, making the countervailing risks as transparent as the target risks is easier said than done.

When decisions about risk trade-offs are made in different cultures, it should be expected that some stark differences will result. In the United States, the national energy policies of both George W. Bush and Barack Obama facilitated a surge of unconventional oil and gas development through innovations such as multi-stage hydraulic fracturing and horizontal drilling. The diffusion of innovation occurred so rapidly in the states of Pennsylvania, North Dakota, Oklahoma and Texas that state regulators are only beginning to fully understand and regulate the resulting risks of earthquakes and water pollution. The same unconventional technologies used in the United States are seen as unacceptable in Germany, where bans on "fracking" were imposed before the new industry could get off the ground. Businesses and households in Germany are incurring high natural gas prices as well as greater dependence on Russian gas as a result of the ban on fracking, but German policy-makers are entitled to make those trade-offs.

Stark international differences in regulatory risk management are less acceptable when the alleged risks relate not to production activity, which is confined to a particular country, but to consumption of goods that are traded across borders in a global economy. The World Trade Organization (WTO) has already exposed several instances where countries have tried to use health-risk concerns to conceal protectionist motivations for product bans and restrictions. The Chinese are concerned that the United States and the European Union behave in this fashion; the United States has already won cases against the European Union at the WTO related to hormone-treated beef and genetically modified seeds.

One of the advantages of evidence-based approaches to resolving trade disputes is that all countries, regardless of cultural norms, have access to scientific evidence. Understanding cultural norms is a more subjective exercise. Scientific knowledge about risk and safety does not stop at an international border, though genuine uncertainty about the severity of established risks might justify differences in the precautionary regulations of different countries. The WTO is far from a perfect organization, but it has potential to promote an evidence-based approach to risk management and foster more international learning about risk trade-offs.

Investing to ease risk trade-offs

Fortunately, the long run opens up more promising opportunities for superior management of risk. New surgical techniques have made coronary artery bypass surgery much safer and more effective today than it was 20 years ago. The fracking techniques used today in the United States and Canada are much more sustainable and cost-effective than the techniques used only five years ago. And progress in battery technology is making electrification of the transport sector a more plausible, sustainable and affordable option than most experts believed possible a decade ago.

The hard question is how to foster productive R&D investments to ease difficult risk trade-offs. When will innovation occur productively

through market competition, and when does an industry require incentives, nudging or even compulsion in order to innovate? Should governmental subsidies focus on basic research, or is there also a need for government to pick some promising technologies and subsidize real-world demonstrations? There are plenty of cases where government R&D policy has produced "duds" in the commercial marketplace, but there are also cases, such as fracking and plug-in electric vehicles, where government R&D policy has played a constructive role in fostering exciting and transformative innovations.

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Managing in the Age of Meltdowns

By András Tilcsik and Chris Clearfield

While we are right to worry about major events—such as natural disasters, extreme weather and coordinated cyber-attacks—it is often the cascading impact of small failures that brings down our systems. The sociologist Charles Perrow identified two aspects of systems that make them vulnerable to these kinds of unexpected failures: complexity and tight coupling.[1] A complex system is like an elaborate web with many intricately connected parts, and much of what goes on in it is invisible to the naked eye. A tightly coupled system is unforgiving: there is little slack in it, and the margin for error is slim.

When something goes wrong in a complex system, problems start popping up everywhere, and it is hard to figure out what's happening. And tight coupling means that the emerging problems quickly spiral out of control and even small errors can cascade into massive meltdowns.

When Perrow developed his framework in the early 1980s, few systems were both highly complex and tightly coupled; the ones that were tended to be in exotic, high-tech domains such as nuclear power plants, missile warning systems and space-exploration missions. Since then, however, we have added an enormous amount of complexity to our world. From connected devices and global supply chains to the financial system and new intricate organizational structures, the potential for small problems to trigger unexpected cascading failures is now all around us.

