

A large background image featuring a night sky with the Milky Way galaxy. A person is silhouetted against the sky, sitting on a rocky outcrop in the lower right corner. The image is partially overlaid by decorative geometric shapes on the left and bottom.

WTW Research Network Annual Review 2022

Science for Resilience

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Foreword

Welcome to the latest review of our research portfolio, which continues to bring leading-edge science into our worlds of people, capital and risk management.

We started this 16th year with a name change: formerly Willis Research Network, we will now go by the name WTW Research Network, to better reflect the expansion of our research portfolio across all of WTW. The aim of the WTW Research Network remains to foster and integrate open science-based approaches to support clients and wider stakeholders to consider their risks and growth opportunities.

This involves a careful balance between embracing the complexity of science (to understand the challenge) whilst distilling and integrating the key insights in a simple and relevant way (to support decision-making).

2022 continues to show us a need for heightened awareness and understanding around people-related risks. The COVID-19 pandemic enters its third year of disruption, whilst conflict in Ukraine and an ensuing humanitarian crisis show the interconnectedness that impacts day-to-day life for people across the globe. Geopolitical risk research continues to be a key area of focus with partners including Oxford Analytica, the University of Cambridge, the American Enterprise Institute and more to follow.

Our established portfolio of research across the full spectrum of risks (natural hazards, people and technology, emerging risks, organizational resilience) continues to grow. It matches our evolving vision of current and future risks, our emphasis on organizational resilience to complement the traditional risk view, and the growing importance of ESG and sustainability (with a nod to the [WTW Thinking Ahead Institute](#) and its influential thought-leadership for investors). These three themes align with perspectives [highlighted by our CEO Carl Hess](#) in his vision statement at the beginning of the year.

Once again this year, to inject new perspectives into our research portfolio, the WTW Research Network invited its members (and potential new partners) to submit short collaborative research projects via our Challenge Fund program. It's a chance to experiment with new ideas and try new methods to answer questions we are seeing, or address topics that may be underrepresented. In 2022 our new themes are: relationships with technology, and the influence of climate change on human health and wider societal impacts.

We hope that you find the WTW Research Network review a useful summary of some of the work we have underway and our growing membership.

“ Our work involves a careful balance between embracing the complexity of science whilst distilling and integrating the key insights in a simple and relevant way to support decision-making.”

Our thanks to all our research partners, WTW Research Network team, clients and colleagues for last year’s progress, including colleagues at Gallagher Re with whom we continue to work closely on a number of these projects. We cannot think of a more pressing time to be harnessing the Network’s capabilities to support lives, livelihoods and assets in the volatile decade we are in.

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About us

The WTW Research Network is an award-winning collaboration between science and the insurance, finance and risk management sector, going back to 2006. Our mission is to encourage and harness innovative research to improve our understanding of a wide range of risks, operationalize this research to support better risk solutions, help clients and society become more resilient and take advantage of growth opportunities.

Whilst the risk and insurance industries continue to evolve and improve at an astonishing rate, no individual institution has the resources or breadth of knowledge to single handedly answer all of the questions around the quantification and management of risk. This is where our long-term investment in research partnerships proves invaluable, bringing the latest science to our clients, and highlighting emerging risks before they make the headlines.

Harnessing relationships with more than 60 organizations across the world from science, academia, think tanks and the private sector, the WTW Research Network forms innovative partnerships to confront the full spectrum of risks.

The WTW Research Network continues to build on the strength of its partnerships, delivering and incorporating solutions into models, methodologies and transactions that increase resilience and improve the market's understanding and coverage of risk.

The WTW Research Network is organized around seven research hubs, which drive a number of research programs and research projects, producing academic and business-focused research outputs.

Outputs include data, models, applications, peer-reviewed journal articles, financial instruments and conferences. Along with longer term research programs, we continue to identify projects with tangible outputs for our clients within shorter time-frame, enabling us to deliver solutions on demand.



We are proud to support early-career scientists, not only through funding, but also via internships and guidance in their studies. This reflects our wish to build long-lasting partnerships with academics at all stages of their careers.





Global partners, local expertise

We drive research with partners in science, academia, think tanks and the private sector, combining specialist expertise with state of the art knowledge across our global network.



Innovative, long-term partnerships

We form long-term, innovative partnerships with the research community, and support early-career scientists.



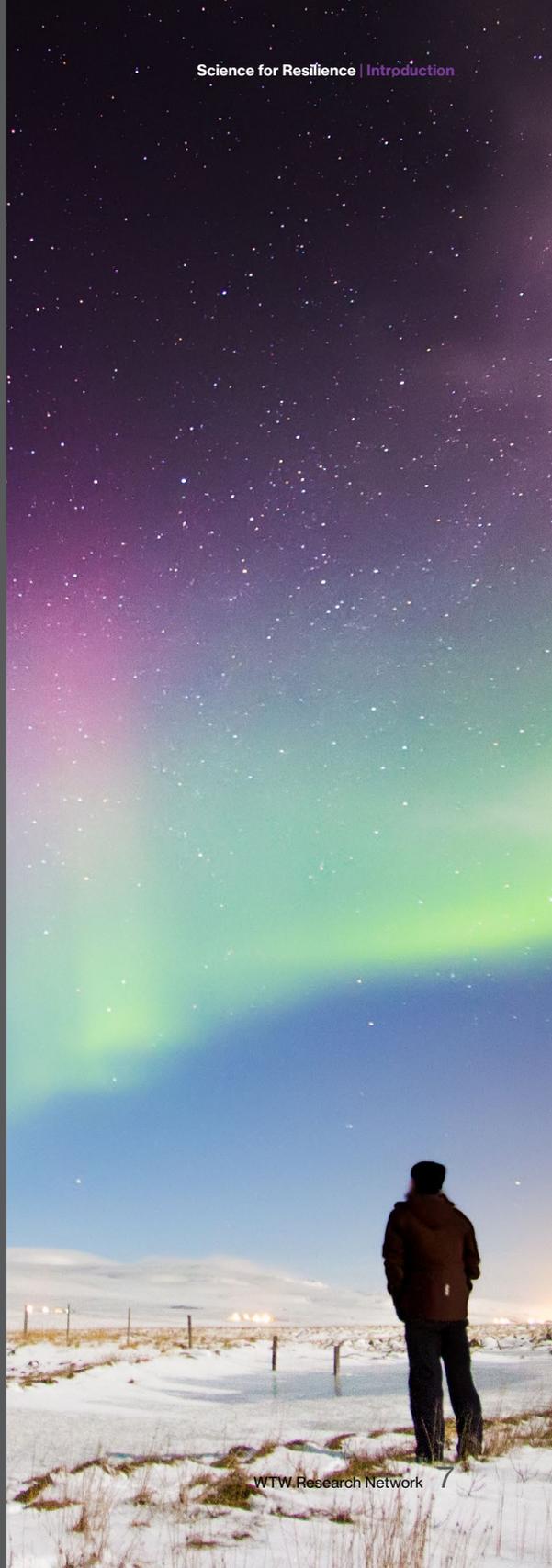
Understanding of risk

Our partnerships identify risks, improve their understanding and quantification for the benefit of our clients and society.



Transmission mechanism

Our dedicated team brings best practice research and evidence into our client proposition: risk models, advice, thought-leadership, insights and events.



How it works

How do we select research projects? There are two main routes: business-driven requests and science-inspired topics. We aim for a good balance between risks on everyone's radar and emerging risks.



Key research hubs

The WTW Research Network is organized around seven research hubs, which drive a number of research programs and shorter-term projects. Throughout the year our hub leaders and partners produce academic and business-focused research outputs, a selection of which can be found in this research overview. You can also keep track of our activities throughout the year by subscribing to our newsletters [here](#), and reach out to any of our hub leaders below.



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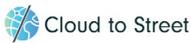


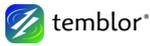
Organizational Resilience Research

Simon Sølvsten

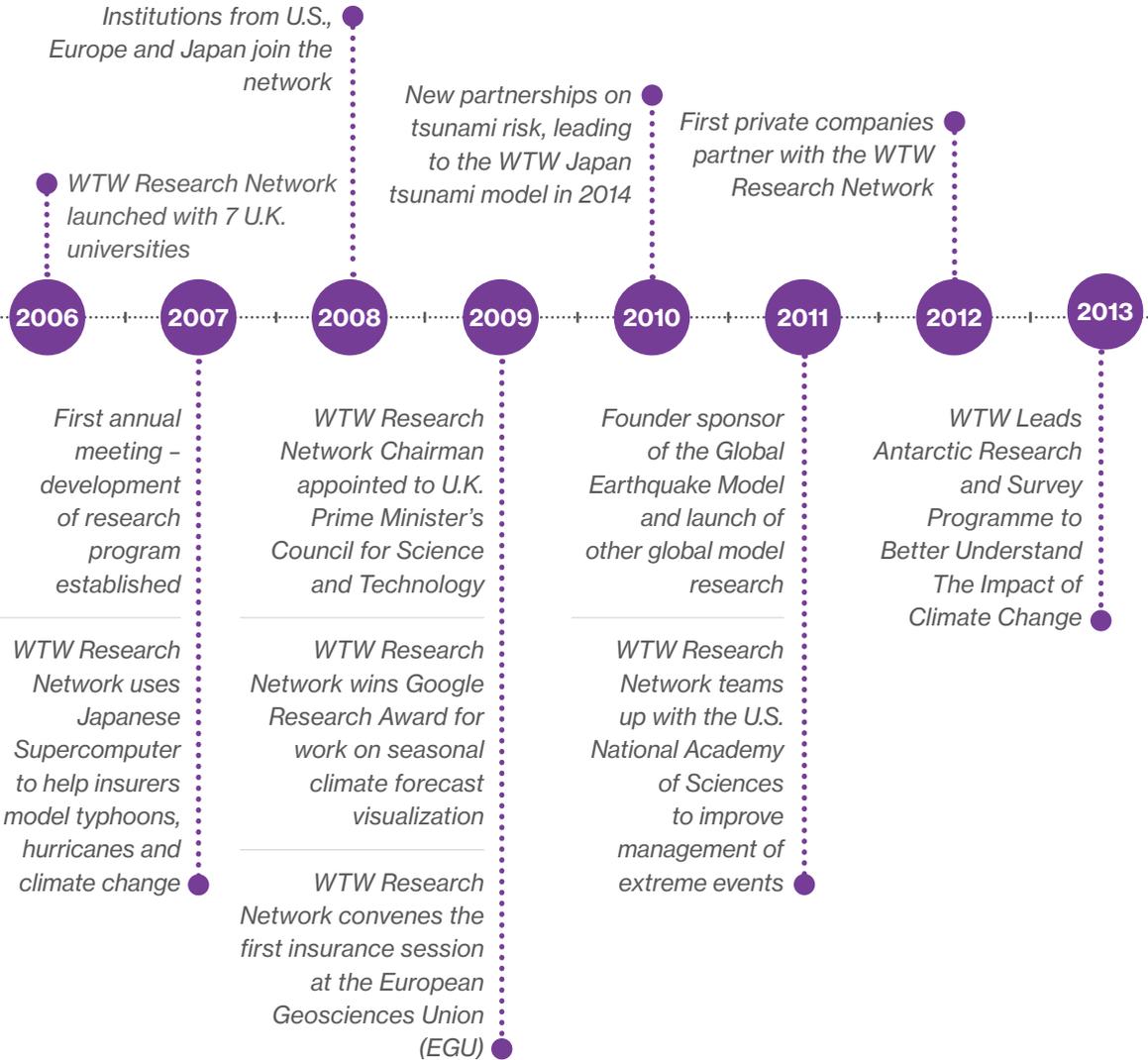
simon.solvsten@willistowerswatson.com

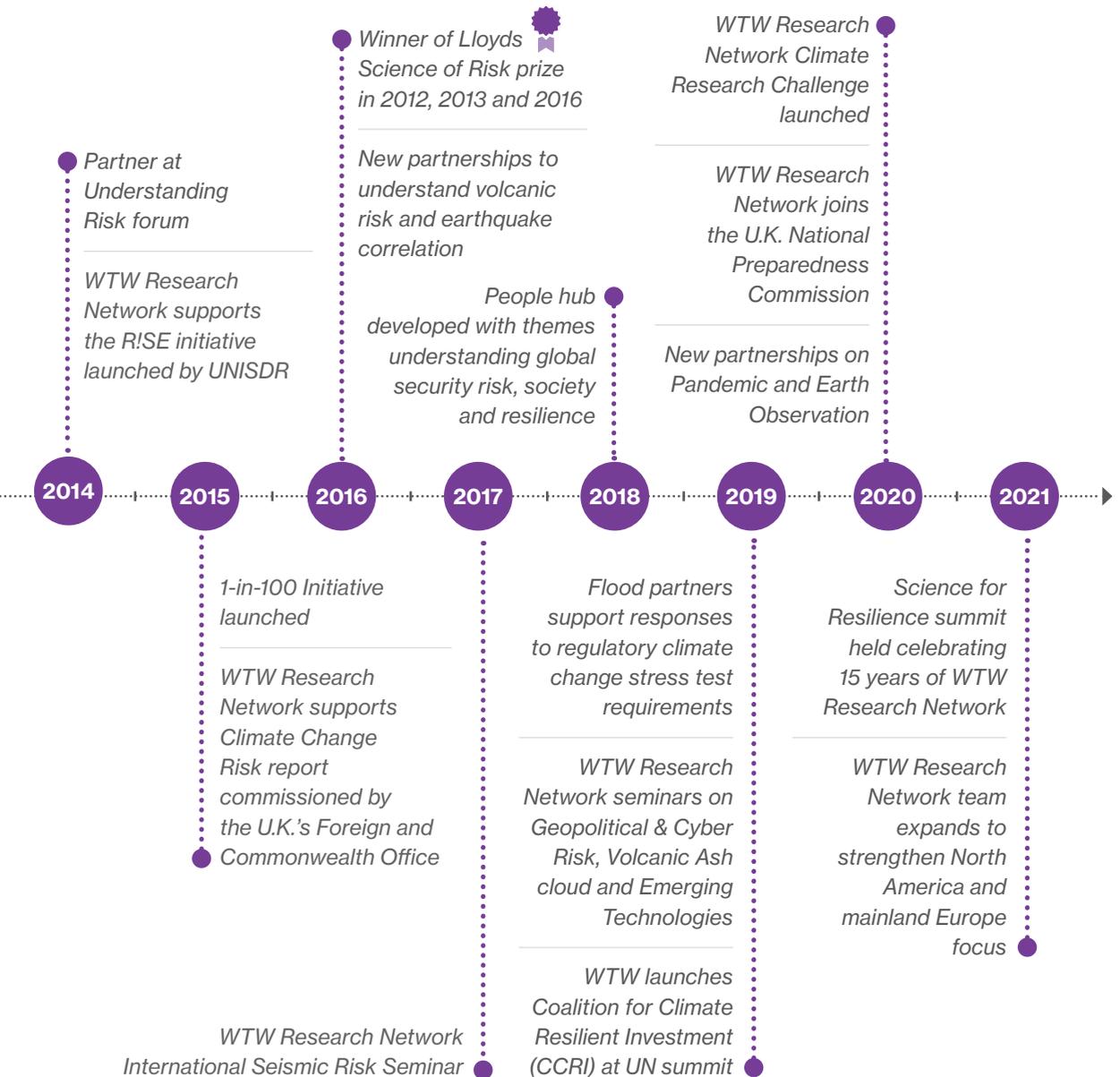
WTW Research Network partners over the years





Our history







A wide-angle photograph of White Sands National Park. The foreground is dominated by bright white sand dunes, heavily marked with footprints. A turquoise-colored lagoon is visible on the right side, with several people standing on the sand and others swimming in the water. The sky is a clear, bright blue with some light clouds. A black rectangular box is overlaid on the middle of the image, containing the text 'Weather and Climate' in white.

