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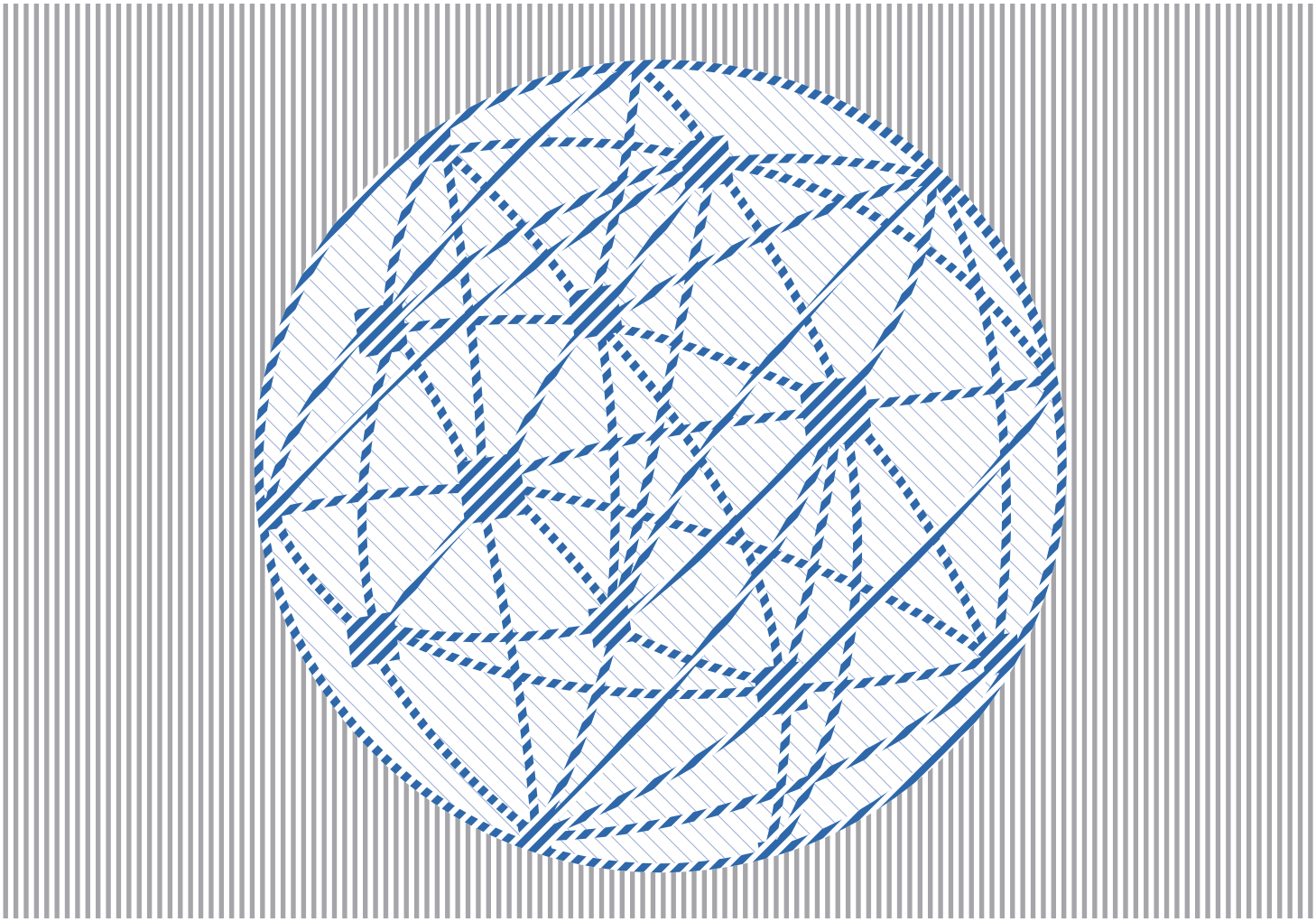
Insight Report

Global Risks 2013
Eighth Edition

An Initiative of the Risk Response Network



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Global Risks 2013
Eighth Edition

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World Economic Forum in collaboration with:

Marsh & McLennan Companies

National University of Singapore

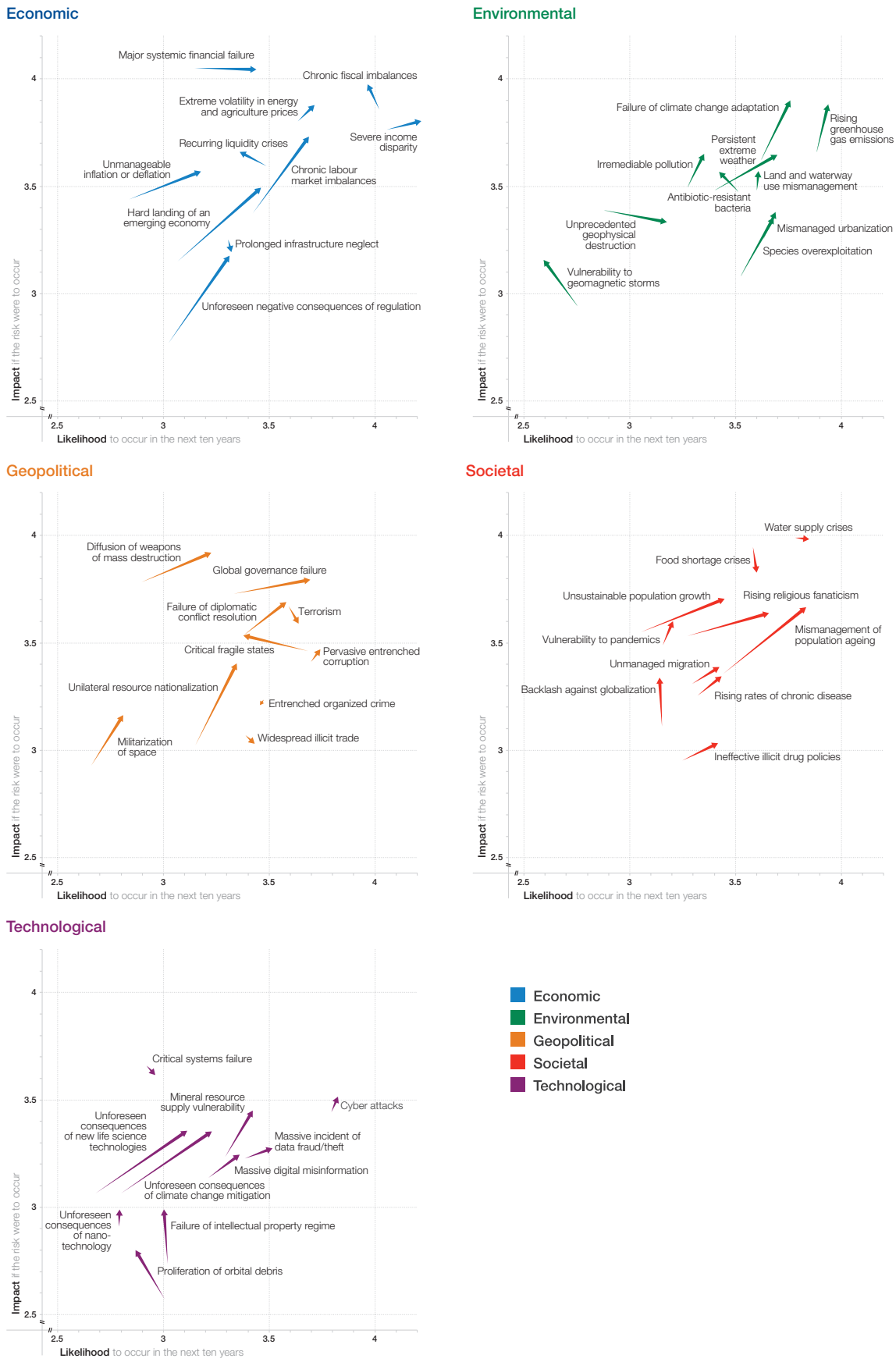
Oxford Martin School, University of Oxford

Swiss Reinsurance Company

Wharton Center for Risk Management, University of Pennsylvania

Zurich Insurance Group

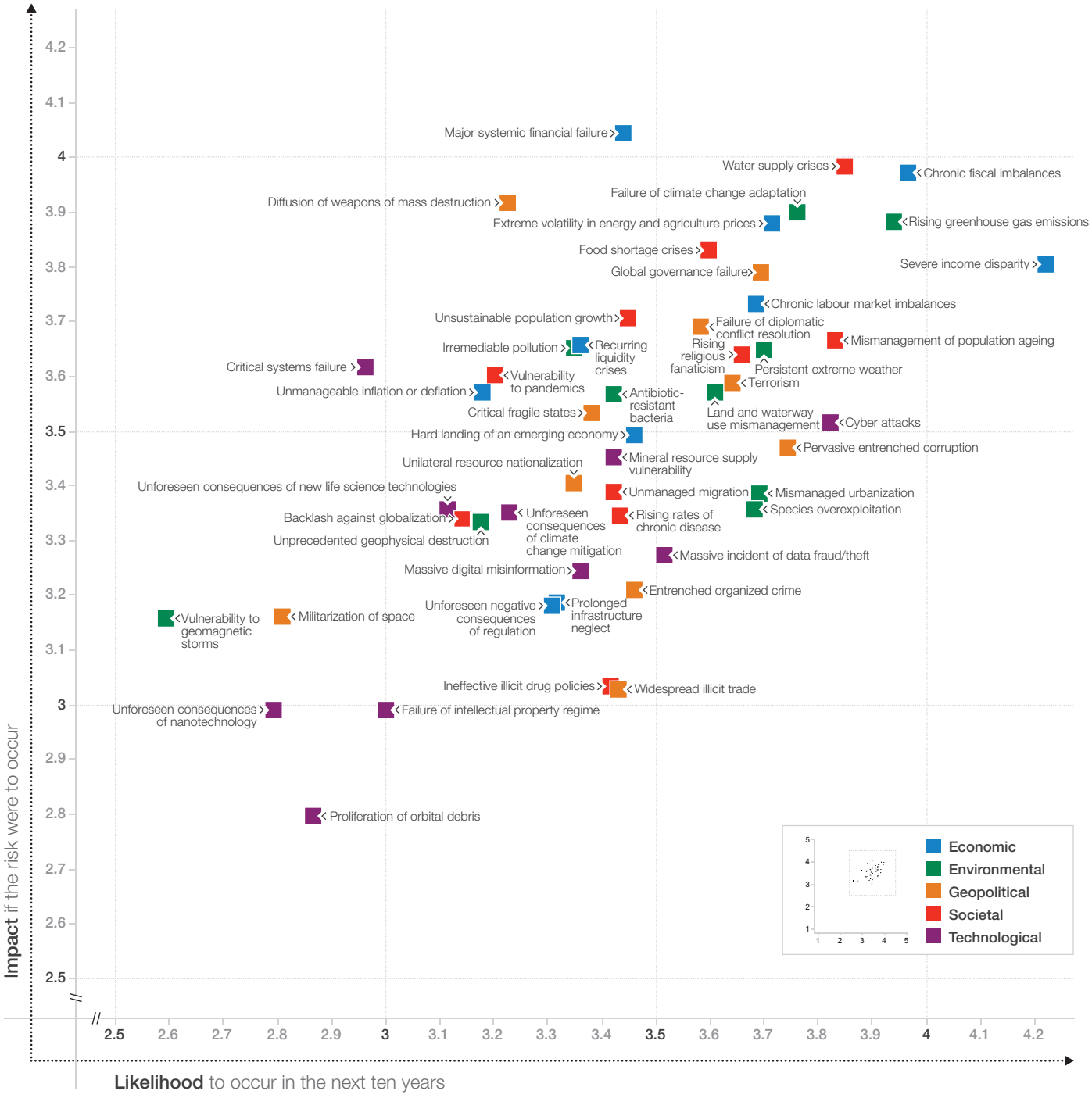
Figure 1: Global Risks Landscape 2013 versus 2012[i]



Source: World Economic Forum

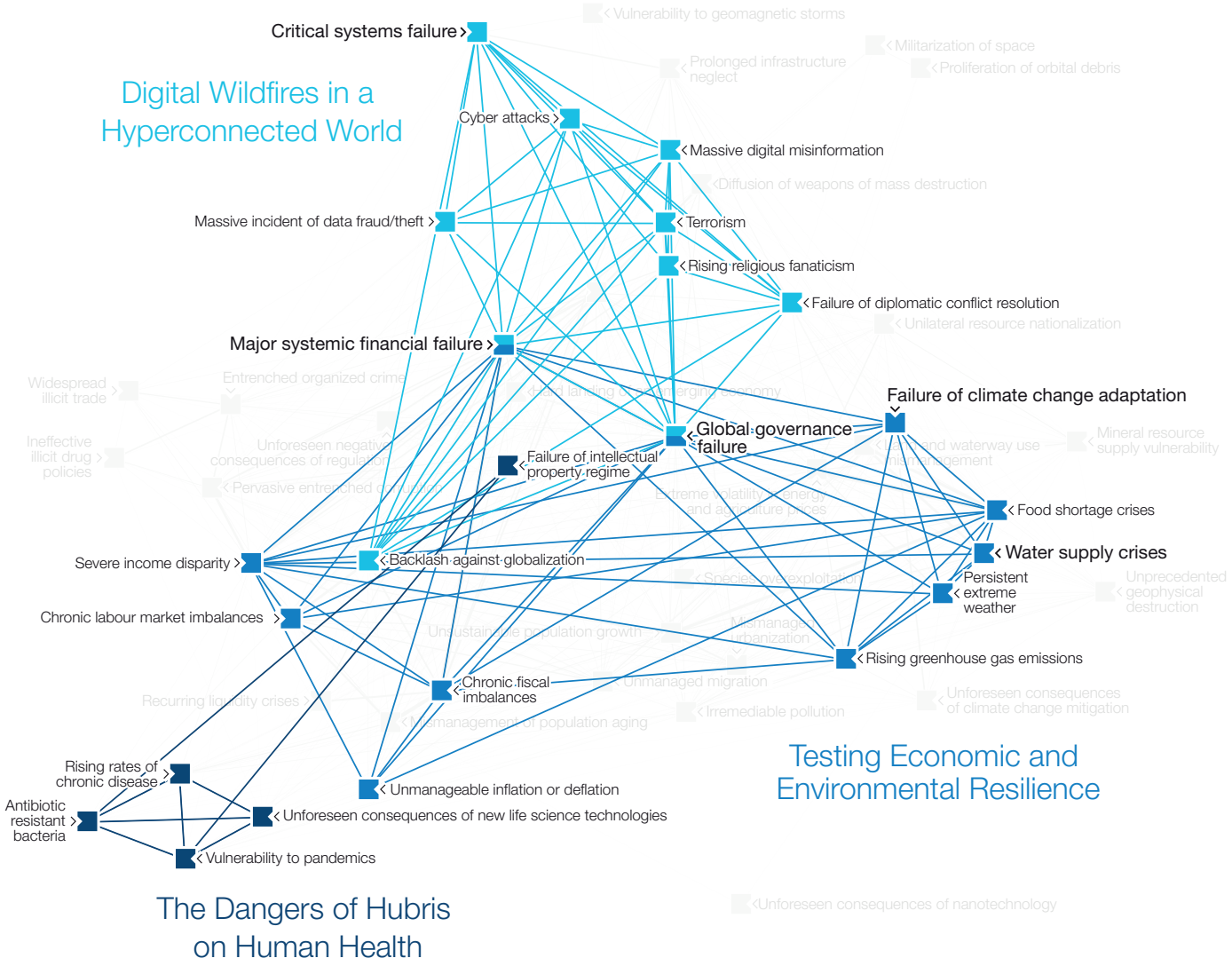
i NB: Some of the movements are due to changes in the composition of the sample. For more detail please see Section 4 Survey Findings.

Figure 2: Global Risks Landscape 2013



Source: World Economic Forum

Figure 3: Global Risks Map 2013[ii]



Source: World Economic Forum

[ii] Please see figure 37 in Survey Findings for the complete global risks interconnection map.

Contents

Preface

Resilient Dynamism is the theme for this year's World Economic Forum Annual Meeting in Davos-Klosters, and I am pleased to introduce the *Global Risks 2013* report in the same spirit. Based on an extensive survey of over 1,000 experts worldwide, the report – now in its eighth edition – serves to orient and inform decision-makers as they seek to make sense of an increasingly complex and fast-changing world. I hope this report challenges, provokes and inspires you, and I invite you to engage – if you have not already done so – with the World Economic Forum's Risk Response Network, which provides private and public sector leaders with a collaborative platform to build national resilience to global risks.

As we strive to restore confidence and growth globally, leaders cannot continue with a "risk-off" mindset if our collective goal remains to seize transformational opportunities that can improve the state of the world. Dynamism in our hyperconnected world requires increasing our resilience to the many global risks that loom before us.

By their nature, global risks do not respect national borders, as highlighted in this report. And we now know that extreme weather events exacerbated by climate change will not limit their effects to countries that are major greenhouse gas emitters; false information posted on social networks can spread like wildfire to the other side of the globe in a matter of milliseconds; and genes that make bacteria resistant to our strongest antibiotics can hitch a ride with patients on an intercontinental flight.

I, therefore, invite you to read the case studies in this report of the three examples cited above to understand better the international and interdependent nature of such constellations of risks. I think you will agree that each one makes a compelling case for stronger cross-border collaboration among stakeholders from governments, business and civil society – a partnership with the purpose of building resilience to global risks. They also highlight the need for strengthening existing mechanisms to mitigate and manage risks, which today primarily exist at the national level. This means that while we can map and describe global risks, we cannot predict when and how they will manifest; therefore, building national resilience to global risks is of paramount importance.

Klaus Schwab
Founder and Executive Chairman
World Economic Forum

Foreword

Resilience is the theme that runs through the eighth edition of this report. It seems an obvious one when contemplating the external nature of global risks because they are beyond any organization's or nation's capacity to manage or mitigate on their own. And yet global risks are often diminished, or even ignored, in current enterprise risk management. One reason for this is that global risks do not fit neatly into existing conceptual frameworks. Fortunately, this is changing. The *Harvard Business Review* recently published a concise and practical taxonomy that may also be used to consider global risks.[1] There are three types of risks as categorized by Professors Kaplan and Mikes.

First are "preventable" risks, such as breakdowns in processes and mistakes by employees. Second are "strategic" risks, which a company undertakes voluntarily, having weighed them against the potential rewards. Third are "external" risks, which this report calls "global risks"; they are complex and go beyond a company's scope to manage and mitigate (i.e. they are exogenous in nature). This differentiation will, we hope, not only improve strategic planning and decision-making but also increase the utility of our report in private and public sector institutions.

The concept of resilience also influenced this year's Global Risks Perception Survey, on which this report is built. The annual survey of experts worldwide added a new question asking respondents to rate their country's resilience – or, precisely, its ability to adapt and recover – in the face of each of the 50 risks covered in the survey. More than 1,000 experts responded to our survey, making the dataset explored in this report more textured and robust than ever.

Per the revamped methodology introduced in 2012, the 2013 report presents three in-depth "risk cases" exploring themes based on analysis of survey data, as well as detailed follow-up expert interviews and partner workshops. This eighth edition increased its geographic breadth and disciplinary depth by bringing on two new report partners from academia: the National University of Singapore (NUS) and the Oxford Martin School at the University of Oxford. We also entered into an exciting editorial partnership with *Nature*, a leading science journal, to push the boundaries of the imagination further with a revamped "X Factors" section of the report.

We have introduced unique content and data online, including an interactive website through which you can explore the risks landscape and a one-year-on follow-up of the three risk cases presented in the 2012 report from a perspective of how to promote resilience.

Our Special Report this year takes the first steps towards developing a national resilience measurement with regard to global risks. It explores the use of qualitative and quantitative indicators to assess overall national resilience to global risks by looking at five national-level subsystems (economic, environmental, governance, infrastructure and social) through the lens of five components: robustness, redundancy, resourcefulness, response and recovery. The aim is to develop a new diagnostic report to enable decision-makers to track progress in building national resilience and possibly identify where further investments are needed. The interim study will be published this summer.

Linked to this research effort is the launch of an online "Resilience Practices Exchange", where leaders can learn and contribute to building resilience using the latest social enterprise technology. These new efforts will enable the World Economic Forum's Risk Response Network (RRN) to become the foremost international platform to enable leaders to map, mitigate, monitor and enhance resilience to global risks. Therefore, I invite you to get in touch with the RRN and share your ideas and initiatives to assess and to improve national resilience to global risks.

Lee Howell
Managing Director
Risk Response Network

[1] Kaplan, R.S., and Mikes, A. Managing Risks: A New Framework. In *Harvard Business Review*, 2012.

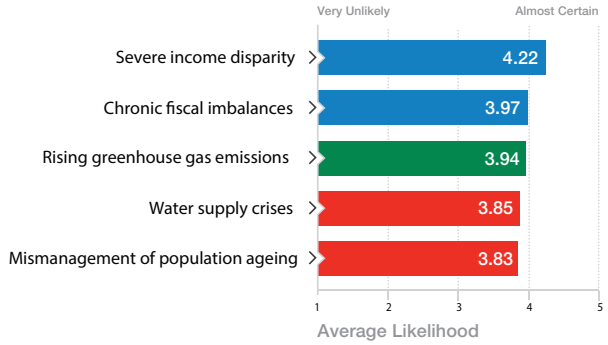
Executive Summary

The World Economic Forum's *Global Risks 2013* report is developed from an annual survey of over 1,000 experts from industry, government, academia and civil society who were asked to review a landscape of 50 global risks.

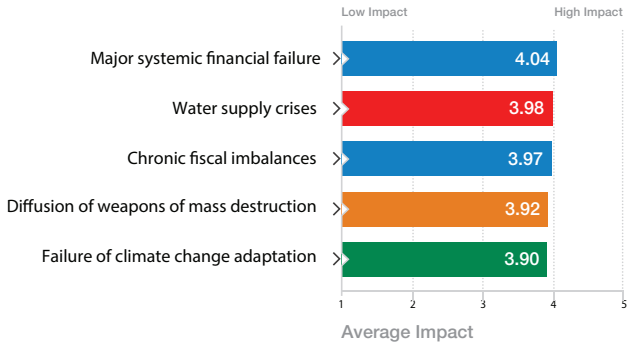
The global risk that respondents rated most likely to manifest over the next 10 years is *severe income disparity*, while the risk rated as having the highest impact if it were to manifest is *major systemic financial failure*. There are also two risks appearing in the top five of both impact and likelihood – *chronic fiscal imbalances* and *water supply crisis* (see Figure 4).

Figure 4: Top Five Risks by Likelihood and Impact

Likelihood



Impact

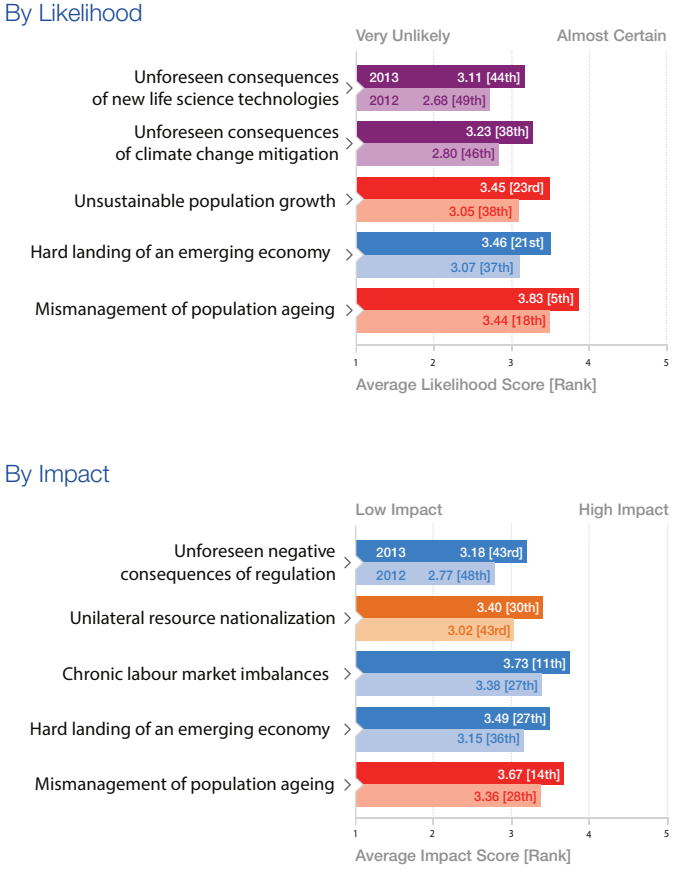


Source: World Economic Forum

This graph has been updated to correct an error in the version from 8 January 2013.

Unforeseen consequences of life science technologies was the biggest mover among global risks when assessing likelihood, while *unforeseen negative consequences of regulation* moved the most on the impact scale when comparing the result with last year's (see Figure 5).

Figure 5: Top Five Changes by Likelihood and Impact



Source: World Economic Forum

This graph has been updated to correct an error in the version from 8 January 2013.

Three Risk Cases

The report introduces three risk cases, based on an analysis of survey results, consultation with experts and further research. Each case represents an interesting constellation of global risks and explores their impact at the global and national levels. The three risk cases are:

Testing Economic and Environmental Resilience

Continued stress on the global economic system is positioned to absorb the attention of leaders for the foreseeable future. Meanwhile, the Earth's environmental system is simultaneously coming under increasing stress. Future simultaneous shocks to both systems could trigger the "perfect global storm", with potentially insurmountable consequences. On the economic front, global resilience is being tested by bold monetary and austere fiscal policies. On the environmental front, the Earth's resilience is being tested by rising global temperatures and extreme weather events that are likely to become more frequent and severe. A sudden and massive collapse on one front is certain to doom the other's chance of developing an effective, long-term solution. Given the likelihood of future financial crises and natural catastrophes, are there ways to build resilience in our economic and environmental systems at the same time?

Digital Wildfires in a Hyperconnected World

In 1938, thousands of Americans confused a radio adaptation of the H.G. Wells novel *The War of the Worlds* with an official news broadcast and panicked, in the belief that the United States had been invaded by Martians. Is it possible that the Internet could be the source of a comparable wave of panic, but with severe geopolitical consequences? Social media allows information to spread around the world at breakneck speed in an open system where norms and rules are starting to emerge but have not yet been defined. While the benefits of our hyperconnected communication systems are undisputed, they could potentially enable the viral spread of information that is either intentionally or unintentionally misleading or provocative. Imagine a real-world example of shouting "fire!" in a crowded theatre. In a virtual equivalent, damage can be done by rapid spread of misinformation even when correct information follows quickly. Are there ways for generators and consumers of social media to develop an ethos of responsibility and healthy scepticism to mitigate the risk of digital wildfires?

The Dangers of Hubris on Human Health

Health is a critical system that is constantly being challenged, be it by emerging pandemics or chronic illnesses. Scientific discoveries and emerging technologies allow us to face such challenges, but the medical successes of the past century may also be creating a false sense of security. Arguably, one of the most effective and common means to protect human life – the use of antibacterial and antimicrobial compounds (antibiotics) – may no longer be readily available in the near future. Every dose of antibiotics creates selective evolutionary pressures, as some bacteria survive to pass on the genetic mutations that enabled them to do so. Until now, new antibiotics have been developed to replace older, increasingly ineffective ones. However, human innovation may no longer be outpacing bacterial mutation. None of the new drugs currently in the development pipeline may be effective against certain new mutations of killer bacteria that could turn into a pandemic. Are there ways to stimulate the development of new antibiotics as well as align incentives to prevent their overuse, or are we in danger of returning to a pre-antibiotic era in which a scratch could be potentially fatal?

Special Report: National Resilience to Global Risks

This year's Special Report examines the difficult issue of how a country should prepare for a global risk that is seemingly beyond its control or influence. One possible approach rests with "systems thinking" and applying the concept of resilience to countries. The report introduces five components of resilience – robustness, redundancy, resourcefulness, response and recovery – that can be applied to five country subsystems: the economic, environmental, governance, infrastructure and social. The result is a diagnostic tool for decision-makers to assess and monitor national resilience to global risks.

X Factors from *Nature*

Developed in partnership with the editors of *Nature*, a leading science journal, the chapter on "X Factors" looks beyond the landscape of 50 global risks to alert decision-makers to five emerging game-changers:

- **Runaway climate change:** Is it possible that we have already passed a point of no return and that Earth's atmosphere is tipping rapidly into an inhospitable state?
- **Significant cognitive enhancement:** Ethical dilemmas akin to doping in sports could start to extend into daily working life; an arms race in the neural "enhancement" of combat troops could also ensue.
- **Rogue deployment of geoengineering:** Technology is now being developed to manipulate the climate; a state or private individual could use it unilaterally.
- **Costs of living longer:** Medical advances are prolonging life, but long-term palliative care is expensive. Covering the costs associated with old age could be a struggle.
- **Discovery of alien life:** Proof of life's existence elsewhere in the universe could have profound psychological implications for human belief systems.

The *Global Risks* report is the flagship research publication of the World Economic Forum's Risk Response Network, which provides an independent platform for stakeholders to explore ways to collaborate on building resilience to global risks. Further information can be found at www.weforum.org/risk.

Box 1: The Evolving Risk Landscape

How do the top risks as identified by the annual Global Risks Perception Survey change over time? Figure 6 shows how this list changed over the past seven years. The average ratings of the risks have changed slightly, as described in detail in Section 4 of the report, but the relative ranking of the risks according to their impact or their likelihood is less affected. Interestingly, the *diffusion of weapons of mass destruction* has moved into the top five risks in terms of impact.[iii]

Figure 6: Top Five Global Risks in Terms of Impact and Likelihood, 2007-2013

Top 5 Global Risks in Terms of Likelihood

	2007	2008	2009	2010	2011	2012*	2013*
1st	Breakdown of critical information infrastructure	Asset price collapse	Asset price collapse	Asset price collapse	Meteorological catastrophes	Severe income disparity	Severe income disparity
2nd	Chronic disease in developed countries	Middle East instability	Slowing Chinese economy (<6%)	Slowing Chinese economy (<6%)	Hydrological catastrophes	Chronic fiscal imbalances	Chronic fiscal imbalances
3rd	Oil price shock	Failed and failing states	Chronic disease	Chronic disease	Corruption	Rising greenhouse gas emissions	Rising greenhouse gas emissions
4th	China economic hard landing	Oil and gas price spike	Global governance gaps	Fiscal crises	Biodiversity loss	Cyber attacks	Water supply crises
5th	Asset price collapse	Chronic disease, developed world	Retrenchment from globalization (emerging)	Global governance gaps	Climatological catastrophes	Water supply crises	Mismanagement of population ageing

Top 5 Global Risks in Terms of Impact

	2007	2008	2009	2010	2011	2012*	2013*
1st	Asset price collapse	Asset price collapse	Asset price collapse	Asset price collapse	Fiscal crises	Major systemic financial failure	Major systemic financial failure
2nd	Retrenchment from globalization	Retrenchment from globalization (developed)	Retrenchment from globalization (developed)	Retrenchment from globalization (developed)	Climatological catastrophes	Water supply crises	Water supply crises
3rd	Interstate and civil wars	Slowing Chinese economy (<6%)	Oil and gas price spike	Oil price spikes	Geopolitical conflict	Food shortage crises	Chronic fiscal imbalances
4th	Pandemics	Oil and gas price spike	Chronic disease	Chronic disease	Asset price collapse	Chronic fiscal imbalances	Diffusion of weapons of mass destruction
5th	Oil price shock	Pandemics	Fiscal crises	Fiscal crises	Extreme energy price volatility	Extreme volatility in energy and agriculture prices	Failure of climate change adaptation

Economic Environmental Geopolitical Societal Technological

Source: World Economic Forum

This graph has been updated to correct an error in the version from 8 January 2013.

[iii] *The survey methodology changed significantly after the 2011 report. In contrast to the years 2007 to 2011, the list of 50 risks that was assessed by the survey did not change in 2012 and 2013.

Introduction

The nature of global risks is constantly changing. Thirty years ago, chlorofluorocarbons (CFCs) were seen as a planetary risk, while threat from a massive cyber attack was treated by many as science fiction. In the same period, the proliferation of nuclear weapons occupied the minds of scientists and politicians, while the proliferation of orbital debris did not. We see a similar story with asbestos then and carbon nanotubes today, and the list goes on.

With new information, the perceptions and realities of risks change, and often in unforeseen directions. Consider that in some circles the threat from greenhouse gas emissions made nuclear energy seem less hazardous than fossil fuels over the long run. Yet the nuclear catastrophe in Fukushima, Japan, not only changed public perceptions there but also energy policy, almost overnight, in some parts of Europe.

The World Economic Forum is now in its eighth year of publishing the *Global Risks* report. The purpose of the current edition is twofold. First, it aims to show how experts from around the world, from different backgrounds, currently perceive the risks that the world is likely to face over the next decade. To capture these opinions, a survey was carried out, interviews were conducted with specialists in different fields, and a series of workshops and conference sessions were held with expert groups to interpret the research findings and to work out the three risk cases developed in the report. Second, with this report the World Economic Forum aims to continue to raise awareness about global risks, to stimulate thinking about how risks can be factored into strategy development, and to challenge global leaders to improve how they approach global risks.

Annual Survey – Assessing Global Risks

The Global Risks Perception Survey was conducted in September 2012. Over 1,000 experts responded to evaluate 50 global risks from five categories – economic, environmental, geopolitical, societal and technological. For each global risk, survey respondents were asked, "On a scale from 1 to 5, how likely is this risk to occur over the next 10 years?", and "If it were to occur, how big would you rate the impact of this risk?" The aggregated responses to these two questions are depicted in the Global Risks Landscape scatterplot in Figure 2.

The evaluation of the 50 risks also focused on their linkages, given their interdependent nature. Survey respondents were asked to nominate pairs of risks that they believe to be strongly connected. They were also asked to nominate a "Centre of Gravity" – the systemically most important risk for each of the five categories of global risks. Putting all paired connections together results in a network diagram presented in Figure 37 in Section 4 – the Survey Findings.

The survey data was also analyzed to examine how the background of the respondents affects their perceptions. Are the views of people based in Europe similar to those in Asia? Do younger people perceive the world differently from older people? And how does specialist knowledge in a field affect how risks are perceived? These questions are explored in Section 4 of this report.

The Cases – Making Sense of Complex Systems

The 50 global risks in this report are interdependent and correlated with each other. The permutations of two, three, four or more risks are too many for the human mind to comprehend. Therefore, an analysis of the network of connections has been undertaken to highlight some interesting constellations of global risks seen in Figure 3.

In Section 2, these constellations of global risks are presented as three important cases for leaders: "Testing Economic and Environmental Resilience" on the challenges of responding to climate change, "Digital Wildfires in a Hyperconnected World" on misinformation spreading via the Internet, and "The Dangers of Hubris on Human Health" on the existential threat posed by *antibiotic-resistant bacteria*.

Each case was inspired by the findings from an initial network analysis and further developed through extensive research into current trends, potential causal effects, levels of awareness and possible solutions. Unlike traditional scenario methodologies, the risk cases do not attempt to develop a full range of all possible outcomes. They are instead an exercise in sense-making as well as a collective attempt to develop a compelling narrative around risks that warrant urgent attention and action by global leaders. Readers are encouraged to refine these cases further and to develop their own scenarios based on the data presented.[iv]

X Factors from *Nature* – Looking Even Further Ahead

The section on X Factors invites the reader to consider emerging concerns that are not yet on the radar of decision-makers. If the 50 global risks represent "known-knowns", then these X factors could be considered as "known unknowns". They were co-developed with the editors of *Nature* and benefit from their contributors' deep knowledge of cutting-edge scientific research that has not yet crossed over into mainstream discourse.

Resilience – Preparing for Future Shocks

This year's Special Report examines the increasingly important issue of building national resilience to global risks. It introduces qualitative and quantitative indicators to assess overall national resilience to global risks by looking at five national-level subsystems (economic, environmental, governance, infrastructure and social) through the lens of five components: robustness, redundancy, resourcefulness, response and recovery. The aim is to develop a future diagnostic report to enable decision-makers to track progress in building national resilience and possibly identify where further investments are needed. The interim study will be published this summer, and we invite readers to review the proposed framework and to share ideas and suggestions with the Risk Response Network.[v]

[iv] See also the World Economic Forum's series of "What-If" interviews for more case studies on a variety of topics: http://forumblog.org/tag/what-if/.

[v] For further details please refer to http://www.weforum.org/risk or contact us at rrn@weforum.org.