The good news is that there are solutions. Though we often cannot simplify our systems, we can change how we manage them. Research shows that small changes in how we organize our teams and approach problems can make a big difference.

Think small

In complex and tightly coupled systems—from massive information technology (IT) projects to business expansion initiatives—it is not possible to identify in advance all the ways that small failures might lead to catastrophic meltdowns. We have to gather information about close calls and little things that are not working to understand how our systems might fail. Small errors give us great data about system vulnerabilities and can help us discover where more serious threats are brewing. But many organizations fail to learn from such near misses. It is an all-too-human tendency familiar from everyday life: we treat a toilet that occasionally clogs as a minor inconvenience rather than a warning sign—until it overflows. Or we ignore subtle warning signs about our car rather than taking it into the repair shop. In a complex system, minor glitches and other anomalies serve as powerful warning signs—but only if we treat them as such.

Leaders can build organizational capabilities that attend to weak signals of failure. The pharmaceutical giant Novo Nordisk started developing such capabilities after senior executives were shocked by a manufacturing quality breakdown that cost more than US$100 million. In the wake of the failure, Novo Nordisk did not blame individuals or encourage managers to be more vigilant. Instead, it created a new group of facilitators tasked with interviewing people in every unit and at all levels to make sure important issues don't get lost at the bottom of the hierarchy. The group follows up on small issues before they become big problems.

Encourage scepticism

When success depends on avoiding small failures, we need to build scepticism into our

[1] Perrow, C. 1999. *Normal Accidents*. Princeton, NJ: Princeton University Press.

organizations so that we consider our decisions from multiple angles and avoid groupthink. One approach, pioneered by NASA's Jet Propulsion Laboratory (JPL), is to embed a sceptic in every project team—specifically, an engineer from JPL's Engineering Technical Authority (ETA).

ETA engineers are ideal sceptics. They are skilled enough to understand the technology and the mission but detached enough to bring a distinct perspective. And the fact that they are embedded in the organization, but with their own reporting lines, means that project managers cannot just dismiss their concerns. If an ETA engineer and a project manager cannot agree about a particular risk, they take their issue to the ETA manager, who tries to broker a technical solution, gets additional resources for the mission, or escalates the issue to JPL's Chief Engineer.

Another effective way to cultivate scepticism is through diversity. Surface-level diversity (differences of race and gender, for example) fosters healthy dissent in organizations. Research shows that diverse groups ask tougher questions, share more information and discuss a broader range of relevant factors before making a decision. Diversity in professional backgrounds matters, too. In one study that tracked over a thousand small banks for nearly two decades, researchers found that banks with fewer bankers on their boards were less likely to fail.[2] The explanation: non-bankers were more likely to disrupt groupthink by challenging seemingly obvious assumptions. As one bank CEO with a professionally diverse board put it: "When we see something we don't like, no one is afraid to bring it up."

Learn to stop

When faced with a problem or surprising event, our instinct is often to push forward. But sticking to a plan in the face of an emerging problem can easily lead to a disaster. Stopping gives us a chance to assess unexpected threats and figure out what to do before things get out of hand. It sounds simple, but in practice it can be nerve-wracking for team members to trigger delays and disruption for something that might turn out to be a false alarm. This is something leaders need to actively encourage.

In some cases, stopping may not be an option. In those situations, effective crisis management requires rapidly cycling between doing, monitoring, and diagnosing. We *do* something to try and fix the system. We *monitor* what happens in response, checking to see if our actions had the intended effect. If they didn't, we use the information from our monitoring to make a new *diagnosis* and move to the next phase of *doing*. Research shows that teams that cycle rapidly in this way are more likely to solve complex, evolving problems.

Imagine failure

Cognitive biases are often the source of the small errors that trigger major failures in complex, tightly coupled systems. Fortunately, there are some simple techniques we can use to make better decisions. One is the "premortem".[3] Imagine that it's six months from now and that the ambitious project you're about to undertake has failed. The premortem involves working backward to come up with reasons for the failure and ideas for what could have been done to prevent it. The process is distinct from brainstorming about risks that *might* emerge: by asserting that failure *has already* happened, we tap into what psychologists call "prospective hindsight", letting us anticipate a broader and more vivid set of problems.