Weather and Climate



Weather and Climate

In a year of change, focus on climate risk grows.

Historically, there has been strong emphasis on natural catastrophe risk related research in the WTW Research Network. In particular, the weather and climate research hub has undertaken the majority of its research with a focus on extreme events such as hurricanes, windstorms, and severe convective storms.

In recent years, the WTW Research Network has been expanding its remit beyond natural catastrophe (as you'll see from browsing this Annual Review for 2022). As the research needs of our clients and industries continue to diversify, 2021 was a year of discovery, both in terms of finding new teams at WTW to collaborate with on exciting new ideas for product innovation, and also through the development of new relationships with academia to explore areas not previously addressed.

The influence of extreme weather on society continues to be a main theme for our weather and climate research program. We have been continuing ground-breaking work with our long-standing partners, for example at NCAR, Columbia and KIT, as well as enhancing and renewing other research relationships with a fresh set of questions.

Concerns related to the effects of climate change on industry and the financial stability of large complex corporations are growing.

After the successful conclusion of our first Challenge Fund in 2021, focused on climate risk, we are continuing to use this platform in 2022 to explore new angles to help develop new tools and services. The research challenges are more diverse but still include the effects of climate change on specific industries, and how they can adapt to the changing risk landscape to come. Thinking about intersections between climate risks and other themes (for example, health and liability) is also an important consideration, allowing our research to cross cut our offerings to our clients.

As pressures mounting from regulators, shareholders, and the general public converges on climate risks through various ESG initiatives, the WTW Research Network continues with its mission to provide WTW, its clients and the industry with access to the latest science to inform credible and impartial views of risk, to support business decision making and lead industrial practice in this space.

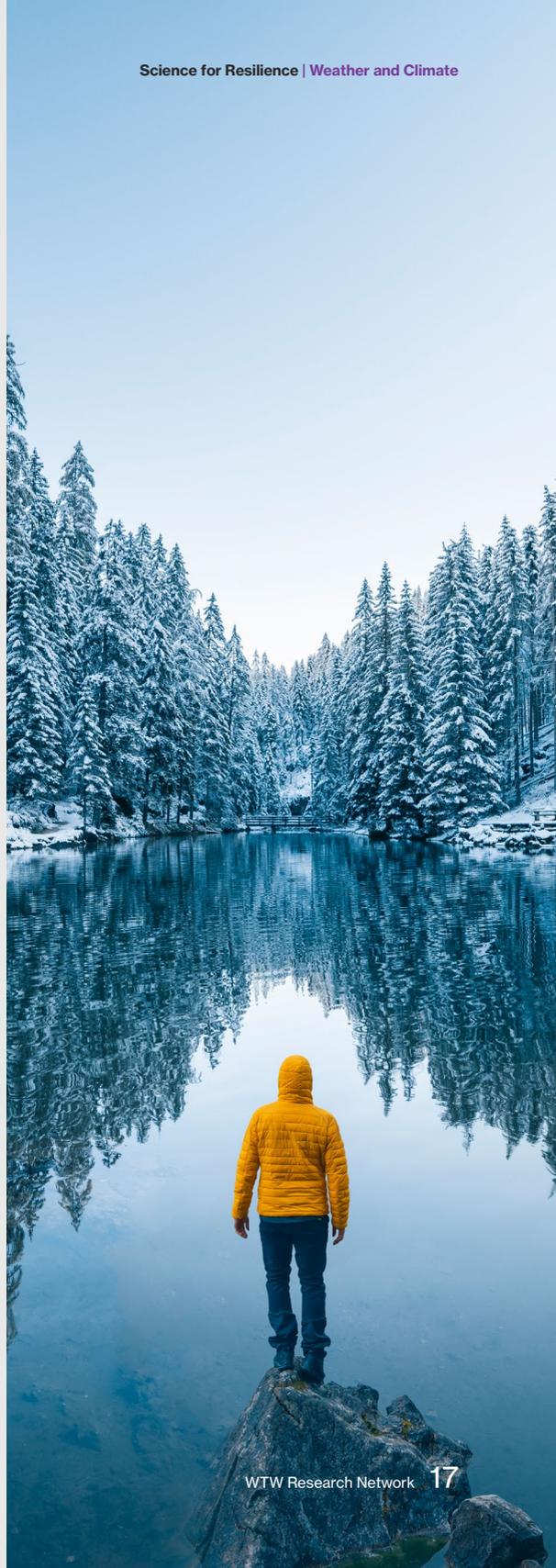
WTW has undergone a period of change through the last year or so, and all in the uncertain context of a global pandemic. However, the research focused on weather risks in current day climate conditions, as well as research exploring climate change related risks, either physical, transitional or litigation driven, remain crucial to our client services and to accelerating innovation.

“ While research can happen without innovation, innovation cannot occur without research. Climate change involves myriad risks that every C-suite executive will need to address in the coming years. ”

While many will opine their views and opinions on climate change issues, it is now more important than ever to ensure that any strategic or tactical business decisions relating to climate risks are made using a clear comprehension of the issues, a deep understanding of the data and science available, and a robust interpretation of model outputs and specialist services. Only then can effective guidance be taken from the latest science and innovation and used to manage these complex risks.

Geoffrey Saville

Head of Weather and Climate
Risks Research



Valuing climate risks in real estate markets

Physical climate hazards such as flooding, and wildfires present a major threat to mortgage lenders, insurers, and the broader financial system. It is becoming clearer that such hazards are increasing in frequency and severity, coinciding with increasing exposure of populations to such threats.

Physical climate hazards are not a new phenomenon – real estate markets have endured and been responsive to extreme weather events throughout history. However, as trends in extreme events emerge, there is growing evidence that these hazards are already having a direct monetary effect on property prices. Changes in property prices pose a major financial risk to homeowners, mortgage and insurance industries, bank portfolios, and wider financial systems.

This is leading to a process of urban area selection where there is greater demand for properties possessing climate resilient traits (e.g. located at higher elevations). This is already driving up property prices possessing such traits, compared to properties more exposed and/or less protected against

physical climate hazards that may experience discounted valuations. Climate gentrification describes this process of area selection and the collective effects of individual and collective investment responses to physical climate hazards (e.g. flooding and wildfires) in residential and commercial housing markets.

To demonstrate climate gentrification in action, we conducted a case study on a flood prone UK city. By using publicly available data a simple repeat-sale hedonic price model was developed to explore the effect of flood zoning and flood history on changes in property prices at the postcode level. Three scenarios were used to analyze changes in property prices (see **Figure 1**). We show that just by being located within Flood Zone 3 (defined by the Environment Agency as land with a 1 in 100 or greater annual probability of river flooding) on average, results in a price difference of 30%, relative to properties that are unexposed. This price difference is further exacerbated under scenario C, for properties that are located within Flood Zone 3, and have had a history of flooding.



City A

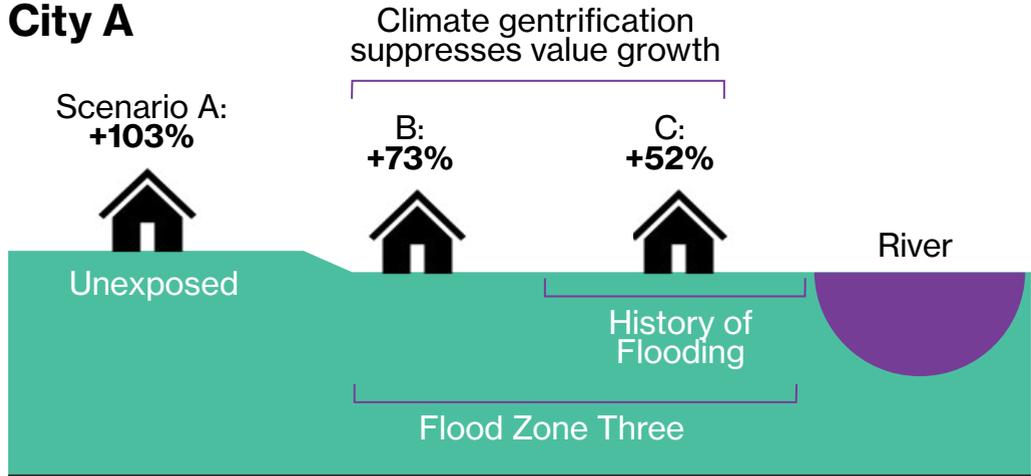


Figure 1. Climate gentrification in action within a flood-prone UK city. Results of the hedonic modeling show changes (%) in property prices in City A between 1995 and 2021 depending on location relative to fluvial flood risk. Scenario A considers the change in price for properties unexposed to fluvial flood risk. Scenario B considers the change in price for properties located within Flood Zone 3 (defined by the Environment Agency as being land with a 1 in 100 or greater annual probability of river flooding). Meanwhile, scenario C considers the change in property price for a property located within Flood Zone 3 and which has been flooded twice.

These findings have been incorporated into a consolidated critique of climate gentrification that has been submitted for publication to the Transactions of the Institute of British Geographers.

Looking forward, we aim to develop a forward-looking analysis framework to understand how

the effects of inland flooding (pluvial and fluvial) and coastal flooding, have on property prices, and how this may change under projected storylines of climate change. In addition, we aim to investigate ethical considerations that should be considered in parallel to the due diligence on evaluating climate risk exposure.

Loughborough
University and
Josh Thompson



The Department Geography and Environment, in the School of Social Sciences and Humanities at Loughborough University conducts cutting-edge research, working internationally with other researchers, industry and government to increase understanding of our rapidly changing planet. It is recognized for excellence and leadership across six interdisciplinary research themes: Cities; Children, Youth and Families; Climate-Water-Energy; Hydroclimate, Risk and Resilience; Migration and Nation; Understanding and Managing Environmental Change. PhD researcher Josh Thompson is conducting this research under the supervision of Professor Rob Wilby, and aims to develop statistical methods to analyze climate gentrification and develop a forward-looking analysis to understand how the effects of flooding on property prices may change under projected storylines of climate change.

Representing European windstorm risk in the past, the present and in the future

The University of Exeter have been partners in the WTW Research Network since the beginning, over 15 years ago. Their early work with WTW focused largely on European windstorm clustering, which quantified the extent to which winter storms in Europe tend to turn up in clusters, and changed the way the industry dealt with windstorm-related losses over a reinsurance contract. Their work then went on to help build the European Extreme Windstorm Catalogue with partners at the Met Office and University of Reading, developing a library of wind storm footprints for historical extreme windstorm events, including storms rated both from a purely meteorological perspective, but also from an industry loss perspective using the input from various industry representatives including WTW. This catalogue was the forebear of the WISC catalogue which has since expanded on this research, and continues to develop wind related risk products. These highlights represent some of the benefits that working with Exeter has brought to WTW and the insurance industry at large, and we are now looking forward to starting a new phase of research with Dr Matthew Priestley, guided by Professors David Stephenson and Adam Scaife, which will look more to the future, and how European windstorm activity can be predicted on a seasonal to decadal timescale, and also how climate change is affecting European winter storms, in particular how different projections may produce different futures for European storminess.

This new work will leverage the statistical expertise and the expertise in climate modeling held by our partners at the University of Exeter's College of Engineering, Mathematics and Physical Sciences, used for both climate prediction over seasons and years, but also longer term projections to quantify the uncertainty relating to current long term trends and future changes under different scenarios. As increasing interest from clients and developing regulatory landscape guide our research portfolio, we will continue to leverage this partnership with the University of Exeter to answer key questions relating to European Windstorm risk in a historical context, and associated with seasonal variability and future climate change scenarios.



Dr Matthew Priestley

WTW Research Network Fellow, Dr Matthew Priestley's current research is on European winter storms, with focus on constructing and evaluating present day risk. A further goal is on understanding the impact of climate change on future risk estimates. At the College of Engineering, Mathematics and Physical Sciences, he works with Professor David Stephenson, Chair in Statistical Climatology (also a founding member of the WTW Research Network) and Professor Adam Scaife, to develop new insights and views of European windstorm risks.

Utilizing latest climate models to assess severe convective storm risks

Our ongoing partnership with Columbia University is helping WTW on a number of practical applications of latest climate model outputs while developing new and cutting-edge science to advance our understanding of convective storm risk.

Their recently published paper “*Future Global Convective Environments in CMIP6 Models*”¹, led by Dr Chiara Lepore, used the latest generation of climate change projections (CMIP6) to address the question of how convective storm risk is expected to change in a warming climate.

Since severe thunderstorms are too small for climate models to represent directly, severe weather proxies were used instead. Severe weather proxies, which climate models can simulate, indicate where large-scale meteorological conditions are favorable for severe thunderstorm development.

Overall, they found that the frequency of severe weather proxy occurrence increases in the order of 5% to 20% (depending on region; see figure 6 of published paper) per degree Celsius of global mean temperature increase. The increases were driven mainly by the increased atmospheric instability of a warmer climate. Using output from multiple climate model projections and scaling the results by global mean temperature change helped to increase their robustness and to remove some of the scenario uncertainty. Two key caveats are that the occurrence of favorable conditions is not the same as severe

thunderstorm occurrence, and that proxies that match convective storm occurrence well in the current climate may perform differently in a future climate.

Severe weather proxies are not standard outputs of climate model and were computed specifically for this application. The resulting one-of-a-kind dataset has the potential for further risk applications. Also, the data-intensive calculations required developing new software and taking advantage of recent advances in cloud computing. These new technologies and workflows involving large climate model datasets bring lessons that WTW analytical teams are learning from in order to better understand and effectively manipulate climate model data.