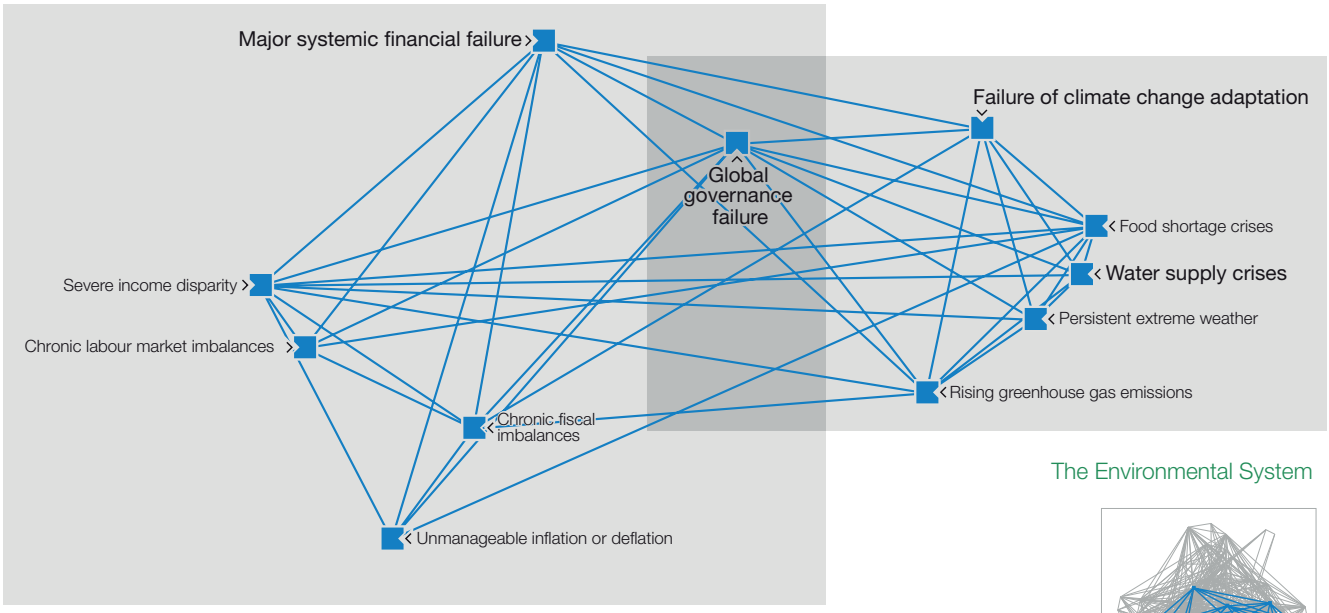
Testing Economic and Environmental Resilience

Economic and environmental systems are simultaneously under stress worldwide, and this is testing resilience at the global and national levels. Economic difficulties worldwide are continuing to make greater demands on political attention and financial resources. Meanwhile, the impact of climate change is more evident as temperature rises and more frequent extreme weather events loom on the horizon. The economic and environmental challenges require both structural changes and strategic investments, but are countries prepared to manage both fronts, conceivably at the same time?

Five years after the financial crisis, macroeconomic worries continue to weigh heavily on leaders' minds. This is confirmed by data from the World Economic Forum's quarterly confidence index[vi] as well as the Global Risks Perception Survey, in which respondents rated *major systemic financial failure* as the economic risk of greatest systemic importance for the next 10 years.

The very same survey respondents also identified the *failure of climate change adaptation* and *rising greenhouse gas emissions* as among those global risks considered to be the most likely to materialize within a decade. Compared to last year's survey, the *failure to adapt to climate change* replaced *rising greenhouse gas emissions* as the most systemically critical. This change in our data mirrors a wider shift in the conversation on the environment from the question of whether our climate is changing to the questions of "by how much" and "how quickly".

Figure 7: Testing Economic and Environmental Resilience Constellation



Source: World Economic Forum

[vi] The Global Confidence Index is an index developed by the World Economic Forum that represents confidence among decision-makers in three areas: global economy, global governance and global cooperation. For greater detail, please consult: http://www.weforum.org/ConfidenceIndex

The narrative emerging from the survey is clear: like a super storm, two major systems are on a collision course. The resulting interplay between stresses on the economic and environmental systems will present unprecedented challenges to global and national resilience.

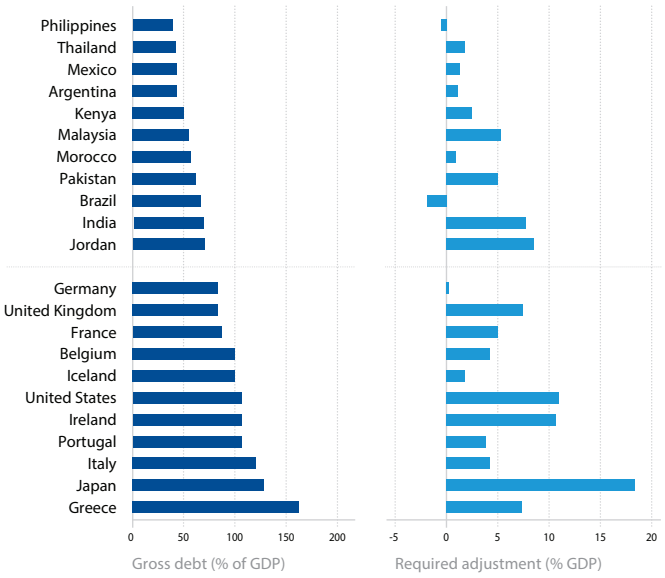
Will countries be able to address complex challenges unfolding on very different time scales simultaneously? A cynic may argue that any future environmental loss could actually have a stimulative economic effect – this is the same rationale used to criticise GDP-driven growth policies, whereby the reconstruction following a massive earthquake can boost overall GDP over the long term. However, this view ignores two realities. First, more people reside and work in urban areas than ever before in human history – this concentration will continue and is likely to drive environment-related losses to even greater historic highs. Second, the existing debt levels of many major economies can be unsustainable. Given this fiscal constraint, we are witnessing the use of extraordinary monetary policies to stimulate global growth, which some argue are essentially experimental.

The fact remains that today's massive socio-economic challenges demand immediate attention, yet availability of public resources is limited – especially to finance efforts to avert the long-term effects of climate change, which, in turn, could severely disrupt the global economy. We face a daunting negative feedback loop. The logic of risk management prescribes that countries should invest today to safeguard critical infrastructure and centres of economic activity against future climate-related losses that could be of much greater magnitude. And there is an even more compelling political logic to do this in order to generate new employment and to revive economic growth as soon as possible. But investment in strategic infrastructure is more easily said than done, despite the short- and long-term benefits.[1] New approaches are needed that are based on a meeting of minds across varied professions, sectors and geographies; a capacity to act decisively is also needed, despite considerable uncertainty about what the best plan of action might be. Hesitating to act now will only add to the burdens of the next generation.

Persistent Global Economic Fragility

The global economic situation remains fragile. The International Monetary Fund projects slow growth in the advanced economies, an annual rate of between 1.3% and 2.6% between 2012 and 2017.[2] Combined with fiscal fragility, this will continue to strain government spending. Given the current levels of government debts and deficits in these economies, "it will take years of concerted political and economic effort before debt to GDP levels of the United States, Japan and many Euro Area countries are brought down" to stabilize at lower levels.[3] Also, the economic growth of emerging markets and developing economies is projected to be slower than at its peak in 2010.[4]

Figure 8: Further Required Deficit Reductions for Fiscal Sustainability (2011)



Source: Adapted from IMF Fiscal Monitor, 2012 as cited in *Global Economic Prospects: Managing Growth in a Volatile World*. June, 2012. Washington DC: World Bank.

The current eurozone instability will continue to shape global prospects in the coming years.[5] The associated risk of systemic financial failure, although limited, cannot be completely discarded. Given the anti-austerity protests across the eurozone, the election of "rejectionist" governments could lead to further economic paralysis and bring the eurozone crisis to a head,[6] potentially destabilizing the global financial system in which confidence is already waning.[7]

This persistent global economic fragility continues to divert our attention from longer-term solutions by limiting the availability of public resources and generating greater caution in use of scarce funds for strategic investment projects. There are other looming issues related to ongoing prescriptions to counter economic malaise. Will the massive quantitative easing undertaken by key central banks to stave off deflation inevitably lead to destabilizing hyper-inflation? Will structural economic reforms deliver the necessary employment gains over the long run?

The Changing Debate on the Global Climate

Mitigation efforts have made significant progress at country level in the past 15 years in areas such as emissions regulations and financial incentives – for example, the US$ 3.4 billion made available to match private sector investment funds in the US Smart Grid Investment Grant program.[8] Nonetheless, in today's increasingly multi-polar geopolitics, it has become harder to reach and effectively implement international agreements on climate change mitigation. Pledges made in the run-up to the 2009 Copenhagen climate change negotiations, which were intended to limit global warming to 2 degrees Celsius, now appear collectively insufficient to meet this target of 2 degrees.[9] Recent scenario projections based on existing government policies and declared policy intentions predict that a long-term increase of more than 3.5 degrees Celsius is probable. The more pessimistic scenario assuming no change in government policies and measures beyond those adopted or enacted by mid-2011 talks of a conceivable increase of 6 degrees Celsius or more.[10]

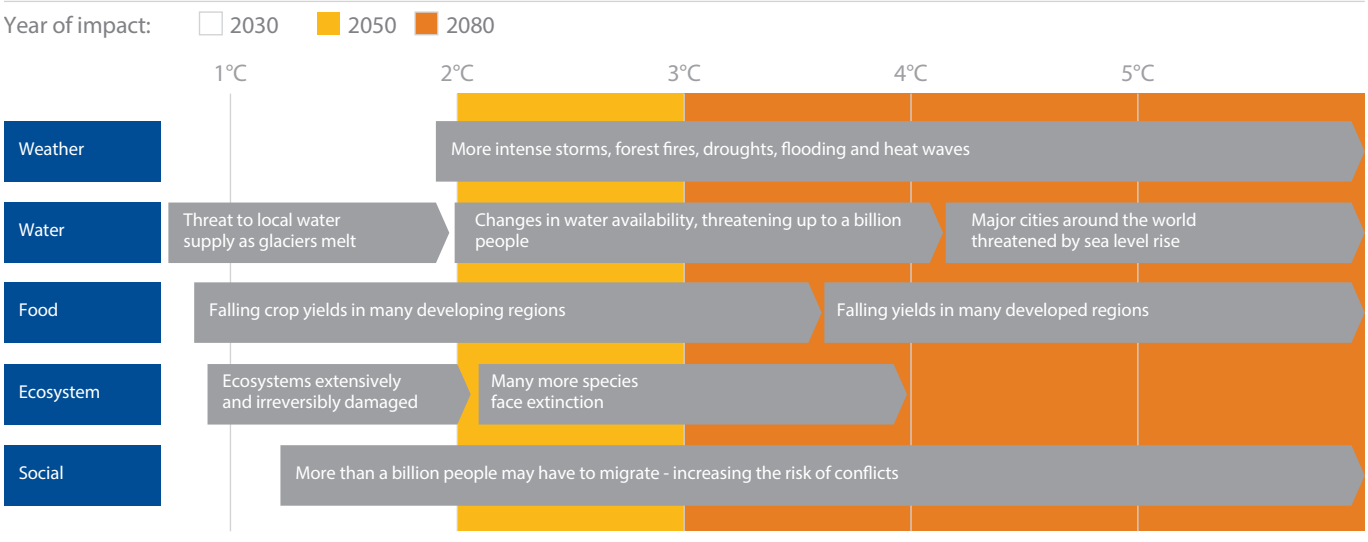
If the current mitigation commitments remain unmet, a global mean temperature increase of 4 degrees Celsius could occur as early as the 2060s. This would likely lead to negative impacts including an increase in the frequency of high-intensity tropical cyclones, inundation of coastal cities as sea levels rise, and increased drought severity in several regions. Together, the effects would not only mean significant economic losses but also mass displacement of populations, rising food insecurity and aggravated water scarcity[11] (also see Figure 9).

Recent climate and weather events, some of which are visualized in Figure 10, have reminded us of the economic and human cost of the kind of natural disasters that we know are likely to become more frequent and severe as climate continues to change. The estimated economic loss of the 2011 Thailand floods, for example, was US$ 30 billion,[12] and of Hurricane Katrina US$ 125 billion; meanwhile, the 2003 European heat wave resulted in more than 35,000 fatalities[13] and the Horn of Africa droughts in 2011 claimed tens of thousands of lives and threatened the livelihoods of 9.5 million people.[14] More recently, Hurricane Sandy left a heavy bill, estimated today at over US$ 70 billion for New York and New Jersey alone.[15] Such events remind us that many economies remain vulnerable to damages arising from climatic events today, let alone those of the future.[16]

While there is no consensus on how fast and how much our climate is changing, the growing realization that some degree of climate change is inevitable is reflected in a shifting of the debate to how to adapt. Advocating for greater attention to be paid to adaptation is controversial in some quarters as it is interpreted as a tacit admission that mitigation efforts are no longer worth pursuing. However, the less effective mitigation efforts are, the more pronounced adaptation challenges will become; therefore, mitigation and adaptation need to be addressed in concert while taking advantage of all possible synergies.

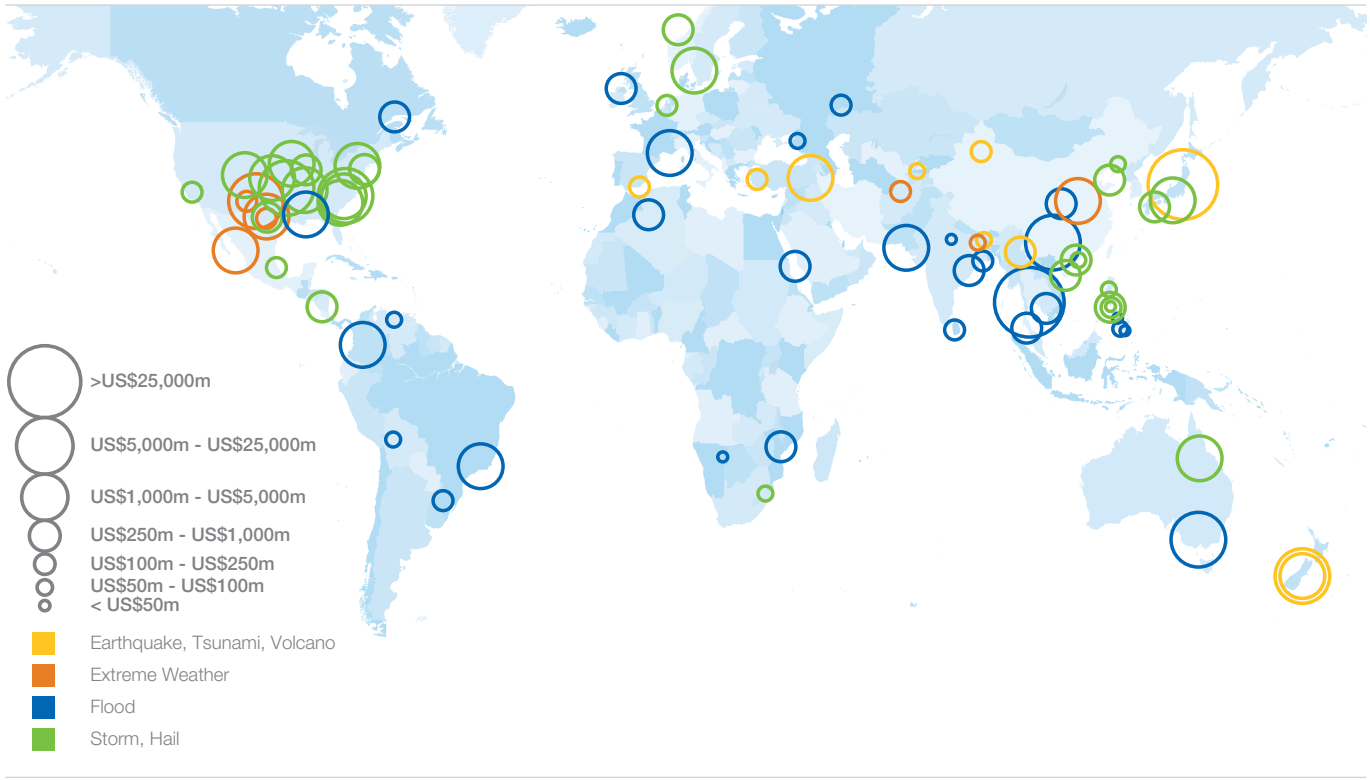
Figure 9: Possible Impact of Global Warming on Different Sectors

Temperature above preindustrial - IPCC scenario A1B



Source: Adapted from *Shaping Climate-Resilient Development: A Framework for Decision-Making*. 2009. Economics of Climate Adaptation Working Group.

Figure 10: 2011 Economic Losses Related to Selected Natural Catastrophes



Source: Adapted from sigma natural catastrophe data base of Swiss Reinsurance Company.

A number of climate adaptation related initiatives and reports have been emerging.[vii] While poorer countries will need help from the international community to finance adaptation investments, adaptation efforts are by their nature local, with countries, companies and individuals being largely responsible for their own adaptation costs.

While it is possible to make various different underlying assumptions in modelling the effects of climate change, it is clear that the economic costs are likely to be considerable. A report by Mercer,[17] which considers the cumulative economic cost of changes to the physical environment, health and food security due to climate change, quotes a possible range of US$ 2 trillion to US$ 4 trillion by 2030 across different climate scenarios.[18] The EU Climate Change Expert Group suggests that the costs of climate change impacts, increasing in magnitude with the rises in global temperature, may amount to 5% to 20% of GDP (or higher) in the long term.[19]

Some people affected by climate change may seek to recover costs from past emitters of greenhouse gases. Although the Alaskan village of Kivalina – which faces being "wiped out" by the changing climate – was unsuccessful in its attempts to file a US$ 400 million lawsuit against oil and coal companies,[20,21] future plaintiffs may be more successful. Five decades ago, the US tobacco industry would not have suspected that in 1997 it would agree to pay US$ 368 billion in health-related damages.[22] For some businesses, investing in climate change mitigation now could be as much about enterprise risk management as about mitigating a global risk.

[vii] For examples please see "Shaping Climate-Resilient Development: A Framework for Decision-Making" by the Economics of Climate Adaptation Working Group, "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation" Special Report of the Intergovernmental Panel on Climate Change, and Private Sector Initiative of the UNFCCC's Nairobi Work Programme featuring good practices and climate change adaptation activities undertaken by the private sector (some of which have been carried out in partnership with NGOs or the public sector) across different regions and sectors.[39]

Decisive Action in a Climate of Uncertainty

As the consensus that the climate change is becoming more evident grows, data across many disciplines (including forestry, water and land management, for example) remains limited, not readily available or communicated in a format that might not facilitate actionable decisions on climate adaptation. Yet, future climate risks may require human judgement today or in the coming years, while the full scientific data may not come until it is too late. Complex systems such as the climate are non-linear by nature – chain reactions through the system are unpredictable and not directly proportional to the size of the triggers. A limited amount of data and constraints on computational power have been strong impediments to bringing greater clarity into predicting future climatic developments at a local level.[23,24] For instance, there have been inconclusive predictions regarding the likely impacts of global warming on rainfall patterns in Guyana: possibilities ranged from a 5% rainfall decline by 2030, lessening the risk of flooding, to a 10% rainfall increase, worsening this risk significantly.[25]

Faced with uncertainty about the likely effectiveness and risk of unintended consequences of a proposed intervention, policy-makers can be paralyzed by a desire to wait for more detailed analyses and data regarding the precise timing, manifestation or impact of future climatic changes in their local environments. Greater support for scientific research, better computational power and data are needed to shed greater clarity into predicting future climatic developments, especially the climate and weather extremes.

While this will come, can leaders embrace the need to make a decision without the complete assurance that they are making the best decision? This is more easily said than done, especially when there are competing demands for attention and resources. For example, the 2008 financial crisis shows how urgent macroeconomic difficulties can divert attention from other significant global governance challenges, from climate change negotiations to the Millennium Development Goals. Yet the actions of the G20 during the crisis also demonstrate the potential for bold, coordinated international action.

As global risks ultimately require a national response, much more attention must be given to how decisions are made in the face of such overwhelming economic and environmental challenges. Perception is typically regarded as a passive process, in which people view an objective reality. Yet perception is actually an active process of understanding, through which people construct their own version of reality.[26] Research in cognitive psychology and decision-making suggests that people use "rules of thumb" to make judgements in the face of ambiguity and complexity.[viii] This approach usually serves well but can lead to predictably faulty judgements under some circumstances. Psychologists call such predictably faulty judgements cognitive biases,[27] and these biases influence how we respond to the best information at our disposal and integrate it in decision-making structures.

Cognitive biases become important when addressing the slow-moving future threat of climate change in the context of an ongoing unstable economic outlook. Some examples are:

- We tend to place too much emphasis on recent personal experience when estimating the likelihood of a risk occurring. For example, experience in the United States shows that many more people buy flood insurance immediately after a major flood. On average, those people hold flood insurance for only two to four years before letting it lapse if they have not suffered a claim because they are likely to view insurance as a bad investment rather than seeing it as a form of protection.[28]
- Through a process known as hyperbolic discounting, we tend to give disproportionately more weight to immediate costs and benefits than to delayed ones. Individuals, for instance, may often be reluctant to incur the upfront costs of measures such as investing in climate change adaptation measures when the benefits will not be felt for several years.[29,30]
- We fail to take protective measures if the perceived likelihood of the risk in question is below our threshold level of concern – for example, discounting entirely the possibility of a natural catastrophe that has a low chance of occurring. This bias is exacerbated by a tendency to underestimate the likelihood of a negative event occurring due to misperceptions of the risk.[31,32]

The cumulative effect of such cognitive biases is that we may not pay due attention to, or act effectively on, risks that are perceived to be long-term and relatively uncertain. The impossibility of fully eradicating ambiguity, along with the relatively lengthy time scales involved, mean that cognitive biases are likely to remain significant hurdles to be acknowledged and overcome on the path towards effective action on climate change and related risks.

[viii] The phrase "rule of thumb" means a quick and easy way of making estimates, based on experience that will not be precisely accurate but will nonetheless be adequate for most everyday situations.

Exploring New Approaches with Climate-Smart Mindsets

Acknowledging the effect of our cognitive biases may be the first step towards building resilience against a future perfect storm of economic and environmental challenges. Only then can we start weighing the various demands equally, in the near and the long term, on scarce public resources and dwindling risk-mitigation budgets.

To reconcile the challenge of building environmental resilience amid economic stress, current policies and strategies may need to be re-evaluated. For instance, in several countries, government insurance schemes and building-permit policies continue to encourage further urbanization in coastal or high flood risk areas rather than preventing it.[33] In doing so, they may be creating large pockets of vulnerability to climate risks. A 2007 OECD study analysing 136 port cities around the world concluded that the population exposed to coastal flooding could triple by the 2070s due to the combined effects of climate change and urbanization, among others.[34]

In light of the increased certainty that global temperatures will rise to some extent, a "climate-smart" mindset needs to permeate all levels of decision-making. "Climate-smart" is a term that originated in agriculture, to describe such agriculture that not only increases resilience in light of climate adaptation but also reduces greenhouse gas emissions.[35] A climate-smart mindset incorporates climate change analysis into strategic and operational decision-making. It entails a search for synergies across climate change mitigation- and adaptation-related efforts where possible. Such a mindset needs to become an integral part of our urban planning, water- and food-security management, investment policy, and demographic policy development, among others. In 2006, during its term over the rotating European Union presidency, Finland introduced a policy innovation which encouraged ministers with other portfolios – from transport and urban planning, to agricultural and employment policies – to consider the effects of their decisions on the population's health.[36] Something similar may be needed to ensure that all ministers enact policies in their domains that are informed by a climate-smart mindset.

The current debt crisis of several leading economies will make it more difficult to finance climate-smart activities, such as the Smart Grid Investment Grant. That said, the private sector has a critical role here as well. In the United States, around 80% of critical infrastructure is owned or operated by the private sector, not governments.[37] It is likely that many of the preparations to weather the colliding economic and environmental storm systems will be found in private-sector initiatives to reinforce critical assets and shield them from potential future risks and liability.

Given the pressure on public finances generally and their scarcity to address climate change-related challenges, new funding models will need to be found. Private funds can be unlocked through innovative public-private collaboration that ranges across disciplines as well as stakeholders. In order to enable scalable, effective partnerships, a variety of actors and professional disciplines will need to converge on mutually beneficial and economically sustainable solutions. This is no minor task since, in addition to the diversity of interests at stake, different professionals often have conflicting biases and have been trained to think in siloed ways. Yet such partnerships have started to emerge.

In order to address the current shortfall in green infrastructure in a number of emerging economies, more than 50 leading companies from finance, infrastructure, energy and agriculture sectors joined public institutions to form the Green Growth Action Alliance (G2A2). As described in greater detail in Box 2, the aim of this initiative is to unlock greater sums of private investment for green infrastructure.

Other examples of innovative partnerships include a company in China which has partnered with government, industry associations and international NGOs to enable a sector-wide replication of green prefabrication production, currently saving 360 hectares of forest and 314,000 tons of greenhouse gas emissions a year; and the Desertec Foundation for Clean Energy Generation, which assisted in founding an industrial initiative of 55 industrial and financial companies and institutions working to enable large-scale generation of renewable power from deserts to serve markets in North Africa, Middle East and Europe.[38]

As the world faces a squeeze in public funds at the same time as the effects of climate change are increasing, it is only through collaboration among governments (to further the public interest), businesses (to search for innovative products and solutions), legal experts (to mitigate fear of liability), science (to bring good quality supporting data and analyses) and the financial sector (to innovate and avoid future damaging costs) that the limits of environmental and economic resilience can be successfully navigated.

Questions for Stakeholders

- How will we reconcile climate change mitigation and adaptation efforts with the desire for prosperity given current demographic trends?
- How can like-minded municipalities, companies and communities drive forward a new set of climate-smart approaches that avoid cognitive biases?
- How can we rethink cross-industry collaboration to find the right balance between competition and cooperation among companies in a resource-constrained and increasingly interconnected world?

Box 2: The Green Growth Action Alliance (G2A2)

As emerging economies grapple with how to grow their economies without worsening their environments, many are developing "green growth" strategies designed to attract investment in sustainable water, energy, transport and agricultural infrastructure. Up to US$1 trillion a year of private sector investment is needed, according to the 2012 B20 Green Growth Task Force. However, due to the limited track record of some technologies, combined with the perception of investment risk, private capital providers are often reluctant to invest in green growth.

To address the current shortfall in green infrastructure investment, more than 50 leading companies from finance, infrastructure, energy and agriculture sectors joined with public finance institutions to launch the Green Growth Action Alliance (G2A2) at the 2012 G20 Summit in Mexico. Chaired by the then Mexican President Felipe Calderón, the G2A2 will pursue four strategic activities over a two-year timeframe:

1. **Highlight innovative models for public-private collaboration:** The G2A2 will launch a report at the 2013 World Economic Forum Annual Meeting identifying existing sources of finance and pinpointing innovative ways for public policy to unlock private funds.
2. **Stimulate private investment at country level:** The G2A2 is working with the governments of Kenya, Vietnam and Mexico to incubate innovative financing models with the domestic and international private sector.
3. **Provide new ideas and models to shape the policy agenda:** The G2A2 has formed working groups on green free trade, end-user financing of renewable energy, institutional investors and energy efficiency. The energy efficiency working group is looking to pilot new financing structures for energy services companies; the green free-trade group has led calls to establish free-trade regulations for clean technologies such as solar.
4. **Help to scale up and replicate successful approaches:** To help governments, development banks and finance institutions to ensure rapid replication and to scale up successful models, the G2A2 will document case studies in the Green Investment Report and engage with policy platforms and investor networks, such as the G20 Development Working Group and Finance Track group on climate finance, the UNFCCC's Momentum for Change Initiative and the International Development Finance Club. The G2A2 will also collaborate closely with the UN Sustainable Energy for All Initiative and the Global Investor Coalition on Climate Change.

The World Economic Forum is serving as the secretariat for the G2A2.

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Digital Wildfires in a Hyperconnected World

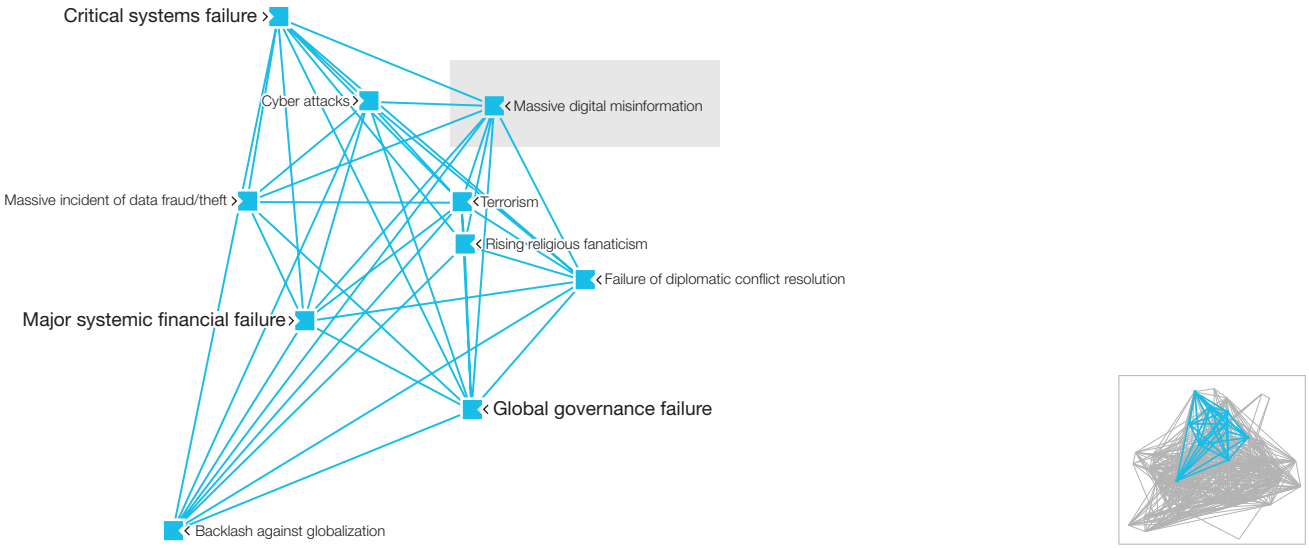
The global risk of *massive digital misinformation* sits at the centre of a constellation of technological and geopolitical risks ranging from *terrorism* to *cyber attacks* and the *failure of global governance*. This risk case examines how hyperconnectivity could enable "digital wildfires" to wreak havoc in the real world. It considers the challenge presented by the misuse of an open and easily accessible system and the greater danger of misguided attempts to prevent such outcomes.

In 1938, when radio had become widespread, thousands of Americans confused an adaptation of the H.G. Wells novel *War of the Worlds* with a news broadcast and jammed police station phone lines in the panicked belief that the United States had been invaded by Martians.

It is difficult to imagine a radio broadcast causing comparably widespread misunderstanding today. In part this is because broadcasters have learned to be more cautious and responsible, in part because the media is a regulated industry, and in part because listeners have learned to be more savvy and sceptical. Moreover, the news industry itself is undergoing a transformation as the Internet offers multiple options to confirm or refute a breaking news story. But the Internet, like radio in 1938, is a relatively young medium. The notion that a tweet, blog or video posting could drive a similar public panic today is not at all far-fetched.

The Internet remains an uncharted, fast-evolving territory. Current generations are able to communicate and share information instantaneously and at a scale larger than ever before. Social media increasingly allows information to spread around the world at breakneck speed. While the benefits of this are obvious and well documented, our hyperconnected world could also enable the rapid viral spread of information that is either intentionally or unintentionally misleading or provocative, with serious consequences. The chances of this happening are exponentially greater today than when the radio was introduced as a disruptive technology, despite our media sophistication. Radio was a communication channel of "one to many" while the Internet is that of "many to many".

Figure 11: Digital Wildfires in a Hyperconnected World Constellation



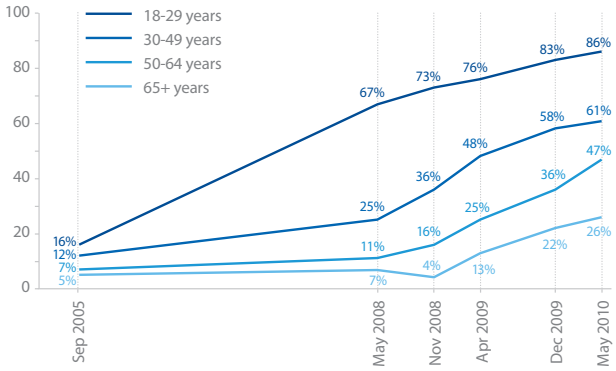
Source: World Economic Forum

The Internet does have self-correcting mechanisms, as Wikipedia demonstrates. While anyone can upload false information, a community of Wikipedia volunteers usually finds and corrects errors speedily. The short-lived existence of false information on its site is generally unlikely to result in severe real-world consequences; however, it is conceivable that a false rumour spreading virally through social networks could have a devastating impact before being effectively corrected. It is just as conceivable that the offending content's original author might not even be aware of its misuse or misrepresentation by others on the Internet, or that it was triggered by an error in translation from one language to another. We can think of such a scenario as an example of a digital wildfire.

How might digital wildfires be prevented? Legal restrictions on online anonymity and freedom of speech are a possible route, but one which may also have undesirable consequences. And what if the source of a digital wildfire is a nation state or an international institution? Ultimately, generators and consumers of social media will need to evolve an ethos of responsibility and healthy scepticism similar to that which evolved among radio broadcasters and listeners since the infamous *War of the Worlds* broadcast in 1938. This risk case asks if explicitly recognizing the potential problem and drawing attention to possible solutions could facilitate and expedite the evolution of such an ethos.

Figure 13: Users Timeline

US Internet users who use social networks sites, by age, in percentage of each group



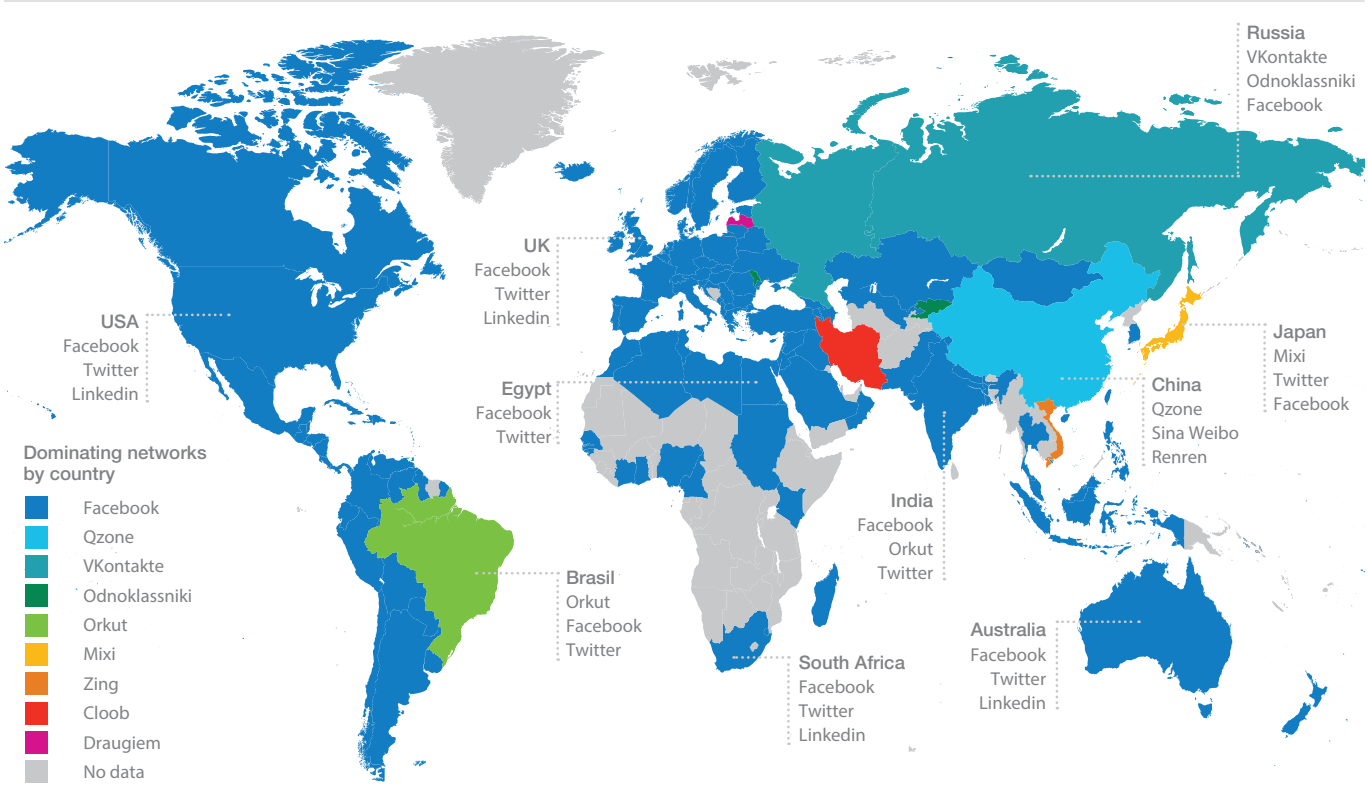
Source: Adapted from "Search Engine Journal", http://www.searchenginejournal.com/wp-content/uploads/2011/09/social-media-black.jpeg, 2012.