Similarly, the use of predetermined criteria to make decisions can prevent us from relying on our (often incorrect) gut reactions. Too often, we base decisions on predictions that are overly simplistic, missing important possible outcomes. For example, we might anticipate that a project will take between one and three months to complete. One way of being more structured about this kind of forecast is to use

[2] Alamandoz, J. and A. Tilcsik. 2016. "When Experts Become Liabilities: Domain Experts on Boards and Organizational Failure". *Academy of Management Journal* 59, 4 (2016): 1124–49.
[3] Klein, G. 2007. "Performing a Project Premortem". *Harvard Business Review*. September 2007.

Subjective Probability Interval Estimates (SPIES), which entails dividing the *entire* possible range of outcomes into intervals and then estimating the probability of each. In our example, we might consider six intervals for the project's duration: zero to one month, one to two months, two to three months, three to four months, four to five months, and more than five months.[4]

Conclusion

Even with all these techniques, things will go wrong. When they do, we need to do a better job of learning lessons. Too often there is practically a script: a superficial post-mortem is conducted, an individual or a specific technical problem is found to be at fault, and a narrow fix is implemented. Then it's back to business as usual. That is not good enough anymore. We need to face reality with a blameless process that not only identifies specific issues but also looks at broader organizational and systemic causes. Only by doing this—and by recognizing early warning signs, building scepticism into organizations, using structured decision tools and managing our crises better—will we be able to prevent the "unprecedented errors" that seem to be a defining feature of the modern world.

Chris Clearfield and András Tilcsik are the co-authors of Meltdown: Why Our Systems Fail and What We Can Do About It *(Penguin Press, 2018).*

[4] Haran, U. and A. Moore. 2014. "A Better Way to Forecast". *California Management Review* 57 (1): 5–15.

Appendices

REUTERS/Nick Oxford

Appendix A | Descriptions of Global Risks and Trends 2019

Global Risks

A "global risk" is defined as an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years.

To ensure legibility, the names of the global risks have been abbreviated in the figures. The portion of the full name used in the abbreviation is in bold.

	Global Risk	Description
Economic	**Asset bubbles** in a major economy	Unsustainably overpriced assets such as commodities, housing, shares, etc. in a major economy or region
	Deflation in a major economy	Prolonged near-zero inflation or deflation in a major economy or region
	Failure of a major **financial mechanism or institution**	Collapse of a financial institution and/or malfunctioning of a financial system that impacts the global economy
	Failure/shortfall of **critical infrastructure**	Failure to adequately invest in, upgrade and/or secure infrastructure networks (e.g. energy, transportation and communications), leading to pressure or a breakdown with system-wide implications
	Fiscal crises in key economies	Excessive debt burdens that generate sovereign debt crises and/or liquidity crises
	High structural unemployment or underemployment	A sustained high level of unemployment or underutilization of the productive capacity of the employed population
	Illicit trade (e.g. illicit financial flows, tax evasion, human trafficking, organized crime, etc.)	Large-scale activities outside the legal framework such as illicit financial flows, tax evasion, human trafficking, counterfeiting and/or organized crime that undermine social interactions, regional or international collaboration, and global growth
	Severe **energy price shock** (increase or decrease)	Significant energy price increases or decreases that place further economic pressures on highly energy-dependent industries and consumers
	Unmanageable inflation	Unmanageable increases in the general price levels of goods and services in key economies