Columbia University in the City of New York is a leading global research university, with engineering and science facilities designed and equipped for next-generation research. The Columbia Initiative on Extreme Weather and Climate focuses on understanding the risks to human life and property from extreme weather events and on developing solutions to mitigate those risks. Dr. Michael Tippett, Professor Adam Sobel, and Dr. Chiara Lepore have been working with the WTW Research Network to help us understand and better manage risks from climate extremes, with a focus on severe thunderstorm impacts.

¹ <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2021EF002277>

Towards a multiperil assessment of tropical cyclone hazards in current and future climates

Over the last couple of years, the partnership with the National Center for Atmospheric Research in Boulder Colorado (NCAR), has produced several robust and relevant research outputs. A key dataset was derived from the development of a new methodology to represent the surface winds associated with Tropical Cyclones (TC) around the world, utilizing storm tracks and an atmospheric boundary layer model to represent the near surface winds that cause impact on the ground. These wind footprints are available in the “WTW Research Network Global Tropical Cyclone Wind Footprint” datasets. This work has been used to validate and adjust industry risk models to create our own view of risk, but also to create wind fields based on realistic disaster scenarios that might represent how historical significant storms might look in a future warmer world, based on the latest science. However, winds are not the only peril associated with TCs, and so in the past year we have started to develop capacity to generate data on tropical cyclone rainfall. This is advancing our understanding of the significant flood risks associated with tropical cyclones around the world.

The tropical cyclone rainfall work is using the same track information used for the global tropical cyclone wind footprints dataset, as inputs to a rainfall model developed by Prof Kerry Emanuel (MIT, U.S.) and collaborators. The rainfall model produces data in seconds yet captures many of the major rainfall producing processes. These rainfall-driving processes include storm intensification, frictional convergence at landfall, flow over coastal terrain, and storm

interactions with neighboring wind patterns. Key to our application is the sharing of common information between the wind model and the rainfall model, thus ensuring a physically consistent view between the hazard components.

This new modeling capability is being used to create a representation of rainfall associated with key storms in the wind footprint catalogues. This is providing a multi-hazard representation of historical storms. Our multi-hazard approach is also well suited to model future storm scenarios that represent both wind and rain hazards, to be used for impact assessment and risk model evaluation and validation.



The *National Center for Atmospheric Research* (NCAR)

is based in Boulder, Colorado and one of the leading research institutions in the US. The WTW Research Network has been collaborating with staff at NCAR's Mesoscale and Microscale Meteorology lab for well over a decade, which has the mission to advance the understanding of the large and small scale aspects of weather and climate, and to apply this knowledge to benefit society. WTW Research Network Senior Fellow Dr. James Done, and Emeritus Director Dr. Greg Holland have been delivering research and applications throughout our partnership, helping us improve our understanding of tropical cyclone impacts through their multi-sectoral research and a variety of wider academic partnerships.

Accelerating research applications with the WTW Research Network's Challenge Fund 2021

At the end of last year, the WTW Research Network set a challenge to its members to come up with ideas for short collaborative research projects that focus on specific elements of risks associated with climate change. From the ideas submitted, three were chosen to pursue during 2021 and have recently presented their findings.

Science is moving fast, can industry keep up?

Before outlining their findings, first some context. The aim of these projects is to advance research into climate change-related risks and accelerate the development of our WTW Research Network project portfolio in this area. It is a chance to experiment with some new ideas and try new methods to answer the kinds of questions we are seeing from the industry. These projects will be used to develop the ideas further, and to guide and feed into our analytical offerings in the climate risk space.

And clearly, it's an important and exciting time to be working on [climate risk analytics](#). The science is moving fast, and practical applications of science are running to catch up. In my 20 years of working in the weather and climate industry, in operational and science application roles, there has never been such an appetite for understanding and using academic models and methods to advance industry practice.

After the positive steps at COP26, both large and small, it is more important than ever to leverage the best science has to offer to guide decision takers and policy makers. As WTW creates a science-led suite of services based

on our academic partnerships, we try to use our projects to provide credible and robust solutions. At the same time, academic endeavors are advancing overall understanding of the risks relating to climate change as society increases efforts to mitigate global warming and adapt to the consequences of the carbon emissions already locked into the climate system.

Presenting the results

On 8 December 2021, the WTW Research Network hosted a webinar for the project teams to present their work to a mixed audience of industry practitioners and academic experts, followed by a question and answer session.

A recording can be found [here](#) with the following projects featured:

- ***“Towards physically-based and usable climate event scenarios”***, presented by Dr James Done, NCAR, and Prof Gabriele Villarini, University of Iowa, and including contributions from Dr John Hillier, Loughborough University, and Dr Jeff Czajkowski, NAIC.

The idea of this project is to provide a framework for using climate model outputs in a variety of different ways to assess physical risks from extreme events. In this case, the team used CESM climate model outputs to investigate tropical cyclone impacts across a global portfolio and flooding in a specific region, in this case Iowa, under various climate change projections compared with today's risk. The key here is to use the same source of climate model information to make two

assessments of different risks but, by using the single source, to keep them physically consistent. If different models, data sources, methodologies are used for this kind of work, significant biases can be introduced which reduce the usefulness of any comparisons or multi-peril assessments. It is hoped that this project can feed into the discussions of regulatory requirements in the U.S. on climate risk and help respond to requirements around the world.

- **“Convective storm characteristics in a changing climate (CSTOCC)”**, presented by Dr Chiara Lepore, Columbia University and Prof Dr Michael Kunz, Karlsruhe Institute of Technology (KIT).

This project leverages the work already undertaken via the WTW Research Network by both research partners in recent years to develop a view of risks associated with severe convective storms in future warmer projected climates. KIT is focusing on developing proxies for extreme hail events that can be applied to both reanalysis data and climate model outputs alike. This enables us to compare current and future risks. The representation of future risk from climate models is what Columbia University has developed using the latest climate models in the Coupled Model Intercomparison Project sixth phase (CMIP6) and through understanding how the models represent convective indices in the future to relate to current climate conditions. This can help us understand how these CMIP6 models represent changes to severe convective events in the future.

- **“Proposed realistic climate change stress tests approaches for disaster prone southeast Asia domain”**, presented by Prof Shie-Yui Liong, National University of Singapore.

Yui and his team worked on this project to enhance one of our existing WTW Research Network projects focused on flood risk in south East Asia. Specifically, they used climate model outputs to develop intensity density frequency curves for cities in the region in the current climate and in the future based on high-emissions scenarios. This can help us assess changes to flood risk in a manner consistent with previous work to model flood risks in current climate conditions.

New projects for 2022

We used this year’s Challenge Fund to focus on physical climate risks, and encouraged collaborative projects looking into techniques that can derive tangible outputs from the years of research and expertise that have underpinned the scientific advances supported by the WTW Research Network and our academic partners.

In spring 2022, we launch our next round of challenge fund themes, so watch this space for future research targeting new and untapped areas that broadens the range of activities in the WTW Research Network.







Flood



Flood

Flood risk is changing but what does that mean for my backyard: Am I still above water?

Flood being one of the key global natural catastrophe risks that governments, industries and corporates are trying to manage, is still a very location-specific peril.

This year WTW Research Network funded research at the National University of Singapore (NUS) provided the critical inputs to adjust JBA's Global Flood Model to reflect climate change impacts on precipitation and temperature changes for Southeast Asia region. The project is one of a kind. With that adjustment we can now quantify the flood risk change under various climate change scenarios based on multiple climate model and ensemble projections, and near and long-term time frames at specific asset level. Conditioning a high-resolution global flood model to represent future flood risk and also providing correlated water stress and drought impacts for chronic risk is a significant achievement. Regional focus is key here because the real impact of climate forcing on flood (and drought) is represented at a regional scale.

This project allowed us to make use of the scientific insight on correlated hydrometeorological extremes and come up with tangible applications, while communicating in the same language as the industry. The model generates financial risk metrics including annual average loss and exceedance probability against real asset exposures from the Spatial Finance Initiative (SFI) database. We had the privilege to present the project findings at United Nation's Climate Change Conference (COP26) in Glasgow.¹

The focus of the project was Southeast Asia. The region is no stranger to catastrophic flood events, and it happens to be quite critical for the world's economy. According to the recent study led by WTW Research Network partner Cloud to Street, "between 2000 and 2015 up to 86 million additional people resided in areas identified as flooded globally, representing a 24% increase in the proportion of population exposed to floods". This increase was not evenly spread across the globe. Countries with increased flood exposure were concentrated in Asia and Sub-Saharan Africa, home to the majority of people on the globe.²

¹ <https://cop-resilience-hub.org/>

² <https://global-flood-database.cloudtostreet.ai/>



Understanding present day flood risk and the expected future changes in flood risk requires a comprehensive analysis. Physical risk change is a function of hazard, exposure, and vulnerability changes at asset level.

Therefore, the change needs to be addressed for three variables at high-resolution. For flood risk, it must be detailed and location specific.

One of the key projects we worked on last year was to calculate the flood risk change at a large industrial facility in the energy sector. The energy sector is critical for the world's economy and the preparedness of major players against climate related risks can be a game changer. Many industrial facilities inherently are quite water intensive facilities. Because of their locations, they are often exposed to various natural hazards. Inland and coastal floods can be loss drivers for these assets. Long-term WTW Research Network partners at Newcastle University, Prof Chris Kilsby and Dr Francesco Serinaldi provided the expertise and the tools to deliver detailed, bespoke and site-specific solutions.

For present day and future flood risk estimates at site level, City Catchment Analysis Tool – “CityCAT” – a fluvial/pluvial and coastal flood inundation risk model, developed by our partners at Newcastle University – was used³. The model provided the flexible platform to calculate changing risk profile at high-resolution and identify necessary mitigation measures for the refinery.

Flood risk is becoming more and more critical in the global risk landscape. Understanding present day flood risk is no longer sufficient to manage asset portfolios. Identifying risk changes, not just hazard but exposure and vulnerability changes too, at location level with high-resolution model outputs will be the next industry standard.

Neil Gunn

Head of Flood Risks Research

³ <http://www.urbanfloodresilience.ac.uk/documents/factsheet-citycat.pdf>

City catchment analysis

Site level risk quantification plays a key role in asset management. In the energy sector, typical oil and gas asset portfolios include both networked and single site assets, from refineries to oil rigs to pipelines. The global nature of these asset portfolios and supply chains means a diverse exposure to natural perils and physical climate risks, including pluvial, fluvial and coastal flooding.

In a recent project, WTW was asked to provide a deep understanding of the underlying property damage and business interruption impacts from physical climate and natural catastrophe risks in the context of climate change for a large industrial installation in Australia.

One of the primary objectives of this study was to focus on an in-depth hazard analysis and to build bespoke, site-specific climate hazard models by utilizing expertise in the WTW Research Network and to capture, where possible, the uncertainty of the modeled results. Long-term Research Network partners at Newcastle University, Prof Chris Kilsby and Dr Francesco Serinaldi provided the expertise and the tools to deliver high quality solutions for this project.

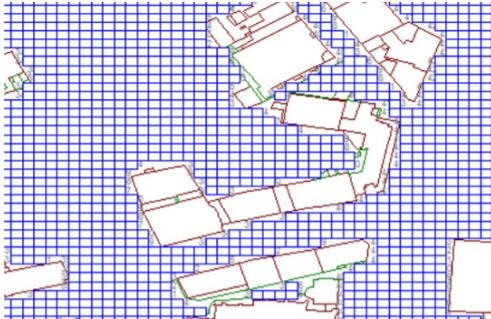
At site level flood risk analysis, very detailed hydrodynamic model is required. To do this, the City Catchment Analysis Tool – “CityCAT” provides a rapid assessment model of combined fluvial, pluvial and coastal flood inundation risk using a fully two-dimensional (2D) shock-capturing finite volume modeling scheme built to solve the flow on a raster-based grid.^{1,2,3}

CityCAT is a novel software system for the assessment of combined pluvial and fluvial flood risk. Using a unique combination of robust software architecture, standard datasets, efficient algorithms for grid generation and accurate solutions of the flow equations, CityCAT stood out to be the most appropriate tool for this analysis.

Advanced software architecture allows for accurate solutions of complex free-surface flow equations over various terrain conditions; permeable and impermeable surfaces, man-made features such as buildings. It is rigorously validated against test cases based on analytical solutions and laboratory studies. Moreover, the model is specifically designed for high-resolution inundation modeling for both fluvial and pluvial floods.

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- 1 Glenis, V., Kutija, V., & Kilsby, C. G. (2018). A fully hydrodynamic urban flood modeling system representing buildings, green space and interventions. *Environmental Modelling & Software*, 109, 272–292.
 - 2 Bertsch, R., Glenis, V., & Kilsby, C. (2017). Urban flood simulation using synthetic storm drain networks. *Water*, 9(12), 925
 - 3 McClean, F., Dawson, R., & Kilsby, C. (2020). Implications of using global digital elevation models for flood risk analysis in cities. *Water Resources Research*, 56(10), e2020WR028241.

Figure 3. An example of the CityCAT computational domain with exclusion of buildings



Using CityCAT as the basis of inundation modeling; rainfall induced flood risk and storm surge driven flood risk under the current climate conditions and future climate conditions based on a plausible climate scenario of representative concentration pathways (RCP) 4.5 (2-3°C global warming), published by the Intergovernmental Panel for Climate Change (IPCC) AR5 report, were calculated. In order to estimate hazard uncertainty, upper and lower boundaries in extreme value analysis (EVA) for storm surge return periods (RPs) and rainfall intensity change are derived statistically.

There are major uncertainties in calculating the magnitude of flood hazards corresponding to low probability of occurrence arising from small sample size and measurement issues. Another key contributor to uncertainties in flood modeling is the accuracy of the input terrain data and its resolution. This plays a great role especially for small scale studies and for terrains with complex network of linear features.⁴ In CityCAT we applied LiDAR dataset with 1m horizontal resolution to achieve higher precision and reduce the uncertainties associated with terrain input data.

The uncertainty is amplified for future conditions under a changed climate where unknown parameters in climate models as well as unknowable future emission scenarios become critical. Furthermore, these uncertainties “cascade” into the subsequent estimation of flood risk via flood extent and depth maps, which are derived using chains of models with their own parameter uncertainties.

For future events, a climate model ensemble is used to generate the event set, with a further procedure to account for sensitivity to emission scenarios (concentration pathways). CityCAT provided us the platform to run these set of events and evaluate the flood extent and depth maps for a through site risk assessment. Based on this assessment, we recommended detailed, tailored risk mitigation measures that focuses on reducing the impact of climate change on physical risks on assets.



Newcastle University

Professor Chris Kilsby and current WTW Research Fellow Dr. Francesco Serinaldi at Newcastle University have significant expertise in the physical mechanisms and statistical analysis of extreme rainfall and river flooding.

In addition, Dr. Serinaldi’s research is world leading in terms of the development of methods to understand the spatial dependence and clustering of extreme processes in hydrology.