Benefits and Risks of Social Media

From cuneiform to the printing press, it has always been hard to predict the ways in which new communication technologies will shape society. The scale and speed of information creation and transfer in today's hyperconnected world are, however, historically unparalleled. Facebook has reached more than 1 billion active users in less than a decade of existence, while Twitter has attracted over 500 million active users in seven years. Sina-Weibo, China's dominant micro-blogging platform, passed 400 million active accounts in summer 2012.[1] Every minute, 48 hours' worth of content is uploaded to YouTube. The world of social media is multicultural and young. Figure 12 shows the preferences across the world for different social networking platforms, and Figure 13 illustrates the trends of social media use by age group in the United States.

Figure 12: The World of Social Media

Leading social media networks by country



Source: Adapted from "Search Engine Journal", http://www.searchenginejournal.com/wp-content/uploads/2011/09/social-media-black.jpeg, 2012.

This phenomenon has many transformative effects. Studies of Twitter and Facebook activity in Egypt and Tunisia leave no doubt about the role social media played in facilitating the Arab Spring.[2,3] The social networking site Patientslikeme.com connects individuals with others who have the same conditions and is helping to expedite the development of new treatments. Analysis of Twitter messages and networks has successfully predicted election results,[4] movie box office success[5] and consumer reactions to specific brands, among other things.[6,7]

However, some individuals and organizations have suffered losses due to the capacity for information to spread virally and globally through social media. Some examples:

- When a musician travelling on United Airlines had his claim for damages denied on a guitar that baggage handlers had allegedly broken, he wrote and performed a song – "United Breaks Guitars" – and uploaded it to YouTube, where it has been viewed more than 12 million times. As the video went viral, United Airlines stock dropped by about 10%, costing shareholders about US$ 180 million.[8,9]
- In November 2012, the BBC broadcast an allegation that a senior politician had been involved in child abuse, which transpired to have been a case of mistaken identity on the part of the victim. Although the BBC did not name the politician, his identity was easily discovered on Twitter, where he was named in about 10,000 tweets or re-tweets.[10] On top of pursuing legal action against all the people who spread this false information on Twitter, the injured politician settled on £185,000 in damages with the BBC.[11]
- The existence on YouTube of a video entitled "Innocence of Muslims", uploaded by a private individual in the United States, sparked riots across the Middle East. These riots are estimated to have claimed over 50 lives.[12]

These are very different cases – a humorous response from a disgruntled customer, a defamation of character and an affront to religious sensitivities. What unites them is that hyperconnectivity amplified their impacts to a degree that would have been unthinkable in a pre-Internet age, when only a small number of large organizations had the capacity to broadcast information widely. This new reality has some challenging implications.

When Digital Wildfires Are Most Dangerous

As Hurricane Sandy battered New York in October 2012, an anonymous Twitter user tweeted that the New York Stock Exchange trading floor was flooded by three feet of water. Other Twitter users quickly corrected the false rumour, though not before it was reported on CNN.[13] In Mexico, there have been cases of mothers needlessly keeping their children from school and shops closing due to false rumours of shootouts spreading through social networks.[14] In the UK, the video imagery related to a low level tactical incident of the British Army in Basra, spread through Reuters agency feed, YouTube and Blinkx, led to a misleading impression of a significant military failure among the British public which was never fully eradicated.[15]

These cases indicate one of the two situations in which digital wildfires are most dangerous: in situations of high tension, when false information or inaccurately presented imagery can cause damage before it is possible to propagate accurate information. The real-world equivalent is shouting "fire!" in a crowded theatre – even if it takes only a minute or two for realization to spread that there is no fire, in that time people may already have been crushed to death in a scramble for the exit.

The other dangerous situation is when information circulates within a bubble of likeminded people who may be resistant to attempts to correct it. In the case of the Sandy NYSE tweet, other Twitter users rapidly posted accurate information, and nobody had a vested interest in continuing to believe the original, false information.[16] Cases in which false information feeds into an existing worldview, making it harder to dislodge, are far from unimaginable. This may be more of a problem with social networks where information is less publicly visible, for example, through friend networks on Facebook or more "opaque" social networks such as e-mail or text messaging.[17] The spread of misinformation in such "trusted networks" can be especially difficult to detect and correct since recipients are more likely to trust any information originating from within the network.

We should, therefore, not underestimate the risk of conflicting false rumours, circulating within two online bubbles of likeminded individuals, creating an explosive situation. The extensive use of Twitter by both sides during the November 2012 clashes between Israel and Hamas in Gaza[18] points to the possibility of future situations in which competing versions of events are propagated in self-reinforcing loops among groups of people who are predisposed to believe one side or the other and do not share a common information source that might help to dissipate some of the self-amplified information loops.

"Astroturfing", Satire, "Trolling" and Attribution Difficulties

While it is certainly possible for a digital wildfire to start accidentally, it is also possible for misinformation to be deliberately propagated by those who stand to reap some kind of benefit. Some examples:

- In politics, the practice of creating the false impression of a grassroots movement reaching a group consensus on an issue is called "astroturfing". During the 2009 Massachusetts special election for the US Senate, a network of fake Twitter accounts successfully spread links to a website smearing one of the candidates.[19]
- Fake tweets have moved markets, offering the potential to profit from digital wildfires. A Twitter user impersonating the Russian Interior Minister Vladimir Kolokoltsev in July 2012 tweeted that Syria's President Bashar al-Assad "has been killed or injured", causing crude oil prices to rise by over US$ 1 before traders realized the news was false.[20]
- Thirty thousand people of Assam origin fled the tech centre Bangalore in panic in 2012 after receiving text messages warning that they would be attacked in retaliation for communal violence in their home state.[21,22]

Executives interviewed by Forbes and Deloitte placed social media among the greatest risks that their corporations face.[23] For example, after the BP oil spill in the Gulf of Mexico, a parody Twitter account quoting the chief executive Tony Hayward as saying such things as "Black sand beaches are very trendy in some places" attracted 12 times more followers than BP's corporate Twitter account.[24] While this example might have been intended to be humorous, it is possible for satire to be mistaken for fact. In October 2012, Iran's official news agency ran a story that originated on the satirical website The Onion, claiming that opinion polls showed Mahmoud Ahmadinejad was more popular than Barack Obama among rural white Americans.[25]

More worrying for businesses may be misinformation that circulates at a time when markets are already anticipating an important announcement. On 18 October 2012, NASDAQ halted trading on Google shares as a leaked earnings report (coupled with weak results it entailed) triggered a US$ 22 billion plunge in Google's market capitalization.[26] In this case, the information was from a credible source, but it demonstrates impacts that could also be achieved by unfortunately timed misinformation or rumours.

It is not always easy to trace the source of a digital wildfire. It would be possible for careful cyber attackers to cover their tracks, raising the possibility of an organization or country being falsely blamed for propagating inaccurate or provocative information. Depending on existing tensions, the consequences of the false attribution could be exponentially worse than if no attribution had been made.

Towards a Global Digital Ethos

Around the world, governments are grappling with the question of how existing laws which limit freedom of speech, for reasons such as incitement of violence or panic, might also be applied to online activities. Such issues can be highly controversial: in the United Kingdom, courts initially convicted a man for making a joke on Twitter in which he threatened to blow up an airport in frustration at the cancellation of his flight – a conviction later overturned on appeal.[27]

Establishing reasonable limits to legal freedoms of online speech is difficult because social media is a recent phenomenon, and digital social norms are not yet well established. The question raises thorny issues of the extent to which it would be possible to impose limits on the ability to maintain online anonymity, without seriously compromising the usefulness of the Internet as a tool for whistle-blowers and political dissidents in repressive regimes.

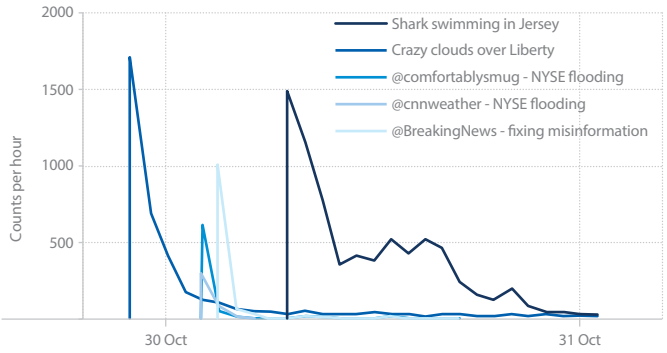
Even if the imposition of such limits were enforceable, what authority would we trust to do it? The World Conference on International Telecommunications in Dubai aiming to revise the 1988 treaty governing the International Telecommunications Union[28] sparked controversy in December 2012 when critics argued that seemingly innocuous technical regulations could have unintended negative consequences. Rules "ostensibly designed to do everything from fight spam to ensure 'quality of service' of Internet traffic could be used by individual governments to either throttle back incoming communications or weed out specific content they want to block".[29] As some revised treaty provisions were believed to "give a U.N. stamp of approval to state censorship and regulation of the Internet and private networks",[30] the United States refused to sign the amended treaty; a decision seconded by Canada and several European countries.[31]

When the incentives behind installing "quality" checks are questionable, who can be trusted? And how do you create an established and recognized authority that can intervene or disrupt misinformation flows when they happen?

There are also profound questions of education and incentives. Users of social media are typically much less knowledgeable than editors of traditional media outlets about laws relating to issues such as libel and defamation. Many also have less to lose than traditional media outlets from spreading information that has not been properly fact-checked. But there are signs that new norms may be emerging. Figure 14 plots misinformation and correction tweets during Hurricane Sandy in October 2012. The misinforming tweet @ComfortablySmug's about the NYSE floor flooding received substantially fewer re-tweets than the tweets that circulated fake photos depicting sharks swimming in New Jersey streets and the Statue of Liberty with monstrous looming storm clouds. Social media analysts say this is not surprising, as visual content tends to spread further than text alone. In addition, the actual misinforming tweets posted by @ComfortablySmug and @CNNweather peaked at significantly fewer re-tweets compared to the correction posted by @BreakingNews, even though the corrected information was posted within an hour of the misinforming tweet.[32]

One can speculate that people may have been more willing to re-tweet the photos of sharks and the Statue of Liberty because they were harmless and surprising and, most important, had significant entertainment value. The entertainment value may also explain the lack of interest in circulating the correction tweets from @BreakingNews. People may have been less prepared to re-tweet information that could be tied to serious consequences, such as NYSE flooding, before verifying. This suggests that norms may be emerging, and also re-emphasizes the fact-checking responsibility of trusted sources of information such as CNN. Slips like this could one day be a litigation risk for media corporations.

Figure 14: Re-Tweets Over Time



Source: "#Sandy: Social Media Mapping". Social Flow, http://blog.socialflow.com/post/7120245759/sandy-social-media-mapping, 2012.

In addition to seeking ways to inculcate an ethos of responsibility among social-media users, it will be necessary for consumers of social media to become more literate in assessing the reliability and bias of sources. Technical solutions could help here. Researchers and developers are working on programmes and browser extensions, such as LazyTruth,[33] Truthy[34] or TEASE[35], that aim to help people assess the credibility of information and sources circulating online. It is possible to imagine the development of more broad and sophisticated automated flags for disputed information, which could become as ubiquitous as programmes that protect Internet users against spam and malware.

Feedback ratings on eBay, which enable users to assess the reliability of vendors, offer a potential template for the development of such a service. Until now, most rating systems are limited to specific websites – users do not carry their rating with them as a record of credibility wherever they go online. It remains still to be seen if that would be a desirable or feasible model. Information disputed for ideological reasons or deliberate misattribution will continue to pose a number of challenges; however, a system could be developed that would trace information to its source and provide information on whether the source was considered by a broader community to be official. The system could also reveal how widely the source was trusted by a spectrum of other Internet users – all while protecting the identity of the source.

It is not yet clear what a global digital ethos would look like, or how it could best be helped to develop. But given the risks posed by digital wildfires in our hyperconnected world, leadership is needed to pose these difficult questions and start the discussion.

Questions for Stakeholders

- Controlling the spread of false information online, either through national laws or sophisticated technologies, raises sensitive questions on the limits to the freedom of speech – a human value that is not regarded or celebrated equally across different societies. How can constructive international discussions be started to define a global digital ethos without further polarizing societies on issues of civil liberties?
- What actions can be taken to promote a new and critical media- or information-literacy among the general public that raises individuals' capacities to assess the credibility of information and its sources?
- Where should different groups of stakeholders look to verify the source of information online? How can different markers of trust and information quality be promulgated to facilitate greater user clarity?

Box 3: Hyperconnected World

Shaping Culture and Governance in Digital Media

Across the globe, the rules of digital content are being formed: laws and policies written, cultural norms emerging, industry coalitions forming. In this dynamic environment, the disparate expectations and interests of the primary stakeholder groups – government, industry, and citizens – are intertwined, and often at odds. Any government policy or business strategy will need to take into account numerous interlinked factors to achieve desired outcomes and avoid unintended consequences.

In a series of workshops held in Mexico City, Istanbul, Brussels, New York and New Delhi, and supported by a survey on Internet usage in 15 countries conducted in collaboration with comScore and Oxford University, the project aims to achieve the following over 2012 and 2013:

1. Develop an alternative framework to think about issues relating to digital media that start with intentions of stakeholders (e.g. reward innovation and make content accessible) rather than the actions taken (e.g. protect intellectual property) to arrive at a shared understanding and framework concerning issues such as freedom of expression, intellectual property and privacy in the digital universe.
2. Account for differences in regional values and cultures and how they are reflected in the digital world, which is borderless.
3. Explore the context and conditions needed for any government or business intervention to be effective and sustainable, showcasing some regulatory policies on intellectual property that may have seemed effective in the short term but too costly in the long term.
4. Highlight cases of collaborative efforts among stakeholders or leadership of a specific group of organizations that can prove most successful, especially relating to technological innovation.

The project is being led by media, entertainment and information industry partners from the publishing, social media, and advertising industries joined by regulatory bodies such as the Federal Communications Commission and the European Commission.

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The Dangers of Hubris on Human Health

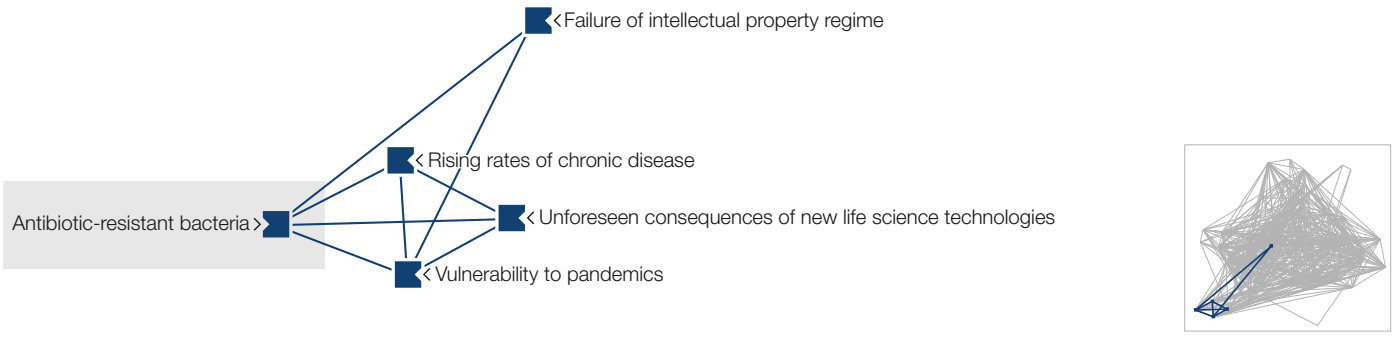
Humanity has always been under constant threat from infectious disease. Globally, we are getting better at monitoring signs of a health-related crisis and alerting each other – there are far fewer deaths from pandemics today than a century ago. And modern medicine is consistently meeting new diseases with new treatements, as shown by the progress on HIV since the 1980s. But have such modern medical successes bred a sense of hubris – excessive confidence that science will always come to the rescue?

Challenges to human health never cease to evolve. Vaccines and antibiotics have helped us to survive leading causes of death from bygone eras, but we face rising rates of chronic illnesses such as heart disease, cancers and diabetes. Although recent pandemics, such as SARS, avian flu and swine flu, have been contained, they also show how easily deadly viruses can mutate and hop from other species to us.[1] For all our successes, we are never far from the edge of catastrophe, as new biological mutations will eventually overcome a prior human innovation.

While viruses may capture more headlines, arguably the greatest risk of hubris to human health comes in the form of *antibiotic-resistant bacteria*. We live in a bacterial world where we will never be able to stay ahead of the mutation curve. A test of our resilience is how far behind the curve we allow ourselves to fall.

Our survey respondents connected this global risk to others including *vulnerability to pandemics, failure of the international Intellectual Property (IP) regime, rising rates of chronic disease* and *unforeseen consequences of new life science technology*. Like storm systems colliding in unpredictable ways, the unexpected interactions of these risks could overwhelm our health systems in the coming decade and unpredictably damage our social and economic systems.

Figure 15: The Dangers of Hubris on Human Health Constellation



Source: World Economic Forum

Many people take for granted that antibiotics will always be available when we need them, but soon this may no longer be the case. Every dose of antibiotics gives an advantage for those small numbers in a bacterial population that are resistant to the drug. The more a particular antibiotic is used, the more quickly bacteria resistant to that antibiotic will be selected and increase in numbers. Until now, leaders have been able to turn a blind eye to this problem, as new antibiotics have always emerged to replace older, increasingly ineffective ones. This is changing.

Although several new compounds for fighting bacteria are in development, experts caution that we are decades behind in comparison with the historical rate at which we have discovered and developed new antibiotics. More worryingly, none of the drugs currently in the development pipeline would be effective against certain killer bacteria, which have newly emerging resistance to our strongest antibiotics (carbapenems) and fatality rates of up to 50%.[3] As shown by the death of six patients – from 18 infected – at the US National Institutes of Health in 2011, antibiotic-resistant infections can kill, even at the world's most advanced medical centres.[4]

While predicting the spread of bacteria is notoriously difficult and complicated by a general lack of good global data, troubling projections are emerging in regions where many efforts have been made to better monitor the situation. Figure 16 shows the most recent data for two resistant pathogens, as well as the trends between 2008 and 2011. A well-known antibiotic-resistant bacteria – meticillin-resistant *Staphylococcus aureus*, better known as MRSA – is stabilizing and possibly decreasing, but not as sharply as had previously been projected.[5] For *K. pneumoniae*, there is a widespread increasing trend.[ix]

As a consequence, experts are starting to take seriously a scenario in which all antibiotics are rendered ineffective for treating even common infections.

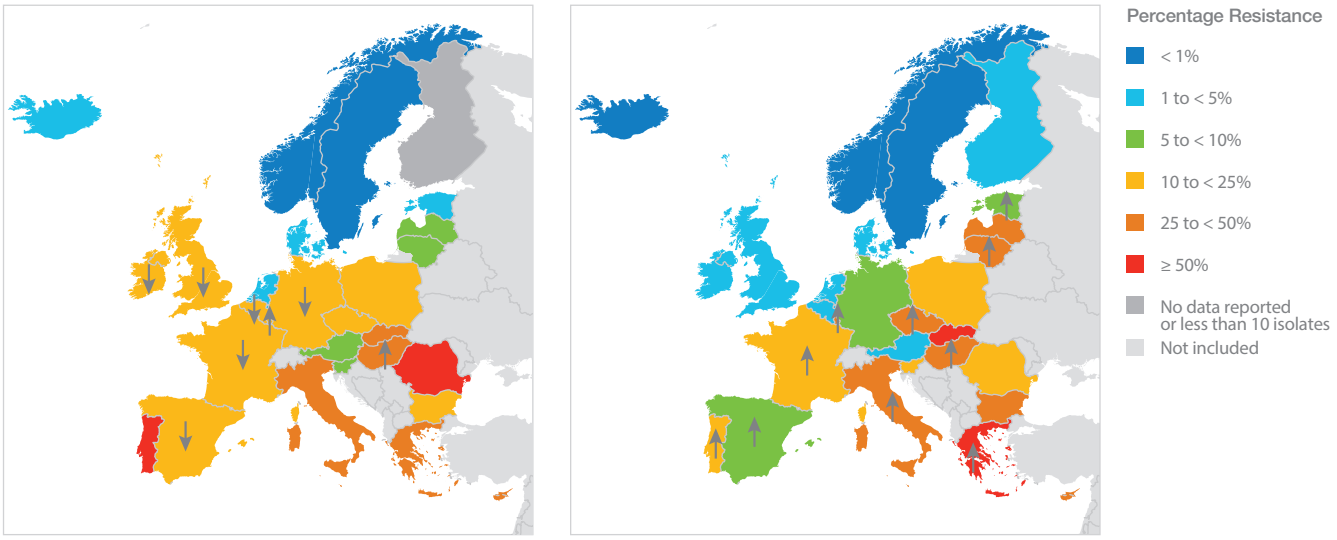
> **A post-antibiotic era means, in effect, an end to modern medicine as we know it. Things as common as strep throat or a child's scratched knee could once again kill.**

Dr Margaret Chan,
Director-General, World Health Organization. March 2012[2]

Figure 16: Percentage of Bloodstream Infections Showing Multi-Drug Resistance, EU/EEA, 2011 and Trends for 2008-2011

A. Staphylococcus aureus, resistance to meticillin (MRSA)

B. Klebsiella pneumoniae, combined resistance to three classes of antibiotics (3rd generation cephalo-sporins, fluoroquinolones and aminoglycosides)



The symbols ↑ and ↓ indicate a significant increasing or decreasing trend for the period 2008-2011, respectively. These trends were calculated on laboratories that consistently reported during 2008-2011.

Source: European Centre for Disease Prevention and Control, EARS-Net, 2012

[ix] Based on the latest data (published November 2012) from the European Centres for Disease Prevention and Control's European Antimicrobial Resistance Surveillance Network (EARS-Net) interactive database. http://ecdc.europa.eu/en/activities/surveillance/EARS-net/database/Pages/database.aspx

The Costs of *Antibiotic-Resistant Bacteria*

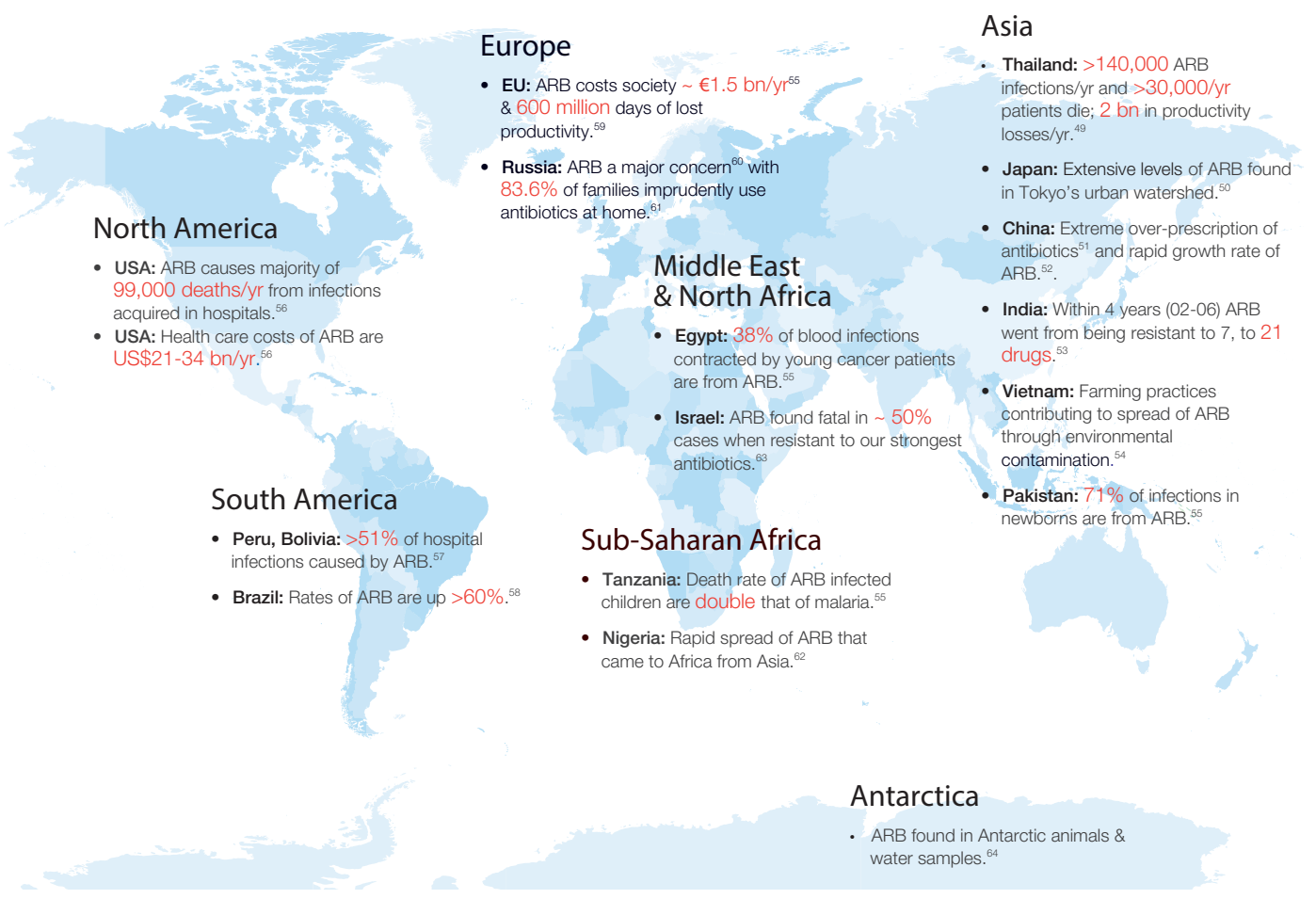
The spread of *antibiotic-resistant bacteria* has implications for everyone. The impacts on human health are likely to be highest in poorer countries, as the spread of pathogens is facilitated by poor hygiene, polluted water supplies, overcrowding in urban areas, civil conflicts and concentrations of people who are immuno-compromised due to malnutrition or HIV.[6] But even in the highest-income countries, few people go through life without needing antibiotics.

The numbers of lives now being lost due to antibiotic-resistant infections may seem small in comparison to heart disease and cancer – for example, currently just under 100,000 Americans, 80,000 Chinese and 25,000 Europeans a year die from hospital-acquired antibiotic-resistant infections.[7,8,9] However, experts believe these figures from only a few years ago may be worse today. The *Global Risks* report covers a 10-year time horizon, over which timescale it is far from unrealistic to project a significant spread of *antibiotic-resistant bacteria* with high mortality rates.[10]

It is important to remember that antibiotics are not used only to treat infections. They also, by guarding against infection, make possible medical procedures such as heart surgery, organ transplantation, the survival of pre-term babies, and aggressive immune-modulating therapy for auto-immune diseases such as rheumatoid arthritis, as well as for cancers of the blood, bone marrow and lymph nodes. With demographic and lifestyle trends such as ageing populations, changes in diet and declining rates of physical activity, we can expect rising rates of chronic diseases which are currently treated through surgery that would be impossible without effective antibiotics.

On top of destabilizing our health systems, there are profound cost implications for economic systems and for the stability of social systems. The annual cost to the US health care system of antibiotic-resistant infections is already estimated at between US$ 21 billion to US$ 34 billion.[11] Elsewhere, losses to GDP have already been estimated at 0.4% to 1.6%.[12] The consequences of a pandemic spread of *antibiotic-resistant bacteria* could also include shortages of food due to untreatable infections in livestock, and as leaders seek to slow the spread of pathogens, restrictions on trade in foodstuffs, and even on travel and migration.[13] Figure 17 provides a global snapshot of the costs, impacts and burden of *antibiotic-resistant bacteria* across the globe.

Figure 17: Spread of Antibiotic-Resistance Bacteria (ARB)[x]



x For more specific and detailed information regarding the simplified key messages outlined in the figure, please consult the referenced papers in the chapter end notes.

Why Antibiotics Are Overused

If we want to minimize the rate at which antibiotics become obsolete, we should use them as sparingly as possible. However, a combination of misaligned incentives and lack of information has led antibiotics to be used where they are not truly needed.

Even in systems which restrict the use of antibiotics by making them available by prescription only, doctors can come under pressure from patients who mistakenly believe antibiotics kill viruses – for example, in a pan-European survey, more than 50% of French respondents expected an antibiotic for an influenza-like illness.[14] Diagnostic methods that are inadequate to distinguish bacterial from viral infection or to specify the kind of bacterial infection, allied with fear of medical malpractice lawsuits, also mean that doctors tend to prescribe a cocktail of whatever antibiotics are available in the hope that one will be effective, especially in cases of severe infection. This imprecision promotes further spread of resistance in bacteria.

Some medical systems incorporate perverse incentives for antibiotics to be overprescribed. In China, for example, drug sales form a significant part of hospitals' income and, until 2010, physicians' pay was linked to profits from the sale of prescription drugs. One study found that 98% of patients in a Beijing children's hospital were given antibiotics for a common cold.[15] Figures from 2009 suggest that 74% of all hospital admissions in China will receive antibiotics to treat their illness or as a preventive measure.[16]

In many medical systems, antibiotics are not prescription-only. They can be purchased over the counter in pharmacies or in local marketplaces, and inappropriate self-medication is furthering the spread of *antibiotic-resistant bacteria*. In India, for example, pharmacy sales of strong antibiotics which should be a last line of defence increased nearly sixfold from 2005 to 2010.[17] Unfortunately, there is no easy answer to the question of how to prevent excess use of antibiotics without unfairly restricting access to antibiotics in cases of genuine need. A national task force in India recommended the end of over-the-counter sales of antibiotics, but India's Health Minister responded with concern that such a move would effectively deny access to antibiotics to patients in rural areas where there are no physicians to prescribe the drug.[18,19] Inadequate and unreliable access to a full range of antibiotics in low- to middle-income countries is also part of the problem. The spread of resistance in these areas is further facilitated by illicit trade in counterfeit drugs of substandard quality.

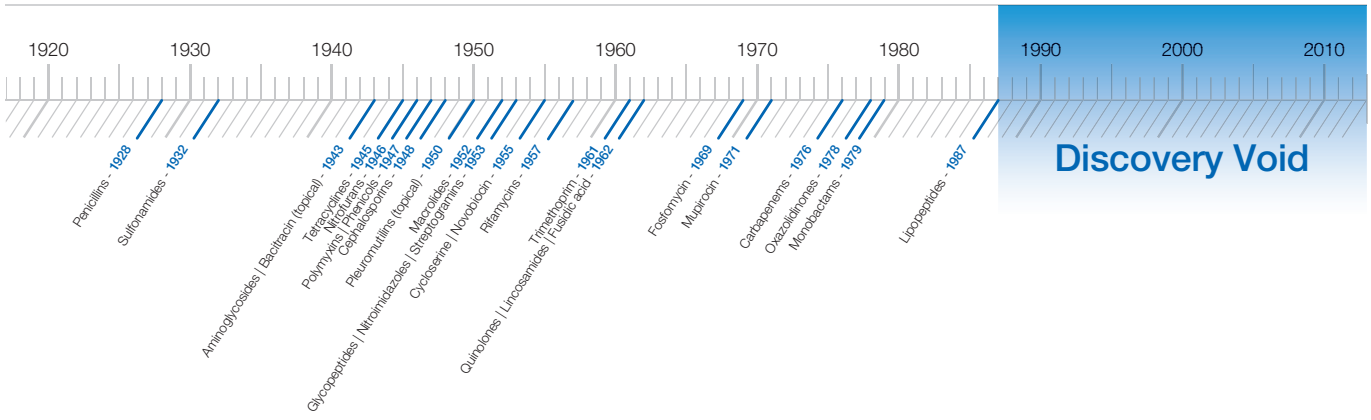
Meanwhile, antibiotics are over-used around the world in livestock and fish farming (e.g. as growth promoters). Resistant bacteria can be transferred to humans through contact with livestock, through the food chain, and through wastewater from these operations, as well as wastewater from hospitals and pharmaceutical plants.[20,21] One study found 45 kg of ciprofloxacin (an antibiotic commonly used to treat bladder and sinus infections) – the equivalent of 45,000 doses – leaking daily from factories into a nearby river.[22,23] Environmental contamination like this has led to an antibiotic-resistant bacteria being detected as far afield as Antarctica.[24,25]

Why the Development of New Antibiotics Has Slowed

Until recently, as older antibiotics have become less useful due to the spread of resistant bacteria, new antibiotics have come along to take their place. But the drug development pipeline for new antibiotics has been drying out. New antibiotics have come to market in recent years, but any sense of progress this provides is false. Our newest antibiotics are the result of scientific discoveries that happened decades ago. A timeline of dates of discovery of distinct classes of antibiotics (as opposed to dates of market introduction) illustrates that there have been no (as yet) successful discoveries of new classes of antibiotics since 1987 (Figure 18).[26] There are several competing and overlapping explanations why.

Figure 18: The Antibiotic Discovery Void[27]

The discovery dates of distinct classes of antibiotics. No new classes have been discovered since 1987.



Source: World Economic Forum, adapted from Silver, L.L. Challenges of Antibacterial Discovery. In *Clinical Microbiology Reviews*, 2011, 24:71-109.

Firstly, drugs to treat chronic illnesses such as diabetes and hypertension increasingly offer a greater potential return on investment for pharmaceutical companies. Unlike with antibiotics, resistance is not an issue with these drugs. They have the potential to rapidly achieve wide market penetration, whereas any new antibiotic is likely to be kept as a last-resort treatment, which will be used only for a few weeks even in that setting, resulting in low sales for companies.[28,xi]

Interestingly, respondents to the Global Risks Perception Survey connected *antibiotic-resistant bacteria* to *failure of the international intellectual property regime*. This global risk is defined in the survey as "the loss of the international intellectual property regime as an effective system for stimulating innovation and investment" – that is, going beyond the mechanisms of protecting IP to encompass the idea that the ultimate purpose of the IP system is to stimulate worthwhile innovation. The connection highlights a global market failure to incentivize front-end investment in antibiotic development through the promise of longer-term commercial reward, a failure which also applies to drugs to fight malaria and vaccines for pandemic influenza.[29]

Secondly, regulatory burdens have also impeded development of new antibiotics.[30] Many smaller pharmaceutical companies cannot afford the cost of meeting complex requirements for clinical trials, and these burdens risk compromising the development of many promising new agents.[31]

Thirdly, an increasing amount of effort has been invested in exploring the potential of new life science technologies such as genomics, nano-scale engineering and synthetic biology, without yet yielding new approaches in the treatment of bacterial disease. One unintended consequence of this has been to divert researchers' attention from the traditional approach of discovering natural compounds to kill bacteria, which may be getting harder.[32,33]

Hubris on health not only means taking for granted that the technologies we have will continue to work, but also assuming that bigger and better scientific breakthroughs are just around the corner. There is no guarantee that putative alternatives to antibiotics will be developed before existing antibiotics become ineffective.

What Can Be Done?

Numerous reports, workshops and conferences have proposed policies and strategies to address the spread of *antibiotic-resistant bacteria*. The World Health Organization (WHO) launched a global strategy for containment of antimicrobial resistance in 2001.[34] However, a hubristic assumption that the medical industry would continue to find solutions has contributed to decision-makers regarding the issue as a relatively low priority. The challenge is complicated by the fact that *antibiotic-resistant bacteria* do not respect borders, so there are limits on what can be done without strong international and multistakeholder collaboration. An effective response to the pandemic spread of *antibiotic-resistant bacteria* would involve tackling failures of both markets and global governance.

To address market failure, incentives have been suggested to encourage pharmaceutical companies to develop more new antibiotics.[35] For example, through advance purchase commitments, governments or philanthropists can promise to purchase a given amount of a new drug that meets stated criteria of effectiveness. This incentivizes private companies to develop new antibiotics, while enabling the sales and marketing of those new antibiotics to be restricted in the public interest.[xii]

Public-private partnerships have also shown promise in incentivizing the development of new antibiotics. One example is part of the Innovative Medicines Initiative (IMI), a €2 billion initiative of the EU Commission and the European Federation of Pharmaceutical Industries and Associations, which earmarks funds for antibiotics discovery and development.[36] The IMI acts as a neutral third party that supports collaborative research projects and builds networks between experts from industry and academia.