Environmental	**Extreme weather events** (e.g. floods, storms, etc.)	Major property, infrastructure, and/or environmental damage as well as loss of human life caused by extreme weather events
	Failure of climate-change mitigation and adaptation	The failure of governments and businesses to enforce or enact effective measures to mitigate climate change, protect populations and help businesses impacted by climate change to adapt
	Major **biodiversity loss and ecosystem collapse** (terrestrial or marine)	Irreversible consequences for the environment, resulting in severely depleted resources for humankind as well as industries
	Major natural disasters (e.g. earthquakes, tsunamis, volcanic eruptions, geomagnetic storms)	Major property, infrastructure, and/or environmental damage as well as loss of human life caused by geophysical disasters such as earthquakes, volcanic activity, landslides, tsunamis, or geomagnetic storms
	Man-made environmental damage and **disasters** (e.g. oil spills, radioactive contamination, etc.)	Failure to prevent major man-made damage and disasters, including environmental crime, causing harm to human lives and health, infrastructure, property, economic activity and the environment
Geopolitical	**Failure of national governance** (e.g. failure of rule of law, corruption, political deadlock, etc.)	Inability to govern a nation of geopolitical importance as a result of weak rule of law, corruption or political deadlock
	Failure of regional or global governance	Inability of regional or global institutions to resolve issues of economic, geopolitical, or environmental importance
	Interstate conflict with regional consequences	A bilateral or multilateral dispute between states that escalates into economic (e.g. trade/currency wars, resource nationalization), military, cyber, societal, or other conflict
	Large-scale **terrorist attacks**	Individuals or non-state groups with political or religious goals that successfully inflict large-scale human or material damage
	State collapse or crisis (e.g. civil conflict, military coup, failed states, etc.)	State collapse of geopolitical importance due to internal violence, regional or global instability, military coup, civil conflict, failed states, etc.
	Weapons of mass destruction	The deployment of nuclear, chemical, biological, and radiological technologies and materials, creating international crises and potential for significant destruction

Societal	**Failure of urban planning**	Poorly planned cities, urban sprawl and associated infrastructure that create social, environmental and health challenges
	Food crises	Inadequate, unaffordable, or unreliable access to appropriate quantities and quality of food and nutrition on a major scale
	Large-scale involuntary migration	Large-scale involuntary migration induced by conflict, disasters, environmental or economic reasons
	Profound social instability	Major social movements or protests (e.g. street riots, social unrest, etc.) that disrupt political or social stability, negatively impacting populations, and economic activity
	Rapid and massive **spread of infectious diseases**	Bacteria, viruses, parasites, or fungi that cause uncontrolled spread of infectious diseases (for instance as a result of resistance to antibiotics, antivirals and other treatments) leading to widespread fatalities and economic disruption
	Water crises	A significant decline in the available quality and quantity of fresh water, resulting in harmful effects on human health and/or economic activity
Technological	**Adverse consequences of technological advances**	Intended or unintended adverse consequences of technological advances such as artificial intelligence, geo-engineering and synthetic biology causing human, environmental, and economic damage
	Breakdown of critical information infrastructure and networks **(Critical information infrastructure breakdown)**	Cyber dependency that increases vulnerability to outage of critical information infrastructure (e.g. internet, satellites, etc.) and networks, causing widespread disruption
	Large-scale **cyber-attacks**	Large-scale cyber-attacks or malware causing large economic damages, geopolitical tensions, or widespread loss of trust in the internet
	Massive incident of **data fraud/theft**	Wrongful exploitation of private or official data that takes place on an unprecedented scale

Trends

A "trend" is defined as a long-term pattern that is currently evolving and that could contribute to amplifying global risks and/or altering the relationship between them.