⁴ Shustikova, I., Domeneghetti, A., Neal, J. C., Bates, P., & Castellarin, A. (2019). Comparing 2D capabilities of HEC-RAS and LISFLOOD-FP on complex topography. *Hydrological Sciences Journal*, 64(14), 1769-1782.

Adjusting a global flood model

This year the WTW Research Network continued their long-standing partnership with National University of Singapore (NUS) Tropical Marine Science Institute (TMSI) to build on the work previously showcased in the 2021 Annual Review on 'Filling in the gaps in model coverage in Asia'. The expansion of this project generated a broader collaboration across the public and private sector including JBA – the global leaders in flood risk modeling, Spatial Finance Initiative (SFI) – which aims to mainstream geospatial capabilities into financial decision making globally.

For the past 15 years WTW Research Network has worked with NUS to explore the influences of climate change on extreme flood and rainfall distributions that could form the basis of scenarios and future event sets. Currently the WTW Research Network is collaborating with multiple partners, utilizing TMSI's outputs as a foundation to provide a forward-looking view of acute flood risk and chronic water stress at asset level in Southeast Asia.

JBA estimates that over 60% of the global population are at risk to inland flooding annually, and almost 50% of global flood losses are in eight countries in Asia. This highlights the importance of evaluating this region and creating a blueprint method for future regional analysis.

TMSI's climate change impact on precipitation and temperature outputs were used to climate condition JBA's global flood model.

Using multiple climate model outputs, downscaling them to regional level and investigating the change factors under various Representative Concentration Pathways (RCP)

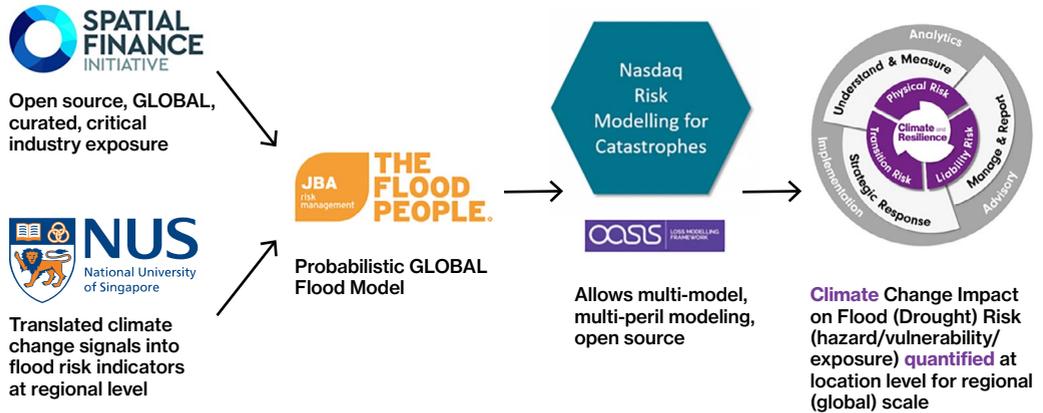
scenarios, NUS provided a range of possible outcomes for temperature and precipitation changes for Southeast Asia model domain. According to their findings the future climate projections indicate that average surface temperatures over Southeast Asia are likely to increase by more than 3.5 °C by the end of the century. As for precipitation, both the mean and extreme rainfall are likely to increase but the biases in the historical simulations could contribute to larger uncertainties in the estimates of rainfall projections.

JBA's flood model contains a global event catalogue of 15 million simulated events, 2 million of these impact Southeast Asia. Using NUS's research outputs, JBA created climate conditioned event sets under various RCP scenarios and for near and long-term future time frames, enabling them to calculate present day and future flood risk at location level. Spatial and temporal variations projected in the precipitation and temperature changes resulted in material risk changes across the region.

The final model will be available on the Nasdaq platform which provides transparency and flexibility for users through the ability to confidently understand the key climate, hazard and exposure assumptions and model settings used.

For location level analysis, SFI provided open-transparent asset data to enable the evaluation of future flood risk for Southeast Asia. SFI provides open, global databases for physical assets in every major sector of global economy. They leverage advances in remote sensing and artificial intelligence to identify and characterize physical assets. For this pilot

Figure 4. Taking climate change signals and communicating the risk change in business language



project SFI provided asset data for steel and cement production, both of which are water dependent activities which can have material risks from both flooding and droughts. This asset data was used as the input exposure data for the JBA flood modeling. Having this level of data helps significantly with comprehensive risk assessment. Exposure is a dynamic input; it changes every day. Therefore, a curated, open-source, consistent database is a major advantage to analyze climate change impact of key asset classes.

This is a unique project, bringing together expertise and capability from different sectors, which demonstrated the value of open-source data and the progress being made in understanding financial risks under a changing climate. Through TMSI's regional climate outputs, SFI's asset data and JBA's baseline and climate conditioned projected risk modeling, the current and future risk change of real assets is possible.



National University of Singapore

The Tropical Marine Science Institute (TMSI)

in NUS is a center of excellence for research, development and consultancy in tropical marine science as well as environmental science. With its multi-disciplinary research laboratories and active international links, it handles projects relevant to Marine Biology, Marine Mammals, Climate Change, Water Resources, Shallow-water acoustics; Underwater technologies and Physical Oceanography. Through active collaboration with academic, government and industrial sectors, TMSI plays a strong role in promoting integrated marine science, in R&D, and as well as to establish itself as a regional and international education and training center. <https://emid.nus.edu.sg/aboutus.jsp>

The Climate and Water Research cluster at TMSI specializes in climate research and has extensive experience, particularly, in high-resolution dynamical downscaling of global climate models at a range of spatial scales – from regional (10-20 km) to local (urban) (400 m – 2 km), that are applicable for a suite of impact studies.

Satellite imaging reveals increased proportion of population exposed to floods worldwide

The industry has been trying to understand the impacts of changing climate, landscape and exposure distribution on flood risk using climate models and projecting plausible scenarios, but the observed data can also give us an insight on how things are changing.

New research¹ published by WTW Research Network partner Cloud to Street provides ground-breaking insights into rising flood risk globally. Cloud to Street uses direct satellite observations of flooding and refines this geospatial data with AI and other methods instead of modeled estimates which are widely used in the insurance industry.

The study led by scientists at Cloud to Street, a global flood tracking and risk analytics platform for disaster managers and insurers, who have been members of the WTW Research Network since May 2020, revealed that by overlaying population information on historically flooded areas, they have calculated that over the years more and more people are exposed to floods.

Co-authored by scientists from NASA, Google Earth Outreach, University of Arizona, Columbia University, University of Michigan, University of Colorado, University of Texas at Austin, and the University of Washington, the output of this study is an open-access database of satellite imagery of over 900 large global flood events between 2000 and 2018. The database is hosted at Cloud to Street's global flood database.²

The research offers a comprehensive view of flood exposure around the world and underscores how alternative methods of analyzing flood risks through platforms like Cloud to Street allows insurers to understand flooding in a new and revolutionary way.

This allows additional analyzes of the scope, impact, and trends of recent flooding. It represents a major advancement in the field of flood mapping and is essential to capture accelerating and record-breaking disasters associated with climate change, while also enabling greater flood insurance penetration worldwide.

The database sets a new standard for providing a view of the true scope of flood risk as the largest and most accurate dataset of observed historical floods in existence.

The analysis reveals that the proportion of global population exposed to floods has grown by 24% since the turn of the millennium, a tenfold difference from what scientists previously thought. Growing exposure and a growing number of flood events are behind the rapid increase, according to the research. The researchers found that between 255 and 290 million people were directly affected and between 2000 and 2015, the number of people living in these flooded locations increased by 58–86 million.

1 <https://doi.org/10.1038/s41586-021-03695-w>

2 <https://global-flood-database.cloudtostreet.ai/>

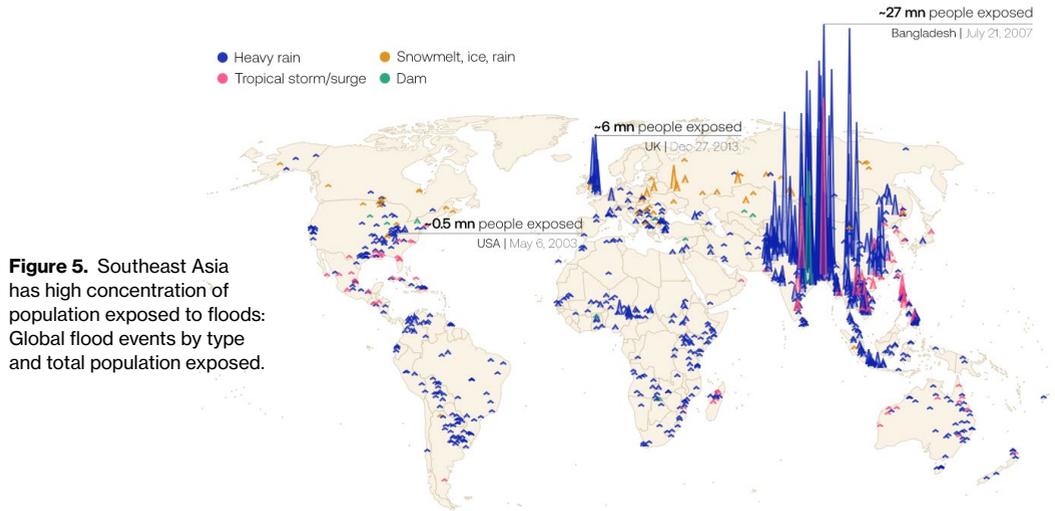


Figure 5. Southeast Asia has high concentration of population exposed to floods: Global flood events by type and total population exposed.

By 2030 the model estimates that climate and demographic change will add 25 new countries to the 32 already experiencing increasing floods.

With high-resolution satellite and machine learning flood monitoring technology and dynamic analytics systems, which include near real-time flood monitoring and high-cadence flood mapping, Cloud to Street is building and implementing reliable and scalable risk transfer solutions to serve current and future clients. These innovative applications enable communities and businesses to be better

prepared for, and act faster after an event, increasing resilience to catastrophic flooding.

As flood risk is expected to increase through population changes and urbanization, overlaid onto a background trend driven by climate change, the dataset will provide a unique and credible benchmark for the insurance industry to assess flood risks, both from an aggregated annual average loss perspective, as well as single extreme loss-making floods. It will also provide an ongoing and essential view of risk to support humanitarian and risk management efforts.

Cloud to Street



Cloud to Street is a flood-mapping and monitoring system designed for governments, humanitarian organizations and insurers in low data environments to effectively respond and prepare for disasters. Originally founded with seed funding from Google in 2014, Cloud to Street's technology combines high resolution satellite imagery, cloud computing, machine learning, and community intelligence to monitor floods in near real-time and analyze flood risk remotely around the globe. Learn more at cloudtostreet.info

Present-day and future flood risk in Puerto Rico

Precipitation-induced flooding due to hurricanes poses an existential risk to small island developing states.

As dominant type of flooding in island states is flooding due to extreme rainfall, it becomes necessary to understand not only present-day risk from hurricane rainfall, but also the change to the risk under various climate change scenarios.

In addition to partnering with prestigious academic institutes around the globe and funding cutting edge research projects, WTW Research Network supports Doctoral Training Programmes (DTP) in these institutes to guide PhD students in their research and provide opportunities to them to interact with business leads on research applications. As part of the DTP program at University of Bristol the WTW Research Network is supporting Leanne Archer's work under the supervision of Dr Jeff Neal.

The primary objective of the research is to understand how intensity, duration, magnitude, and the spatial characteristics of hurricane rainfall influenced flood estimates, and how these would change under 1.5°C and 2°C warming scenarios.

For the purpose of this exercise, current climate is defined as 2006–2015 and the climate change scenarios are for 2106–2115 time period.

To start with an event set of 59,000 synthetic hurricane rainfall events is considered. The event set is produced using a Tropical Cyclone Rainfall model^{1, 2}, using four regional climate model ensembles from the HAPPI-MIP initiative. From this, a synthetic hurricane rainfall event set is created that consists of around 20,000 events for current day, 1.5°C, and 2°C.

These synthetic rainfall events in turn became the input rainfall for the “rain on grid” flood hazard model.³ The ultimate output was then the creation of an event-based rainfall driven flood hazard model for hurricane rainfall for Puerto Rico. This model has a 20m resolution and provides estimates of both current and future flood risk.

The model was validated against high water marks collected following Hurricane Maria in 2017 by USGS.

1 Vosper, E.L., Mitchell, M., Emanuel, K., 2020. Extreme Hurricane Rainfall affecting the Caribbean mitigated by the Paris Agreement Goals. *Environmental Research Letters* 15, 10. <https://doi.org/10.1088/1748-9326/ab9794>

2 Emanuel, K. (2017). Assessing the present and future probability of Hurricane Harvey's rainfall. *Proceedings of the National Academy of Sciences of the United States of America*, 114(48), 12681–12684. <https://doi.org/10.1073/pnas.1716222114>

3 Sampson, C.C., Bates, P.D., Neal, J.C., Horritt, M.S., 2013. An automated routing methodology to enable direct rainfall in high resolution shallow water models. *Hydrological Processes* 27, 467–476. <https://doi.org/10.1002/hyp.9515>

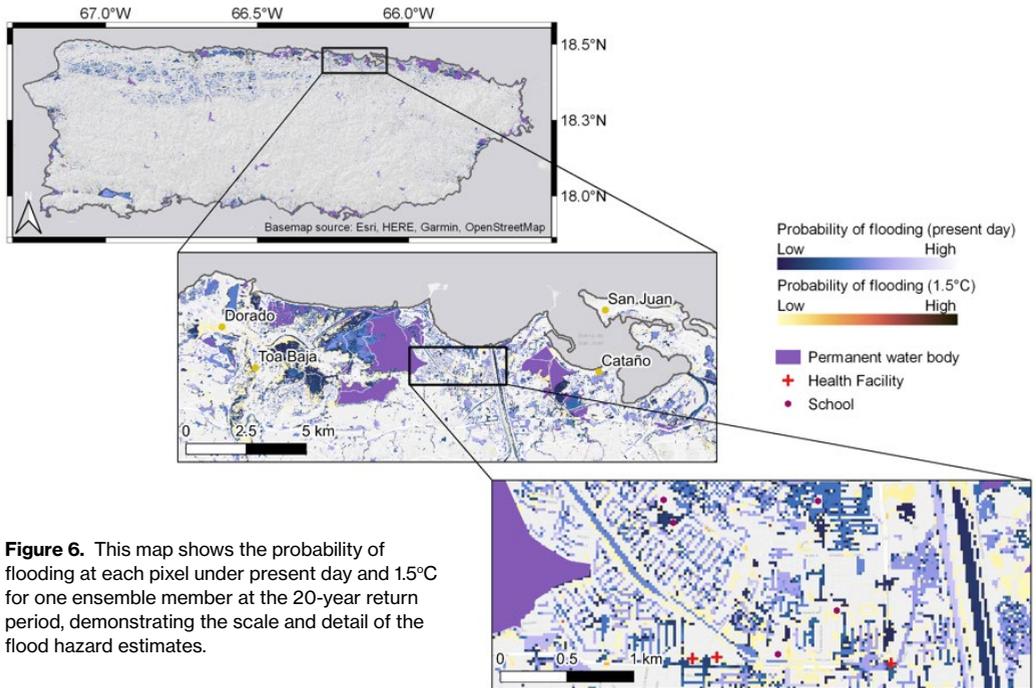


Figure 6. This map shows the probability of flooding at each pixel under present day and 1.5°C for one ensemble member at the 20-year return period, demonstrating the scale and detail of the flood hazard estimates.