There is also potential to use public or philanthropic funding to incentivize academic collaboration with pharmaceutical industry researchers, and more inter-company collaboration as well. Breakthroughs in antibiotic innovation will require pooling and sharing of knowledge among academia, private companies and government regulators.[37] Companies and foundations like GlaxoSmithKline (GSK) and the Bill and Melinda Gates Foundation are pioneering an "open-lab" approach to research which refutes the idea that secrecy and patented monopolies are the bedrock of innovation. GSK has opened its Tres Cantos research facilities to outside academic, government and biotech scientists in order to collaborate on finding antibiotics, and the Bill and Melinda Gates Foundation has "organized a tuberculosis Drug Accelerator program that brings together research teams from Abbott Laboratories, AstraZeneca, Bayer, Eli Lilly, GlaxoSmithKline, Merck and Sanofi with scientists from four academic and government institutions".[38]

International efforts would be required to address licensing and regulatory barriers to the development of new antibiotics, such as lack of clarity and stability within the regulatory framework and lack of harmonization in processes of clinical trials between countries.[39]

Similarly, international collaboration would be required to facilitate improvements in data gathering, to enable more accurate and continuous monitoring of the global spread of *antibiotic-resistant bacteria*.[40] Experience from Europe over the past decade shows that if data on antibiotic use and resistance is publicly available, and national coordinated policies on prevention and control of *antibiotic-resistant bacteria* are implemented and enforced, significant reduction in antibiotic use can be achieved in human medicine.[41]

xi For the time being, priorities for R&D into new drugs are still guided by potential returns on investments and R&D of drugs that will make peak annual worldwide sales of several billion US dollars (e.g. for treating chronic diseases). These are preferred to new antibiotics that will make peak annual worldwide sales of US$ 500 million to US$ 1 billion, as exemplified in recent years by the sales of antibiotics like linezolid or daptomycin. These sales levels would have been considered acceptable 15 years ago when a "blockbuster" was defined as a drug making peak sales of US$ 1 billion or more annually. In 1997, the most-sold drug (overall) had sales of US$ 3.6 billion and 28 drugs had sales of US$ 1 billion or above (therefore considered a "blockbuster"). The most sold licensed antibiotic ranked ninth place with sales of US$ 1.5 billion. In 2011, the most sold drug had sales of US$ 10.7 billion, and 119 drugs had sales of US$ 1 billion or above. The most-sold licensed antibiotic ranked 28 with sales of US$ 1.4 billion. (Based on expert interviews)

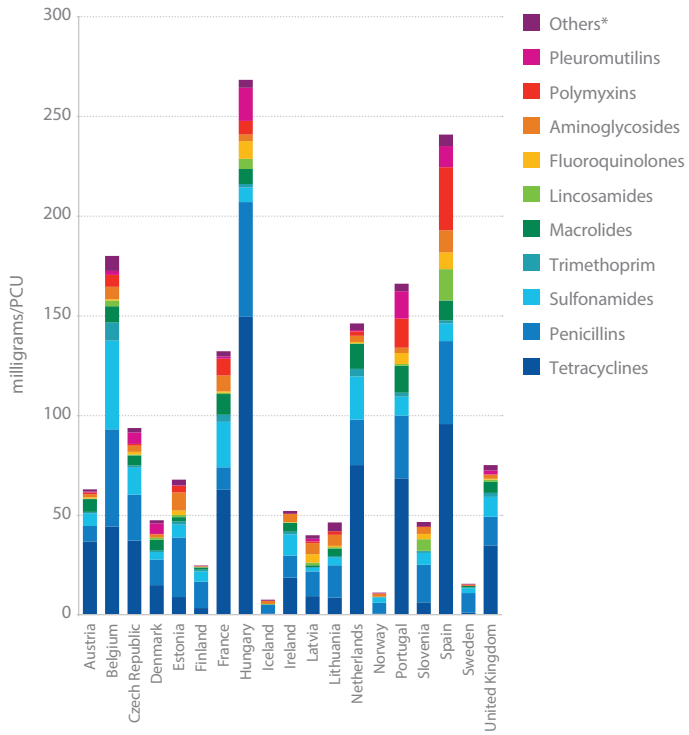
xii For an overview of mechanisms to incentivize pharmaceutical R&D see Morel, C.M. and E. Mossialos. Stocking the Antibiotic Pipeline. In *BMJ*, 2010, 340.[48]

More efforts, however, will be needed to slow the use of antibiotics in agriculture, aquaculture and animal husbandry. Research is needed to understand how Nordic countries have made significant progress – part of the answer may be small herd sizes – and to assess what works in awareness-raising campaigns, such as the Pew Charitable Trusts Campaign on Human Health and Industrial Farming.[xiii] Figure 19 shows that the amounts of antibiotics used to raise animals for food-production is still high, even in highly regulated markets like Europe.[42]

As new antibiotics become available, international collaboration will be required to limit their use to cases of need. This implies considering access to antibiotics as a development aid issue for low- to middle-income countries, and finding international mechanisms to promote collaboration on governance issues. There are opportunities to learn from each others' experience in controlling antibiotic use through aligning financial incentives in the health system to tackle over-prescription, through educational interventions to tackle the problem of unnecessary self-medication, and through improving technologies to diagnose the existence and nature of bacterial infections[xiv] and antibiotic stewardship.[44]

Figure 19: Sales of Antibiotics for Food-Producing Animals[43]

Sales of antibiotics for food-producing animals, including horses, in milligrams of antibiotics per population correction unit (PCU, i.e. 1 kilogram of animal), 2010



Source: Adapted from *Sales of Veterinary Antimicrobial Agents in 19 EU/EEA Countries in 2010*. 2012. European Medicines Agency.

The late Nobel Laureate Elinor Ostrom has compared the issue of antibiotic-resistant bacteria to that of climate change, "in the sense that both phenomena involve non-renewable global resources, both are caused by human activity and are intrinsically linked to our behaviour. The problem can only be addressed through international cooperation".[65] A cause for optimism is that, unlike with climate change, we know what actions are required. The challenge is to create the will and mechanisms to take them.[45]

Questions for Stakeholders

- How can the threat of *antibiotic-resistant bacteria* be addressed, considering that it crosses both national and species borders? How can we build visibility and political momentum to the levels currently surrounding climate change and pandemics?
- How do we re-establish antibiotic discovery, research and development given the higher return on investment on R&D of drugs for chronic diseases? What incentives are feasible? What can facilitate the work of academia and small and medium enterprises on antibiotics?
- How do we preserve current antibiotics until new agents are available? How can we align incentives to tackle overuse of antibiotics in farming of livestock and fish? What incentives work best in health financing systems? How can the international organizations be supported to take on a global leadership role to preserve the utility of current antibiotics?

[xiii] Like campaigns such as ReAct-Action on Antibiotic Resistance, Antibiotic Action, and the World Alliance against Antibiotic Resistance (WAAR), the Pew Campaign on Human Health and Industrial Farming is working to preserve the effectiveness of antibiotics by raising awareness and shaping international policies in all sectors. Their websites are rich in content and information resources.

[xiv] Molecular diagnostic technology available today can diagnose bacterial infections and the sensitivity of the bacteria to various antibiotics in a very cost-effective fashion. These technologies need to be scaled to allow for more efficient and appropriate treatment and antibiotic usage in health systems in high-, middle- and low-income economies.

Box 4: Bringing Space Down to Earth

Damage to space-based infrastructure is one of the more esoteric global risks on which our experts are surveyed annually. Members of the World Economic Forum's Global Agenda Council on Space Security believe that lack of broad awareness of the importance of satellites explains why this risk consistently ranks at the bottom of the global risk landscape. Few people appreciate how much we depend on satellites to support our most critical infrastructure and to live modern and mobile lives:

- The daily operations of telephony and Internet networks, financial markets, the banking industry, data centres and energy networks all rely on precise timing information conveyed by satellite.
- The €300 billion global TV industry would not be possible without satellites.[46] Nor would accurate weather predictions, estimated to equal €60 billion in socio-economic benefits a year in the EU alone.[47]
- Rescuers in emergency situations depend on satellites for communication, when mobile networks are overloaded. Peacekeeping and military missions also rely on secure satellite communications.

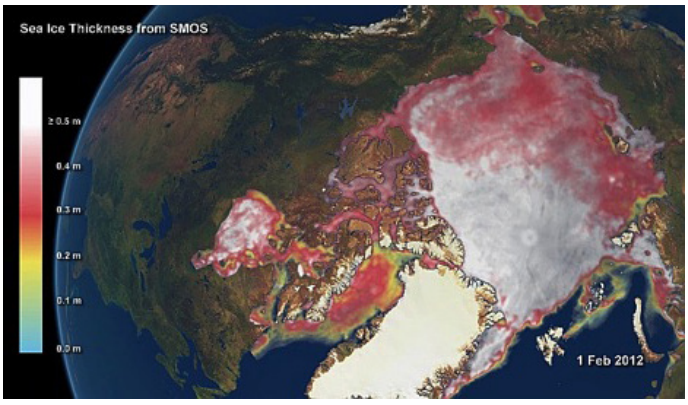
Satellites are at risk of three main "black swan" events which are captured in our global risk landscape: being targeted in a conflict between states; a strong geomagnetic storm; and collisions with space debris. These low-likelihood but high-impact risks are, however, not those that keep satellite operators awake at night. They worry far more about near-term risks on Earth. As society becomes increasingly dependent on invisible signals from space, the unforeseen long-term consequences of shortsighted management of the spectrum – the term for radio waves which satellites use to communicate – threaten essential satellite services. The desire to share scarce spectrum resources to deliver new-age digital services is taking regulators by storm, while invisible yet crucial services are squeezed into silence.

These global risks are not only physical risks to satellites but also are risks which would greatly weaken our ability to respond and prevent some of the most likely and high-impact global risks in the landscape.

- *Rising greenhouse gas emissions* and *Climate Change Adaptation:* Satellite imaging, data and communications can be used to provide early warning systems for extreme weather events and to monitor floods, desertification, and rising sea levels and temperatures in real time.
- *Food and water crises:* Satellite imagery allows food supplies to be tracked and the availability and quality of arable land and potable water resources to be assessed, as well as the locations and density of the populations that rely on them. Satellite communications allow effective and secure food distribution, as well as tracking for the personal safety of aid workers who distribute it.
- *Severe income disparity:* Connecting the world via satellite broadband has fundamental and far-reaching effects on individual lives, whether by enabling universal primary education in the most remote areas, bringing healthcare and telemedicine to those who might otherwise die because their homes are too far away from healthcare facilities, or making critical solutions such as micro-finance possible in areas where no other communications infrastructure exists.
- *Critical Systems Failure:* With virtually every network infrastructure using satellite for its timing reference – whether telephony, Internet, financial markets or banking, from data centres to energy networks – risks to satellite infrastructure could result in a global communications meltdown.
- *Land and waterway use mismanagement:* Governments have started to use satellite images in near real-time to monitor activities such as forest clearing in the Amazon rainforest and to identify illegal logging.
- *Diffusion of weapons of mass destruction and Failure of diplomatic conflict resolution:* Satellites play a critical role in the control of weapons of mass destruction by monitoring disarmament agreements. They can provide irreplaceable means for improving transparency and measures for building confidence.

Through their ability to see and speak to all corners of the world, land, air and sea, satellites are enablers that strengthen our resilience to a wide range of global risks. Broader awareness of this fact is needed to ensure that our critical space-based infrastructure is managed sustainably and that we do not underestimate the potential impacts if these critical systems fail.

Figure 20: Looking Deeper into Sea Ice



Source: "ESA satellites looking deeper into sea ice". European Space Agency (ESA), http://spaceinimages.esa.int/Images/2012/10/ESA_satellites_looking_deeper_into_sea_ice, 2012

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Special Report: Building National Resilience to Global Risks

Global risks would meet with global responses in an ideal world, but the reality is that countries and their communities are on the frontline when it comes to systemic shocks and catastrophic events. In an increasingly interdependent and hyperconnected world, one nation's failure to address a global risk can have a ripple effect on others. Resilience to global risks – incorporating the ability to withstand, adapt and recover from shocks – is, therefore, becoming more critical. This special report is organized around two axioms:

- Global risks are expressed at the national level.
- No country alone can prevent their occurrence.

As global risks can be expressed in many countries at the same time, they can spread through countries that share borders, have similar fundamentals or depend on the same critical systems. This special report is a pioneering effort to construct a diagnostic framework that applies the concept of "resilience" to assess national preparedness for global risks.

The proposed resilience framework would function as the "MRI" for national decision-makers to reveal underlying weaknesses in global risk readiness that may not be apparent via more traditional risk assessment methods. It is a prototype featuring potential qualitative[xv] and quantitative indicators produced by the World Economic Forum and by other research institutions. The aim is to refine and improve this framework by soliciting feedback from readers of this Special Report and then to introduce an interim finding that provides more detail on national resilience to global risks during summer 2013.

Types of Risk

To assess and evaluate a nation's resilience to global risks requires defining such risks in their most appropriate organizational context. Although this report does not differentiate between the views of a public or private sector organization, it does underscore the importance of understanding the qualitative distinctions among the types of risks that organizations face.[1] Harvard Business School Professors Robert Kaplan and Annette Mikes distinguish three types of risks:

1. *Preventable Risks*, such as breakdowns in processes and human error
2. *Strategic Risks*, which are undertaken voluntarily after weighing them against the potential rewards
3. *External Risks*, which are beyond one's capacity to influence or control

In the case of business, Kaplan and Mikes suggest that the first two types can be approached through traditional risk management methods, focusing mostly on organizational culture and strict compliance with regulatory, industry or institutional directives. Given the exogenous nature of external risks, cultivating resilience is the preferred approach for this last type of risk.[2]

Another way of categorizing risk is to ask two questions: How predictable is its likelihood and potential impact, and how much do we know about how to deal with it? If we can predict it and we know a lot about it, we can come up with specific strategies to anticipate the risk, mitigate its effects and minimize losses. As Figure 21 shows, resilience is most important for risks that are difficult to predict and/or where there is little knowledge on how to handle such risks.[3]

[xv] In this report, qualitative data refers to perception surveys.

Figure 21: Resilience is Most Applicable to Unpredictable Risks with Little Knowledge About Effective Measures

Source: Adapted from Comfort, L. K., Boin, A., & Demchak, C. C. *The Rise of Resilience, in Designing Resilience: Preparing for extreme events*. Pittsburg: University of Pittsburgh Press, 2010.

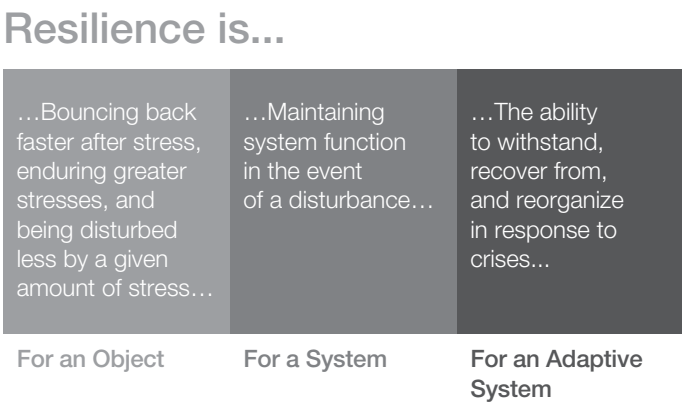
The majority of the 50 global risks, viewed with a 10 year time horizon, that feature annually in the World Economic Forum's *Global Risks* report fall under this categorization of risks. The 50 include risks which could manifest either suddenly or through gradual shifts. Although they are known risks, mapped and monitored by the Forum's Risk Response Network, there are varying degrees of uncertainty regarding how and when they might manifest, especially in this interconnected world, and regarding what primary and secondary consequences they would have for countries.

Resilience: A Working Definition

In the wake of unprecedented disasters in recent years, "resilience" has become a popular buzzword across a wide range of disciplines, with each discipline attributing its own working definition to the term. A definition that has long been used in engineering[4] is that resilience is the capacity for "bouncing back faster after stress, enduring greater stresses, and being disturbed less by a given amount of stress".[xvi] This definition is commonly applied to objects, such as bridges or skyscrapers. However, most global risks are systemic in nature,[xvii] and a system – unlike an object – may show resilience not by returning exactly to its previous state, but instead by finding different ways to carry out essential functions; that is, by adapting.[5] For a system, an additional definition of resilience is "maintaining system function[xviii] in the event of disturbance" (see Figure 22).

The working definition of a resilient country for this report is, therefore, one that has the capability to 1) adapt to changing contexts, 2) withstand sudden shocks and 3) recover to a desired equilibrium, either the previous one or a new one, while preserving the continuity of its operations.[xix] The three elements in this definition encompass both recoverability (the capacity for *speedy recovery* after a crisis) and adaptability (*timely adaptation* in response to a changing environment).

Figure 22: Resilient Systems



Source: Adapted from Martin-Breen, P. & Anderies, J.M. "Resilience: A Literature Review". Rockefeller Foundation, http://www.rockefellerfoundation.org/news/publications/resilience-literature-review, 2011.

Systems Thinking

Resilience applies to different entities, ranging from communities to countries, but the critical point is to avoid examining any of them in isolation.[6] We need to think of a country as a system that is comprised of smaller systems and a part of larger systems. A country's resilience is affected by the resilience of those smaller and larger systems.[7]

What makes a system resilient?[xx] Unlike an object, such as the aforementioned bridge, systems are too complex for mathematical calculations to predict the stresses that might arise.[8] Systems thinking provide a foundation to assess resilience through considering such components as the system's robustness, redundancy, resourcefulness, response and/or recovery, all of which are defined in the following section.[9]

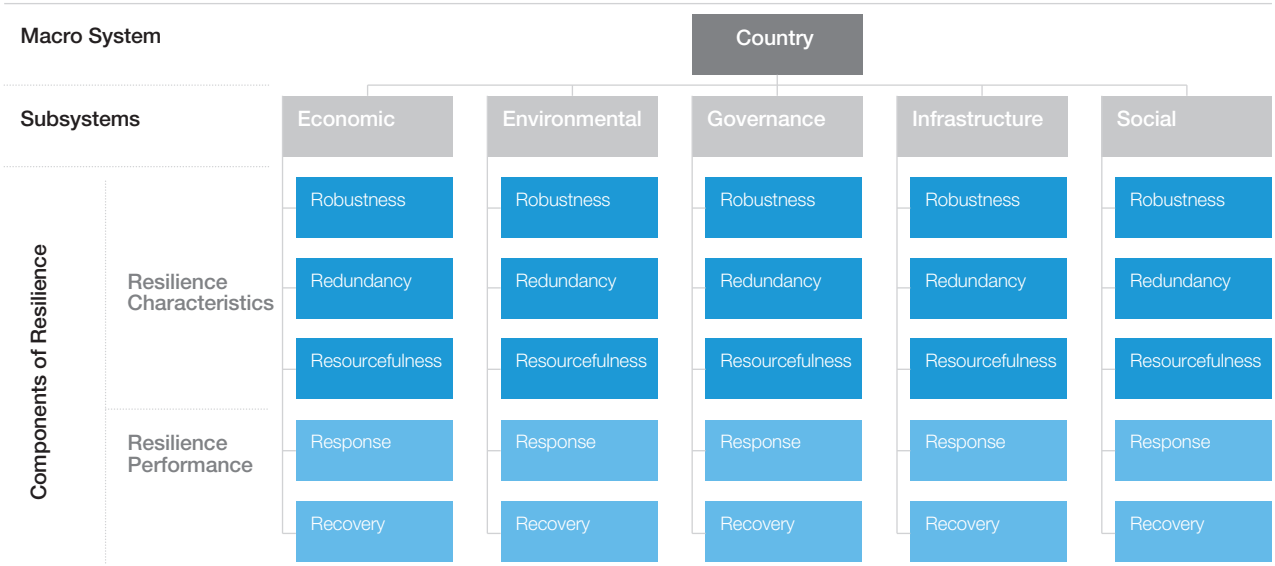
National Resilience: Five Subsystems and Five Components

This diagnostic tool is intended to measure the resilience of a country to global risks by treating it as a system composed of subsystems.[xxi] Several methods already exist to measure the resilience of such subsystems, mostly as they relate to the economy or ecosystem.[xxii] But what makes an economic system resilient is different from what makes an ecological system resilient (not only are the threats and risks different, but so are the interconnections with other systems). The aim of this report, therefore, is to present a prototype framework to measure a country's overall resilience via a five-part initial framework, depicted in Figure 23. This framework considers the country as comprised of five[xxiii] core subsystems:[xxiv]

1. **Economic subsystem:** includes aspects such as the macroeconomic environment, goods and services market, financial market, labour market, sustainability and productivity.[10]
2. **Environmental subsystem:** includes aspects such as natural resources, urbanization and the ecological system.
3. **Governance subsystem:** includes aspects such as institutions, government, leadership, policies and the rule of law.
4. **Infrastructure subsystem:** includes aspects such as critical infrastructure (namely communications, energy, transport, water and health).[11]
5. **Social subsystem:** includes aspects such as human capital, health, the community and the individual.

xvi "Stress" can imply either chronic difficulty or an acute crisis.
xvii Systemic means "relating to a system," especially as opposed to a particular part.
xviii This refers to the ability of a system to continue to meet its core functions.
xix The current definition of resilience is a working definition.
xx "Systems thinking" in this context focuses on the design of systems, the flexibility and adaptability of systems to be redesigned and their ability to redesign themselves organically in the face of a crisis.
xxi Many indices and studies break their topic, issue or subject into systems (terminology differs and words such as categories, dimensions, environments or spheres have been used interchangeably). For example: Sustainability, resilience and resource efficiency study by the Environment and Development Division, UNESCAP; the Global Political Risk Index by Eurasia Group; the Failed States Index by The Fund of Peace; Understanding community resilience and program factors that strengthen them by the International Federation of Red Cross and Red Crescent Societies; the Sustainability Index by Zurich Cantonal Bank; Wealth of Nations Triangle Index by Money Matters Institute; and World Competitiveness Scoreboard by the International Institute for Management Development.
xxii Risk Management Index by Inter-American Development Bank assesses risk management performance; Prevalent Vulnerability Index by Inter-American Development Bank estimates countries' predominant vulnerability conditions through three broad categories: (i) exposure and susceptibility; (ii) socio-economic fragility inequality; (iii) lack of social resilience; Economic Resilience Index by Commonwealth Secretariat/University of Malta measures countries' resilience through four key indicators (i) macroeconomic stability; (ii) microeconomic market efficiency; (iii) governance; (iv) social development; Composite Vulnerability Index by Commonwealth Secretariat measures the vulnerability of countries through three key components (i) lack of expert diversification; (ii) export dependence; (iii) impact on natural disasters; and Environmental Sustainability Index by Yale University/ Columbia University measures the ability of countries to protect the environment through five core components: (i) environmental systems; (ii) environmental stresses; (iii) human vulnerability to environmental stresses; (iv) social and institutional capacity; (v) global stewardship.
xxiii Many aspects of competitiveness are taken into account in the five core subsystems.
xxiv During 2013, workshops and expert calls will be conducted to define, verify and validate the five core subsystems in this framework.

Figure 23: National Resilience Beta Framework



Source: World Economic Forum

As depicted in Figure 23, each of the five subsystems is assessed further using five components of resilience: 1) robustness, 2) redundancy, 3) resourcefulness, 4) response and 5) recovery.[xxv] These five components can be categorized further into two types: resilience characteristics (robustness, redundancy and resourcefulness) and resilience performance (response and recovery). The measurement of these components presents a significant research challenge, as there are many attributes underpinning each of them, and these attributes are overlapping and complementary (Appendix 3 identifies potential qualitative and quantitative indicators[xxvi]).

This report has adopted one approach from the World Economic Forum's annual *Global Competitiveness Report* (GCR), which measures the microeconomic and macroeconomic foundations of national competitiveness.[xxvii] Similar to the concept of national resilience, the measurement of national competitiveness uses data from both international sources as well as from the Forum's annual Executive Opinion Survey (EOS) to capture concepts that require a more qualitative assessment, or for which internationally comparable statistical data are not readily available. For the purposes of this inaugural effort, we started the analysis by using data from EOS to assess components of national resilience.[xxviii]

Since 2011, the *Global Competitiveness Report* has included a prototype Sustainability-Adjusted Global Competitiveness Index (GCI).[xxix] This not only measures the propensity to prosper and grow but also integrates the idea of "quality growth", taking into account environmental stewardship and social sustainability. The quality of growth is an important aspect for resilience, and this will be addressed as we develop the framework further.

Resilience Characteristics (Robustness, Redundancy and Resourcefulness)

The following three components of resilience are used to describe a country's state of resilience. These components should be designed into a system and, as such, will enable assessments of a country's inherent resilience capabilities.[12] Relevant perception data and potential hard data for the three resilience characteristics are available in Appendix 3.

A. Robustness

Robustness incorporates the concept of reliability and refers to the ability to absorb and withstand disturbances and crises.[13] The assumptions underlying this component of resilience are that: 1) if fail-safes and firewalls are designed into a nation's critical networks,[xxx] and 2) if that nation's decision-making chains of command become more modular in response to changing circumstances, then potential damage to one part of a country is less likely to spread far and wide.

Example of Attributes

- *Monitoring system health:* Regularly monitoring and assessing the quality of the subsystem ensures its reliability.
- *Modularity:* Mechanisms designed to prevent unexpected shocks in one part of a system from spreading to other parts of a system can localize their impact, as happened with the contagion from investment banking to retail banking during the 2007-2008 financial crisis.
- *Adaptive decision-making models:* Networked managerial structures can allow an organization to become more or less centralized depending on circumstances, such as when branch offices of the Japanese retailer Lawson's continued operating through the serious disruptions of the Great East Japan Earthquake in 2011.[14] These measures can include having in place the right investment and incentive structures to overcome competing interests.

xxv During 2013, workshops and expert calls will be conducted to define, verify and validate the five components of resilience in this framework.

xxvi Indicators proposed are examples of currently available indices and indicators.

xxvii Since 2005, the World Economic Forum has based its competitiveness analysis on the Global Competitiveness Index (GCI), a comprehensive tool that measures the microeconomic and macroeconomic foundations of national competitiveness (defined as the set of institutions, policies and factors that determine the level of productivity of a country). The GCR aims to provide insight and stimulate discussion among all stakeholders on the best strategies and policies to help countries to overcome the obstacles to improving competitiveness.

xxviii The Global Competitiveness Report observed that the more competitive an economy is, the more able it is to weather an economic crisis.

xxix For more information, please see http://www.weforum.org/sustainablecompetitiveness.

xxx Critical networks are not limited to ICT but included critical social, political, ecological and economic networks.

B. Redundancy

Redundancy involves having excess capacity and back-up systems, which enable the maintenance of core functionality in the event of disturbances.[15] This component assumes that a country will be less likely to experience a collapse in the wake of stresses or failures of some of its infrastructure, if the design of that country's critical infrastructure and institutions incorporates a diversity of overlapping methods, policies, strategies or services to accomplish objects and fulfil purposes.

Examples of Attributes

- *Redundancy of critical infrastructure:* Designing replication of modules which are not strictly necessary to maintaining core function day to day, but are necessary to maintaining core function in the event of crises.
- *Diversity of solutions and strategy:* Promoting diversity of mechanisms for a given function. Balancing diversity with efficiency and redundancy will enable communities and countries to cope and adapt better than those that have none.

C. Resourcefulness

Resourcefulness means the ability to adapt to crises, respond flexibly and – when possible – transform a negative impact into a positive.[16] For a system to be adaptive means that it has inherent flexibility, which is crucial to enabling the ability to influence of resilience.[17] The assumption underlying this component of resilience is that if industries and communities can build trust within their networks and are able to self-organize, then they are more likely to spontaneously react and discover solutions to resolve unanticipated challenges when larger country-level institutions and governance systems are challenged or fail.

Example of Attributes

- *Capacity for self-organization[18]:* This includes factors such as the extent of social and human capital, the relationship between social networks and state, and the existence of institutions that enable face-to-face networking. These factors are critical in circumstances such as failures of government institutions when communities need to self-organize and continue to deliver essential public services.
- *Creativity and innovation:* In countries and industries, the ability to innovate is linked to the availability of spare resources and the rigidity of boundaries between disciplines, organizations and social groups.[19]

Resilience Performance (Response and Recovery)

These two components of resilience describe how a system performs in the event of crises. Response and recovery are dependent on risk, event and time. These components will provide us with the ability to compare systems and feed the measurements and results to calibrate the resilience characteristics. As we are dealing with global risks, the ability to adapt the framework is also very important.

D. Response

Response means the ability to mobilize quickly in the face of crises.[20] This component of resilience assesses whether a nation has good methods for gathering relevant information from all parts of society and communicating the relevant data and information to others, as well as the ability for decision-makers to recognize emerging issues quickly.

Example of Attributes

- *Communication:* Effective communication and trust in the information conveyed increase the likelihood that, in the event of a crisis, stakeholders are able to disseminate and share information quickly, and to ensure cooperation and quick response from the audience.
- *Inclusive participation:* Inclusive participation among public sector, private sector and civil society stakeholders can build a shared understanding of the issues underpinning global risks in local contexts, reduce the possibility of important interdependencies being overlooked,[21] and strengthen trust among participants.[22]

E. Recovery

Recovery means the ability to regain a degree of normality after a crisis or event, including the ability of a system to be flexible and adaptable and to evolve to deal with the new or changed circumstances after the manifestation of a risk.[23,xxxi] This component of resilience assesses the nation's capacities and strategies for feeding information into public policies and business strategies, and the ability for decision-makers to take action to adapt to changing circumstances.

Example of Attributes

- *Active "horizon scanning"*: Critical to this attribute are multistakeholder processes tasked with uncovering gaps in existing knowledge and commissioning research to fill those gaps.[24, xxxii]
- *Responsive regulatory feedback mechanisms:* Systems to translate new information from horizon-scanning activities into action – for example, defining "automatic policy adjustments triggers" – can clarify circumstances in which policies must be reassessed.[25]

As an example of the overlapping and complementary nature of these attributes, inclusive participation is listed as a key attribute of response, but it is also vital in other areas such as recovery and resourcefulness. Also inherent in all resilience characteristics, though referenced above only in the attribute of adaptive decision-making models, are investment and incentive structures and design requirements to overcome collective action problems and competing interests. There are many individual stakeholders who would benefit from greater shared resilience but currently lack either the incentive or feel too pressed for time and resources to take the necessary actions.

xxxi Brittle or unchangeable systems are not likely to recover well, but those that are more flexible and willing or able to adapt to new realities are more likely to recover better.

xxxii Examples of types and applications of horizon scanning activities have been suggested by Amanatidou, E., Butter, M., Carabias, V., et al. On Concepts and Methods in Horizon Scanning: Lessons from Initiating Policy Dialogues on Emerging Issues. In *Science and Public Policy*, 2012, 39:208-221.

Qualitative Assessment of National Resilience

As a first step towards developing the diagnostic framework, we have begun to explore perception survey data in assessing resilience. This year, the World Economic Forum introduced questions about resilience into two of its global surveys: 1) the Global Risks Perception Survey (GRPS) measured the perceptions of the Forum's expert network about their nation's[xxxiii] resilience to global risks; and 2) the Executive Opinion Survey (EOS) introduced a question to assess a government's effectiveness in managing risks in 2012.[26]

The qualitative assessment will be coupled with a quantitative one that includes statistical data by country.[xxxiv] This will result in a rating that combines perception data and objective data (i.e. qualitative and quantitative data), and that enables an analysis of patterns among resilience, risk management, competitiveness and sustainability (see Appendix 3 for examples). Our working hypothesis is that if leaders wish to assess the potential support for improving their country's resilience, then perception surveys are a good place to start.

Global Risks Perception Survey (GRPS): Resilience Question

Over 1,000 respondents to the GRPS[xxxv] were asked, per risk and regarding their country of expertise:

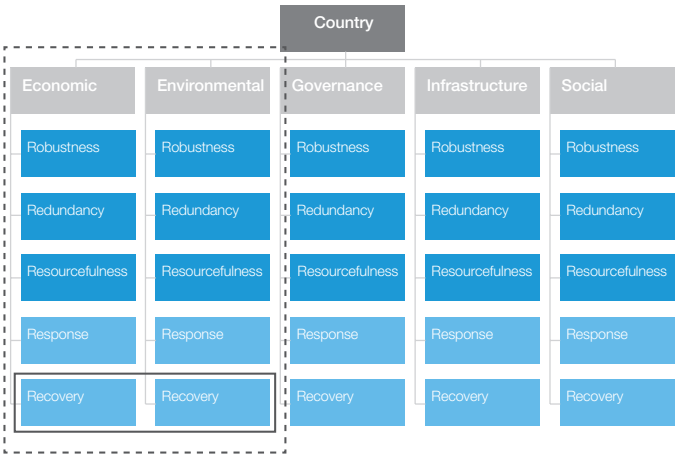
"If this risk materialized in your country of expertise, what is the ability of the country to adapt and/or recover from the impact?"*

*(*Your country refers to the country you selected in the respondent's information page.)*

This question enables us to understand respondents' perceptions of the ability of a country to adapt and/or recover from the impact of global risks. In the survey, respondents assess this ability against all five categories of global risks: economic, environmental, geopolitical, societal and technological. Assuming, economic global risks will highly impact the country's economic subsystem, and environmental global risks will highly impact the country's environmental subsystem (see Figure 24).[xxxvi] This section focuses on analyzing how these country subsystems are expected to recover after a crisis caused by economic and environmental global risks.

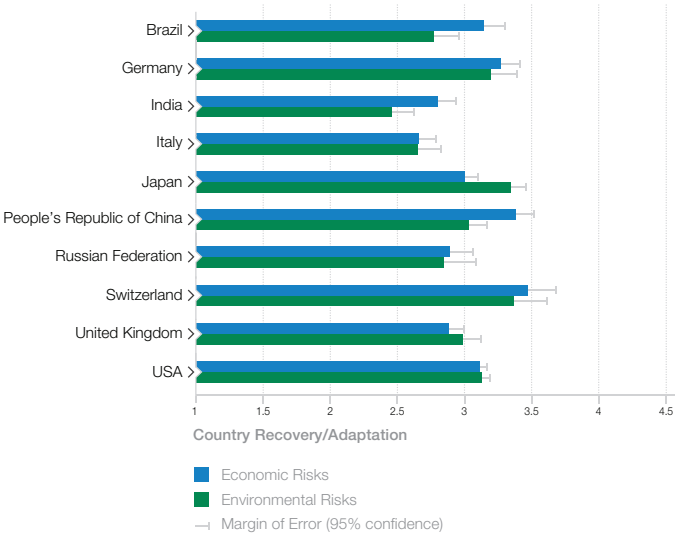
Data collected from the current GRPS gave us sufficient responses for the analysis of 10 countries: Brazil, China, Germany, India, Italy, Japan, Switzerland, Russia, the United Kingdom and the United States.[27,xxxvii] Figure 25 illustrates these countries' ability to recover from and adapt to economic and environmental risks respectively.

Figure 24: Resilience Question may be a Potential Variable for Recovery Component of Resilience



Source: World Economic Forum

Figure 25: Countries' Ability to Adapt and Recover from Economic and Environmental Risks[xxxviii]



Source: World Economic Forum

Switzerland was perceived as having the highest ability to adapt and/or recover from economic and environmental global risks; both Italy and India were rated relatively low. Japan was seen to have a comparable ability to Switzerland to adapt and recover from environmental risks, but lower in terms of economic risks. This may be a reflection of frustration about Japan's economic position and the risk of recession.

The question from the GRPS is one indicator for the response component of the proposed resilience framework. It represents the way respondents perceive their country's ability to adapt to and/or recover from certain types of global risks. In building a framework for National Resilience, further analysis will provide insights into areas needing greater investment and resources to build resilience.

xxxiii Country is the country of expertise.

xxxiv Statistical data may be obtained from open-source databases and other indices. See Appendix 3 for more potential qualitative and quantitative indicators identified.

xxxv The Global Risks Perception Survey is a major input into the annual Global Risks Report. See Appendix 1.

xxxvi Further work will try to identify how one type of risk can affect multiple or all of the country's subsystems, not just the subsystems from which the risk originally manifested itself.

xxxvii These countries had a calculated margin of error smaller than 0.5 units. Please see Appendix 3 for more details on sample size and margin of errors for these and other countries.

xxxviii The error bars in the figure indicate the margin of error for each country per category (at a 95% confidence level).