Trend	Description
Ageing population	Ageing populations in developed and developing countries driven by declining fertility and decrease of middle- and old-age mortality
Changing landscape of international governance	Changing landscape of global or regional institutions (e.g. UN, IMF, NATO, etc.), agreements or networks
Changing climate	Change of climate, which is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere, in addition to natural climate variability
Degrading environment	Deterioration in the quality of air, soil and water from ambient concentrations of pollutants and other activities and processes
Growing middle class in emerging economies	Growing share of population reaching middle-class income levels in emerging economies
Increasing national sentiment	Increasing national sentiment among populations and political leaders affecting countries' national and international political and economic positions
Increasing polarization of societies	Inability to reach agreement on key issues within countries because of diverging or extreme values, political or religious views
Rising chronic diseases	Increasing rates of non-communicable diseases, also known as "chronic diseases", leading to rising costs of long-term treatment and threatening recent societal gains in life expectancy and quality
Rising cyber dependency	Rise of cyber dependency due to increasing digital interconnection of people, things and organizations
Rising geographic mobility	Increasing mobility of people and things due to quicker and better-performing means of transport and lowered regulatory barriers
Rising income and wealth disparity	Increasing socioeconomic gap between rich and poor in major countries or regions
Shifting power	Shifting power from state to non-state actors and individuals, from global to regional levels, and from developed to emerging markets and developing economies
Rising urbanization	Rising number of people living in urban areas resulting in physical growth of cities

Appendix B | Global Risks Perception Survey and Methodology

The Global Risks Perception Survey (GRPS) is the World Economic Forum's source of original risks data, harnessing the expertise of the Forum's extensive network of business, government, civil society and thought leaders. The survey was conducted from 6 September to 22 October 2018 among the World Economic Forum's multistakeholder communities, the professional networks of its Advisory Board, and members of the Institute of Risk Management. The results of the GRPS are used to create the Global Risks Landscape, Interconnections Map, and Trends Map presented at the beginning of the report, and to offer insights used throughout.

Both the GRPS and the *Global Risks Report* adopt the following definitions of global risk and trend:

Global risk: A "global risk" is an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years.

Trend: A "trend" is defined as a long-term pattern that is currently evolving and that could contribute to amplifying global risks and/or altering the relationship between them.

Methodology

The world in 2019

In the first section of the GRPS, respondents were asked to assess whether the risks associated with 42 current issues would increase or decrease in 2019 compared to 2018. For a list of these issues, see Figure 1.2 (page 12), which summarizes the results.

The possible answers ranged from "significantly decrease" to "significantly increase" along a 1–5 scale. For each issue, the share for each answer ("significantly increase", "somewhat increase", "no change", "somewhat decrease" or "significantly decrease") was obtained by dividing the number of respondents who selected that answer by the total number of answers.

In most cases, respondents were asked to base their answers on developments in their region. They were asked the following question: "In your region specifically, do you think that in 2019 the risks presented by the following issues will increase or decrease compared to 2018?" For the following seven issues, the question was framed globally: "On a global level, do you think that in 2019 the risks presented by the following issues will increase or decrease compared to 2018?"

- Economic confrontations/ frictions between major powers[1]
- Political confrontations/ frictions between major powers
- Erosion of global policy coordination on climate change
- Erosion of multilateral trading rules and agreements
- Loss of confidence in collective security alliances
- Regional conflicts drawing in major power(s)
- State-on-state military conflict or incursion

[1] In last year's Global Risks Perception Survey 2017–2018, respondents were asked to assess "Political or economic confrontations/frictions between major powers". In this year's survey, we separated this into two separate issues, one economic and one political.

The global risks landscape

For each of the 30 global risks listed in Appendix A, respondents were asked to assess (1) the likelihood of the risk occurring globally within the next 10 years, and (2) its negative impact for several countries or industries over the same timeframe.

For the first of these questions, the possible answers ranged from "very unlikely" to "very likely" along a 1–5 scale (1 = very unlikely, 5 = very Likely). For the second question, respondents could select one of five choices: "minimal", "minor", "moderate", "severe", or "catastrophic", again using a 1–5 scale (1 = minimal, 5 = catastrophic). Respondents could choose "no opinion" if they felt unable to provide an informed answer, and they could also leave the question completely blank. Partial responses for any risk—those assessing only the likelihood of occurrence or only the negative impact—were dropped.