Using the model outputs and population metrics, the team has found that Puerto Rico's population would be 1.6–15.2% and 0.7–22.3% more exposed to flooding from hurricane rainfall at 1.5°C and 2°C climate change scenarios compared to present day scenarios, depending on the climate model used.

The next steps for this work include a WTW Research Network Partner collaboration between University of Bristol and NCAR to improve modeling hurricane winds and hurricane-induced precipitation. Through this collaboration we hope to expand on this research to develop a greater understanding of changes to population exposure to flooding for high-magnitude, low-probability events (for example, Hurricane Maria). Further interrogation will require a larger event set and greater understanding of population exposure and changes to population exposure in the future.



The School of Geographical Sciences at the *University of Bristol* is a major international center for the development and delivery of geographical research and scholarship, the only Geography department in the country to come in the top category across every RAE that has been undertaken since 1986. PhD researcher Leanne Archer is investigating how flood inundation estimates can be improved in small islands under current and future climate change. She works with supervisor, Dr Jeff Neal, to provide insights into the impacts of tropical cyclone rainfall may change in a warmer climate.





Earth



Earth Risk – A Tale Of Two Halves

The past few decades have been an interesting time for earth scientists and those involved in monitoring and protecting against natural hazards.

In many ways things are the same as they have always been; tectonic plates move continuously, pressure builds beneath volcanoes until it overcomes the strength of rocks around it and breaches the surface in eruptions of lava and ash, strain builds on fault systems until it releases through earthquakes, and ground displacement caused by these quakes generates tsunamis that put coastal communities at risk. But at the same time, significant changes to the risk landscape are also occurring. The impacts of climate change are becoming ever more apparent, with effects being felt in the form of stronger storms, warmer temperatures, melting ice caps and rising seas. This has a knock-on effect on earth hazards around the world, with increased rainfall and more intense storms on land hastening landslide activity and subsidence, and with rising and more turbulent seas hastening coastal erosion and adding to the strength of and damage done by tsunamis. There has even been research that suggests that events such as intense rainfall and the retreat of glaciers may contribute to the triggering of volcanic eruptions.

But all is not doom and gloom. Positive changes have been taking place in the fields of geohazard monitoring, remote earth observation and computer modeling. This is allowing geoscientists such as our WTW Research Network partners to not only observe the occurrence of earthquakes, volcanic eruptions, tsunamis and landslides more frequently and in far greater detail, but also combine this information with historic data to model when, where and how severely similar events may occur in future. Examples of the sorts of models being produced include our partners at San Diego State University, University College London, Temblor Inc. and the Global Earthquake Model Foundation working to predict the risks posed by large earthquakes and their aftershocks, as well as assessing the vulnerability of infrastructure affected by these quakes. Mitiga Solutions is modeling the risk posed by airborne contaminants such as volcanic ash in the atmosphere, enabling airlines to adapt flight paths and avoid losses from flight cancellations and damage to aircraft engines. And academics at Tohoku University are modeling propagation and wave heights from tsunamis, allowing coastal communities to develop resilience strategies that will save lives as well as infrastructure.

Improvements within the risk sphere can already be seen when natural disasters occur, with the eruption of the submarine Hunga Tonga-Hunga Ha'apai volcano serving as a recent example. Despite the sudden and violent nature of the eruption, with hazards including ash and tsunami waves affecting large parts of the Pacific Ocean, the death toll was relatively minor thanks in part to hazard modeling and early warning systems in place following previous eruption and tsunami events. These models will continue to improve as monitoring networks on the ground and in orbit become more comprehensive, the data obtained gains quality, quantity and frequency, and computing power increases at an almost exponential pace. The WTW Research Network aims to help facilitate these improvements wherever it can, working with our partners to deliver accurate and timely risk information by modeling where, when, and at what cost earth risks will occur.

James Dalziel

WTW Research Network –
Head of Earth Risks



Improving catastrophic loss estimation using supercomputing

It is critical for the financial health of the earthquake insurance and re-insurance industry to ensure that premiums accurately reflect expected losses in a catastrophic event.

This process conventionally relies on regression of empirical ground motion recordings (Ground Motion Prediction Equations, or GMPEs) from historical earthquakes to estimate the insured losses. However, GMPEs by construction produce large uncertainty due to the inherent smoothing, and potential bias in the estimated ground motions, and include major gaps in data in the near field and for large-magnitude events.

To alleviate the uncertainty in ground motion prediction in the GMPEs, the use of wave propagation simulations carried out in a state-of-the-art 3D earth model have the potential to help refine the expected range of ground motions and thus loss estimates. Since 2017, the WTW Research Network has been working with researchers from San Diego State University (SDSU) exploring how physics-based 3D ground motion simulations can improve the accuracy of catastrophe modeling. SDSU scientists Prof. Kim Olsen and his research team pioneered the first large-scale wave propagation simulations more than 2 decades ago, demonstrating how 3D effects of sedimentary basins can strongly affect the resulting ground motion predictions.

In a first research collaboration with the WTW Research Network, the SDSU team focused on risk assessment in the Cascadia region of the Pacific Northwest, USA. They showed that the range of predicted losses can be significantly reduced by estimating the ground motions input to the loss calculation by wave propagation simulations carried out in a state-of-the-art 3D earth model for M9 subduction earthquake scenarios. Reasons for the smaller range of estimated losses from the 3D simulations, likely include basin amplification, wave focusing, and nonlinear soil effects that are insufficiently covered by the GMPEs.

The current SDSU-WTW Research Network research collaboration takes a closer look at the seismic risks along the South American west coast. The primary objective of the project is to generate ground motion footprints for Chile and Peru using a 3D velocity model and rupture models for large subduction earthquake scenarios. This region has experienced frequent M8-9+ megathrust earthquakes, including the largest historical event of 1960 (M9.5) and the 2010 M8.8 Maule earthquake. The region includes large insurance exposure at population centers such as Santiago, Chile and Lima, Peru. As for Cascadia, the project aims to provide more accurate levels of ground motions and enable refined loss estimates for large, damaging, earthquake scenarios, as compared to GMPE-based estimates.



The wave propagation simulations for Peru and Chile require an accurate 3D earth model of the trench and basins in the South American west coast region. The assembly of such a model involves elaborate combination of a series of geophysical and geotechnical features, including geometry of the subducting slab, mantle and crustal velocities, and sedimentary basin parameters. Furthermore, the model must be validated against recorded strong ground motions and ground motion prediction equations, such as from the 2010 M8.8 Maule, Chile, earthquake, before generating accurate footprints of scenario ground motion (see **Figure 7–Figure 8**).

Figure 8 shows how ground motions from a leading GMPE (conventionally used in risk modeling) compares to those from strong motion observations and the 3D simulation of the 2010 Maule earthquake. In general, the simulation tends to predict the recorded ground motions better than the GMPE;

in particular, the GMPE tends to underpredict the values in and around the sedimentary deposits of Santiago.

The improved ground motion estimates come with an added cost – they require use of thousands of processing units on today’s largest supercomputers for hours. However, the fact that the insurance industry utilized future megathrust earthquakes in the Pacific Northwest based on 3D simulations to stress test cat model outputs and assess impact on reinsurance capacity purchasing constitutes a major milestone and success for state-of-the-art scientific numerical modeling. 3D earthquake simulations have progressively presented themselves as alternatives to strong motion data records in the near field and large magnitude gaps that persist, and we are at the point where synthetic seismograms produced by 3D models are making their way into decision makings for the society.

Figure 7. Simulation of the 2010 M8.8 Maule, Chile, earthquake, to validate the 3D earth model for generation of footprints for large scenario earthquakes. (left) Compound source model for the Maule event, generated by combining background slip with high stress drop subevents. The star depicts the epicenter, the color shading is the slip distribution in meters, and the contours show the rupture initiation times. (right) Snapshot of 3D wave propagation for the Maule event, 100 s after rupture initiation. Cool and hot colors depict large ground motion amplitudes.

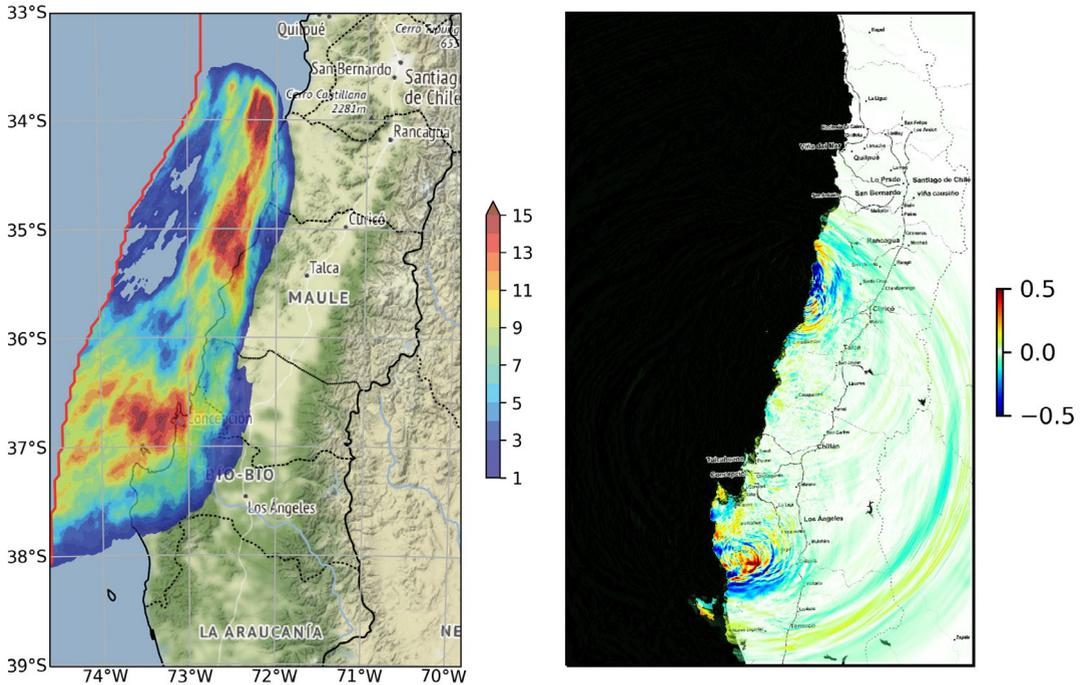
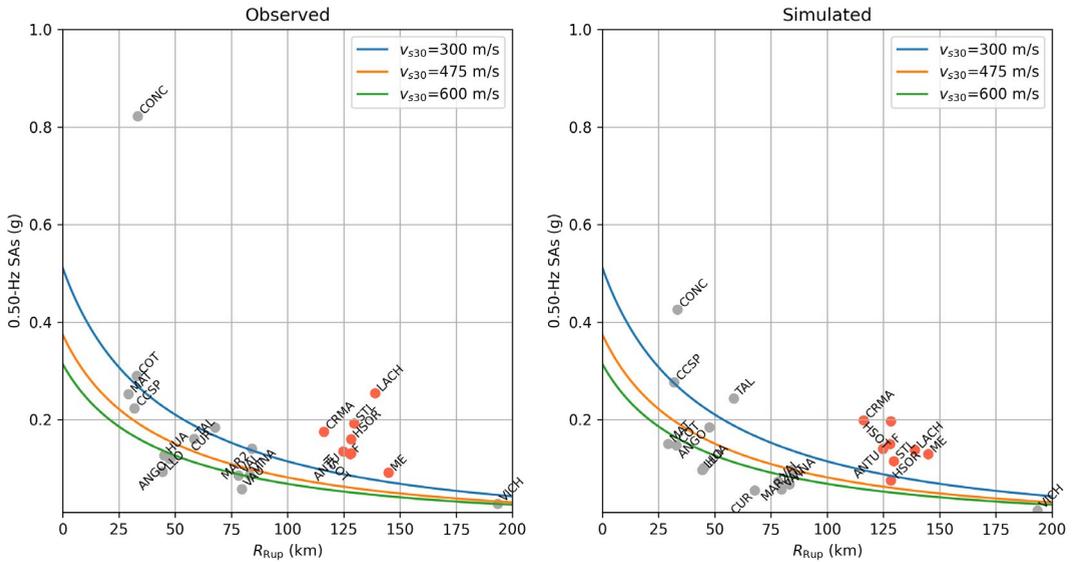


Figure 8. Comparison of spectral accelerations at a period of 2 seconds from a leading ground motion equation with three different values of V_{s30} (solid lines) to (left) observations and (right) the results of a 3D simulation of the 2010 Maule event. Red and gray circles depict values from stations in and around Santiago and along the coastal regions, respectively.



San Diego State University (SDSU) has been a member of the WTW Research Network since 2017. Prof. Kim Olsen and Dr. Daniel Roten at SDSU are among the primary developers of the Anelastic Wave Propagation (AWP) code used to generate physics-based ground motion predictions for future catastrophic earthquakes in regions with high exposure. The simulations are taking into account the three-dimensional structure of the sedimentary basins, the ocean water layer, realistic variation in the rupture pattern, and the amplification and nonlinear effects of the near-surface low-velocity layers.

An integrated end-to-end approach to time-dependent earthquake risk assessment

Conventional probabilistic seismic hazard and risk analysis only considers mainshock events and uses a time-independent earthquake rupture forecast to describe the occurrence of mainshocks for the majority of fault systems.

This approach neglects (1) long-term repeated occurrences of large earthquakes on specific fault segments; (2) the interaction of adjacent faults; (3) the short-term spatial and temporal clustering of aftershocks; and (4) the accumulation of damage to engineered assets from multiple sequential events.

The WTW Research Network and University College London (UCL), UK, are currently tackling these shortcomings, providing scientifically-proven and industry-oriented solutions for the (re)insurance and earthquake risk-modeling industries.

The proposed framework

A unified seismic hazard and risk modeling framework (**Figure 9**), currently under development by PhD candidate Salvatore Iacchetti, Dr. Gemma Cremen and Prof. Carmine Galasso at UCL, incorporates the latest scientific advancements in earthquake interaction, aftershock modeling, and time-dependent vulnerability assessment.