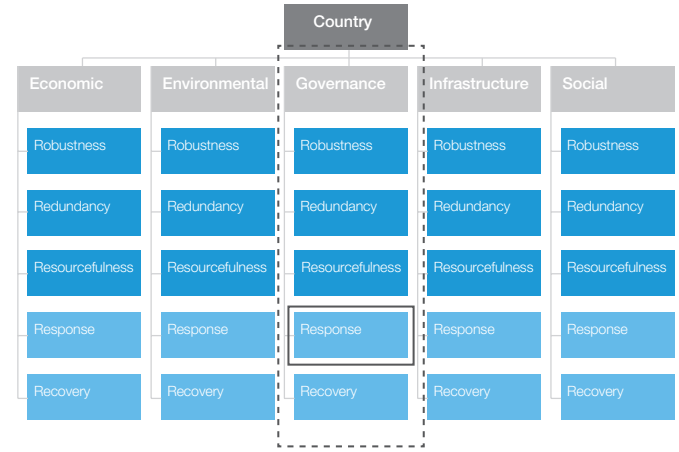
Executive Opinion Survey: Risk Management Effectiveness Question

Over 14,000 respondents to the Executive Opinion Survey (EOS)[xxxix] were asked:

"How would you assess your national government's overall risk management effectiveness of monitoring, preparing for, responding to and mitigating against major global risks (e.g. financial crisis, natural disasters, climate change, pandemics, etc.)? (1 = Not effective in managing major global risks; 7 = Effective in managing major global risks)"

Research[28] has linked the ability to respond effectively and efficiently during a crisis with good risk management, which cuts across all five subsystems. The question above from the EOS collected perceptions from business managers about their government's risk-management effectiveness. Therefore, for the purpose of this analysis, we focus on the governance subsystem and response component of resilience, as illustrated in Figure 26.

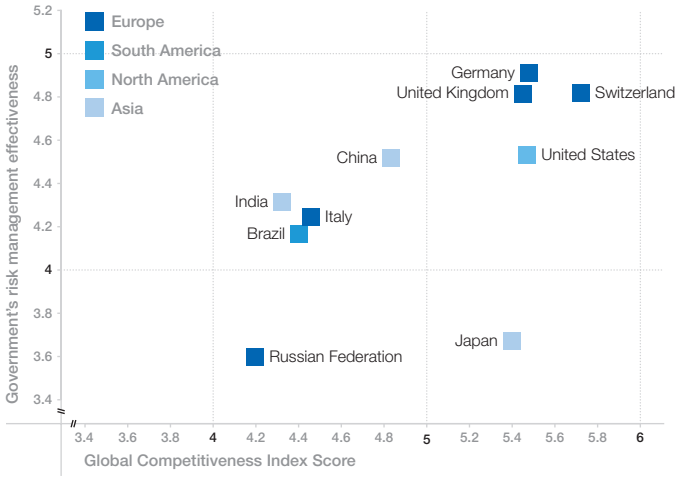
Figure 26: Government's Risk Management Effectiveness may be a Potential Variable for the Response Component of the Governance Subsystem.



Source: World Economic Forum

Figure 27 demonstrates that there may be a link between a government's risk management effectiveness and that country's overall competitiveness. As observed, a country with high risk-management effectiveness appears to have scored highly in competitiveness, and a country with low risk-management effectiveness appears to have scored low in competitiveness (except Japan). From further analysis of the EOS question on the 10 countries from the Global Risks Survey,[xl] we can see that governments in Germany, Switzerland and the United Kingdom are perceived by business leaders to have comparatively high risk-management effectiveness. While India and Italy scored relatively lower on the GRPS output, Russia was seen as having the least effective risk management based on the EOS responses. In addition, although in Figure 25 Japan was seen to have greater ability to recover from environmental risks, its government's risk-management effectiveness was rated poorly in comparison to other countries'.

Figure 27: Government's Risk Management Effectiveness and the Country's Overall Competitiveness Score



Source: World Economic Forum

Additional analysis revealed other potential indicators that may be linked to risk management, which will require further scrutiny. Correlation analysis showed there were moderate relationships between the government's risk management effectiveness and the following seven indicators from the EOS (Further details are available in Appendix 3).[xli]

- Politicians' ability to govern
- Business-government relations
- Reform implementation efficiency
- Public trust of politicians
- Wastefulness of government spending
- Measures to combat corruption and bribery
- Government provision of services for improved business performance

The most related questions seem to be intuitively what one might expect. Of the seven indicators, the most highly correlated question is that on leadership, i.e. a politician's ability to govern. This corroborates the message about leadership in risk management at the country level of the *Global Risks 2012* report special feature on The Great East Japan Earthquake. It also underscores the recommendation from the *Global Risks 2007* report to establish the role of National Risk Officers.[xlii]

Other interesting relationships highlighted above were with business-government relations and government provision of services for improved business performance. These relationships require further analysis but they may indicate the ability to share information effectively to improve monitoring and risk preparedness. By assessing government wastefulness, reform-process efficiency and corruption, we may be able to deduce that effective risk management practices are likely to be transparent and adaptive.

The analysis in this subsection is an initial indication for how we intend to proceed with building the National Resilience Rating. It is also a step towards understanding how questions from the GRPS and the EOS may identify indicators for the different components of resilience, which will be further complemented with quantitative data in the interim report in summer 2013.

xxxix The Executive Opinion Survey is carried out among CEOs and top executives and is a major input into the annual *Global Competitiveness Report* and the Global Competitiveness Index, and Sustainable Competitiveness work. http://www.weforum.org/globalcompetitiveness

xl These countries had sufficient sample sizes.

xli Analysis has shown that there are strong relationships between most of the questions (other than the risk management question) in the Executive Opinion Survey.

xlii A Country Risk Officer – analogous to Chief Risk Officers in the corporate world – would be the focal point for managing a portfolio of risk across disparate interests, setting national prioritization of risk and allowing governments to engage in the forward action needed to begin managing global risks rather than merely coping with them.

Next Steps Towards a National Resilience Rating

As early as 2007, the *Global Risks* report suggested the creation of the role of Country Risk Officer. The national resilience rating proposed in this Special Report would enable such officers and other decision-makers to benchmark and track a nation's level of resilience, understand the balance that needs to be struck between resilience and other goals, and identify areas that may require further investment.

For example, the national resilience rating will also help decision-makers to think about resilience in supply chains.[xliii] According to the World Economic Forum's Dynamic Resilience in Supply Chain project, this is rising to the top of the political and executive agendas in the wake of recent major disruptions, but there remains a reluctance to invest in resilience due to lack of good data (see Box 5).

There is also a lack of knowledge about practical actions that leaders can take to build resilience. To tackle this shortfall, the Risk Response Network has built its Resilience Practices Exchange (RPE)[xliv] using the latest social network technology, which will build and share knowledge about effective practices online (see Box 6).

More broadly, the Risk Response Network's goal is to build a common discussion framework in the global community, nurturing a culture of risk and resilience awareness across stakeholder groups. We invite readers of this Special Report to contact us at http://www.weforum.org/globalrisks2013 or at rrn@weforum.org with suggestions on how to approach measuring national resilience.

Box 5: Supply Chain Risk Initiative

Launched by the World Economic Forum in May 2011, the Supply Chain Risk Initiative (SCRI) addresses the need for a better risk-based approach for safeguarding global supply chains and published the report "*New Models for Addressing Supply Chain and Transport Risk*" in 2012. US Secretary of Homeland Security Janet Napolitano also joined the call for increased global dialogue by launching at the Annual Meeting 2012 in Davos-Klosters the first US Strategy for Global Supply Chain Security.

Phase I of the work brought agreement on priorities and recommendations for action:

1. Improve international and interagency compatibility of resilience standards and programmes
2. More explicitly assess supply chain and transport risks as part of procurement, management and governance processes
3. Develop trusted networks of suppliers, customers, competitors and government focused on risk management
4. Improve network risk visibility, through two-way information sharing and collaborative development of standardized risk assessment and quantification tools
5. Improve pre- and post-event communication on systemic disruptions and balance security and facilitation to bring a more balanced public discussion

Phase II[xlv] of the Supply Chain Risk Initiative entailed regional workshop across Asia, Europe and North America which brought together supply chain and risk experts from across government and industry to:

- Deepen collective understanding of the risk and threat landscape
- Work towards a blueprint for a resilient global supply chain
- Improve transparency across supply chains.

Addressing the vulnerabilities identified in Phase I (e.g. reliance on oil and weak information flow), Phase II focused on shared efforts to build resilience. Resilience has been the core focus as risk assessment goes hand in hand with resilience it has implications to the strategy of governments and organizations. The Forum identified measures such as improving information sharing between governments and businesses, harmonizing legislative standards and building a common risk assessment framework for building resilient supply chains.

Development of risk assessment framework is critical to improve supply chains adaptability to build resilience. The core components are data and information sharing for improved visibility along the supply chain.

xliii The World Economic Forum's findings in "Dynamic Resilience in Supply Chains" provide multiple working definitions, which include concepts related to the ability to reorganize and deliver core function continually, to bounce back from large scale disruptions, and to build capacity through collective and simultaneous efforts.

xliv For more details, please refer to the box on the Resilience Practices Exchange.

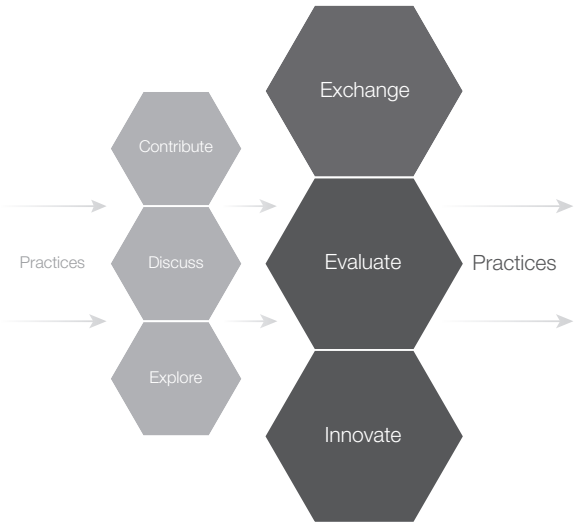
xlv The initiative's Phase II report, "Dynamic Resilience in Supply Chains", is scheduled for a launch at the January 2013 Annual Meeting in Davos-Klosters. To learn more about the initiative please visit http://www.weforum.org/supplychain.

Box 6: Resilience Practices Exchange (RPE)

The Resilience Practices Exchange (RPE) is an initiative of the World Economic Forum to share insights and ideas that improve national and organizational resilience to global risks.

By providing an online, interactive repository of ideas, the RPE aims to improve resilience to global risks within organizations, industries and countries, as well as across economic, environmental, geopolitical, societal and technological areas. A digital platform enables a diverse community of experts to contribute, discuss and explore various existing practices as a basis for further exchange, evaluation and innovation (Figure 28).

Figure 28: Resilience Practices Exchange Process



Source: World Economic Forum

The aim is to develop a process that takes a suggested practice through a community discussion phase and then on to a process of evaluation and innovation to improve that practice. This is limited not only to the online exchange but can also involve in-person meetings, virtual meetings, workshops and other forms of engagement with the Forum's Risk Response Network.

The RPE is a secure platform currently accessible only by members of the Forum's Risk Response Network and Network of Global Agenda Councils. The RPE may be accessed through a secure and trusted online platform of the World Economic Forum.[xlvi]

Examples of Resilience Building Practices

- *The G20 establishing the cross-border Financial Stability Board (FSB):* A regulatory body to coordinate financial services regulators and international standard-setting bodies across borders and organizations.
- *The Indonesian government response to the 2004 Tsunami in Aceh Province, Indonesia:* After the 2004 Indian Ocean tsunami and earthquake, the Government of Indonesia set up a pragmatic and region-based agency to effectively lead the relief efforts in the province of Aceh.
- *Governmental cyber risk information-sharing partnerships:* Governments are setting up agencies to share information with international partners, including overseas governments, agencies and businesses to provide an international, informed response to cyber risks.

Please contact resilience.exchange@weforum.org for further information.

[xlvi] For more information, please see http://rpe.weforum.org.

Box 7: One Year On Resilience Practices

Practices to Improve Resilience from the 2012 Risk Cases

World Economic Forum's Risk Response Network, in collaboration with PwC, has revisited the three cases in the *Global Risks 2012* report – Seeds of Dystopia, How Safe are Our Safeguards? and The Dark Side of Connectivity – to analyse practices to improve resilience against the risks highlighted in each case, available on our interactive website.

- **Seeds of Dystopia** (with further collaboration from Eurasia Group): As fiscal, ageing and employment trends combine to threaten the emergence of a new class of fragile states, the private sector, civil society, local and national governments, as well as multilateral organizations need to work in concert to create a modern and sustainable social contract. The resilience practices highlighted here are engaging multiple stakeholders in solutions based on holistic insights; continuous monitoring of trends to enable assumptions to be revisited; promoting open and inclusive attitudes towards immigrants; and embracing innovative financing models.
- **How Safe are Our Safeguards?** Jurisdictional safeguards against cross-border risks can quickly become outdated in an interdependent and rapidly changing environment. Practices that improve resilience can be found by looking for common threads in two very different areas – financial system stability and pandemic influenza. The resilience-enhancing practices highlighted are: revisiting underlying assumptions related to safeguards in place; introducing forward-looking elements such as stress testing and scenario planning into safeguard development; leveraging incentives; and promoting cross-border collaboration among governments and other organisations.
- **The Dark Side of Connectivity:** In an increasingly hyperconnected world, the impacts of our successes and mistakes are significantly magnified. Resilience of cyberspace could be strengthened by treating cyber security as a board-level issue within organisations; establishing mechanisms for governments and private companies to share information in a trusted space, and for governments to collaborate in emergency cyber-attack situations; and designing devices and systems that incorporate as much protection as possible against inevitable human error.

For the full case responses, please refer to the following webpage, http://www.weforum.org/globalrisks2013/followup2012.

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Survey Findings

In this section, the results from the annual Global Risks Perception Survey are presented in detail. They collate the views of more than 1,000 experts from the World Economic Forum's communities. Respondents are aged between 19 and 79, come from different types of organizations, different fields of specialist knowledge, and from over 100 countries.[xlvii]

The Risk Landscape

For each of the 50 global risks, respondents were asked to assess, on a scale from 1 to 5, the likelihood of the risks occurring over the next 10 years and the impact if the risk were to occur.

Figure 29 indicates the average values of these two measures for each of the 50 global risks in their respective categories (see also Figure 2 the Global Risks Landscape scatterplot, showing them in one combined graph). Almost all dots on the scatterplots are above and to the right of the midpoints (at 3 or more) of the 1 to 5 axes, suggesting that the majority of the 50 global risks were rated, on average, as having high likelihood and impact.

Nonetheless, there is some interesting variation in the dots' placement on the landscape. Some economic risks, such as *major systemic financial failure*, *chronic fiscal imbalances* and *severe income disparity* are far out towards the top-right hand corner, with impact and likelihood scores around 4 (on a scale from 1 to 5, which is high for an average ranking). Some of the technological risks are closer to the middle of the axes, with impact and likelihood scores 3 or less.

As was observed in previous editions of the *Global Risks* report, there appears to be a strong relationship between the likelihood and impact. The dots seem to line up loosely around the 45-degree line and there are no dots in the bottom-right or top-left corners of the plot. Survey respondents seem to be associating high-likelihood events with high impacts.

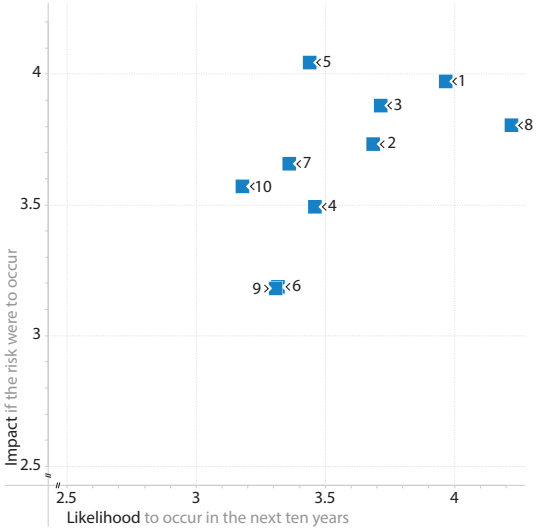
This finding holds up even when looking at individual responses for each of the risks, and not only average numbers. The colourful tiles in Figure 30 show how the responses are distributed across the scatterplot for each of the 50 risks. While there were some responses that were off the 45-degree line, the combinations of impact and likelihood that got the most votes from survey respondents – as indicated by the dark-coloured tiles – seem to be near that diagonal in almost all of the 50 diagrams.

Still it is interesting to observe how for some risks, particularly technological risks such as *critical systems failure*, the answers are more distributed than for others – *chronic fiscal imbalances* are a good example. It appears that there is less agreement among experts over the former and stronger consensus over the latter.

[xlvii] See Appendix 1 for a more detailed description of the sample.

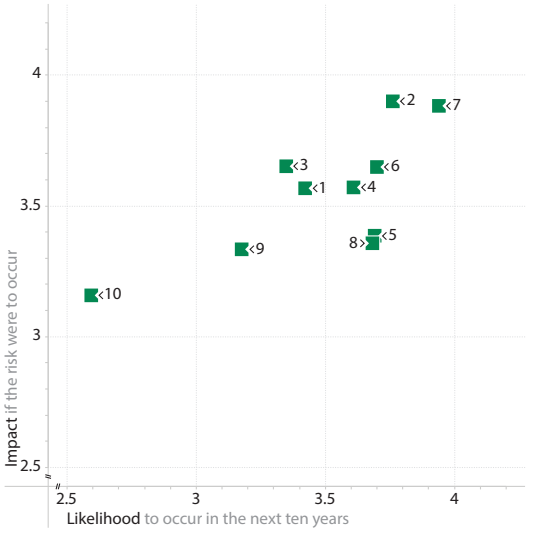
Figure 29: Global Risks Landscape by Categories and their Descriptions

Economic



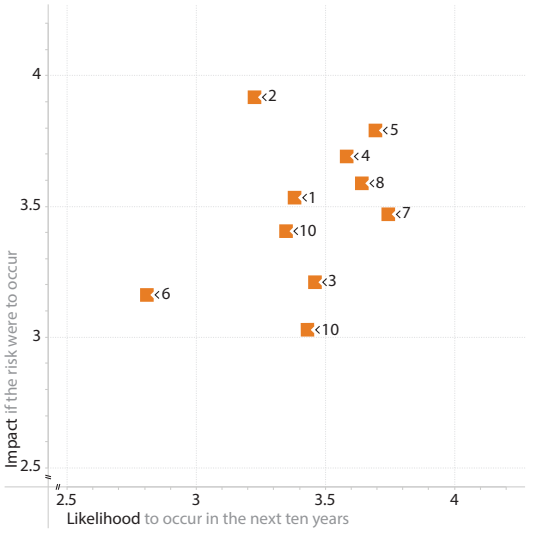
1	Chronic fiscal imbalances	Failure to redress excessive government debt obligations.
2	Chronic labour market imbalances	A sustained high level of underemployment and unemployment that is structural rather than cyclical in nature.
3	Extreme volatility in energy and agriculture prices	Severe price fluctuations make critical commodities unaffordable, slow growth, provoke public protest and increase geopolitical tension.
4	Hard landing of an emerging economy	The abrupt slowdown of a critical emerging economy.
5	Major systemic financial failure	A financial institution or currency regime of systemic importance collapses with implications throughout the global financial system.
6	Prolonged infrastructure neglect	Chronic failure to adequately invest in, upgrade and secure infrastructure networks.
7	Recurring liquidity crises	Recurring shortages of financial resources from banks and capital markets.
8	Severe income disparity	Widening gaps between the richest and poorest citizens.
9	Unforeseen negative consequences of regulation	Regulations which do not achieve the desired effect, and instead negatively impact industry structures, capital flows and market competition.
10	Unmanageable inflation or deflation	Failure to redress extreme rise or fall in the value of money relative to prices and wages.

Environmental



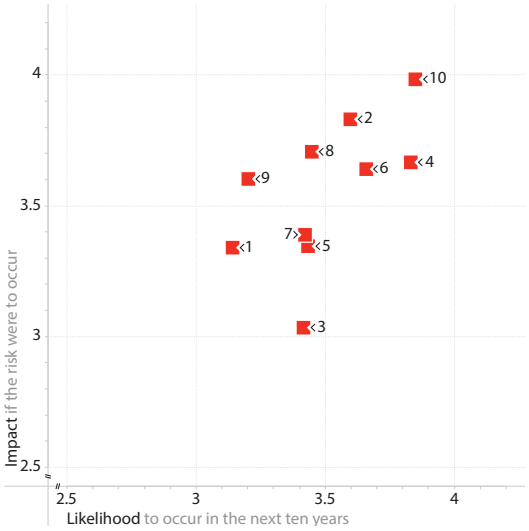
1	Antibiotic-resistant bacteria	Growing resistance of deadly bacteria to known antibiotics.
2	Failure of climate change adaptation	Governments and business fail to enforce or enact effective measures to protect populations and transition businesses impacted by climate change.
3	Irremediable pollution	Air, water or land permanently contaminated to a degree that threatens ecosystems, social stability, health outcomes and economic development.
4	Land and waterway use mismanagement	Deforestation, waterway diversion, mineral extraction and other environment modifying projects with devastating impacts on ecosystems and associated industries.
5	Mismanaged urbanization	Poorly planned cities, urban sprawl and associated infrastructure that amplify drivers of environmental degradation and cope ineffectively with rural exodus.
6	Persistent extreme weather	Increasing damage linked to greater concentration of property in risk zones, urbanization or increased frequency of extreme weather events.
7	Rising greenhouse gas emissions	Governments, businesses and consumers fail to reduce greenhouse gas emissions and expand carbon sinks.
8	Species overexploitation	Threat of irreversible biodiversity loss through species extinction or ecosystem collapse.
9	Unprecedented geophysical destruction	Existing precautions and preparedness measures fail in the face of geophysical disasters of unparalleled magnitude such as earthquakes, volcanic activity, landslides or tsunamis.
10	Vulnerability to geomagnetic storms	Critical communication and navigation systems disabled by effects from colossal solar flares.

Geopolitical



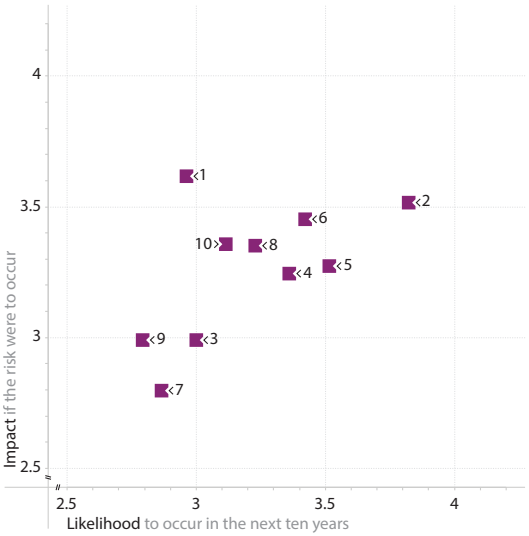
1	Critical fragile states	A weak state of high economic and geopolitical importance that faces strong likelihood of collapse.
2	Diffusion of weapons of mass destruction	The availability of nuclear, chemical, biological and radiological technologies and materials leads to crises.
3	Entrenched organized crime	Highly organized and very agile global networks committing criminal offences.
4	Failure of diplomatic conflict resolution	The escalation of international disputes into armed conflicts.
5	Global governance failure	Weak or inadequate global institutions, agreements or networks, combined with competing national and political interests, impede attempts to cooperate on addressing global risks.
6	Militarization of space	Targeting of commercial, civil and military space assets and related ground systems that can precipitate or escalate an armed conflict.
7	Pervasive entrenched corruption	The widespread and deep-rooted abuse of entrusted power for private gain.
8	Terrorism	Individuals or a non-state group successfully inflict large-scale human or material damage.
9	Unilateral resource nationalization	Unilateral moves by states to ban exports of key commodities, stockpile reserves and expropriate natural resources.
10	Widespread illicit trade	Unchecked spread of illegal trafficking of goods and people throughout the global economy.

Societal



1	Backlash against globalization	Resistance to further increased cross-border mobility of labour, goods and capital.
2	Food shortage crises	Inadequate or unreliable access to appropriate quantities and quality of food and nutrition.
3	Ineffective illicit drug policies	Continued support for policies that do not abate illegal drug use but do embolden criminal organizations, stigmatize drug users and exhaust public resources.
4	Mismanagement of population ageing	Failure to address both the rising costs and social challenges associated with population ageing.
5	Rising rates of chronic disease	Increasing burden of illness and long-term costs of treatment threaten recent societal gains in life expectancy and quality.
6	Rising religious fanaticism	Uncompromising sectarian views that polarize societies and exacerbate regional tensions.
7	Unmanaged migration	Mass migration driven by resource scarcity, environmental degradation and lack of opportunity, security or social stability.
8	Unsustainable population growth	Unsustainably low or high population growth rates and sizes, creating intense and rising pressure on resources, public institutions and social stability.
9	Vulnerability to pandemics	Inadequate disease surveillance systems, failed international coordination and the lack of vaccine production capacity.
10	Water supply crises	Decline in the quality and quantity of fresh water combine with increased competition among resource-intensive systems, such as food and energy production.

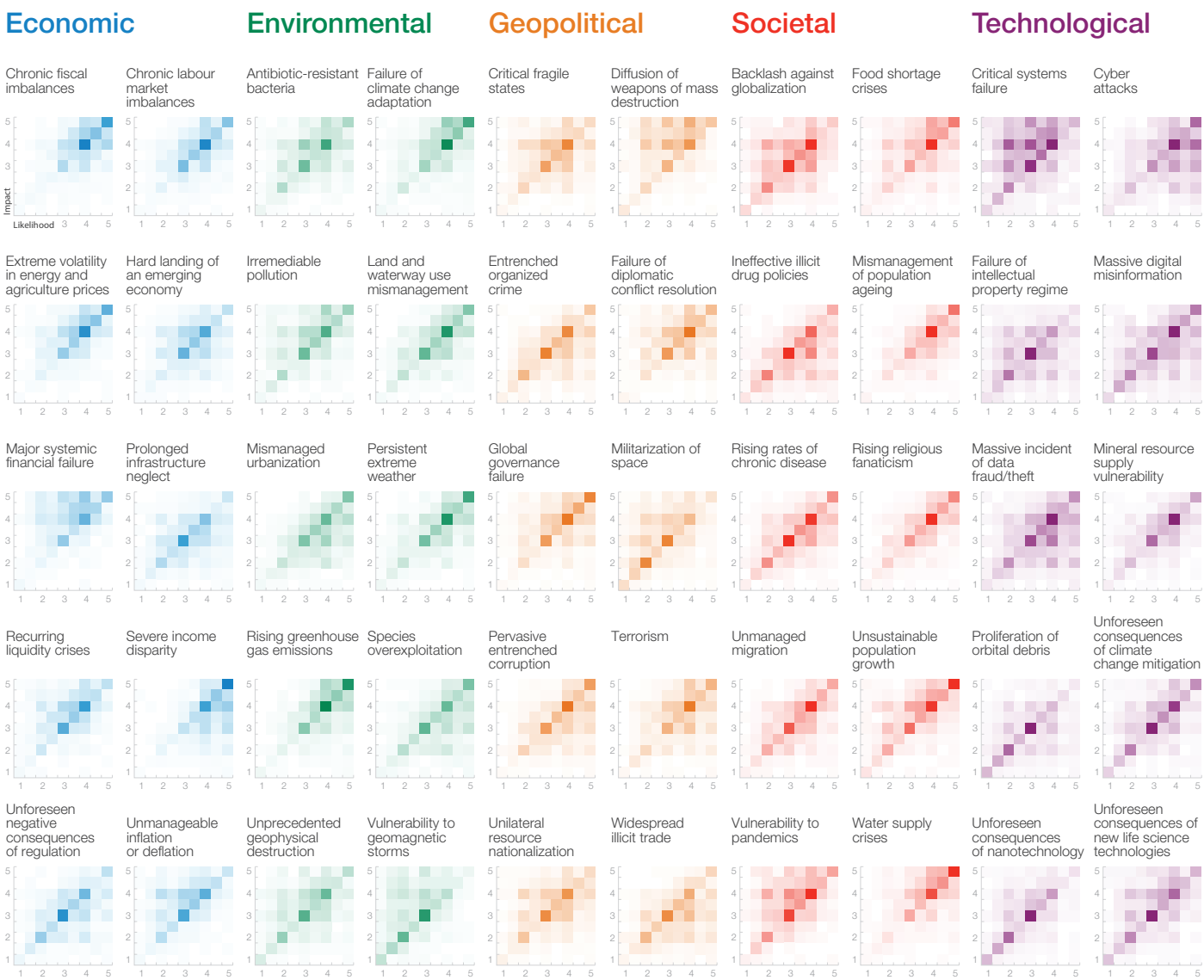
Technological



1	Critical systems failure	Single-point system vulnerabilities trigger cascading failure of critical information infrastructure and networks.
2	Cyber attacks	State-sponsored, state-affiliated, criminal or terrorist cyber attacks.
3	Failure of intellectual property regime	The loss of the international intellectual property regime as an effective system for stimulating innovation and investment.
4	Massive digital misinformation	Deliberately provocative, misleading or incomplete information disseminates rapidly and extensively with dangerous consequences.
5	Massive incident of data fraud/theft	Criminal or wrongful exploitation of private data on an unprecedented scale.
6	Mineral resource supply vulnerability	Growing dependence of industries on minerals that are not widely sourced with long extraction-to-market time lag for new sources.
7	Proliferation of orbital debris	Rapidly accumulating debris in high-traffic geocentric orbits jeopardizes critical satellite infrastructure.
8	Unforeseen consequences of climate change mitigation	Attempts at geoengineering or renewable energy development result in new complex challenges.
9	Unforeseen consequences of nanotechnology	The manipulation of matter on an atomic and molecular level raises concerns on nanomaterial toxicity.
10	Unforeseen consequences of new life science technologies	Advances in genetics and synthetic biology produce unintended consequences, mishaps or are used as weapons.

NB: The scatter plots show the average value, across all responses, of the likelihood and impact of the 50 global risks, as measured on the horizontal and vertical axes, respectively.
Source: World Economic Forum

Figure 30: Distribution of Survey Responses



NB: These diagrams show how individual survey responses are distributed across the different possible combinations of likelihood and impact scores, as measured, respectively, on the horizontal and vertical axes of the graphs. The darker the colour of the tile, the more often that particular combination was chosen by the experts who took the survey.

Source: World Economic Forum

Compared with Last Year

While there is some movement of individual dots, compared with last year's scatter plot, the general distribution of the risks on the risk landscape is, perhaps unsurprisingly, similar (see Figure 1). What is surprising, though, is that respondents this year see risks as more likely and as having a higher impact than respondents to the previous year's survey. The average likelihood score is 0.15 units higher (on a scale from 1 to 5), and the average impact score is 0.13 units higher.

Part of the increase in impact (about a quarter of the difference) can be explained by the fact that the average age of the survey sample has decreased, and as shown below, younger people tend to give higher answers when it comes to assessing a risk's impact. Nonetheless, even controlling for age and other different characteristics of the sample, the fact remains that the perceived likelihood and impact of many of the risks have increased.

Particularly interesting cases which had big increases in both likelihood and impact scores are:

- the technological risks: *unforeseen consequences of new life science technologies* and *unforeseen consequences of climate change mitigation*;
- the economic risks: *unforeseen negative consequences of regulation, hard landing of an emerging economy* and *chronic labour market imbalances*;
- the two sides of global demographic imbalances: *unsustainable population growth* and *mismanagement of population ageing*; and
- the geopolitical risk: *unilateral resource nationalization*.

Only very few risks had their average scores decrease from last year. On the likelihood scale, these include *recurring liquidity crises, vulnerability to geomagnetic storms* and *proliferation of orbital debris*. The only risk where there was a statistically significant decrease in terms of its impact was *food shortage crises*.

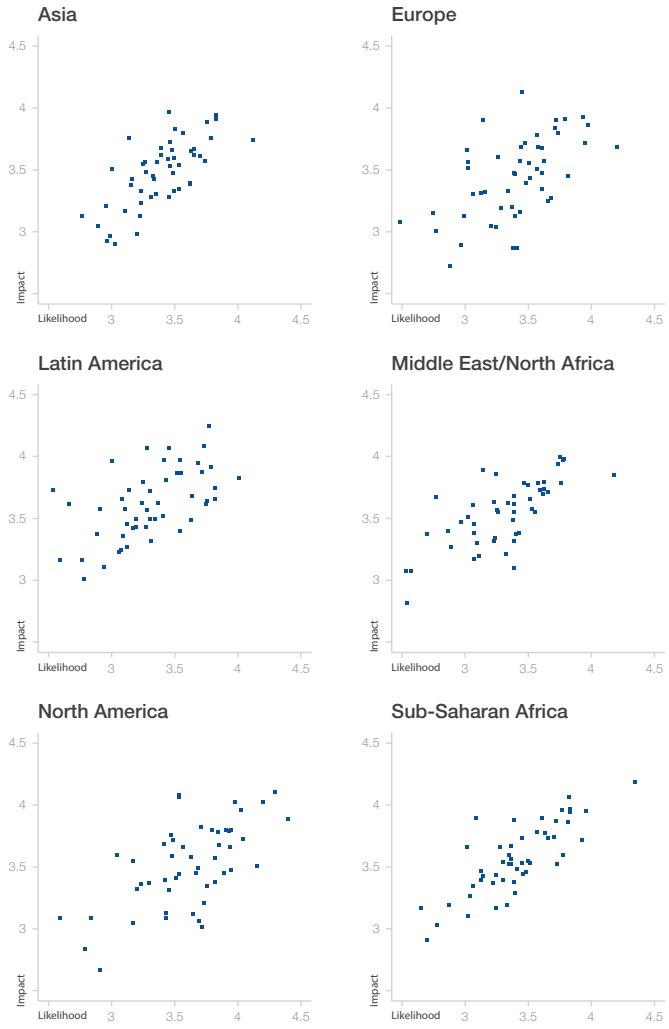
By Region of Residence

Survey respondents were asked to provide some information about their background: their age, their gender, where they live, for what kind of organization they work, and their subject-area expertise. Using this demographic data the risks landscape was cut up in different ways to see how different groups with specific characteristics perceive global risks.

Figure 31, for instance, shows how respondents based in North America tend to rate many risks as having a higher likelihood than respondents in other regions. The dots are markedly further to the right in the scatter plot, and for a large number of risks the differences with other regions are statistically significant. These include *chronic fiscal imbalances, prolonged infrastructure neglect, rising greenhouse gas emissions, diffusion of weapons of mass destruction* and *cyber attacks* (see Appendix 2 for detailed results).

The scatterplot for Latin America demonstrates that respondents based in that region tend to assign a higher impact to risks. For instance, they see the impact of *ineffective illicit drug policies* as significantly higher than survey takers from other regions. It is also interesting that average responses from respondents based in Asia are clustered more densely together.

Figure 31: Comparison between Regions of Residence

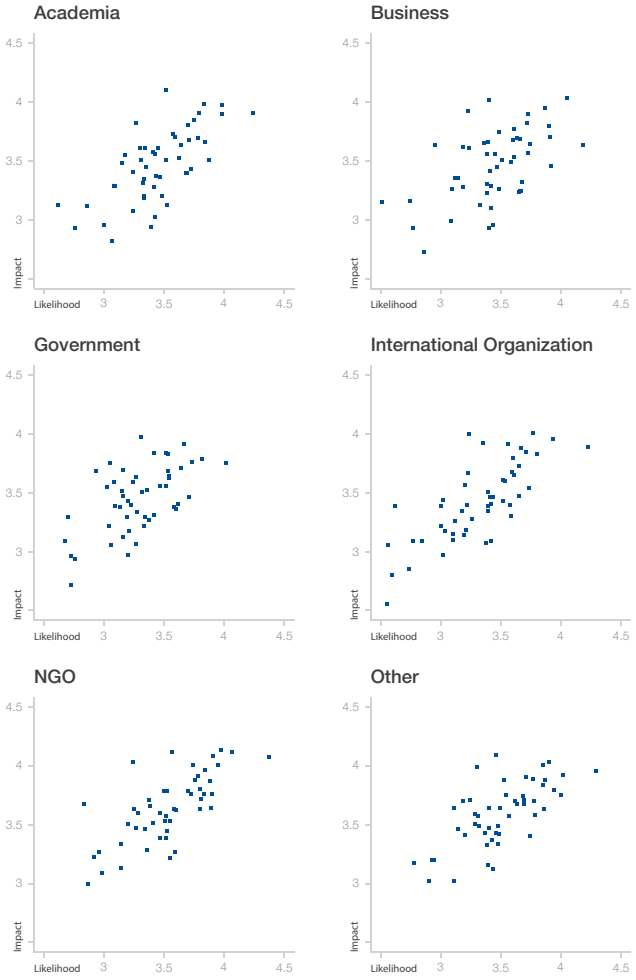


Source: World Economic Forum

By Organization

Similarly, it is possible to look at how the perceptions of people who work at different types of organizations differ. This year, the differences are less pronounced than last year. One striking observation, though, is that for many risks, people working for NGOs tend to assign higher scores than their peers from other organizations. In particular, people from NGOs see many risks as more likely than respondents from the government sector, and they rate impacts more highly than those in the business world (see Appendix 2 for more results).