A simple average for both likelihood and impact for each of the 30 global risks was calculated on this basis. The results are illustrated in the Global Risks Landscape 2019 (Figure I).

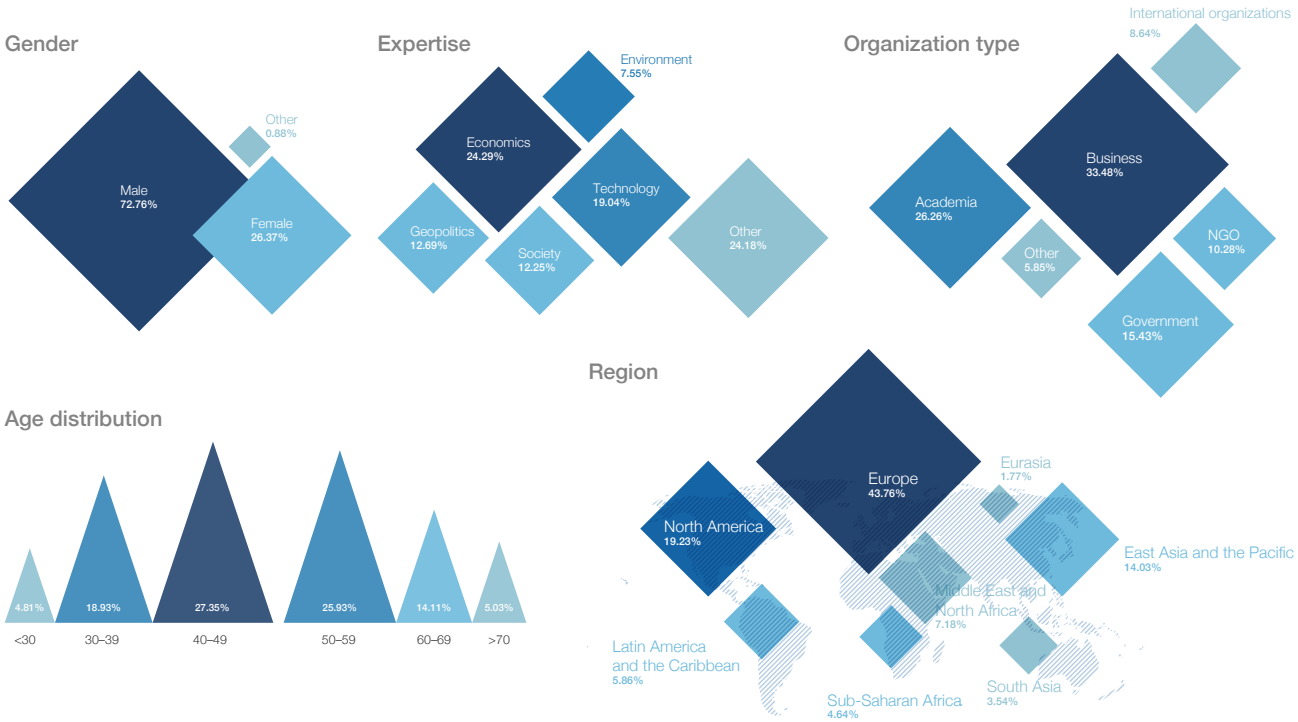
Formally, for any given risk *i*, its likelihood and impact—denoted respectively $likelihood_i$ and $impact_i$—are:

$$likelihood_i = \frac{1}{N_i}\sum_{n=1}^{N_i^1} likelihood_{i,n}$$

$$impact_i = \frac{1}{N_i}\sum_{n=1} impact_{i,n}$$

where N_i is the number of respondents for risk *i*, and $likelihood_{i,n}$ and $impact_{i,n}$ are, respectively, the likelihood and impact assigned by respondent *n* to risk *i*. The likelihood is measured on a scale of 1–5 and the impact on a scale of 1–5. N_i is the number of respondents for risk *i* who assessed both the likelihood and impact of that specific risk.