The hazard component of the framework facilitates the modeling of realistic earthquake ruptures that reflect the behavior of recent damaging events such as the 2016 Mw 6.5 Norcia (central Italy) or the 2016 Mw 7.8 Kaikōura (New Zealand) earthquakes. Long-term time-dependent behavior of earthquakes and interaction between adjacent faults

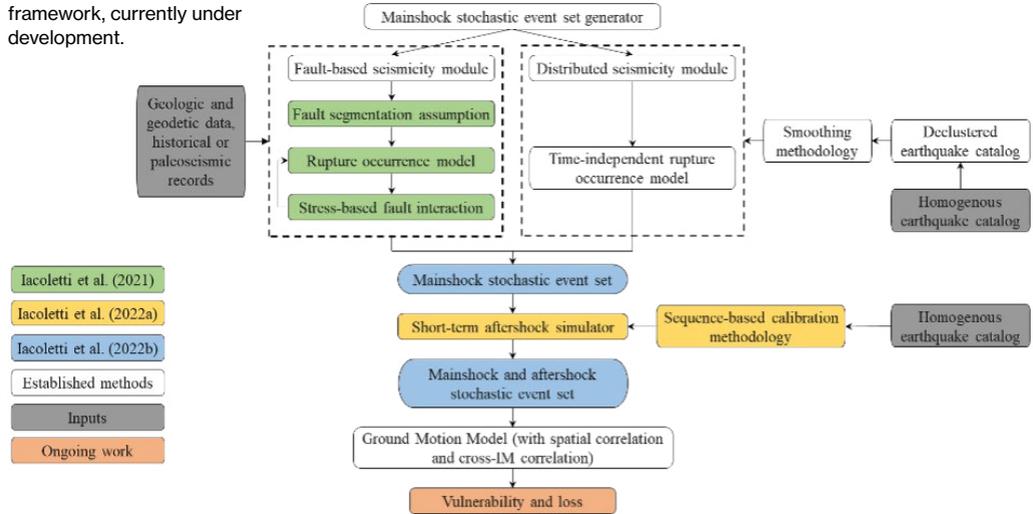
are built-in features of the hazard module, promising more accurate hazard and risk estimates. The proposed framework also includes a versatile and flexible methodology to incorporate aftershocks within the generated stochastic event set, which is often neglected in current practice. Case studies focusing on Wellington (New Zealand), the Nankai subduction zone (Japan), and central Italy (**Figure 10**) have been used to test the hazard module's capabilities, limitations, and sensitivities. UCL and WTW are leveraging the results of these analyzes to develop a comprehensive set of guidelines for advancing the simplified seismic-hazard approaches currently used in the (re)insurance industry.

Ongoing improvements

Aftershocks can be more damaging to engineered assets than the corresponding mainshock (e.g., 2010 Canterbury, New Zealand, sequence) due partly to the increased vulnerability resulting from physical damage accumulation during an earthquake sequence. For this reason, the proposed time-dependent risk module of the framework will build on state-dependent fragility relationships of structures subjected to ground-motion sequences (e.g., mainshock-aftershock or triggered earthquakes), to develop vector-valued vulnerability relationships that account for the damaging effect of two (or more) ground-motion records.

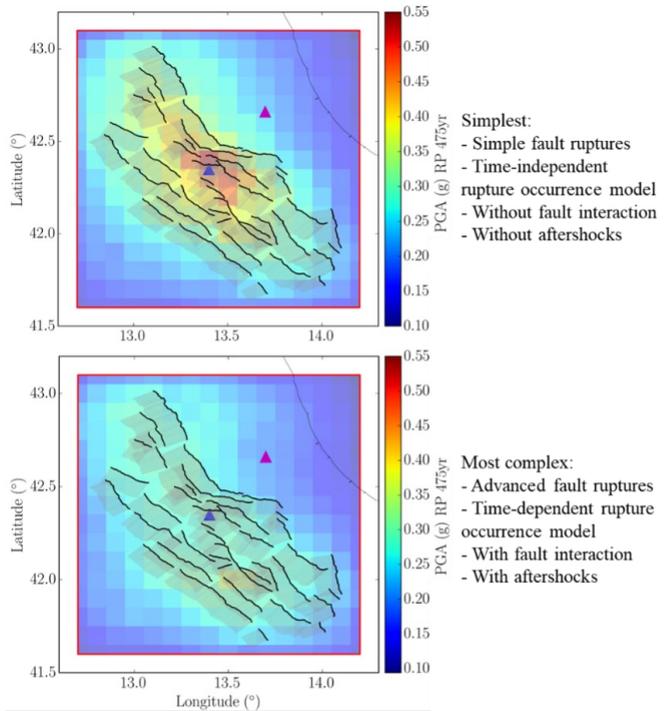
The unified framework results from continuous discussions and collaborations between UCL researchers and the WTW Research Network, who are committed to providing state-of-art solutions for clients in the (re)insurance and earthquake risk-modeling industries.

Figure 9. Schematic representation of the unified hazard and risk modeling framework, currently under development.



- Iacoletti et al. (2021)
- Iacoletti et al. (2022a)
- Iacoletti et al. (2022b)
- Established methods
- Inputs
- Ongoing work

Figure 10. Example hazard maps (for a 475yr return period, RP) for the Central Italy case study, incorporating modeling assumptions with varying degrees of complexity.



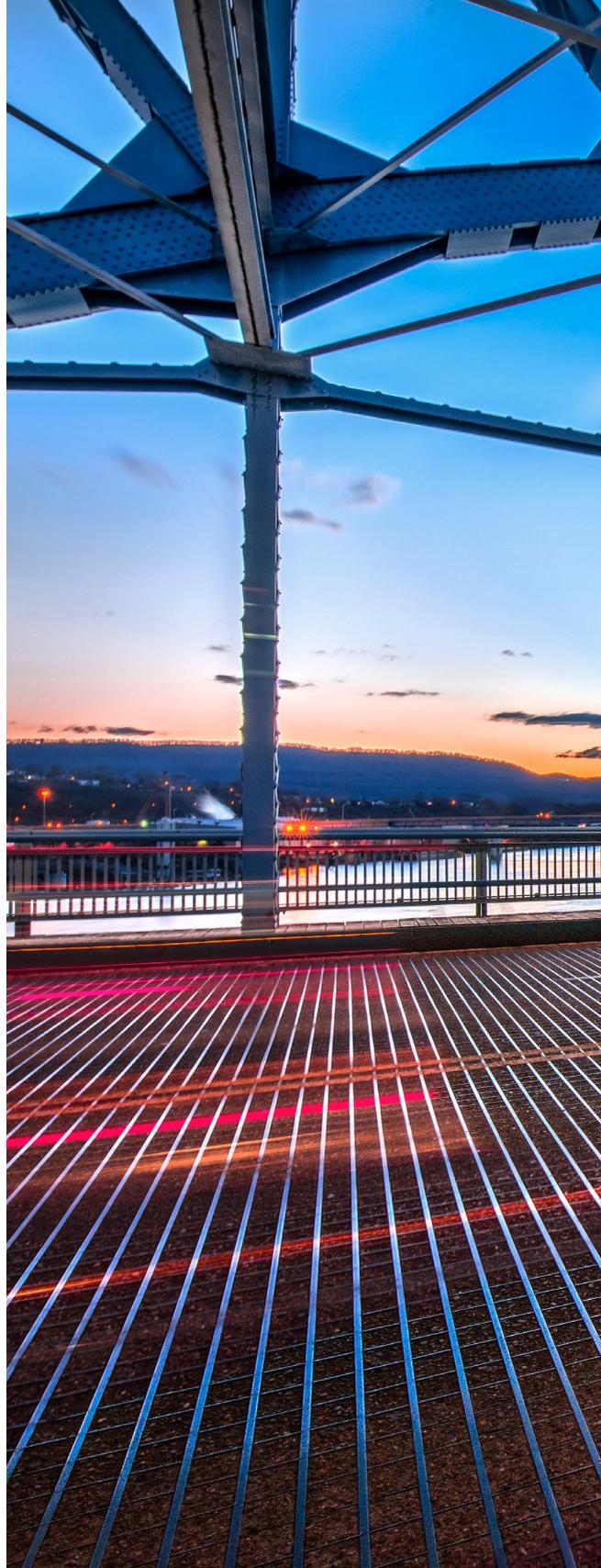


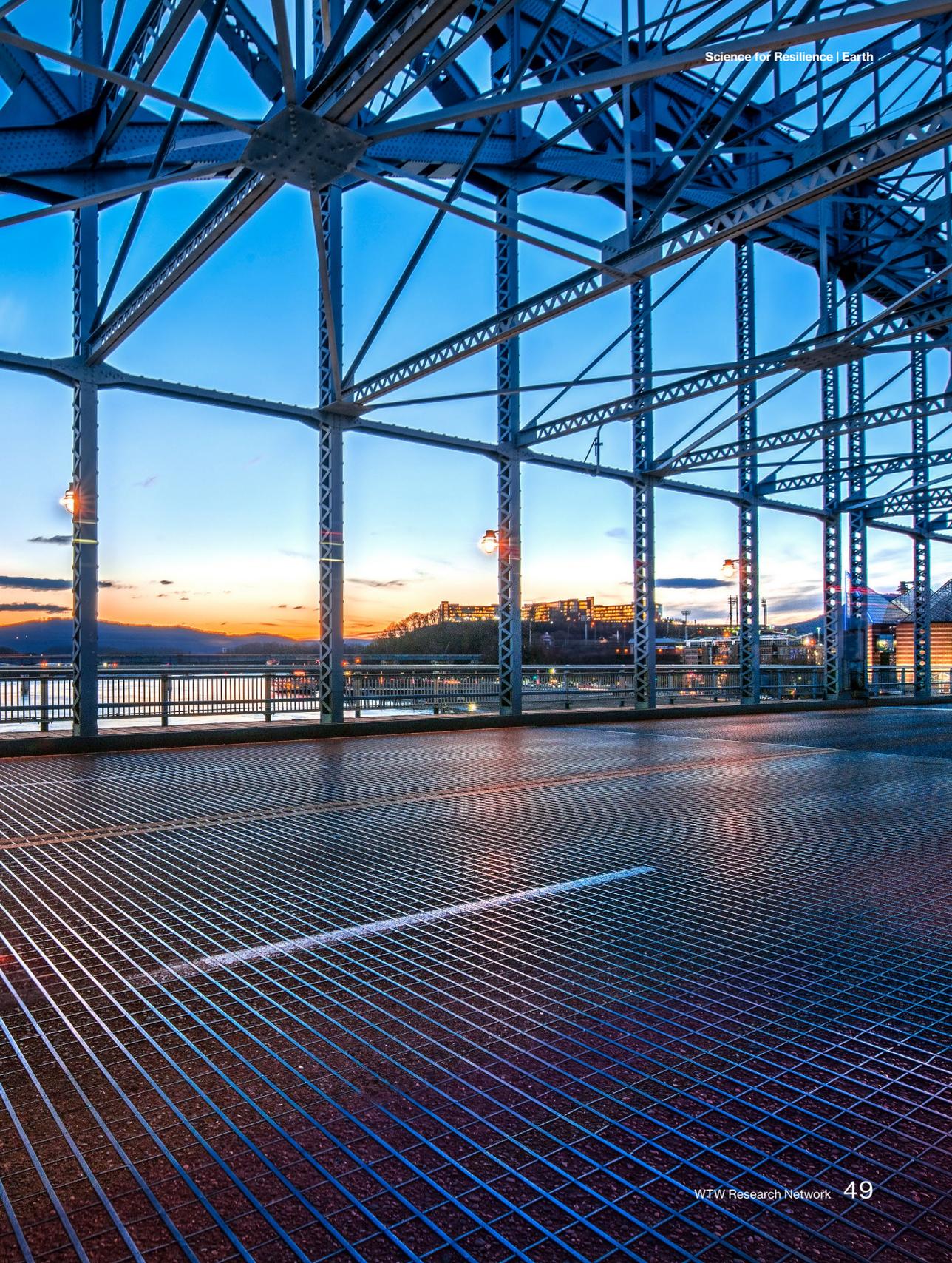
University College London

UCL Civil, Environmental and Geomatic Engineering (CEGE) is a multidisciplinary department renowned for excellence in research and teaching. It currently holds a substantial UK Research and Innovation (UKRI) research portfolio in civil engineering. Home to world-leading research projects, groups and centers, CEGE reflects a broad, enquiring and human-centered view of the engineering world. Strong links to industry and research are embedded throughout a diverse range of programs. These links are enhanced by CEGE's proximity to both significant infrastructure projects and leading firms, thanks to its central London location. Within CEGE, Prof Galasso's and Dr Cremen's research focuses on developing and applying probabilistic and statistical methods and tools for catastrophe risk modeling and disaster risk reduction. They investigate risks to building portfolios and infrastructure exposed to multiple natural hazards, including earthquakes, strong wind, and flooding, with special emphasis on developing countries.'

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Realtime risk: Forecasting next year's hazard in the cities that rim the Marmara Sea

In its work with the WTW Research Network, Temblor has developed **Realtime Risk**, which forecasts next year's hazard, or losses, based on how the stress imparted by recent large earthquakes causes the hazard to depart from its long-term average. Even though insurance policies are renewed annually, re/insurers have traditionally used only long-term ("time-independent"), or very slowly increasing ("time-dependent") hazard in their catastrophe modeling. But large aftershocks, progressive mainshocks, and seismic swarms all signal that slow or no change is not how the Earth works. Instead, earthquakes are in a kind of conversation governed by the transfer of stress. Coulomb stress increases promote aftershocks and the next large quakes, while Coulomb stress decreases inhibit earthquakes. Knowing where and how much the quake rate is likely to change next year helps insurers with risk selection and accumulation management, and helps the public contend with the earthquake threat.

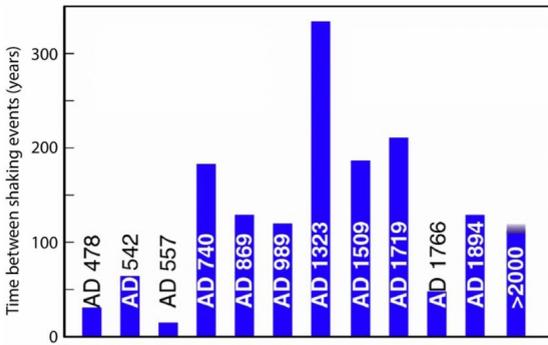
Perhaps the most spectacular illustration of this 'earthquake conversation' is the falling-domino sequence of large shocks spanning almost 1,000 km of Turkey's North Anatolian Fault in 1939-1999, each damaging shock promoted by its predecessor. The average recurrence rate of large quakes along the fault is about 200-300 years, but all twelve events struck in a span of just 60 years. This indicates that these are not independent events, which long-term earthquake rate fails to capture. The Izmit M 7.4 shock, at the eastern edge of the Marmara Sea, struck in 1999. On the basis of Coulomb stress transfer, Stein et al. (1997) identified the Izmit site,

and one other along the fault, as the most likely next to fail. A month after the Izmit earthquake, Barka (1999) calculated that the Izmit event had stressed two new sites toward failure. Two months later, one of those, at Düzce, ruptured in a M 7.1 shock.