Figure 32: Comparison between Organizational Affiliations



Source: World Economic Forum

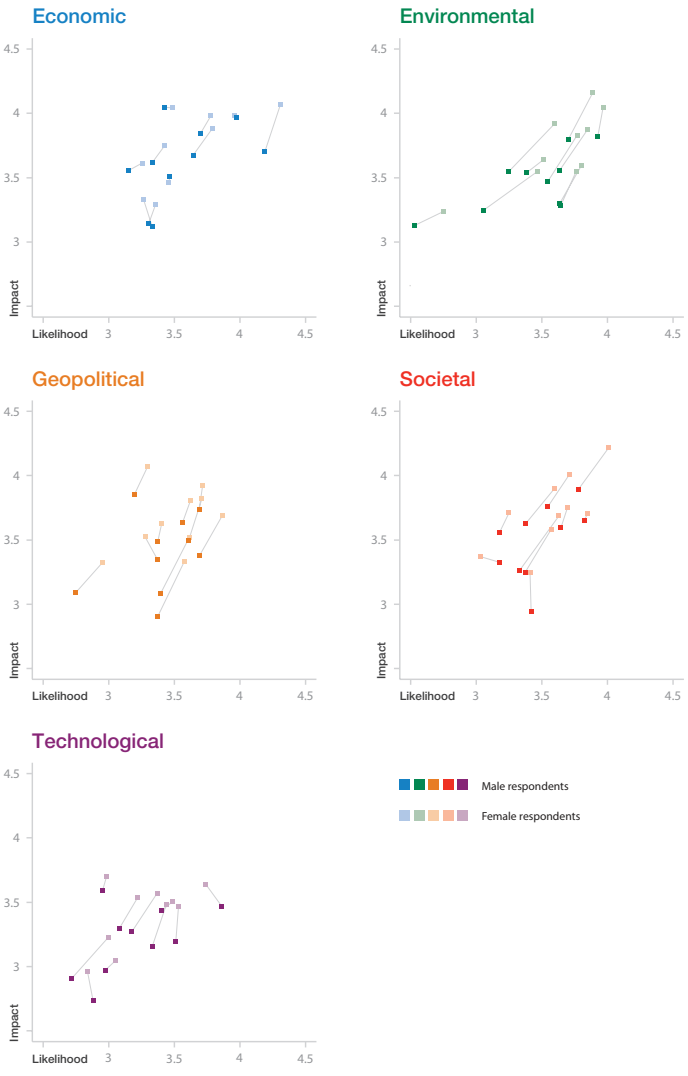
By Gender

The difference in perception between genders is very pronounced, with women tending to rate both the likelihood and impact of most risks higher than men. On average, the likelihood rating is 0.11 units higher for women than for men, while the difference between the impact scores is 0.21 units.[xlviii]

For most individual risks, this difference was statistically significant at the 5% level. There is only one risk, *backlash against globalization*, which men rated as more likely than women.

The overall finding that men are generally less worried about risks than women is in line with what has been observed in other surveys about perceptions of other kinds of risk.[1] The literature is not in agreement as to the reasons for this result. Some believe that women are generally more risk-averse than men, while others argue the two genders perceive risks similarly but worry about different risks, so it matters which risks surveys ask about. Either explanation would have important implications for risk managers and policy-makers wanting to use expert perceptions to identify and assess global risks, and to make the most informed decisions.

Figure 33: Comparison between Genders



Source: World Economic Forum

xlviii Controlling for other characteristics of the sample, the respective differences would be 0.087 and 0.18 units.

By Age

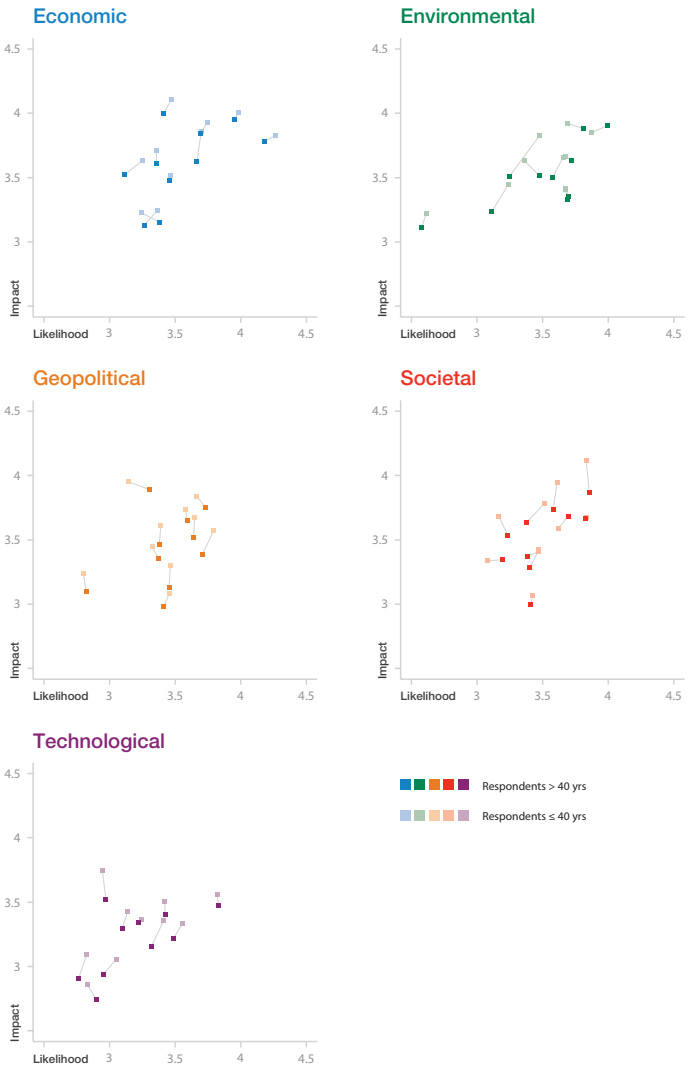
Figure 34 shows that respondents aged 40 or younger tend to rate most risks as higher in impact than those over 40. There is no risk where the older group's impact scores are significantly higher.

For many risks, the younger experts also chose higher likelihood scores. But there are a few exceptions, where respondents over 40 rated risks as more likely to occur in the next 10 years than the respondents under 40: *prolonged infrastructure neglect, failure of climate change adaptation, rising greenhouse gas emissions* and *diffusion of weapons of mass destruction*.

In contrast to the differences between the genders, the psychometric literature is less clear on the effect of age on risk perceptions. Some studies find that younger people generally worry less about risks.[2] However, most of these look at adolescents and personal risks such as driving, drinking and smoking. It is not surprising that this finding does not carry over to perceptions of global risks among experts in their third or fourth decade of life. On the other hand, studies that look at age differences in general, not only at teenagers, support the finding from the present survey that younger people generally perceive risks as higher.[3]

It is interesting that high-level decision-makers tend to be drawn mostly from the group – older males – that the breakdowns by age and gender indicate is least inclined to worry about global risks.

Figure 34: Comparison between Age Groups



Source: World Economic Forum

By Subject-matter Expertise

Finally, it is possible to look at how subject expertise affects risk perceptions. Respondents were asked to identify in which of the five categories (which group the 50 risks) they consider themselves experts. While there is no generalization that can be made about all risks, there are some interesting cases where experts are more worried about risks.

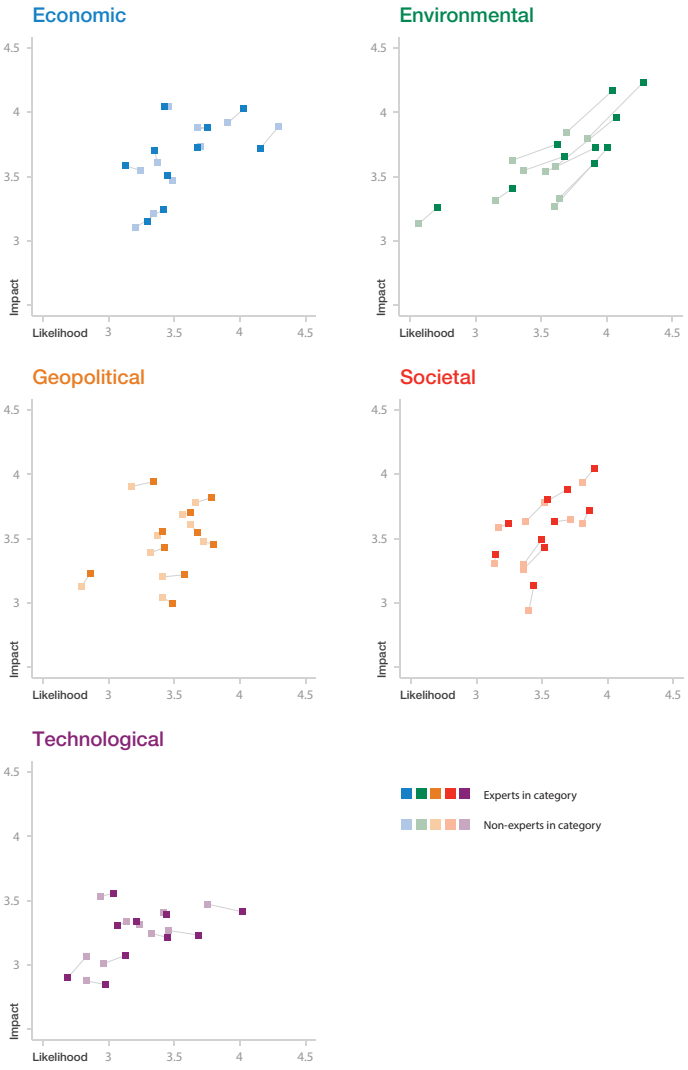
The differences between environmental experts and their peers from other fields are striking – they assign higher impact and likelihood scores to all 10 risks in the environmental category, with most of these differences being statistically significant at the 5% level (see Appendix 2).

Also there are a number of societal risks where specialists are more alarmed than other respondents, such as *rising rates of chronic diseases, unsustainable population growth* or *unmanaged migration*. In the economic category, this pattern holds only for *chronic fiscal imbalances*. For most other risks in this category, as well as in the geopolitical and in the technological domains, there are few statistically significant differences.

On the other side of the equation, experts in economic issues worry less about the impact and likelihood of *severe income disparity* than non-experts. Similarly, technological experts worry less than non-experts about the likelihood and impact of *unforeseen consequences of nanotechnology*.

These findings raise interesting questions. Are economists more informed about economic issues than others, or are there ideological differences at play? Are the technological specialists more knowledgeable here, or does their excitement about new technologies dampen their risk perceptions? And where experts are more worried, does that mean that we should listen to them more, or do they just feel more strongly about their issue without knowing enough about other threats?

Figure 35: Comparison between Experts



Source: World Economic Forum

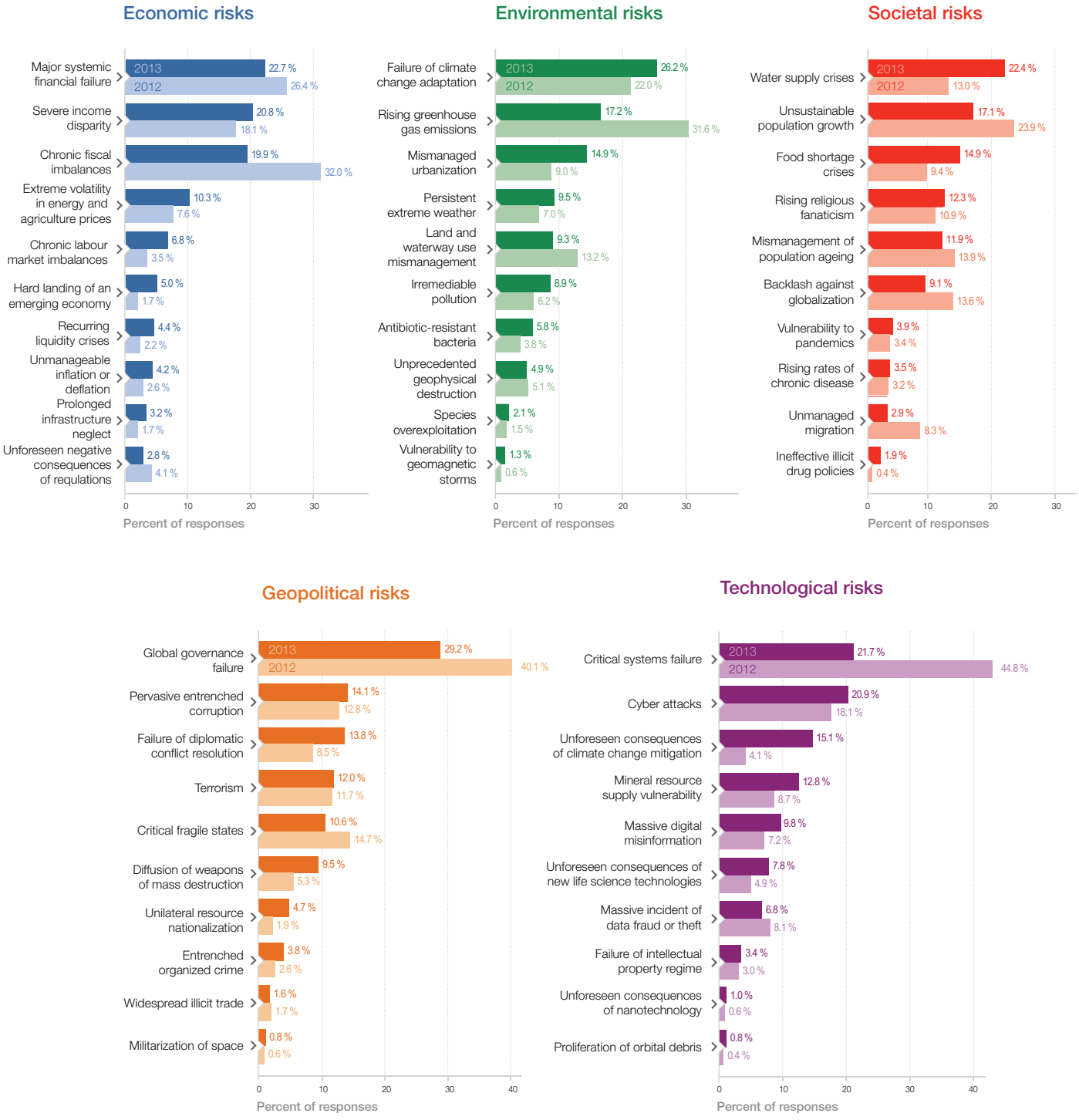
Centres of Gravity

For each of the five categories, survey-takers were asked to pick a "Centre of Gravity" – the one risk that they thought is the systemically most important one in that group. Due to their influence on other risks, these are the risks to which leaders and policy-makers should pay particularly close attention. Figure 36 shows how the answers to this question are distributed among the different options. The top selected risks for Centres of Gravity this year are:

- *major systemic financial failure* (economic)
- *failure of climate change adaptation* (environmental)
- *global governance failure* (geopolitical)
- *water supply crises* (societal)
- *critical systems failure* (technological)

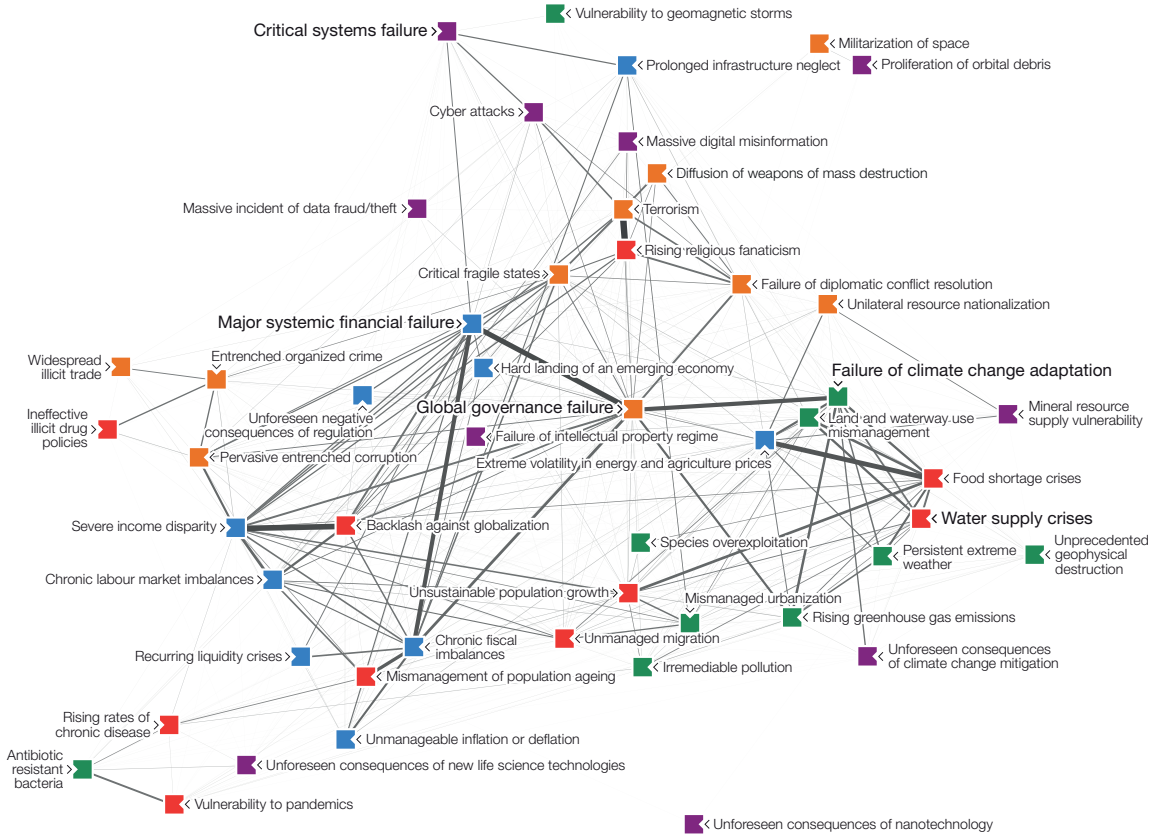
Three of the centres of gravity have changed from last year's report, in the economic, environmental and societal categories.

Figure 36: Centres of Gravity by Category



Source: World Economic Forum

Figure 37: The Risk Interconnection Map 2013



Source: World Economic Forum

Interconnections

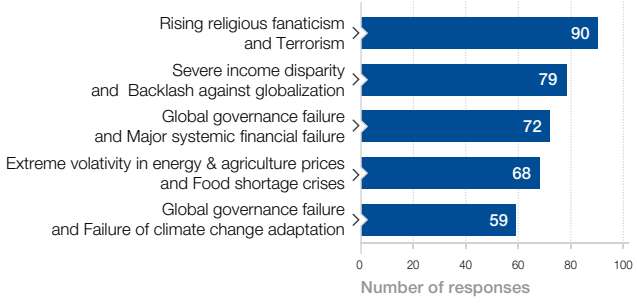
Finally, the survey asked respondents to choose pairs of risks which they think are strongly interconnected.[xlix] They were asked to pick a minimum of three and maximum of ten such connections.

Putting together all chosen paired connections from all respondents leads to the network diagram presented in Figure 37 – the Risk Interconnection Map. The diagram is constructed so that more connected risks are closer to the centre, while weakly connected risks are further out. The strength of the line depends on how many people had selected that particular combination.

529 different connections were identified by survey respondents out of the theoretical maximum of 1,225 combinations possible. The top selected combinations are shown in Figure 38.

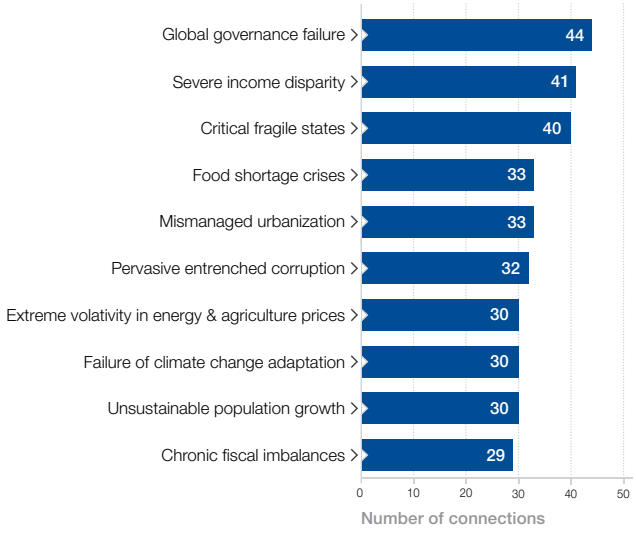
It is also interesting to see which are the most connected risks (see Figure 39) and where the five centres of gravity are located in the network (see Figure 40).

Figure 38: Top Five Most Selected Connections



Source: World Economic Forum

Figure 39: Top 10 Most Connected Risks



Source: World Economic Forum

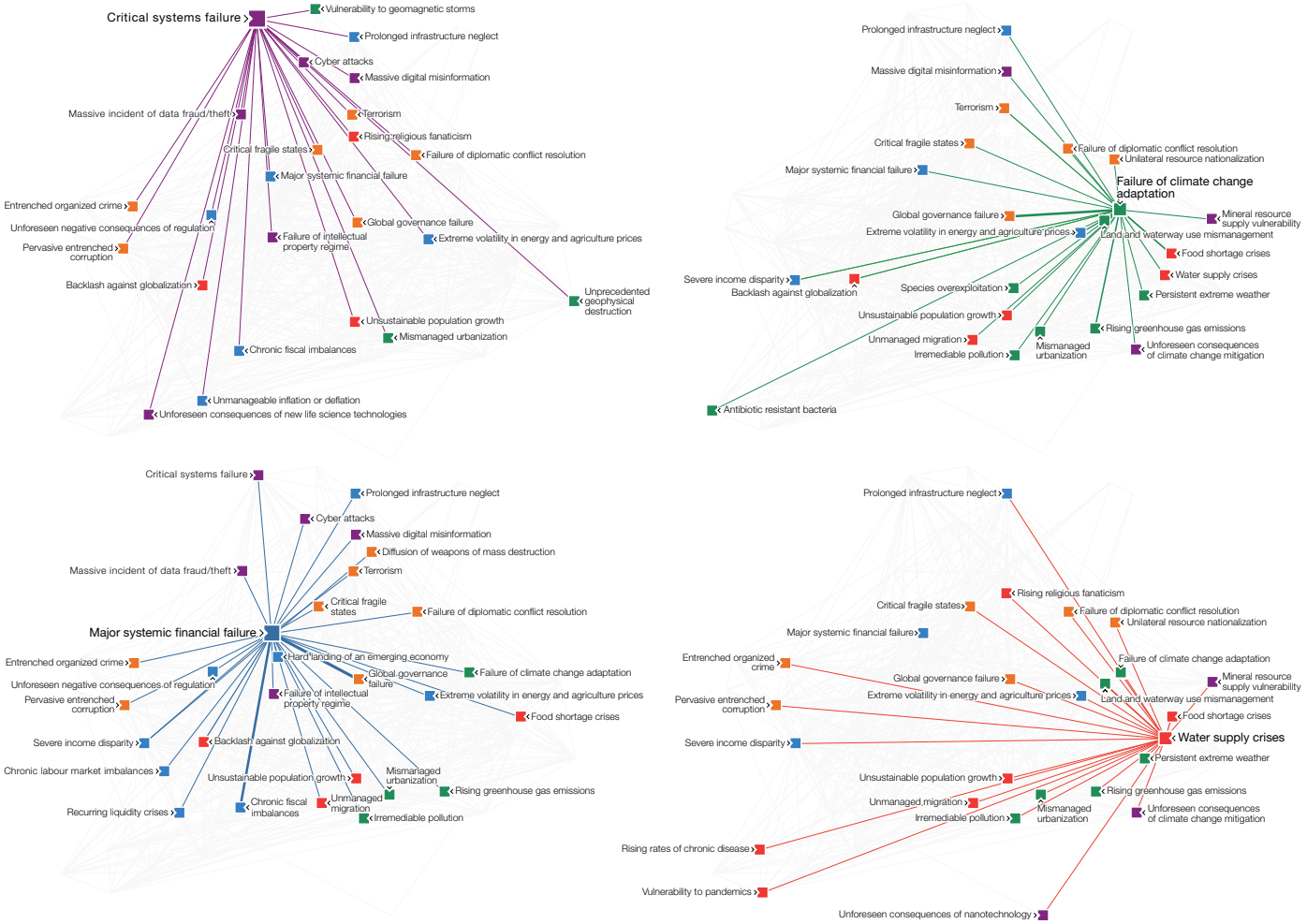
Box 8: The Global Risks 2013 Data Explorer

Readers are invited to visit the Data Explorer on the accompanying website to the *Global Risks 2013* report. There it is possible to interact with the Global Risks Landscape, the Global Interconnection Map, and the data from the two new survey questions on national resilience. The data explorer is also an entry point to other relevant Forum reports, videos, and blog posts – including the "What-If? Interview" series[l] by the Risk Response Network – and many other types of resources around each of the 50 global risks covered in this report.

Visit the Global Risks Data Explorer: http://www.weforum.org/globalrisks2013/dataexplorer.

[xlix] When two risks are connected, it simply means that respondents believe that there is some sort of correlation between the two. Causal direction cannot be deduced.

Figure 40: Centres of Gravity and their Connections



Source: World Economic Forum

1. Finucane, M. L., Slovic, P., Mertz, C. K., & Flynn, J. Gender, Race, and Perceived Risk: the 'White Male' Effect. In *Health, Risk and Society*, 2000, 2:159-172; Gustafson, P.E. Gender Differences in Risk Perception: Theoretical and Methodological Perspectives. In *Risk Analysis*, 1998, 18:805-811; and Harris, C. R., Jenkins, M., & Glaser, D. Gender Differences in Risk Assessment: Why do Women Take Fewer Risks than Men. In *Judgment and Decision Making*, 2006, 1:48-63.
2. Deery, H.A. Hazard and Risk Perception among Young Novice Drivers. In *Journal of Safety Research*, 1999, 30:225-236; and Jonah, B.A., & Dawson, N.E. Youth and Risk: Age Differences in Risky Driving, Risk Perception, and Risk Utility. In *Alcohol, Drugs & Driving*, 1987, 3:13-29.
3. Savage, I. Demographic Influences on Risk Perceptions. In *Risk Analysis*, 1993, 13:413-420.

I The "What If?" series seeks to generate new insights around risks that global experts from academia, business, government and civil society believe to be underappreciated. By exploring hypothetical scenarios in detail, leaders are able to uncover complex interconnectivity between systems and issues and by exploring global risks as scenarios, experts have the space to surface sensitive issues. The What-If series is a platform for leaders to assess their resilience against such risks and even seize opportunities they may present.

X Factors

In this section, developed in collaboration with *Nature*, a leading science journal, the Risk Response Network asks readers to look beyond our high-risk concerns of the moment to consider a set of five X factors and reflect on what countries or companies should be doing to anticipate them.

In a world of many uncertainties we are constantly on the search to identify "X factors" – emerging concerns of possible future importance and with unknown consequences. Looking forward and identifying emerging issues will help us to anticipate future challenges and adopt a more proactive approach, rather than being caught by surprise and forced into a fully reactive mode.

X factors are serious issues, grounded in the latest scientific findings, but somewhat remote from what are generally seen as more immediate concerns such as failed states, extreme weather events, famine, macroeconomic instability or armed conflict. They capture broad and vaguely understood issues that could be hatching grounds for potential future risks (or opportunities).

Runaway Climate Change

The threat of climate change is well known. But have we passed the point of no return? What if we have already triggered a runaway chain reaction that is in the process of rapidly tipping Earth's atmosphere into an inhospitable state?

The natural greenhouse effect is a prerequisite for life on our planet. Without it, Earth's global average surface temperature would be far below zero. But our planet's climate is a volatile beast. Small fluctuations in the Earth's orbit around the sun can exert a major influence on our climate. So can the varying concentration in Earth's atmosphere of heat-trapping molecules such as carbon dioxide, to which we have been adding through greenhouse gas emissions.

How pronounced and how fast the warming will be (and how it will affect rainfall and storminess where you live) is hard to say as even the most sophisticated computer models cannot capture all the factors involved in a system as complex as the Earth. But it could be more dramatic and difficult to adapt to than most scientists predict, because of the natural 'feedbacks' in the system, linked to processes in the oceans[1] and on land[2]. They have the potential of amplifying climate change to a point of fundamentally disrupting the global system. The much-debated questions are where these tipping points lie, how soon they might be reached, whether they can be predicted – and what will happen when they are crossed.[3]

The perhaps best-known positive feedback mechanism is the so-called ice-albedo feedback. In a warmer world there will be less snow and sea ice. Their melting reveals the darker land and water surfaces below, which absorb more solar heat. More absorption then causes yet more melting and warming, and so forth, in a self-reinforcing feedback loop. The unprecedented thawing of 97% of Greenland's surface ice in July 2012, for example, has led to a darkening of Greenland's ice cap, meaning it will begin to absorb higher levels of solar energy and melt faster still.

Melting of the complete Arctic summer sea ice – the Arctic is expected to be seasonally ice-free by around 2040 – could probably be reversed on human timescales if greenhouse gases are reduced and temperature drops. But if the several kilometre-thick ice sheets that cover Greenland and Antarctica dwindle, they may not so easily reappear in a cooler world. New ice would have to form at low elevations, where temperatures are higher.

Permafrost melting, land use and vegetation changes, and the effects of changing cloud cover provide for other major feedback mechanisms. Some scientists suspect that by 2040 up to 63 billion extra tonnes of carbon – and up to 380 billion tonnes by 2100 – might be released by the thaw and degradation of permafrost soil alone.[4]

Finally, there is the potentially huge feedback effect of water vapour, a natural greenhouse gas in itself. A warmer atmosphere can hold more water. As the average air temperature soars in response to our burning of fossil fuels, evaporation and atmospheric concentration of water vapour will increase, further intensifying the greenhouse effect. On Venus, this probably caused a runaway greenhouse effect, which boiled away the oceans that may have existed in the planet's early history.

Luckily, man-made climate warming has virtually no chance of producing a runaway greenhouse effect analogous to Venus. Even so, scientists with the Intergovernmental Panel on Climate Change (IPCC) reckon that the water vapour feedback on Earth could be strong enough to double the greenhouse effect due to the added carbon dioxide alone.

While climate change debates of the past decade centred around whether or not mankind could be responsible at all for altering a system as great at Earth's climate, we may be rapidly moving into forced discussions on how best to strengthen mankind's resilience and adaptive capacity to cope as Earth's climate auto-pilot mercilessly hurtles us toward a new and unknown equilibrium.

Significant Cognitive Enhancement

Once the preserve of science fiction, superhuman abilities are fast approaching the horizon of plausibility. Will it be ethically accepted for the world to divide into the cognitively-enhanced and unenhanced? What might be the military implications?

Scientists are working hard to develop the medicines and therapies needed to heal the brain of mental illnesses such as Alzheimers and schizophrenia. Although progress has been slow, it is conceivable that in the not-too-distant future, researchers will identify compounds that improve on existing cognitive pharmaceutical enhancers (e.g. Ritalin, modafinil). Although they will be prescribed for significant neurological disease, effective new compounds which appear to enhance intelligence or cognition are sure to be used off-label by healthy people looking for an edge at work or school.

Enhancement could come from hardware as well as drugs. A handful of studies in people show that electrical stimulation – either directly via implanted electrodes or through the scalp with transcranial magnetic stimulation (TMS) – can boost memory. Cochlear implants are already standard treatment for the deaf, and motor implants for controlling neural prosthetics and devices are developing fast and seem likely to become available more widely in coming years. Retinal implants for the blind are a bit further behind, but the field is booming and it seems likely that they will be worked out soon.

The best interfaces still rely on invasive brain electrodes (noninvasive techniques do work, but are slow and inefficient), which is the major barrier to these being adopted by healthy people. But it seems conceivable that within 10 years we will either have a new method for recording brain activity or the noninvasive signals will be decoded more efficiently. Direct brain interfaces of devices and sensors within our lifetimes is not out of the question, opening a new realm of enhanced neurobiology for those who can afford it.

This will pose ethical issues in many walks of life akin to those which surround "doping" in the world of professional sports. Will we accept the idea that significant cognitive enhancement should be available to purchase on the open market? Or will there be, as there now is with performance enhancers in competitive sports, a push for legislation to maintain a more level playing field?

There is, in addition, a significant risk of cognitive enhancement going very wrong. Cognitive enhancement pharmaceuticals work by targeting particular neurotransmitter systems, and therefore will most likely have wide-ranging action. There is a significant possibility of unintended effects on other systems – for example, drugs to enhance learning might lead to a greater willingness to take risks; drugs to enhance working memory might lead to increased impulsive behavior. Recent research suggests that, in addition to boosting memory, TMS could be used to manipulate a person's beliefs of right versus wrong or to suspend moral judgement altogether. It could also be used to "erase" memory and deliberately cause permanent brain damage without the use of invasive procedure or blunt force trauma.

Both the intended and unintended effects of such new technologies would open whole new categories of potential "dual-use" dilemmas. (Dual-use describes technologies which can be used for good as well as for substantial harm.) It is not difficult to see how such drugs could find applications in armed forces and law enforcement contexts, or conversely by criminal organizations and terrorist groups. They could spark an arms race in the neural "enhancement" of combat troops.[5]

Such advancements could have profound impacts in 20 to 50 years on societal norms affecting how we approach issues incuding education and training, disparity between groups in society, informed consent and exploitation, and international laws on warfare.

Rogue Deployment of Geoengineering

In response to growing concerns about climate change, scientists are exploring ways in which they could, with international agreement, manipulate the earth's climate. But what if this technology were to be hijacked by a rogue state or individual?

Geoengineering can refer to many things, but it is most often associated with a scientific field that has come to be known as "solar radiation management". The basic idea is that small particles could be injected high into the stratosphere to block some of the incoming solar energy and reflect it back into space, much as severe volcanic eruptions have done in the past. In stark contrast to decades of technological evolution and political disputes about overhauling energy infrastructure to reduce greenhouse emissions, solar radiation management would act quickly and would be cheap to implement – though side-effects may make it a very expensive option.

Most research has focused on sulphur injection via aircraft. Recent studies suggest that a small fleet of aircraft could inject a million tonnes of sulphur compounds into the stratosphere – enough to offset roughly half of the global warming experienced to date – for US$1-2 billion annually.[li] In theory, the technology would be tantamount to a planetary thermostat, giving humans direct control over global temperature. The direct impact of dimming the sun would be felt within weeks to months.

However, a long series of ethical, legal and scientific questions quickly arises about countless knock-on effects that might be much more difficult to assess. The problem is that incoming solar radiation drives the entire climate system, so reducing sunlight would fundamentally alter the way energy and water moves around the planet. Almost any change in weather and climate patterns is likely to create winners and losers, but determining causation and quantifying impacts on any given region or country would be a massive challenge.

Nobody envisions deployment of solar radiation management anytime soon, given the difficulties in resolving a suite of governance issues (evidenced by the fact that even the relatively simple SPICE[lii] experiment in the UK foundered in the midst of controversy).[6] Beginning with Britain's Royal Society, many academic and policy bodies have called for cautious research as well as broader conversation about the implications of such technologies.

But this has led some geoengineering analysts to begin thinking about a corollary scenario, in which a country or small group of countries precipitates an international crisis by moving ahead with deployment or large-scale research independent of the global community. The global climate could, in effect, be hijacked by a rogue country or even a wealthy individual, with unpredictable costs to agriculture, infrastructure and global stability.

The problem is that the only way to truly test solar radiation management is at scale. This potentially conflates large-scale research with deployment, thereby giving rogue nations political cover under the guise of science. Much research has gone into whether a programme could be targeted at the Arctic, for instance, where the impacts of global warming are being felt the most, but some researchers suggest that the impacts could quickly migrate from the Arctic to other regions. Many say that a true test of solar radiation management would have to be global.

Due to such complexities, most of the science to date has been conducted via computer modelling, although scientists are looking for ways to test these ideas with local experiments. But overall, despite calls for more coordinated government science programmes, the funding landscape for this kind of science remains spotty.

This leaves a gap for unregulated experimentation by "rogue" parties. For example, an island state threatened with rising sea levels may decide they have nothing to lose, or a well funded individual with good intentions may take matters into their own hands. There are signs that this is already starting to occur. In July 2012 an American businessman sparked controversy when he dumped around 100 tonnes of iron sulphate into the Pacific Ocean off the west coast of Canada in a scheme to spawn an artificial plankton bloom. The plankton absorb carbon dioxide and may then sink to the ocean bed, removing the carbon – another type of geoengineering, known as ocean fertilisation. Satellite images confirm that his actions succeeded in produce an artificial plankton bloom as large as 10,000 square kilometres.