Figure B.1: Survey Sample Composition



Source: World Economic Forum Global Risks Perception Survey 2018–2019.
Note: Reported shares are based on the number of participants (916) who responded to biographical questions.

Global risks interconnections

Part 3 of the GRPS assesses interconnections between pairs of global risks. Part 4 assesses interconnections between global risks and a set of underlying trends or drivers.

For the interconnections between pairs of risks, survey respondents were asked the following question: "Global risks are not isolated, and it is important to assess their interconnections. In your view, which are the most **strongly connected** global risks? Please select three to six pairs of global risks." The results are illustrated in the Global Risks Interconnections Map 2019 (Figure III).

For the interconnections between trends and risks, respondents were first asked to identify up to three trends (for the full list, see Appendix A) that they considered most important in shaping the global agenda in the next 10 years. They were then asked to identify the three global risks that are most strongly driven by each of the three chosen trends. The two questions read: "What are the **three most important trends** (in no particular order) that will shape global development in the **next 10 years**?" followed by "For each of the three trends identified [in the previous question,] select up to three global risks . . . that are most **strongly driven** by these trends." The results are illustrated in the Risks-Trends Interconnections Map 2019 (Figure II).

In both cases, a tally was made of the number of times each pair was cited. This value was then divided by the count of the most frequently cited pair. As a final step, the square root of this ratio was taken to dampen the long-tail effect (i.e. a few very strong links and many weak ones) and to make the differences more apparent across the weakest connections. Formally, the intensity of the interconnection between risks *i* and *j*, or between trend *i* and risk *j*, denoted $\text{interconnection}_{ij}$, corresponds to:

$$\text{interconnection}_{ij} = \sqrt{\frac{\sum_{n=1}^{N} \text{pair}_{ij,n}}{\text{pair}_{max}}}$$

with

$$\text{pair}_{max} = \max_{ij}\left(\sum_{n=1}^{N} \text{pair}_{ij,n}\right)$$

where *N* is the number of respondents.

Variable $\text{pair}_{ij,n}$ is 1 when respondent *n* selected the pair of risks *i* and *j* as part of his/her selection. Otherwise, it is 0. The value of the interconnection determines the thickness of each connecting line in Figures II and III, with the most frequently cited pair having the thickest line.

In the Global Risks Landscape and the Risks-Trends Interconnections Map, the size of each risk is scaled according to the degree of weight of that node in the system. Moreover, in the Risks-Trends Interconnections Map, the size of the trend represents the perception of its importance in shaping global development (answer to the first part of the question on trend, as explained above); the most-frequently cited trend is the one considered to be the most important in shaping global development.

The placement of the nodes in the Risks-Trends Interconnections Map was computed using ForceAtlas2, a force-directed network layout algorithm implemented in Gephi software, which minimizes edge lengths and edge crossings by running a physical particle simulation.[2]

Completion thresholds

We did not apply an overall threshold for the GRPS completion rate. Instead, we set specific validity criteria for each section of the survey:

Part 1 "The World in 2019": Only respondents who assessed at least three of the risks listed in this question were considered (916 respondents met the criterion).

Part 2 "Assessment of Global Risks": The answers from the 885 respondents who assessed the impact and likelihood of at least one risk were used to compute the results (the answer "no opinion" is considered a valid answer, but leaving the question entirely blank is not).

Part 3 "Global Risk Interconnections": The answers from the 635 respondents who selected at least one valid pair of risks were used in the computation.

Part 4 "Assessments of Trends": The answers from the 749 respondents who selected at least one combination of an important trend and at least one associated risk were used in the computation.

Figure B.1 presents some key descriptive statistics and information about the profiles of the respondents.

[2] Jacomy, M., T. Venturini, S. Heymann, and M. Bastian. 2014. "ForceAtlas2: A Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software". *PLoS ONE 9* (6): e98679. doi:10.1371/journal.pone.0098679

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