So given the success and evident utility of using Coulomb stress transfer technology for risk analysis, what insights can Temblor offer for the Marmara today?

Graced by the ancient jewel of Istanbul, the Marmara is among a handful of regions worldwide with a record of damaging shocks long enough to ground any assessment of the average, long-term quake rate. Built in AD 537, Hagia Sophia was the largest domed building in the world – for 500 years. The record of damage and repairs of this architectural and engineering marvel render it a seismometer of antiquity. The rate of severe shaking events recorded over 1500 years is 0.008/yr (with an average time between severe shaking events of 125 years). But shaking from Marmara events far to the East, such as the 1999 M 7.4 Izmit quake, and far to the West, such as the 1912 M 7.4 Ganos (Sarkoy) event, were not as severe as those at Hagia Sophia. So, if one were to multiply the Istanbul rate by a factor of 2-3 to capture the entire Marmara Sea, one would reach a quake rate of about 0.02/yr. We can compare that rate to the record for the past 500 years, for which the distribution of shaking is rich enough to assign earthquake magnitudes and locations, and during which 10 $M \geq 7$ shocks struck (Parsons et al., 2000).

1500-year record of severe shaking at Hagia Sophia in Istanbul

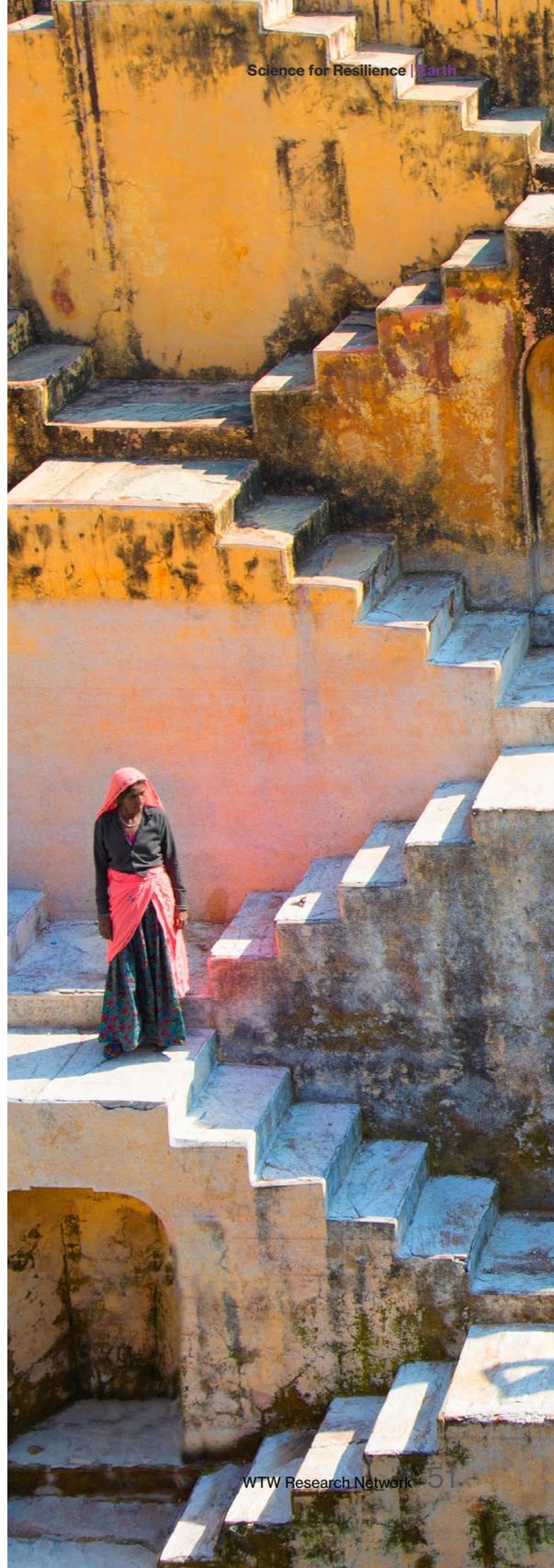


30-year Poisson probability of Istanbul shaking = $20 \pm 5\%$



Figure 11. Unmatched the world over, the record in Istanbul yields a severe shaking rate of 0.008/year. One of these events was the great 1509 M-7.6 earthquake, which breached and flooded the fortified city walls, and partially destroyed Hagia Sophia.

This, too, yields an average event rate of 0.02/year. Finally, when one sums the net slip from all the shocks in the past 500 years across the Marmara Fault (the local name for the North Anatolian Fault), the average slip rate is in close agreement with the rate measured by GPS receivers over the past 15 years. These three measures greatly strengthen our confidence in the 0.02/yr quake rate. Put another way, any viable model must have this long-term rate.

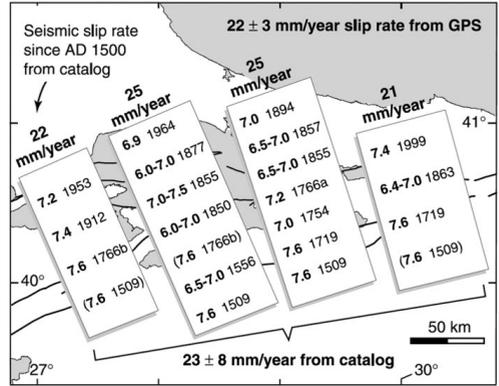


Some recently published hazard models for the region (Murru et al., 2016; Sesetyan et al., 2019) yield $M \geq 7$ quake rates of 0.08/yr, four times too high. Thus, in our judgment, these models are unsuitable and can be discounted. On the other hand, the rate of Chantier et al. (2021) is about right. Using the Global Earthquake Activity Rate model of Bird et al. (2015) the rate is 0.01/yr, about half what it should be, but a small enough difference that we chose to use it after correction.

For our analysis, we perturbed the long-term record by the stress transferred from the recent $M \geq 5$ shocks, whose effect fades with time, using Realtime Risk (Toda and Stein, 2020). We found that small to moderate quakes are most strongly influenced by stress transfer, whereas large quakes are more strongly governed by the long-term loading of the major faults. Nevertheless, because of the 1999 M 7.4 and Izmit and M 7.1 Düzce shocks, and the 2019 M 5.6 Marmara Sea shock, our forecast for small-to-moderate M5.0-5.9 earthquakes next year is significantly higher than its long-term average.

The strength of the Marmara model is its uniquely well-documented long-term quake rate. But other areas, such as California, Japan, and New Zealand, benefit from much better seismic networks even though their long-term rate is less well known. Earthquake rates in Japan, Chile and Mexico are vastly higher than the Marmara, which is also beneficial to modeling. Each region has its own unique strengths, and we have been able to utilize these and use Realtime Risk to forecast annual or multi-year hazard for all of these locations.

Figure 12. Here, the magnitude (bold) of the Marmara quakes have been converted to earthquake slip. The slip in each section across the Marmara is then summed and divided by 500 years to infer the slip rate, which comes to 23 ± 8 mm/yr, which is indistinguishable from that measured by GPS (22 ± 3 mm/yr). The figure is from Parsons et al. (2000).



Temblor, Inc.

Temblor is a Silicon Valley tech company providing personal, immediate, and credible sources of seismic risk solutions. Their free mobile and web app and daily blog have gained 900,000 users worldwide in under 16 months, and their enterprise projects for insurance and financial clients has given them an understanding of key unmet needs. Temblor's CEO Ross Stein, CTO Volkan Sevilgen, and collaborator Shinji Toda from IRIDeS of Tohoku University, are the world pioneers in Coulomb stress transfer.

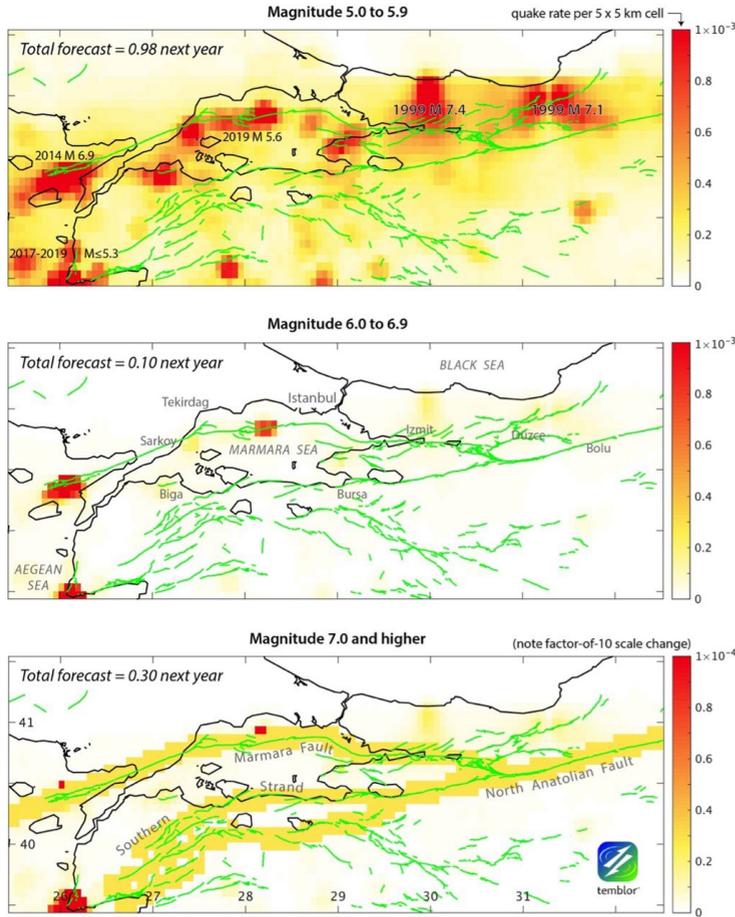


Figure 13. Temblor’s forecast, which uses the corrected Global Earthquake Activity Rate (GEAR) model for the average or long-term quake rates, modified by the stress imparted by recent earthquakes, whose impact fades with time. Small to moderate quakes are most influenced by the stress transfer (*upper panel*), whereas large quakes are most influenced by the major faults (*bottom panel*). Past quakes that transferred stress are shown in the *upper panel*, geographic features in the *center panel*, and fault names in the *lower panel*.

The 2011 Great East Japan Earthquake and Tsunami 10 years on

A WTW Research Network perspective

WTW Research Network partners reflect on how tsunami modeling techniques have been transformed to protect lives, livelihoods and assets.

On Friday 11th March 2011 a Magnitude 9.0 undersea megathrust earthquake triggered a tsunami off the Pacific coast of Tohoku (Japan) and started a cascading chain of events, including the Fukushima nuclear radiation disaster, which became the costliest natural disaster to date. It was the most powerful earthquake ever recorded in Japan and triggered a powerful tsunami wave that may have reached heights of up to 40.5 meters and which travelled at 700 km/h and up to 10 km inland. Residents of the Tohoku region including Sendai, the largest city in the area, had less than fifteen minutes of warning before more than a 100 evacuation sites were washed away. The tsunami swept the north-eastern mainland leading to US\$210 billion economic losses according to a [World Bank report](#) and almost 20,000 people losing their life, mainly through drowning.

The event also had an impact on the financial system, with estimates of insured losses from the earthquake alone between USD30 and USD39 billion as of 2018 (Source: Swiss Re Sigma Report and Munich Re NatCatService 2018), leading the Bank of Japan to intervene in an effort to normalize market conditions. It posed some fundamental questions to those affected: have we witnessed the

worst that could be? or Is the largest and most catastrophic earthquake-triggered tsunami yet to happen? And how ready and resilient are our interconnected societies to the consequences from these natural phenomena?

Since it was first created in 2006, the WTW Research Network has strived to ask thought-provoking questions in the understanding of extreme events, their impact on society and on the insurance industry and the wider financial system. For nearly 15 years the WTW Research Network has collaborated with academics at the forefront of science and pioneered research to challenge assumptions and existing models to ensure the future doesn't take us off guard. As a testament to this, in 2010, prior to the 2011 Tohoku disaster, the WTW Research Network, in collaboration with Gallagher Re, Tohoku University and UCL began a [research project](#) to build what would be known as one of the first tsunami catastrophe models in the industry, acknowledging the then lack of tsunami risk models to estimate the losses from this so-called "secondary" peril.

Tohoku University, world leaders in the study and modeling of tsunami hazard, led by Prof Imamura and his team, developed a physics-based numerical model to feed the shake hazard module. The UCL EPICentre, a world leader in the study of tsunami vulnerability, led by Prof Tiziana Rossetto, developed the vulnerability module, and Gallagher Re built a complete tsunami risk model with added financial component. To this date, the WTW Research Network continues to work with

these institutions to further our knowledge of secondary perils, widening the collaboration to account for newer areas of research, such as Coulomb stress transfer and aftershock modeling with Dr Ross S. Stein, at Temblor, Inc., and Prof Shinji Toda, from IRIDeS at Tohoku University, and 3D modeling of earthquake wave propagation with Prof Kim Olsen and Dr Daniel Roten from San Diego State University.

In this article we show the WTW Research Network learning curve on earthquake and tsunami risk over the past 10 years as a leading example of the great progress that applied research collaborations have brought to the (re)insurance and disaster risk management sectors.

Bridging the gap between science and industry

Catastrophic tsunami losses have traditionally not been able to be well quantified by the insurance market. Tsunamis and other less-modeled components of earthquakes (such as fire following earthquake and landslides) have all emphasized the need to understand and quantify the risks from such so-called secondary perils (“sub-perils”).



The WTW Research Network and Gallagher Re co-developed a tsunami model that enables our clients to quantify and manage the risks from these extreme events using our natural catastrophe modeling expertise and insurance market knowledge.

The WTW Research Network and Gallagher Re co-developed a tsunami model that enables our clients to quantify and manage the risks from these extreme events using our natural catastrophe modeling expertise and insurance market knowledge. In particular, the Gallagher Re Japan Tsunami Model is a probabilistic and deterministic model of the country, that quantifies tsunami losses from a catalogue of tsunamigenic earthquake sources. It can also combine the shaking damage output from a third party vendor model with tsunami losses allowing for a more complete view of risk, and use custom vulnerability functions developed in conjunction with WTW Research Network partner UCL EPICentre, and an in-house expert view of exposure data unique to Gallagher Re, to integrate into a catastrophe modeling platform.