The individual hoped to net lucrative carbon credits, but his actions may have been in violation of two international agreements.[7] Observers are concerned that this may be a sign of what is to come.[8]

[li] The most detailed cost and engineering analysis was commissioned by David Keith, currently at Harvard University, and conducted by Aurora Flight Sciences. That analysis, formally completed in July 2011, suggests that a small fleet of aircraft could inject a million tonnes of sulphur into the stratosphere – enough to offset roughly half of the global warming experienced to date – for US$ 1-2 billion annually.

[lii] Stratospheric Particle Injection for Climate Engineering (SPICE) is a UK government-funded geoengineering research project that aims to assess the feasibility of injecting particles into the stratosphere from a tethered balloon for the purposes of solar radiation management.

Costs of Living Longer

We are getting better at keeping people alive for longer. Are we setting up a future society struggling to cope with a mass of arthritic, demented and, above all, expensive, elderly who are in need of long term care and palliative solutions?

The blessings of 20th-century medicine look set to explode with the deciphering of the genome and attendant advances. It is hoped that big inroads against common banes such as heart disease, cancer and stroke, may be in the offing. Consider the impact on society of a growing number of elderly infirm who are protected from the most common causes of death today, but with an ever deteriorating quality of life as other ailments that do not kill, but seriously disable, start to dominate.

Current trends are already setting the stage for such a future scenario in the West. Already, the demographics of the Baby Boom are working against us: conservative estimates say that the number of Americans afflicted with Alzheimer's disease will at least double, to 11 million, by mid-century.[9] Similar rises are projected for many countries, with the global population of the demented expected to double every 20 years until it exceeds 115 million in 2050.[10] A key driver will be increasing elderly populations and potentially declining fertility rates in low and middle income countries.

The looming expense of caring for these masses is mind boggling, especially in high-income countries. The UK, for instance, spends nearly as much each year caring for the demented (£23 billion) as it does on stroke (£5 billion), heart disease (£8 billion) and cancer (£12 billion) combined.[11] And the numbers afflicted with all of these maladies are only going to grow.

Consider Medicare, the US health programme for the elderly. Assuming no policy changes – for instance, no increase in the age of eligibility – the programme's outlays are expected to exceed its taxpayer-funded income by more than US $24 trillon over the next 75 years.[12,liii] The spending trend is not limited to government support, either. In the US, the cumulative total of public and private consumption by the elderly has ballooned in the last half century. The burden is accentuated in rapidly-aging countries like Germany, where the ratio of effective producers per consumer is projected to decline nearly 25% by 2030.[13]

liii See page 46 and 47 under "financial statements" at http://www.gao.gov/financial/fy2011/11stmt.pdf. Add total liabilities for Medicare parts A, B and D together to get US$ 24.5 trillion. (3,252 billion + 18,854 billion + 7,466 billion)

Life expectancy has increased steadily in every decade since 1840, but these gains do not necessarily portend better health in later life.[14] Thus, a new wave of disabled seniors may be on the way. The proportion of Americans aged 50 to 64 who reported needing help with personal care activities – things like getting into and out of bed, and climbing ten steps – increased significantly in the decade ending in 2007. Arthritis was the top cause, and diabetes played a prominent and growing role.[15]

Are there fixes that can avert the coming storm? There are well-known but difficult-to-implement preventive measures that could help us live both longer and better quality of lives: paramount among them is exercise, with its near-universal benefits for our physiologies and for warding off pathology.[16] Obvious ways to mitigate cost implications would include raising the eligibility ages for the programmes that support the elderly from the public purse – retirement income, social support services or reduced-cost health care – and raising the retirement age, requiring older adults to be productive economically for longer. One recent analysis, using a "delayed aging" model, found that hundreds of billions of dollars in increased costs to the US Medicare and Social Security programmes could be entirely offset by raising the eligibility ages for Medicare and Social Security by a few years (from 65 to 68, and from 67 to 68).[17]

However, raising eligibility ages for public services is not a panacea, in part because financial costs are not the only challenge. The impacts of aging populations will be felt throughout society, from changing best practices in urban planning to impacting social norms around care-giving. More research is needed to turn chronic conditions to acute conditions (i.e. by developing curative treatments), and find solutions that increase the capacity of all citizens to manage chronic conditions and to create wealth at the same time.

Discovery of Alien Life

Given the pace of space exploration, it is increasingly conceivable that we may discover the existence of alien life or other planets that could support human life. What would be the effects on science funding flows and humanity's self-image?It was only in 1995 that we first found evidence that other stars also have planets orbiting them. Now thousands of "exoplanets" revolving around distant stars have been detected. NASA's Kepler mission to identify Earth-sized planets located in the "Goldilocks Zone" (not too hot, nor too cold) of Sun-like stars, has only been operating for 3 years and has already turned up thousands of candidates, including one the size of Earth. The fact that Kepler has found so many planet candidates in such a tiny fraction of the sky suggests there are countless Earth-like planets orbiting sun-like stars in our galaxy. In 10 years' time we may have evidence not only that Earth is not unique, but that life exists elsewhere in the universe.

Suppose the astronomers who study exoplanets one day find chemical signs of life – for example, a spectrum showing the presence of oxygen, a highly reactive element that would quickly disappear from Earth's atmosphere if it were not being replenished by plants. Money might well start flowing for new telescopes to study these living worlds in detail, both from the ground and from space. New funding and new brain power might be attracted to the challenges of human space flight and the technologies necessary for humanity, or its A.I. emissaries, to survive an inter-stellar crossing.

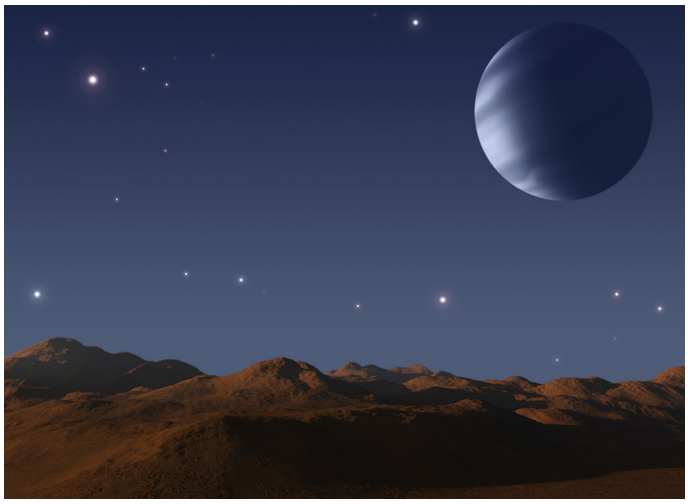
The discovery would certainly be one of the biggest news stories of the year, and interest would be intense. But it would not change the world immediately. Alien life has been 'discovered' before, after all. Around the turn of the 20th century, the US astronomer Percival Lowell convinced a great many people (including himself) that Mars was crisscrossed by a vast system of canals built by a dying civilization. But the belief that humankind was not alone did not do much to usher in an era of brotherhood and earthly harmony, nor did it stop the outbreak of World War I in 1914.

The discovery's largest near-term impact would likely be on science itself. Suppose observations point to a potential future home for mankind around another star, or the existence of life in our solar system – in the Martian poles, or in the subsurface oceans of Jupiter's frozen moon Europa, or even in the hydrocarbon lakes of Saturn's moon Titan. Scientists will immediately start pushing for robotic and even human missions to study the life forms in situ – and funding agencies, caught up in the excitement, might be willing to listen.

The fledgling space economy had a big year in 2012, which saw the birth of space trucking when the first commercially built and operated spacecraft successfully rendezvoused with the International Space Station, and a host of celebrity billionaires declared intentions to make asteroid mining a reality. Discovery of an Earth 2.0 or life beyond our planet might inspire new generations of space entrepreneurs to also take on the challenge of taking human exploration of the galaxy from the realm of fiction to fact.

Over the long term the psychological and philosophical implications of the discovery could be profound. If lifeforms (even fossilized lifeforms) are found in our own solar system, for example, it will tell us that the origin of life is 'easy' – that anyplace in the universe life can emerge, it will emerge. It will suggest that life is as natural and as ubiquitous a part of the universe as stars and galaxies are. The discovery of even simple life would fuel speculation about the existence of other intelligent beings and challenge many assumptions which underpin human philosophy and religion.

Through basic education and awareness campaigns the general public can achieve a higher science and space literacy and cognitive resilience that would prepare them and prevent undesired social consequences of such a profound discovery and paradigm shift concerning mankind's position in the universe.



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Conclusion

The eighth edition of the *Global Risks* report has sought to highlight the theme of resilience in the context of systems thinking. Exogenous in nature, global risks cannot be adequately managed or mitigated by any single organisation. We have introduced the conceptual framework of Professors Kaplan and Mikes[1], contrasting "external" risks such as global risks with "preventable" and "strategic" risks, to assist clarity of thought about how global risks should be approached. Whenever it is difficult to predict how and when a risk will manifest, nurturing resilience is the preferred approach.

Throughout this report we have sought to frame risks in a systems context given its nature of interdependencies and to assist clarity of thinking about the best ways to build resilience. Our three risk cases have discussed what happens when two major systems are stressed simultaneously (Testing Economic and Environmental Resilience); when a seemingly more minor system punches above its weight (Digital Wildfires in a Hyperconnected World); and when we become complacent in the continued ability of a system to stay one step ahead of a changing problem (The Dangers of Hubris on Human Health). In the Special Report, we explored the thinking of systems theorists about how to build resilient systems, describing how five components – redundancy, robustness, resourcefulness, response and recovery – can be applied to selected national subsystems.

As ever, this report forms the starting point of dialogue which will continue throughout the year, through a number of channels: our dedicated virtual platform for members of the Risk Response Network's trusted community; the Resilience Practices Exchange; workshops with our report partners and their stakeholders; regional events around the world; and, of course, our Annual Meetings in the People's Republic of China and in Davos-Klosters, Switzerland, where the theme for 2013 is resilient dynamism.

Specifically, in 2013 we will take forward the task of building a trusted network of risk experts to help global leaders map, mitigate, monitor and enhance resilience to global risks. And we will work to develop and refine the National Resilience Rating proposed in the Special Report. The hyperconnected nature of the modern world makes it increasingly urgent to understand how best to build resilience in the face of global risks.

More information on these initiatives and other World Economic Forum activities on global risks can be found at www.weforum.org/risk. You can contact us at rrn@weforum.org and stay connected by following us at @WEFRisk.

1 Kaplan, R.S. & Mikes, A. Managing Risks: A New Framework. In *Harvard Business Review*, 2012.

Appendix 1 The Survey

Survey Sample

The Global Risks Perception Survey was carried out as an online survey during September 2012. The purpose of the survey is to sample the views of the World Economic Forum's communities, which comprise of top experts and high-level leaders from business, academia, NGOs, international organizations, the public sector and civil society. Over 6,000 invitations were sent out and 1,234 respondents returned the questionnaire with usable information; 1,006 of these were complete responses – compared to 469 in 2011.

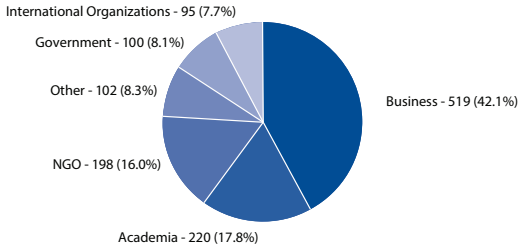
In the 2012 survey, in addition to greater diversity of affiliation, respondents also come from more diverse regions of the world (see Figure 41). They indicated 101 different countries as their country of residence, and self-identified expertise on 115 different countries. This has increased compared to 2011, where only 69 countries were chosen as country of residence. There was an increase in representation from Asia, Latin America, Middle East/North Africa and Sub-Saharan Africa with a larger number of responses from Japan, China and India for Asia; Costa Rica, Mexico and Brazil for Latin America; and Nigeria and South Africa for Sub-Saharan Africa.

The survey sample includes experts in a range of subjects. Approximately 29% of respondents are female, and the average age of survey respondents is 43. With the inclusion of the new Global Shapers Community – a group of young leaders between 20 and 30 years old[liv] – the range of age groups covered by the survey is wider than it was last year.

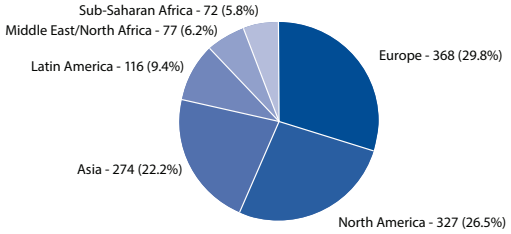
The survey sample closely resembles the targeted survey population as described above. The distribution of people across regions and types of organizations is nearly identical; the average age is slightly lower (by two years) and the proportion of women is slightly higher (by 3 percentage points). It is important to note that the data is not intended to be representative of wider populations than this specific survey population.

Figure 41: Breakdown of Survey Sample

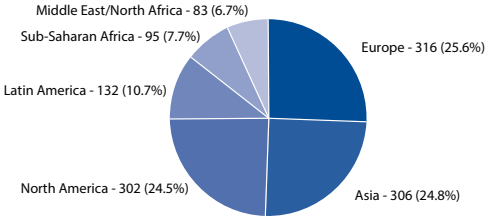
Type of Organization



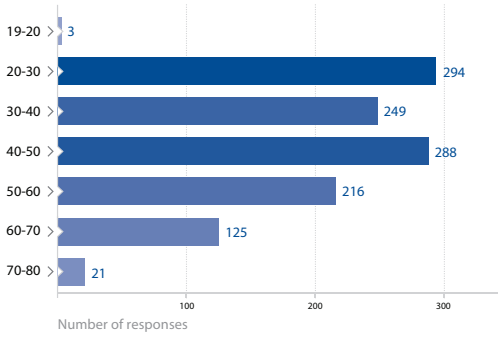
Region of Residence



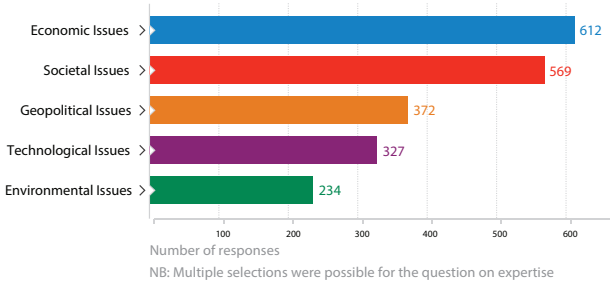
Region of Expertise



Age



Area of Expertise



NB: Multiple selections were possible for the question on expertise

Source: World Economic Forum

[liv] See http://www.weforum.org/globalshapers for more information.

The Questionnaire

The questionnaire consisted of three different sections with the following questions:

Section 1 covered the above-mentioned demographic information.

In Section 2, respondents were asked to assess each of the 50 global risks covered in this report, by stating how they would rate, on a scale from 1 to 5, the likelihood that the risk is to occur over the next 10 years, and if it were to occur, the impact it would have on the world.

In addition, a new question was introduced this year to think about the country that they had identified in Section 1 as the country about which they have most expertise, and rate the ability of that country to adapt and/or recover from the impact of each of the 50 global risks.

The answer options to these three questions were presented as Likert-type scales, where the respondent, using a slider on the screen, was able to select a value ranging from 1 (low) to 5 (high) as well as the midpoints between these integers.

For each category of risks – economic, environmental, geopolitical, societal and technological – the last question in Section 2 asks survey respondents to select what they thought would be the "Centre of Gravity", i.e. the single most important risk from a systemic perspective. They could choose from the 10 risks in each category via a drop-down menu.

Finally, in Section 3, respondents were asked to identify strong connections between pairs of risks. They had the opportunity to select at least three and up to 10 combinations, by dragging tiles into paired boxes from the pool of 50 risks.

Margin of Errors

Based on the spread of the answers as well as the survey sample size, one can calculate the margin of error, based on a 95% confidence level.

For the global likelihood and global impact questions (Figures 1, 2, 29, 30), which were answered by all 1,234 respondents, the maximum[lv] margin of error is 0.07 units.

For the question on the Centres of Gravity (Figure 36), the maximum[lvi] margin of error is 2.7 percentage points.

For the question on country recovery and adaptability, the margin of error is heavily dependent on how many people assessed the country in the question (as explained above, survey respondents could choose which country to assess). The tables in Appendix 3 detail the values.

[lv] The margin of error varies slightly across the 50 risks. See Table 3 in Appendix 2.
[lvi] The margin of error varies across the five categories and the different possible answers.

Appendix 2 Likelihood and Impact

Likelihood: Comparisons

The number of survey responses received from different regions ranges from 64 from Sub-Saharan Africa to 330 from Europe. For stakeholder groups the range was from 88 from international organizations to 471 from business. As illustrated in Table 1, out of 50 global risks, only two risks – *extreme volatility in energy and agriculture prices* and *major systemic financial failure* – did not have any statistically significant differences between any groups. The other 48 risks had at least one group difference. Arguably the risk with the most differences, especially between regions, was *failure of drug policies*.

Only 8 out of 50 risks had statistically significant differences between respondents under 40 and over 40 years of age. Four of these risks were in the environmental category: *failure of climate change adaptation, irremediable pollution, rising greenhouse gas emissions,* and *unprecedented geophysical destruction*.

Similarly, the environmental category had the largest percentage of risks with statistically significant differences between experts and non-experts. Where there are differences, generally experts perceived the risk as more likely to occur, though non-experts found four risks more likely: *severe income disparity, unmanageable inflation and deflation, rising religious fanaticism* and *unforeseen consequences of nanotechnology.* Interestingly, *rising religious fanaticism* was one of the most highly connected risks in the Risks Interconnection Map.

Finally, where there were statistically significant gender differences, females were more pessimistic and rated the risks as more likely to occur. The biggest difference between male and female opinions was regarding the risk of *unprecedented geophysical destruction*, with a difference of 0.41 (on a scale of 1 to 5).

Table 1-2: Legends

Region of Residence		Stakeholder	
As	Asia	Ac	Academia
E	Europe	B	Business
LatAm	Latin America	G	Government
NthA	North America	IO	International Organization
MENA	Middle East/ North Africa	N	NGO
SSA	Sub-Saharan Africa	Other	Other

Table 1: Comparisons between Groups[lvii] for Likelihood of Global Risks Occurring in the Next 10 Years[lviii]

Risk	Region of Residence	Stakeholder	Age		Gender		Expertise	
			Under 40	Over 40	Male	Female	Expert	Non-Expert
Chronic fiscal imbalances	NthA > All other regions	-	-		-		4.02 >	3.91
Chronic labour market imbalances	NthA, SSA > E, LatAm	-	-		3.65 <	3.79	-	
Extreme volatility in energy and agriculture prices	-	-	-		-		-	
Hard landing of an emerging economy	NthA > E, LatAm, MENA, SSA As > MENA	-	-		-		-	
Major systemic financial failure	-	-	-		-		-	
Prolonged infrastructure neglect	NthA > All other regions	-	3.24 <	3.38	-		-	
Recurring liquidity crises	NthA, E, MENA > LatAm	-	-		-		-	
Severe income disparity	NthA > As, E, LatAm	NGO > G	-		4.19 <	4.31	4.15 <	4.29
Unforeseen negative consequences of regulation	NthA > LatAm	B > NGO, Ac, G, IO	-		-		3.41 >	3.21
Unmanageable inflation or deflation	As > NthA, E, LatAm SSA > LatAm	-	3.25 >	3.11	-		3.12 <	3.24
Antibiotic-resistant bacteria	NthA > As, LatAm E > LatAm	Other > IO	-		-		3.67 >	3.36
Failure of climate change adaptation	NthA > As, E, MENA	NGO > G	3.69 <	3.81	3.71 <	3.89	4.04 >	3.69
Irremediable pollution	-	-	3.48 >	3.24	3.25 <	3.6	3.62 >	3.28
Land and waterway use mismanagement	NthA > As, E, MENA	NGO > IO	-		3.54 <	3.77	3.91 >	3.53
Mismanaged urbanization	NthA > As, E, MENA	-	-		3.64 <	3.8	3.9 >	3.64
Persistent extreme weather	NthA > As, E, MENA	NGO > B	-		3.64 <	3.85	4.07 >	3.61
Rising greenhouse gas emissions	NthA > All other regions	-	3.87 <	4	-		4.28 >	3.86
Species overexploitation	NthA > MENA	NGO > G	-		-		4 >	3.6
Unprecedented geophysical destruction	As > MENA, E NthA > E	-	3.24 >	3.11	3.06 <	3.47	-	
Vulnerability to geomagnetic storms	As > E, MENA	-	-		2.53 <	2.75	-	
Critical fragile states	NthA > As, LatAm	-	-		-		-	
Diffusion of weapons of mass destruction	NthA > All other regions	-	3.14 <	3.3	-		3.34 >	3.18
Entrenched organized crime	NthA, LatAm > As, E	-	-		3.4 <	3.61	3.57 >	3.41
Failure of diplomatic conflict resolution	NthA > As, E, LatAm, SSA NthA > As, LatAm	All other stakeholders > G	-		-		-	
Global governance failure	E > As	-	-		-		-	
Militarization of space	As > LatAm	-	-		2.75 <	2.95	-	
Pervasive entrenched corruption	NthA > As, E	-	-		3.69 <	3.87	-	
Terrorism	NthA > As, LatAm, E	-	-		-		-	
Unilateral resource nationalization	NthA > MENA, LatAm, SSA	-	-		-		-	
Widespread illicit trade	NthA > As, E, LatAm	-	-		3.38 <	3.57	-	
Backlash against globalization	NthA > LatAm	-	-		3.18 >	3.04	-	
Food shortage crises	NthA > As, LatAm	-	-		3.55 <	3.71	3.69 >	3.52
Ineffective illicit drug policies	LatAm, NthA > As, E, SSA E > As	-	-		-		-	
Mismanagement of population ageing	NthA, E > As, LatAm, SSA, MENA	NGO > G	-		-		-	
Rising rates of chronic disease	NthA > As, E, MENA, LatAm	-	-		3.37 <	3.57	3.52 >	3.36
Rising religious fanaticism	NthA > As, E, LatAm	-	-		-		3.59 <	3.71
Unmanaged migration	NthA, E > As	NGO > G	-		3.34 <	3.63	3.5 >	3.36
Unsustainable population growth	-	-	3.52 >	3.38	3.39 <	3.6	3.53 >	3.37
Vulnerability to pandemics	NthA > E, MENA, LatAm As > E	-	-		-		-	
Water supply crises	-	-	-		3.78 <	4.01	-	
Critical systems failure	NthA, E, As, SSA > LatAm	Ac, Other > IO, NGO	-		-		-	
Cyber attacks	NthA > All other regions E > SSA	Ac, B, NGO > IO	-		-		4.01 >	3.75
Failure of intellectual property regime	As, E, NthA > MENA	B > G	-		-		3.13 >	2.96
Massive digital misinformation	As > LatAm	-	-		-		-	
Massive incident of data fraud/theft	NthA > As, E, LatAm	B > IO	-		-		3.68 >	3.46
Mineral resource supply vulnerability	E > LatAm, MENA As > MENA	NGO, B > IO	-		-		-	
Proliferation of orbital debris	-	Ac > IO	-		-		2.97 >	2.83
Unforeseen consequences of climate change mitigation	NthA > E	Other > IO	-		3.17 <	3.36	-	
Unforeseen consequences of nanotechnology	-	-	-		2.71 <	3	2.69 <	2.83
Unforeseen consequences of new life science technologies	-	-	-		3.08 <	3.22	-	

[lvii] An analysis of variance (ANOVA) tested whether or not the means of sub-groups were all equal. For those risks where they were not all equal, a Sidak post-hoc test established which of the pair-wise differences between groups were significant at the 5% level.

[lviii] Only statistically significant differences are noted; otherwise, the table cell is empty.

Impact: Comparisons

In terms of perceived impact, regional differences were found for 48% of the risks, with the most differences found in the environmental category and the least in the economic category (see Table 2). Where there were statistically significant differences, respondents from Latin America perceived 50% of these risks as having higher impact than did respondents from other regions. Apart from the risk *mineral resource supply vulnerability*, European respondents generally perceived risks as having lower impact.

Among stakeholder groups, statistically significant differences were found for less than half the risks, with NGOs perceiving impacts to be higher and businesses lower. There were two exceptions: *hard landing of an emerging economy* and *mismanagement of population ageing*.

Between respondents under and over 40 years of age, there were statistically significant differences for half the risks, with younger respondents perceiving higher impact. The largest difference, 0.32 units, was for *irremediable pollution*.

Male and female opinions differed significantly for 39 out of 50 risks, most obviously in the geopolitical category, with all 10 risks having differences. In all 39 cases, men perceived the impact of the risks as lower, with the largest difference, of 0.43, for *entrenched organized crime*.

Fewest statistically significant differences were found between experts and non-experts – only 15 risks, none in the geopolitical category and only one in the technological category. Where there were differences, experts generally rated risks as having a higher impact, except in the case of two risks: *severe income disparity* and *unforeseen consequences of nanotechnology*.

Table 2: Comparisons between Groups[lix] for Impact of Global Risks if they were to Materialize[lx]

Risk	Region of Residence	Stakeholder	Age		Gender		Expertise	
			Under 40	Over 40	Male	Female	Expert	Non-Expert
Chronic fiscal imbalances	-	-	-		-		4.03 >	3.92
Chronic labour market imbalances	-	-	3.86 >	3.62	3.68 <	3.88	-	
Extreme volatility in energy and agriculture prices	-	-	-		3.84 <	3.98	-	
Hard landing of an emerging economy	-	B, Ac > G	-		-		-	
Major systemic financial failure	-	-	4.1 >	4	-		-	
Prolonged infrastructure neglect	NthA > E	-	-		3.15 <	3.29	-	
Recurring liquidity crises	-	-	3.71 >	3.61	3.62 <	3.75	-	
Severe income disparity	SSA > As, E	Ac, NGO, Other > B	-		3.71 <	4.06	3.72 <	3.89
Unforeseen negative consequences of regulation	SSA > E, NthA As > E	Other > Ac, IO	3.24 >	3.13	3.12 <	3.33	3.25 >	3.11
Unmanageable inflation or deflation	-	-	3.63 >	3.52	-		-	
Antibiotic-resistant bacteria	-	-	3.63 >	3.51	-		-	
Failure of climate change adaptation	-	NGO > B	-		3.8 <	4.16	4.17 >	3.84
Irremediable pollution	LatAm > E, NthA	-	3.82 >	3.5	3.55 <	3.92	-	
Land and waterway use mismanagement	LatAm > As, E	NGO > Ac, B	3.66 >	3.5	3.47 <	3.83	3.72 >	3.54
Mismanaged urbanization	LatAm > E	NGO, Other > B	-		3.31 <	3.59	3.6 >	3.33
Persistent extreme weather	NthA, LatAm > E	NGO > B	-		3.56 <	3.87	3.95 >	3.57
Rising greenhouse gas emissions	NthA > As	NGO > B, G	-		3.82 <	4.04	4.23 >	3.8
Species overexploitation	-	NGO > B	-		3.29 <	3.55	3.72 >	3.27
Unprecedented geophysical destruction	NthA, LatAm, As > E	-	3.45 >	3.24	3.25 <	3.55	-	
Vulnerability to geomagnetic storms	LatAm > NthA, E, As	-	-		-		-	
Critical fragile states	-	-	3.61 >	3.46	3.5 <	3.63	-	
Diffusion of weapons of mass destruction	NthA > As	-	-		3.86 <	4.07	-	
Entrenched organized crime	LatAm > As, E, NthA	IO, NGO > B	3.3 >	3.13	3.09 <	3.52	-	
Failure of diplomatic conflict resolution	-	-	-		3.64 <	3.81	-	
Global governance failure	-	Other > B	-		3.74 <	3.92	-	
Militarization of space	-	-	3.24 >	3.1	3.1 <	3.33	-	
Pervasive entrenched corruption	LatAm > As, E SSA > E	NGO > Ac, B, G Other > B	3.57 >	3.38	3.38 <	3.69	-	
Terrorism	NthA, As, MENA > E	-	3.67 >	3.52	3.5 <	3.82	-	
Unilateral resource nationalization	-	NGO > IO	-		3.36 <	3.53	-	
Widespread illicit trade	MENA > As, E, NthA LatAm > As, E SSA > E	NGO > Ac, B	-		2.91 <	3.33	-	
Backlash against globalization	-	-	-		-		-	
Food shortage crises	-	-	3.94 >	3.73	3.76 <	4.01	-	
Ineffective illicit drug policies	LatAm > All other regions	NGO > B	-		2.95 <	3.25	3.14 >	2.94
Mismanagement of population ageing	-	NGO, B > G	-		-		-	
Rising rates of chronic disease	LatAm, NthA > E	-	3.42 >	3.28	3.25 <	3.58	3.44 >	3.27
Rising religious fanaticism	NthA > E, As	-	-		3.59 <	3.76	-	
Unmanaged migration	-	NGO > B	-		3.27 <	3.69	3.49 >	3.3
Unsustainable population growth	-	-	3.78 >	3.64	3.63 <	3.91	3.8 >	3.63
Vulnerability to pandemics	NthA > E	-	3.68 >	3.54	3.56 <	3.71	-	
Water supply crises	LatAm > E, As	-	4.12 >	3.87	3.89 <	4.22	4.05 >	3.93
Critical systems failure	-	-	3.74 >	3.52	-		-	
Cyber attacks	-	-	-		3.47 <	3.63	-	
Failure of intellectual property regime	-	-	3.05 >	2.94	-		-	
Massive digital misinformation	MENA > E, NthA	-	3.36 >	3.15	3.15 <	3.48	-	
Massive incident of data fraud/theft	MENA, LatAm > E	-	3.34 >	3.21	3.2 <	3.46	-	
Mineral resource supply vulnerability	E > NthA	NGO > IO	-		-		-	
Proliferation of orbital debris	LatAm, As > NthA	NGO > B, IO Other > IO	-		2.73 <	2.96	-	
Unforeseen consequences of climate change mitigation	-	Other > B	-		3.27 <	3.57	-	
Unforeseen consequences of nanotechnology	-	NGO > B, IO	3.09 >	2.91	2.9 <	3.23	2.84 <	3.04
Unforeseen consequences of new life science technologies	-	NGO > IO	3.43 >	3.3	3.29 <	3.53	-	

[lix] An analysis of variance (ANOVA) tested whether or not the means of sub-groups were all equal. For those risks where they were not all equal, a Sidak post-hoc test established which of the pair-wise differences between groups were significant at the 5% level.

[lx] Only statistically significant differences are noted; otherwise, the table cell is left empty.

Likelihood and Impact – Average Scores and Margin of Error

The table below shows the average likelihood and impact scores and their margins of error (based on a 95% confidence level). The larger the margin of error, the lower the confidence that the result is close to the "true" figure of the whole survey populations (see Appendix 1).

Table 3: Average Likelihood and Impact Scores and their Margin of Error

Risk	Likelihood	Impact
Chronic fiscal imbalances	3.97 +/- 0.05	3.97 +/- 0.05
Chronic labour market imbalances	3.69 +/- 0.05	3.73 +/- 0.05
Extreme volatility in energy and agriculture prices	3.71 +/- 0.05	3.88 +/- 0.05
Hard landing of an emerging economy	3.46 +/- 0.05	3.49 +/- 0.05
Major systemic financial failure	3.44 +/- 0.06	4.04 +/- 0.05
Prolonged infrastructure neglect	3.32 +/- 0.06	3.19 +/- 0.05
Recurring liquidity crises	3.36 +/- 0.05	3.66 +/- 0.05
Severe income disparity	4.22 +/- 0.05	3.8 +/- 0.05
Unforeseen negative consequences of regulation	3.31 +/- 0.06	3.18 +/- 0.06
Unmanageable inflation or deflation	3.18 +/- 0.05	3.57 +/- 0.05
Antibiotic-resistant bacteria	3.42 +/- 0.06	3.57 +/- 0.06
Failure of climate change adaptation	3.76 +/- 0.06	3.9 +/- 0.06
Irremediable pollution	3.35 +/- 0.06	3.65 +/- 0.06
Land and waterway use mismanagement	3.61 +/- 0.06	3.57 +/- 0.05
Mismanaged urbanization	3.69 +/- 0.06	3.39 +/- 0.06
Persistent extreme weather	3.7 +/- 0.06	3.65 +/- 0.06
Rising greenhouse gas emissions	3.94 +/- 0.05	3.88 +/- 0.05
Species overexploitation	3.68 +/- 0.06	3.36 +/- 0.06
Unprecedented geophysical destruction	3.17 +/- 0.06	3.33 +/- 0.06
Vulnerability to geomagnetic storms	2.59 +/- 0.06	3.16 +/- 0.06
Critical fragile states	3.38 +/- 0.06	3.53 +/- 0.05
Diffusion of weapons of mass destruction	3.23 +/- 0.06	3.92 +/- 0.06
Entrenched organized crime	3.46 +/- 0.06	3.21 +/- 0.06
Failure of diplomatic conflict resolution	3.58 +/- 0.06	3.69 +/- 0.05
Global governance failure	3.69 +/- 0.06	3.79 +/- 0.05
Militarization of space	2.81 +/- 0.06	3.16 +/- 0.06
Pervasive entrenched corruption	3.74 +/- 0.06	3.47 +/- 0.06
Terrorism	3.64 +/- 0.06	3.59 +/- 0.06
Unilateral resource nationalization	3.35 +/- 0.06	3.4 +/- 0.06
Widespread illicit trade	3.43 +/- 0.06	3.03 +/- 0.06
Backlash against globalization	3.14 +/- 0.06	3.34 +/- 0.06
Food shortage crises	3.6 +/- 0.06	3.83 +/- 0.06
Ineffective illicit drug policies	3.41 +/- 0.06	3.03 +/- 0.06
Mismanagement of population ageing	3.83 +/- 0.05	3.67 +/- 0.05
Rising rates of chronic disease	3.43 +/- 0.06	3.35 +/- 0.05
Rising religious fanaticism	3.66 +/- 0.06	3.64 +/- 0.06
Unmanaged migration	3.42 +/- 0.06	3.39 +/- 0.06
Unsustainable population growth	3.45 +/- 0.06	3.71 +/- 0.06
Vulnerability to pandemics	3.2 +/- 0.06	3.6 +/- 0.06
Water supply crises	3.85 +/- 0.05	3.98 +/- 0.05
Critical systems failure	2.96 +/- 0.06	3.62 +/- 0.06
Cyber attacks	3.82 +/- 0.06	3.52 +/- 0.06
Failure of intellectual property regime	3 +/- 0.06	2.99 +/- 0.06
Massive digital misinformation	3.36 +/- 0.07	3.24 +/- 0.06
Massive incident of data fraud/theft	3.52 +/- 0.06	3.27 +/- 0.06
Mineral resource supply vulnerability	3.42 +/- 0.06	3.45 +/- 0.06
Proliferation of orbital debris	2.87 +/- 0.06	2.8 +/- 0.06
Unforeseen consequences of climate change mitigation	3.23 +/- 0.06	3.35 +/- 0.06
Unforeseen consequences of nanotechnology	2.79 +/- 0.06	2.99 +/- 0.06
Unforeseen consequences of new life science technologies	3.11 +/- 0.06	3.36 +/- 0.06

Appendix 3 Resilience

Appendix 3.1

Over 14,000 respondents to the World Economic Forum's Executive Opinion Survey[lxi] were asked to rate their government's risk management effectiveness:

> *How would you assess your national government's overall risk management effectiveness of monitoring, preparing for, responding to and mitigating against major global risks (e.g. financial crisis, natural disasters, climate change, pandemics, etc.)? (1 = Not effective in managing major global risks; 7 = Effective in managing major global risks)*

Table 4 provides the average results for each country, ranked from highest (best) to lowest (worst). Singapore and many innovation-driven economies (Stage 3 in the Forum's Global Competitiveness Index) are ranked higher than factor-driven (Stage 1) economies (for definitions of stages, see page 68). The table also gives the survey sample size and the margin of error for each country, its ISO code, and development stage. Countries marked in light blue were used for the preliminary analysis presented in the Special Report section; the selection criterion was the available sample size from the Global Risks Perception Survey (see Table 5).

[lxi] The Executive Opinion Survey is the Forum's flagship opinion poll that is conducted every year to sample the perception of top managers from small- and medium-sized firms on the economies in which they are operating.

Table 4: Executive Opinion Survey Question 2.07 Risk Management Effectiveness Results[lxii]

Rank	Country	ISO	Economic Development Stage	Sample	Risk Management Score	Margin of Error at 95% Confidence Level
1	Singapore	SGP	Stage 3	171	6.08	0.11
2	Qatar	QAT	Transition from 1 to 2	113	6.01	0.18
3	Oman	OMN	Transition from 2 to 3	75	5.55	0.26
4	United Arab Emirates	ARE	Stage 3	163	5.47	0.17
5	Canada	CAN	Stage 3	101	5.41	0.20
6	Sweden	SWE	Stage 3	76	5.41	0.28
7	Saudi Arabia	SAU	Transition from 1 to 2	94	5.41	0.29
8	New Zealand	NZL	Stage 3	52	5.40	0.24
9	Finland	FIN	Stage 3	36	5.32	0.43
10	Chile	CHL	Transition from 2 to 3	78	5.20	0.29
11	Norway	NOR	Stage 3	74	5.15	0.24
12	Mexico	MEX	Transition from 2 to 3	268	5.13	0.15
13	Netherlands	NLD	Stage 3	81	5.06	0.25
14	Malaysia	MYS	Transition from 2 to 3	78	4.97	0.25
15	Hong Kong SAR	HKG	Stage 3	68	4.96	0.35
16	Kazakhstan	KAZ	Transition from 2 to 3	100	4.93	0.35
17	Germany	DEU	Stage 3	127	4.90	0.25
18	Turkey	TUR	Transition from 2 to 3	84	4.83	0.28
19	Switzerland	CHE	Stage 3	77	4.82	0.32
20	United Kingdom	GBR	Stage 3	102	4.81	0.28
21	Botswana	BWA	Transition from 1 to 2	78	4.80	0.27
22	Gambia, The	GMB	Stage 1	84	4.78	0.26
23	Taiwan, China	TWN	Stage 3	70	4.75	0.26
24	Brunei Darussalam	BRN	Transition from 1 to 2	41	4.75	0.39
25	Luxembourg	LUX	Stage 3	44	4.65	0.43
26	Azerbaijan	AZE	Transition from 1 to 2	89	4.63	0.30
27	Mauritius	MUS	Stage 2	91	4.58	0.31
28	Estonia	EST	Transition from 2 to 3	82	4.54	0.31
29	United States	USA	Stage 3	390	4.53	0.14
30	China	CHN	Stage 2	369	4.51	0.13
31	France	FRA	Stage 3	128	4.51	0.27
32	Australia	AUS	Stage 3	67	4.49	0.41
33	Bahrain	BHR	Transition from 2 to 3	63	4.47	0.38
34	South Africa	ZAF	Stage 2	45	4.42	0.38
35	Malta	MLT	Stage 3	57	4.36	0.44
36	Gabon	GAB	Transition from 1 to 2	48	4.34	0.36
37	Morocco	MAR	Stage 2	40	4.33	0.45
38	India	IND	Stage 1	119	4.31	0.27
39	Italy	ITA	Stage 3	86	4.24	0.32
40	Barbados	BRB	Transition from 2 to 3	69	4.24	0.34
41	Korea, Rep.	KOR	Stage 3	98	4.23	0.25
42	Montenegro	MNE	Stage 2	74	4.20	0.35
43	Seychelles	SYC	Transition from 2 to 3	32	4.20	0.51
44	Israel	ISR	Stage 3	50	4.19	0.40
45	Brazil	BRA	Transition from 2 to 3	141	4.16	0.23
46	Panama	PAN	Stage 2	132	4.15	0.20
47	Denmark	DNK	Stage 3	128	4.10	0.28
48	Cambodia	KHM	Stage 1	73	4.09	0.33
49	Indonesia	IDN	Stage 2	88	4.08	0.32
50	Belgium	BEL	Stage 3	83	4.07	0.36
51	Portugal	PRT	Stage 3	114	4.06	0.25
52	Puerto Rico	PRI	Stage 3	70	4.05	0.40
53	Spain	ESP	Stage 3	90	4.03	0.36
54	Jordan	JOR	Stage 2	155	3.92	0.24
55	Tajikistan	TJK	Stage 1	97	3.91	0.35
56	Macedonia, FYR	MKD	Stage 2	86	3.90	0.35
57	Poland	POL	Transition from 2 to 3	205	3.87	0.19
58	Czech Republic	CZE	Stage 3	159	3.87	0.25
59	Peru	PER	Stage 2	83	3.83	0.31
60	Ethiopia	ETH	Stage 1	57	3.83	0.34
61	Uruguay	URY	Transition from 2 to 3	80	3.80	0.33
62	Austria	AUT	Stage 3	105	3.80	0.29
63	Cape Verde	CPV	Stage 2	103	3.75	0.27
64	Lithuania	LTU	Transition from 2 to 3	148	3.74	0.25
65	Ireland	IRL	Stage 3	60	3.70	0.34
66	Philippines	PHL	Transition from 1 to 2	126	3.69	0.25
67	Japan	JPN	Stage 3	111	3.67	0.28
68	Armenia	ARM	Stage 2	77	3.65	0.28
69	Burkina Faso	BFA	Stage 1	39	3.64	0.46
70	Benin	BEN	Stage 1	81	3.62	0.40
71	Guinea	GIN	Stage 1	57	3.61	0.44
72	Namibia	NAM	Stage 2	81	3.60	0.32
73	Russian Federation	RUS	Transition from 2 to 3	413	3.60	0.14
74	Iceland	ISL	Stage 3	92	3.58	0.31
75	Iran, Islamic Rep.	IRN	Transition from 1 to 2	560	3.57	0.13
76	Nicaragua	NIC	Stage 1	77	3.57	0.25
77	Zambia	ZMB	Stage 1	88	3.57	0.33
78	Mozambique	MOZ	Stage 1	87	3.56	0.35
79	Liberia	LBR	Stage 1	84	3.56	0.31
80	Jamaica	JAM	Stage 2	75	3.53	0.30
81	Ghana	GHA	Stage 1	77	3.53	0.31
82	Bolivia	BOL	Transition from 1 to 2	71	3.52	0.27
83	Côte d'Ivoire	CIV	Stage 1	91	3.46	0.30
84	Costa Rica	CRI	Stage 2	94	3.44	0.27
85	Colombia	COL	Stage 2	281	3.43	0.17
86	Vietnam	VNM	Stage 1	94	3.40	0.30
87	Timor-Leste	TLS	Stage 2	33	3.39	0.61
88	Dominican Republic	DOM	Stage 2	90	3.38	0.32
89	Senegal	SEN	Stage 1	91	3.35	0.33
90	Libya	LBY	Transition from 1 to 2	68	3.33	0.40
91	Mongolia	MNG	Transition from 1 to 2	82	3.27	0.31
92	Bulgaria	BGR	Stage 2	119	3.26	0.24
93	Latvia	LVA	Transition from 2 to 3	98	3.24	0.29
94	Bosnia and Herzegovina	BIH	Stage 2	100	3.22	0.24
95	Cameroon	CMR	Stage 1	61	3.21	0.36
96	Trinidad and Tobago	TTO	Transition from 2 to 3	149	3.21	0.23
97	Suriname	SUR	Stage 2	36	3.17	0.37
98	Slovak Republic	SVK	Stage 3	65	3.11	0.33
99	Mali	MLI	Stage 1	99	3.06	0.35
100	Malawi	MWI	Stage 1	60	3.05	0.38
101	Nigeria	NGA	Stage 1	102	3.05	0.31
102	Guatemala	GTM	Stage 2	83	3.04	0.29
103	Hungary	HUN	Transition from 2 to 3	103	3.03	0.32
104	Bangladesh	BGD	Stage 1	84	3.03	0.31
105	Egypt	EGY	Transition from 1 to 2	73	3.02	0.33
106	Guyana	GUY	Stage 2	89	3.02	0.31
107	Croatia	HRV	Transition from 2 to 3	107	3.00	0.23

[lxii] Countries highlighted had sufficient sample sizes based on responses for the Global Risks Perception Survey.

Table continued on next page

Rank	Country	ISO	Economic Development Stage	Sample	Risk Management Score	Margin of Error at 95% Confidence Level
108	Uganda	UGA	Stage 1	87	2.99	0.30
109	Thailand	THA	Stage 2	75	2.98	0.37
110	Cyprus	CYP	Stage 3	78	2.97	0.30
111	Mauritania	MRT	Stage 1	78	2.97	0.37
112	Kenya	KEN	Stage 1	109	2.93	0.31
113	Moldova	MDA	Stage 1	112	2.93	0.25
114	Tanzania	TZA	Stage 1	97	2.90	0.29
115	Lesotho	LSO	Stage 1	80	2.87	0.34
116	Slovenia	SVN	Stage 3	109	2.84	0.28
117	Kuwait	KWT	Transition from 1 to 2	37	2.81	0.62
118	Serbia	SRB	Stage 2	99	2.81	0.31
119	Ukraine	UKR	Stage 2	108	2.65	0.27
120	Nepal	NPL	Stage 1	91	2.64	0.28
121	Algeria	DZA	Transition from 1 to 2	33	2.64	0.57
122	Sierra Leone	SLE	Stage 1	99	2.59	0.31
123	Romania	ROU	Stage 2	98	2.53	0.27
124	Swaziland	SWZ	Stage 2	50	2.52	0.39
125	Chad	TCD	Stage 1	103	2.49	0.27
126	Pakistan	PAK	Stage 1	106	2.47	0.24
127	Zimbabwe	ZWE	Stage 1	63	2.46	0.28
128	Honduras	HND	Transition from 1 to 2	85	2.43	0.27
129	Lebanon	LBN	Transition from 2 to 3	38	2.42	0.39
130	Madagascar	MDG	Stage 1	88	2.40	0.21
131	Paraguay	PRY	Stage 2	78	2.29	0.26
132	El Salvador	SLV	Stage 2	34	2.28	0.41
133	Kyrgyz Republic	KGZ	Stage 1	96	2.21	0.26
134	Burundi	BDI	Stage 1	90	2.18	0.21
135	Haiti	HTI	Stage 1	66	2.16	0.29
136	Greece	GRC	Stage 3	78	2.12	0.23
137	Yemen	YEM	Stage 1	52	2.12	0.35
138	Argentina	ARG	Transition from 2 to 3	96	2.08	0.25
139	Venezuela	VEN	Transition from 1 to 2	38	1.68	0.28

Meanwhile, respondents to the Global Risks Perception Survey were asked, per risk, about their country of expertise's ability to adapt and or recover from its impact:

> *"What would be your country's capability to adapt* and or *recover from the national impact of this global risk?"*

Table 5 ranks the countries from the highest to lowest according to their adaptability/ recoverability score. As with the Executive Opinion Survey risk-management question results, Singapore again and many Stage 3, innovation-driven economies are ranked higher than Stage 1, factor-driven economies. Additional details about the survey sample size for each country and its economic development stage are also provided in the table. Analysing the countries in table 5 in terms of their economic development stage presents an interesting way to group countries and tests whether this is the best method to do so.[lxiii] In the *Global Competitiveness Report 2012-2013*, the economic development stages are as defined below:

- Economies in the first stage are mainly *factor-driven* and compete based on their factor endowments—primarily low-skilled labour and natural resources.
- Transition from stage 1 to stage 2
- Economies in the second stage have moved into an *efficiency-driven* stage of development, when they must begin to develop more efficient production processes and increase product quality because wages have risen and they cannot increase prices.
- Transition from stage 2 to stage 3
- Economies in stage 3 have moved into the *innovation-driven* stage, wages will have risen by so much that they are able to sustain those higher wages and the associated standard of living only if their businesses are able to compete with new and/or unique products, services, models, and processes.

Countries highlighted in blue were used for the preliminary analysis presented in the Special Report section. The selection criterion was the sufficiency of the country sample size to guarantee a margin of error smaller than 0.5 units (equal to a 95% confidence interval of less than one unit). 66 countries were not included below as the sample size was smaller than 5.[lxiv]

[lxiii] The economic development stage groupings are the best data currently available for this report. Further analysis will investigate other potential groups, for example, GDP per capita or income level.

[lxiv] Margin of errors can still be large for the countries with small sample sizes listed in Table 5 and therefore were not included in the detailed analysis.

Table 5: Global Risks Perception Survey Resilience Question Results

Rank	Country *by country of expertise	Economic Development Stage	Sample	Adaptability/ Recoverability Score	Margin of Error at 95% Confidence Level
1	Singapore	Stage 3	10	3.66	0.93
2	Norway	Stage 3	6	3.56	1.62
3	Sweden	Stage 3	8	3.46	1.07
4	Switzerland	Stage 3	32	3.37	0.43
5	United Arab Emirates	Stage 3	11	3.28	1.01
6	Canada	Stage 3	18	3.27	0.63
7	People's Republic of China	Stage 2	72	3.26	0.25
8	Chile	Transition from 2 to 3	6	3.24	1.71
9	USA	Stage 3	283	3.23	0.12
10	Denmark	Stage 3	8	3.21	1.20
11	Netherlands	Stage 3	20	3.19	0.51
12	Germany	Stage 3	40	3.19	0.36
13	Israel	Stage 3	8	3.16	1.26
14	Australia	Stage 3	13	3.15	0.76
15	Belgium	Stage 3	7	3.15	1.35
16	Japan	Stage 3	60	3.07	0.29
17	Brazil	Transition from 2 to 3	35	3.01	0.44
18	South Korea	Stage 3	6	2.96	1.32
19	United Kingdom	Stage 3	64	2.95	0.29
20	Mexico	Transition from 2 to 3	25	2.93	0.52
21	Indonesia	Stage 2	9	2.9	1.08
22	Saudi Arabia	Transition from 1 to 2	9	2.87	1.21
23	Poland	Transition from 2 to 3	14	2.86	0.74
24	Tunisia	Stage 2	16	2.85	0.77
25	Russian Federation	Transition from 2 to 3	35	2.84	0.48
26	France	Stage 3	6	2.81	1.63
27	Vietnam	Stage 1	13	2.79	0.77
28	South Africa	Stage 2	25	2.77	0.57
29	Thailand	Stage 2	6	2.75	1.51
30	Costa Rica	Stage 2	11	2.74	0.97
31	Peru	Stage 2	6	2.73	1.65
32	India	Stage 1	64	2.71	0.28
33	Panama	Stage 2	13	2.67	0.95
34	Italy	Stage 3	31	2.67	0.40
35	Malaysia	Transition from 2 to 3	10	2.64	0.80
36	Turkey	Transition from 2 to 3	11	2.61	0.95
37	Ukraine	Stage 2	11	2.54	0.99
38	Kuwait	Transition from 1 to 2	7	2.52	1.48
39	Egypt	Transition from 1 to 2	10	2.47	0.89
40	Mauritius	Stage 2	9	2.46	1.01
41	Argentina	Transition from 2 to 3	6	2.46	1.41
42	Dominican Republic	Stage 2	5	2.44	1.94
43	Spain	Stage 3	9	2.4	1.10
44	Philippines	Transition from 1 to 2	9	2.4	0.89
45	Pakistan	Stage 1	10	2.37	1.17
46	Colombia	Stage 2	7	2.34	1.20
47	Jordan	Stage 2	7	2.23	1.48
48	Nigeria	Stage 1	16	2.21	0.66
49	Ethiopia	Stage 1	7	2.08	1.41

Appendix 3.2

As presented in the Special Report section, a country system is assessed using five components of resilience: robustness, redundancy, resourcefulness, response and recovery. Each component is further defined by key attributes, and for each of these attributes, potential qualitative[lxv] and quantitative indicators have been identified (see Table 6).

Table 6: Potential Indicators for Resilience Components[lxvi]

Resilience Components	Component Attributes	Potential Executive Opinion Survey Indicators	Potential Quantitative Indicators
Robustness	Monitoring system health	Quality of natural environment Quality of healthcare system Quality of overall infrastructure Quality of education system	Logistics Performance Index from the World Bank
	Modularity	State cluster development	Economic Freedom of the World Index from Gwartney, J., Lawson, R., & Clark, J. R. *Economic Freedom of the world, 2012*.
	Adaptive decision-making models	Willingness to delegate authority	Index of Economic Freedom from *2012 Index of Economic Freedom*, the Heritage Foundation.
Redundancy	Redundancy of critical infrastructure	Quantity of local suppliers	Reserves Renewable freshwater resources Density of physicians from *World Health Statistics*, World Health Organization.
	Diversity of solutions and strategy	Value chain breadth	Environmental Performance Index (Ecosystem Vitality) from *Environmental Performance Index*, Yale University.
Resourcefulness	Capacity for self-organization	Accessibility of digital content Extent to which virtual social networks are used	Education Index from *International Human Development Indicators*, United Nations Development Programme.
	Creativity and innovation	Latest technologies	Research and development expenditure as a percentage of gross domestic production from *World Development Indicators*, the World Bank.
Response	Communi-cation	Public trust in politicians	Media Sustainability Index from IREX.
	Inclusive participation	Business-government relations	Business regulatory environment Structural policies cluster from *Country Policy and Institutional Assessment*, the World Bank.
Recovery	Responsive regulatory feedback mechanisms	Reform implementation efficiency	Actionable Governance Indicators from *Actionable Governance Indicators Data Portal*, the World Bank.
	Active "horizon scanning"	Collaboration within clusters	Some studies have suggested potential quantitative data for this attribute including developing public-private partnerships for Research and Development and Innovation and promoting centres and networks of excellence, regional research driven clusters and innovation poles (Manjón, J. & Vicente J. A Proposal of Indicators and Policy Framework for Innovation Benchmark in Europe. In *Journal of Technology Management and Innovation*, 2010, 5:13-23.)

Table 7 shows the questions identified in the Executive Opinion Survey that are potential variables for the Country Resilience framework described in the Special Report section of this report.

[lxv] See Table 7 for detailed questions for each of the qualitative indicators.

[lxvi] These potential indicators are still work in progress. Further development, research and refinement will be conducted in the coming year.

Table 7: Executive Opinion Survey Questions

Question	Variable Name	Executive Opinion Survey Question
0208	Business-government relations	How would you characterize business-government relations in your country? (1 = Generally confrontational; 7 = Generally cooperative)
0304	Public trust of politicians	How would you rate the level of public trust in the ethical standards of politicians in your country? (1 = Very low; 7 = Very high)
0305	Reform implementation efficiency	In your country, to what extent are government reforms implemented efficiently? (1 = Reforms are never implemented; 7 = Reforms are implemented highly efficiently)
0306	Politicians' ability to govern	In your country, how you would rate the ability of politicians to govern effectively? (1 = Very weak; 7 = Very strong)
0308	Wastefulness of government spending	How would you rate the composition of public spending in your country? (1 = Extremely wasteful; 7 = Highly efficient in providing necessary goods and services)
0510	Government provision of services for improved business performance	To what extent does the government in your country continuously improve its provision of services to help businesses in your country boost their economic performance? (1 = Not at all; 7 = Extensively)
0401	Quality of overall infrastructure	How would you assess general infrastructure (e.g. transport, telephony and energy) in your country? (1 = Extremely underdeveloped; 7 = Extensive and efficient by international standards)
0501	Availability of latest technologies	To what extent are the latest technologies available in your country? (1 = Not available; 7 = Widely available)
0507	Collaborations within clusters	In your country, how extensive is collaboration among firms (e.g. suppliers, competitors, clients) in order to promote knowledge flows and innovation? (1 = Collaboration is non-existent; 7 = Collaboration is extensive)
0524	Accessibility of digital content	In your country, how accessible is digital content (e.g. text and audio-visual content, software products) via multiple platforms (e.g. fixed-line Internet, wireless Internet, mobile network, satellite)? (1 = Not accessible at all; 7 = Widely accessible)
0525	Extent of virtual social networks use	How widely used are virtual social networks (e.g. Facebook, Twitter, LinkedIn) for professional and personal communications in your country? (1 = Not used at all; 7 = Used widely)
0803	Local supplier quantity	How numerous are local suppliers in your country? (1 = Largely non-existent; 7 = Very numerous)
0809	State of cluster development	In your country, how prevalent are well-developed and deep clusters (geographic concentrations of firms, suppliers, producers of related products and services, and specialized institutions in a particular field)? (1 = Non-existent; 7 = Widespread in many fields)
0902	Value chain breadth	In your country, do exporting companies have a narrow or broad presence in the value chain? (1 = Narrow, primarily involved in individual steps of the value chain (e.g., resource extraction or production); 7 = Broad, present across the entire value chain (i.e. do not only produce but also perform product design, marketing sales, logistics and after-sales services))
0910	Willingness to delegate authority	In your country, how do you assess the willingness to delegate authority to subordinates? (1 = Not willing – top management controls all important decisions; 7 = Very willing – authority is mostly delegated to business unit heads and other lower-level managers)
1001	Quality of the educational system	How well does the educational system in your country meet the needs of a competitive economy? (1 = Not well at all; 7 = Very well)
1102	Measures to combat corruption and bribery	In your country, how effective are the government's efforts to combat corruption and bribery? (1 = Not effective at all; 7 = Extremely effective)
1303	Quality of natural environment	How would you assess the quality of the natural environment in your country? (1 = Extremely poor; 7 = Among the world's most pristine)
1401	Quality of healthcare services	How would you assess the quality of healthcare (public and private) provided for ordinary citizens in your country? (1 = Very poor; 7 = Excellent, among the best healthcare delivery systems of the world)

Appendix 3.3

As explained in the Special Report, 10 countries were identified that had a margin of error of less than 0.5: Brazil, China, Germany, India, Italy, Japan, Russia, Switzerland, United Kingdom and United States. Statistical analysis[lxvii] was conducted to identify paired differences between groups for the 10 countries, regions[lxviii] and economic development stages.[lxix]

Generally, respondents from Stage 3, innovation-driven economies had greater confidence that their country will be able to adapt and/or recover from the impact of a global risk. Respondents from Stage 1, factor-driven economies, were more pessimistic. Most interestingly, in the societal category, we found the only risk that had no statistically significant difference, *mismanagement of population ageing*, and the only risk where Stage 2, efficiency-driven economies were more optimistic than Stage 3 economies was *rising religious fanaticism*.

Following similar patterns, North Americans generally had greater confidence, while Sub-Saharan Africans had less. Statistically significant differences between countries were found for all risks, other than the two risks *hard landing of an emerging economy* and *species overexploitation*. Depending on the category and sometimes the risk, different countries were seen to have comparatively higher ability to adapt and/or recover from the impact of the risks. For the economic and environmental categories, it was Switzerland; for the geopolitical, it was China; for the technological, it was the United States; and for the societal category, there was no one particular country.

Across 50 global risks, where there are statistically significant differences (56% of the risks for age and 44% of the risks for gender), respondents under 40 years of age and female respondents rate their country as having less ability to adapt and/or recover from the impact of the risk. The majority of risks that had no statistically significant differences were from the geopolitical and technological category for gender and the environmental category for age. The largest differences in opinion were found on the *unsustainable population growth* and *water supply crises*.

With regards to perceptions of experts versus non-experts, unlike with likelihood and impact, for this group statistically significant differences were found only in the societal and technological category. Self-identified societal experts were more *pessimistic* about our recovery from societal risks, while self-identified technological experts were more *optimistic* about our recovery from technological risks.

lxvii An analysis of variance (ANOVA) tested whether or not the means of sub-groups were all equal. For those risks where they were not all equal, a Sidak post-hoc test established which of the pair-wise differences between groups were significant at the 5% level.

lxviii The whole survey sample was used.

lxix The whole survey sample was used and grouped according to their economic development stages as identified by the *Global Competitiveness Report.*

Table 8: Comparisons between Groups[lxx] for a Country's Ability to Adapt and/or Recover from the Impact of Global Risks[lxxi]

Country of Expertise		Region of Eexpertise		Economic Development Stages		Stakeholder	
Brazil	BRA	Asia	A	Stage 3	S3	Academia	A
China	CHN	Europe	E	Transition from 2 to 3	T2.5	Business	B
Germany	DEU	Latin America	LA	Stage 2	S2	Government	G
India	IND	North America	NA	Transition from 1 to 2	T1.5	International Organization	IO
Italy	ITA	Middle East/ North Africa	MENA	Stage 1	S1	NGO	N
Japan	JPN	Sub-Saharan Africa	SSA			Other	Other
Russia	RUS						
Switzerland	CHE						
United Kingdom	GBR						
United States	USA						

Risk	Country of Expertise *only for the 10 identified countries	Region of Expertise	Economic Development Stages	Stakeholder	Age			Gender			Expertise	
					Under 40		Over 40	Male		Female	Expert	Non-Expert
Chronic fiscal imbalances	CHE > GBR, IND, ITA, JPN, USA CHN > GBR, ITA, JPN, USA DEU, BRA > JPN	-	T2.5 > S1, T1.5, S3 S2, S3 > S1	-	2.91	<	3.11	3.06	>	2.91	-	
Chronic labour market imbalances	CHE > GBR, IND, ITA, JPN, USA CHN > IND, ITA, USA DEU, BRA, USA > ITA	LA, A, E, NA > SSA	T2.5, S3 > S1, T1.5 S2 > S1	-	2.86	<	3.09	3.04	>	2.86	-	
Extreme volatility in energy and agriculture prices	CHN, USA > GBR, IND, JPN BRA > IND, JPN CHE, DEU > JPN	NA > E, A, LA, SSA MENA, E, A, LA > SSA	S3 > S1, T1.5, S2 S2, T2.5 > S1	-	2.93	<	3.06		-		-	
Hard landing of an emerging economy	-	NA > E, SSA	S3 > All other stages S2 > S1	-		-			-		-	
Major systemic financial failure	CHN > GBR, RUS USA > GBR	NA, A > E	S2, T2.5, S3 > S1	B, G > IO	2.85	<	3.01	2.98	>	2.83	-	
Prolonged infrastructure neglect	CHE, CHN > BRA, GBR, IND, ITA, RUS, USA DEU, JPN > BRA, GBR, IND, ITA, RUS USA > IND	A > LA, SSA E, NA > SSA	S3 > S1, T1.5, T2.5 S2 > S1, T1.5 T2.5 > S1	-	2.92	<	3.06	3.06	>	2.85	-	
Recurring liquidity crises	CHN > GBR, ITA CHE, USA > ITA	A > E, SSA NA > SSA	S2, T2.5, S3 > T1.5, S1	G > IO, N	2.92	<	3.17	3.11	>	2.91	-	
Severe income disparity	DEU > GBR, IND, RUS, USA CHE, JPN > IND	E > LA, SSA MENA, NA, A > SSA	S3 > All other stages S2, T2.5 > S1	B > N	2.7	<	2.89	2.87	>	2.64	-	
Unforeseen negative consequences of regulation	CHE, CHN > IND, ITA, RUS DEU, USA > ITA	NA > SSA	S3 > S1, T1.5, T2.5 S2 > S1, T1.5	A, B > IO	2.85	<	3.02	2.98	>	2.84	-	
Unmanageable inflation or deflation	CHN, USA > IND	NA > SSA	S3 > S1, T1.5, S2 S2, T2.5 > S1, T1.5	G > IO	2.86	<	3.06	3.01	>	2.84	-	
Antibiotic-resistant bacteria	CHE, JPN, USA > BRA, IND, RUS	A, E, NA > LA, SSA MENA > SSA	S3 > All S2, T2.5 > S1	-		-			-		-	
Failure of climate change adaptation	CHE, CHN, DEU, JPN, USA > IND	A, E, NA > SSA	S3 > S1, T1.5 S2, T2.5 > S1	-		-			-		-	
Irremediable pollution	CHE > CHN, IND, ITA GBR, JPN, USA > IND, ITA DEU > IND	NA > SSA, LA A, E > SSA	S3 > All other stages T2.5 > S1, T1.5 S2 > S1	-	2.81	<	2.97	2.96	>	2.73	-	

[lxx] An analysis of variance (ANOVA) tested whether or not the means of sub-groups are all equal; for those that were not all equal, a Sidak post-hoc test was then conducted to establish which of the pair-wise differences between groups are significant at the 5% level.

[lxxi] Only statistically significant differences are noted; otherwise, the table cell is left empty.

Land and waterway use mismanagement	CHE > CHN, IND, ITA, RUS JPN > IND, ITA BRA, DEU, GBR, USA > IND	NA > SSA, LA A, E > SSA	S3 > All other stages T2.5 > S1, T1.5 S2 > S1	-	2.85	<	3.01	3.02	>	2.74	-
Mismanaged urbanization	CHE > BRA, CHN, IND, RUS DEU, JPN > BRA, IND, RUS CHN, GBR, USA > BRA, IND ITA > IND	E > A, MENA, SSA, LA A, NA > SSA, LA	S3 > All other stages S2 > S1, T1.5 T2.5 > S1	-		-		3.12	>	2.93	-
Persistent extreme weather	CHE > BRA, IND, ITA DEU, JPN > IND, ITA CHN, GBR, USA > IND	NA, E > SSA, LA A > SSA	S3 > All other stages S2, T2.5 > S1	-		-		2.98	>	2.80	-
Rising greenhouse gas emissions	CHN, JPN > GBR, IND, USA BRA, CHE, DEU > IND	-	S2, T2.5, S3 > S1, T1.5	-		-			-		-
Species overexploitation	-	-	S3 > S1, T1.5 T2.5 > T1.5	-		-			-		-
Unprecedented geophysical destruction	CHN, DEU > ITA JPN, USA > IND, ITA	NA > MENA, LA, E, SSA A > MENA, SSA E > SSA	S3 > S1, T1.5, S2 T2.5 > S1, T1.5 S2 > S1	A, B > IO		-			-		-
Vulnerability to geomagnetic storms	CHN > BRA USA > BRA, ITA	NA > E, LA, MENA, SSA A > MENA, LA, SSA E > LA	S3 > All other stages	-		-			-		-
Critical fragile states	CHE > ITA, JPN, RUS CHN > ITA	A, E, NA > SSA	S3 > S1, T1.5, S2 T2.5 > S1, T1.5 S2 > S1	-	3.13	<	3.27	3.26	>	3.09	-
Diffusion of weapons of mass destruction	CHN, USA > ITA, JPN	A, NA > LA, SSA E > SSA	S3 > S1, T1.5 S2 > S1	-		-		2.88	>	2.72	-
Entrenched organized crime	CHN, USA > BRA, ITA, JPN, RUS CHE, DEU, GBR > ITA, RUS IND, JPN > ITA	NA > E, LA, SSA, A, E, MENA > LA, SSA	S3 > All other stages	-	2.95	<	3.13	3.11	>	2.88	-
Failure of diplomatic conflict resolution	CHE, CHN > ITA, JPN, RUS BRA, USA > ITA, JPN DEU, GBR > JPN	NA > LA, SSA	S3 > S1, T1.5, S2 T2.5 > S1	-	3.01	<	3.13		-		-
Global governance failure	CHN > IND, ITA, JPN, RUS CHE > ITA, JPN, RUS USA > ITA	A, NA > SSA	S3 > S1, T1.5 S2 > S1	-		-			-		-
Militarization of space	USA > BRA, DEU, GBR, IND, ITA, JPN CHN > GBR, ITA, JPN	NA > All other regions A > LA	S3 > S1, T1.5, T2.5	-		-			-		-
Pervasive entrenched corruption	USA > BRA, CHN, IND, ITA, RUS CHE, JPN > BRA, IND, ITA, RUS CHN, DEU, GBR > IND, ITA, RUS	NA > A, E, LA, SSA A, E, MENA > LA, SSA	S3 > All other stages S2, T2.5 > S1	-	2.72	<	2.97		-		-
Terrorism	CHN > IND, ITA, JPN, RUS USA > IND, JPN, RUS	E, NA, MENA > LA, SSA A > LA	S3 > S1, T1.5, T2.5 S2, T2.5 > S1	-	3.01	<	3.16		-		-
Unilateral resource nationalization	BRA, CHN, USA > DEU, GBR, IND, ITA, JPN CHE > ITA, JPN	NA > A, E, LA, SSA	T2.5, S3 > S1	-	2.89	<	3.12		-		-
Widespread illicit trade	CHN, USA > ITA, RUS	NA > E, LA, SSA A > LA, SSA E, MENA > SSA	S3 > All other stages S2 > S1	-	2.98	<	3.13		-		-
Backlash against globalization	DEU > GBR, IND, ITA, JPN USA > JPN	-	S3 > S1, T1.5, S2 T2.5 > S1	-		-		3.17	>	3.04	

Food shortage crises	BRA > GBR, IND, JPN CHE, CHN, DEU, USA > IND, JPN	NA > A, MENA, LA, SSA E > A, SSA A > SSA	T2.5, S3 > S1, T1.5, S2 S2 > S1, T1.5	-	3.23	<	3.38		-		3.21	<	3.39
Ineffective illicit drug policies	CHE, CHN > BRA, GBR, ITA, RUS, USA JPN > BRA, ITA, RUS, USA DEU > BRA, ITA	A > LA, NA, SSA E, MENA > LA	S3 > S1, T1.5, T2.5	-		-			-			-	
Mismanagement of population ageing	IND > GBR, ITA, RUS CHE > ITA, RUS	MENA > NA, E	-	-	2.81	<	2.95		-			-	
Rising rates of chronic disease	JPN > BRA, GBR, IND, RUS, USA	A > LA, SSA E, NA, MENA > SSA	S3 > All other stages S2 > S1	-		-		2.98	>	2.82	2.87	<	2.99
Rising religious fanaticism	BRA, CHN > IND, RUS, USA CHE > IND, USA JPN > IND	LA > E, MENA, NA, SSA	S2 > S1, T1.5, S3 S3 > S1, T1.5 T2.5 > S1	-	3.06	<	3.19	3.19	>	2.99		-	
Unmanaged migration	BRA > IND, ITA, RUS USA > IND, ITA CHN > IND	NA > E All other regions > SSA	T2.5, S3 > S1, S2 T1.5, S2 > S1	-	2.91	<	3.13	3.08	>	2.89	2.94	<	3.10
Unsustainable population growth	CHE, CHN, USA > IND	NA > A, SSA E > SSA	T2.5, S3 > S1, T1.5 S2 > S1	-	2.89	<	3.21	3.10	>	2.95	2.99	<	3.12
Vulnerability to pandemics	CHE, CHN, USA > BRA, IND, RUS DEU, JPN > IND, RUS	A, E, NA > LA, SSA	S3 > All other stages S2, T2.5 > S1	-		-			-			-	
Water supply crises	BRA > CHN, GBR, IND, ITA, USA CHE, DEU, JPN > CHN, IND, ITA CHN, GBR, RUS, USA > IND	E > A, MENA, SSA NA > A, SSA LA > SSA	T2.5, S3 > S1, T1.5, S2 S2 > S1	G, A, B > N	3.1	<	3.25	3.27	>	2.97	3.03	<	3.31
Critical systems failure	USA > BRA, GBR, IND, ITA, RUS CHE > IND, ITA, RUS	NA > A, E, LA, SSA A > LA, SSA E, MENA > SSA	S3 > All other stages S2 > S1	-		-			-		3.14	>	2.87
Cyber attacks	USA > GBR, IND, ITA, JPN, RUS CHN > IND	NA > A, E, LA, SSA A, E, MENA > SSA	S3 > All other stages S2, T2.5 > S1	-		-			-		3.11	>	2.93
Failure of intellectual property regime	USA > RUS	NA > LA, SSA, MENA	S3 > All other stages	-		-			-			-	
Massive digital misinformation	USA > IND, ITA, RUS CHE, CHN > IND, ITA DEU, GBR, JPN > IND	NA > A, E, LA, SSA A, E, MENA > SSA	S3 > All other stages S2, T2.5 > S1	B > IO	2.99	<	3.11		-		3.18	>	3.01
Massive incident of data fraud/theft	USA > BRA, GBR, IND, ITA, RUS	NA > A, E, LA, SSA A > LA, SSA E, MENA > SSA	S3 > All other stages	-	2.88	<	3.04		-		3.13	>	2.91
Mineral resource supply vulnerability	USA > DEU, GBR, IND, ITA, JPN CHN, RUS > GBR, IND, ITA, JPN	NA > All other regions	T2.5, S3 > S1, T1.5 S2 > S1	-	2.85	<	3.01		-			-	
Proliferation of orbital debris	USA > BRA, GBR, IND, ITA, JPN CHN > BRA	NA > All other regions A > LA	S3 > S1, S2, T2.5	-		-			-		2.84	>	2.67
Unforeseen consequences of climate change mitigation	JPN > GBR, IND CHN, USA > GBR	NA > LA, SSA	S3 > All other stages	-		-			-			-	
Unforeseen consequences of nanotechnology	USA > BRA, GBR, IND CHN, JPN > BRA	NA > E, LA, MENA, SSA A > LA, MENA, SSA Europe > LA, SSA	S3 > All other stages	-		-		2.77	>	2.62	2.92	>	2.65
Unforeseen consequences of new life science technologies	USA > BRA, GBR, ITA, RUS	NA > E, LA, SSA, MENA A, E > LA, SSA	S3 > All other stages	-	2.64	<	2.82		-		2.85	>	2.70

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