The model uniquely quantifies client risk from catastrophic tsunamis affecting Japan, and provides inputs to the Gallagher Re financial analysis. It significantly contributes to discussions on natural catastrophe risk with reinsurers and rating agencies with Gallagher Re expertise.

As science evolves, the WTW Research Network has strengthened its earthquake and tsunami-related research program to understand external agents that might play a fundamental role in triggering these events: e.g. looking at seismic event rates post-Tohoku, incorporating static (Coulomb) stress. By pushing research boundaries, we help anticipate the previously unforeseeable. In the following sections, we present some of these initiatives that continue to inform the Gallagher Re View of Risk, in collaboration with the research groups we have the privilege to count among our WTW Research Network members.

Understanding and Modeling Tsunami Hazard: A Tohoku University collaboration

In the 21st century, damaging tsunamis have happened more frequently in the world, not because of an increasing frequency, but largely driven by increased coastal exposure. To improve our understanding of this secondary peril the WTW Research Network began a collaboration with Tohoku University's International Research Institute of Disaster Science (IRIDeS), world leaders in the area of tsunami numerical simulation techniques and led by Professor Fumihiko Imamura. The aim was to develop a new research method for the global tsunami risk assessment considering the characteristic of regions and probability of occurrence. Under this collaborative research, the tsunami hazard was to be modeled using tsunami sources and performing numerical simulations based on historical tsunami databases. By the time the 2011 tsunami happened, the WTW Research Network had already been working on this research topic for some time.

During the 2011 Tohoku event, a maximum tsunami runup height of about 40m was observed on the Sanriku coast of Iwate Prefecture. Since then, scientists have been attempting to reproduce the 2011 Tohoku tsunami to understand such large tsunami generation mechanism. There are two possible reasons for this "silent tsunami": 1) a tsunami earthquake, a slow earthquake with shallow depth which makes less ground shaking but generates a large tsunami and 2) a submarine landslide tsunami, as in the 2011 event. In fact, a tsunami earthquake occurred in the same area in 1896 and resulted in more than 20,000 deaths mostly from the unexpectedly large tsunami rather than from the limited ground shaking. It is also possible that a large submarine landslide could have occurred together with the earthquake so that the observed tsunami exceeded the seismic energy.



The IRIDeS is able to generate mechanisms of such silent tsunamis by numerical simulation, demonstrating the underrated risk of "silent tsunamis".

The IRIDeS is able to generate mechanisms of such silent tsunamis by numerical simulation, demonstrating the underrated risk of "silent tsunamis" (**Figure 14**). "Silent tsunamis" are still very difficult to predict using the current technology but real-time observations of deep sea could help improve the accuracy of tsunami warning. Such tsunamis are not well considered in the insurance industry and the inclusion of such events may be necessary for a portfolio stress-test.

Assessment of the tsunami mitigation effect of coastal defense structures

As we reflect on the 10th anniversary of the 2011 Tohoku event, the IRIDeS research focus continues on the assessment of tsunami countermeasures in Japan. Based on lessons from the 2011 event, tsunami numerical simulations were applied to assess the performance of multi-layered infrastructure as a structural tsunami countermeasure in Sendai and support the reconstruction decision making process. There are five components of the multi-layered infrastructure: the existing seawall, the reconstructed seawall, the greenbelt area (park and coastal forest), the elevated road, and the existing highway. The performance of multi-layered structures for tsunami mitigation was evaluated by inundation area and maximum flow depth.

Figure 15 shows an example of the simulation results in Sendai. The simulations show that

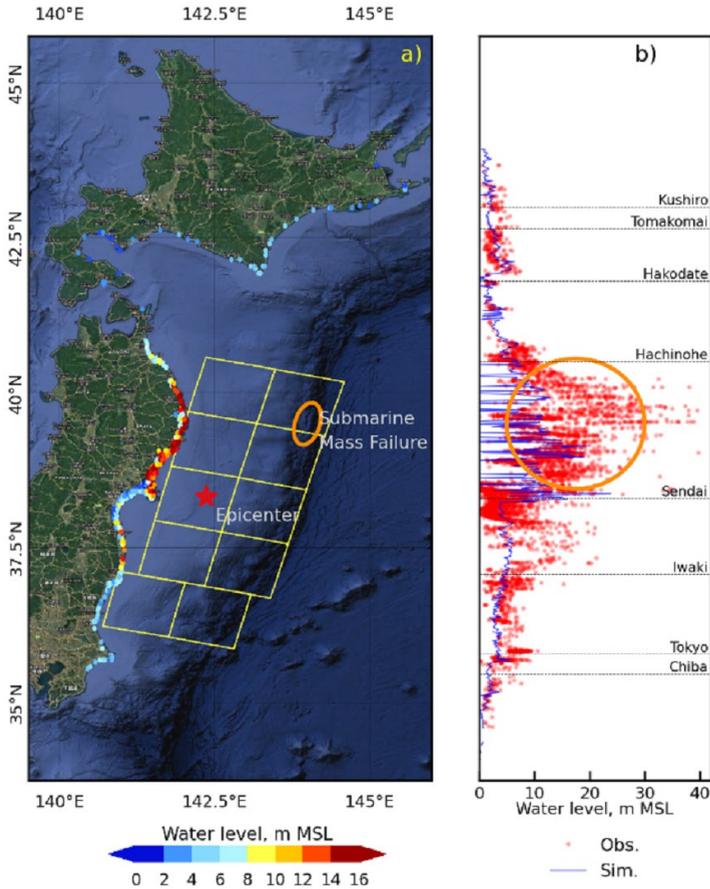


Figure 14. Left, yellow blocks are earthquake rupture areas. Orange circle is the suspected submarine landslide area. Right, orange circle is the same location showing that the simulated tsunami (from seismic source, blue line) is lower than the observation (red points)..

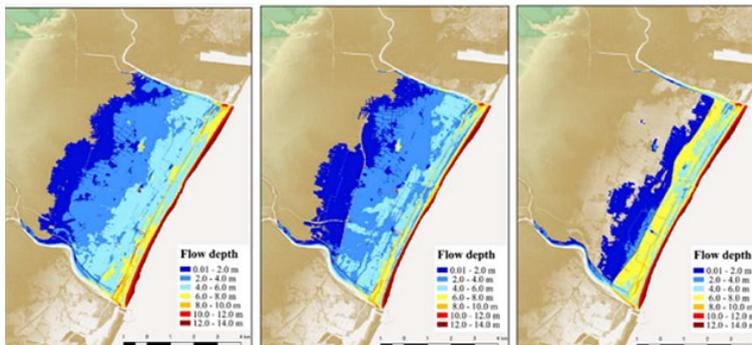


Figure 15. Simulated inundation area and maximum flow depth for each scenario. Left: without any infrastructure, Middle: reproduction of the 2011 tsunami, Right: the present completed infrastructures.

with the present infrastructure, the tsunami affected area in Sendai by the 2011 Tohoku event could have been reduced by 68%. The large buffer areas in yellow shown along the coast are due a new elevated road built by Sendai City which withholds tsunami water to the east. To the west of the road, they are designed to limit the inundation depth to below 2m.

IRIDeS has since expanded their research to the rest of Japan to assess the potential impact of such infrastructure on future tsunami events; with countermeasures in place, a far-future assessment incorporated a view of climate change through sea level rise (SLR), derived from the RCP 8.5 scenario of the IPCC report. The new SLR scenario demonstrated that for Sendai-City, if the countermeasures reduced the impacted inundation area by approximately 80% compared to the actual event, then with an additional SLR component, the impacted area was still reduced by approximately 63%. Whilst SLR will provide an increase to the area where buildings take damage from a tsunami, the new countermeasure can still prove to be effective mitigation.

A global assessment of tsunami hazards over the last 400 years

World Tsunami Awareness Day was designated by the United Nations General Assembly in 2015, calling all counties, international bodies and civil society t

o raise tsunami awareness and share innovative approaches to risk reduction. To commemorate, IRIDeS contributed to a report featuring a global tsunami hazard assessment based on a 400-year database. Numerical models for tsunami propagation were created based on more than 100 earthquakes from around the world. Information going back to 1600 AD show that tsunamis have occurred all over the world, not just along the Pacific Rim, as shown in **Figure 16**. The most damaging ones were documented between 1970-2016 in the Indian Ocean and East Japan regions. However, poor documentation from 1600-1969 AD might leave other areas of high tsunami risk exposed if not properly studied. This assessment aims to draw attention to these areas and highlight that just because we have not witnessed it in recent times it does not mean it cannot happen.

Quantifying tsunami and earthquake vulnerability: A UCL EPICentre collaboration

UCL EPICentre have been members of the WTW Research Network since 2006. They are a multidisciplinary research group that investigates risk to society and infrastructure from earthquakes and other natural hazards. Our collaboration with them looks at developing a novel, robust, unified framework for assessing the vulnerability of critical urban infrastructure to the combined effects

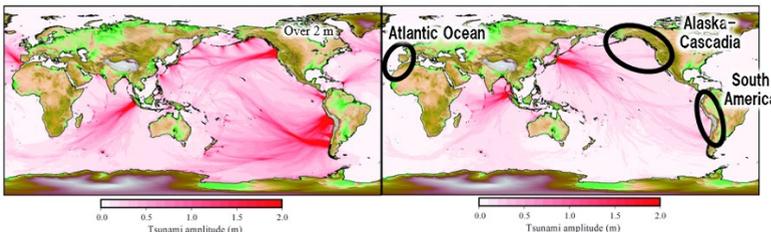


Figure 16. Simulation of historical tsunamis, Left: 1600-1969 AD, Right: 1970-2016 AD.

of earthquake ground shaking, tsunamis and induced soil liquefaction. The research is not only looking at these cascading hazards but is also taking into account the effect of infrastructure interdependence across various systems and how this affects the infrastructure's ability to provide its services. To estimate tsunami risk, we need reliable tools for assessing the damage to coastal structures from tsunami inundation. To this extent, the EPICentre, under the leadership of Professor Tiziana Rossetto, has been conducting physical experiments, field work and numerical analyzes to understand how tsunami flows interact with buildings, towards their fragility assessment. Inspired by the Tohoku event, it has also investigated the cumulative effect of earthquake ground shaking and tsunami.



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A new analysis method for assessing buildings under tsunami loading

UCL EPICentre developed a new advanced structural analysis procedure, called the Variable Depth Push Over (VDPO), first used in 2017 to evaluate the response of a tsunami evacuation building in Japan. The VDPO analysis showed that although the building was seismically designed, it was still vulnerable to the failure of its ground story from tsunami. Simply enhancing seismic

design does not provide tsunami resistance, as tsunami induce significantly different failure mechanisms in structures. Building response to tsunami is almost binary, i.e. the structure either survives structurally intact, or collapses, with only very few cases of intermediate damage seen. This is explained by the long duration of the tsunami loading, not previously appropriately accounted for.

The VDPO approach has since been extended and has been used in the assessment of buildings in Chile, USA, Sri Lanka and Indonesia. It is also being referred to as an accepted structural analysis approach in the next revision of the ASCE7 Standard for Tsunami that will be published in 2022.

Buildings Under Sequential Earthquakes and Tsunami

Earthquake ground shaking often precedes tsunami inundation, yet after a tsunami it is not possible to distinguish how much damage is from the earthquake and how much from the tsunami. A number of papers were published jointly with the WTW Research Network where buildings were assessed under sequential earthquakes and tsunami, with fragility surfaces being derived for the two hazards. Contrary to general perception, the research consistently found that the preceding earthquake ground motion only slightly influenced the tsunami resistance of the building. This is due to the fundamentally different response of the structure to the two perils. These studies showed that fragility of buildings can be approximated by assessing the earthquake and tsunami response separately, with the worst damage occurring from the two hazards dominating the final damage state.

Accounting for aftershock impact and Coulomb stress through Temblor, Inc collaborations

The 2011 Tohoku earthquake was a cruel reminder of the seismic risk Japan faces. The subduction of the Pacific Plate beneath northern Honshu along the Japan Trench – which slipped up to 80 m in about 120 seconds during the M9.0 shock – and the subduction of the Philippine Sea Plate beneath southern Honshu along the Nankai Trough, are the principal drivers of its outsized earthquake hazard (**Figure 17**). But Japan also has its own San Andreas-like ‘transform’ fault, the Median Tectonic Line, that extends from southern Honshu through Kyushu, and ruptured in the 1995 M6.9 Kobe shock at its northern end, and the 2016 M7.0 Kumamoto shock at its southern end. A series of blind thrust faults also underly the Japan Sea coastline.

The WTW Research Network has been collaborating with Dr Ross S. Stein, at Temblor, Inc., and Prof Shinji Toda, from IRIDeS at Tohoku University for a number of years to further our understanding of earthquake risk and how it varies in time and space due to static (Coulomb) stress transfer.

In early 2020, the Temblor team identified a mild swarm of $M \geq 5$ shocks ranging from the Greater Tokyo area, and extending up the Tohoku coastline. With the prior Tohoku and Kumamoto shocks, along with this newly observed mild swarm, they built new forecasts which are used to inform their view of risk.

On 13th February 2021, a M7.2 struck offshore Fukushima at a depth of 50 km. Why did it strike and what does it foretell? According to Dr. Stein and Prof Toda, The M7.2 shock is an aftershock of the M9.0 Tohoku mainshock, which testifies to the huge lasting impact of the 2011 shock. It also struck in areas they previously forecasted as having a very high chance of $M \geq 7$ shocks. This shock has further transferred stress closer to the Japanese mainland and away from the M9.0 rupture; Temblor used this new information to update their models.

However large, one earthquake cannot prove or disprove a forecast. So, can we understand the broader pattern of seismicity of central Japan, and how it has changed since the M9.0 earthquake struck?

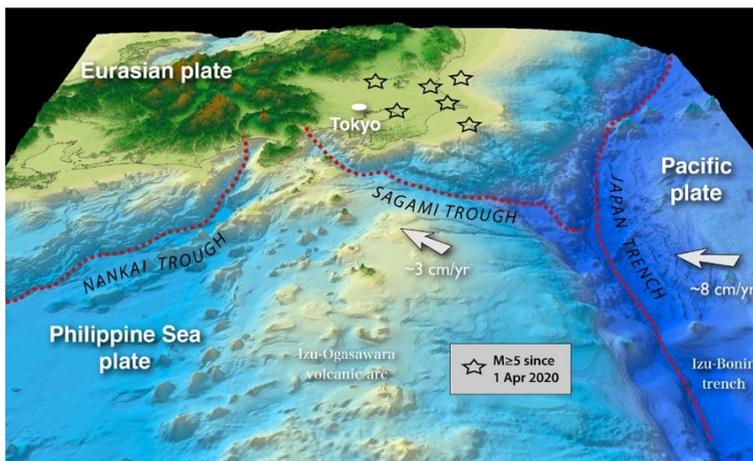
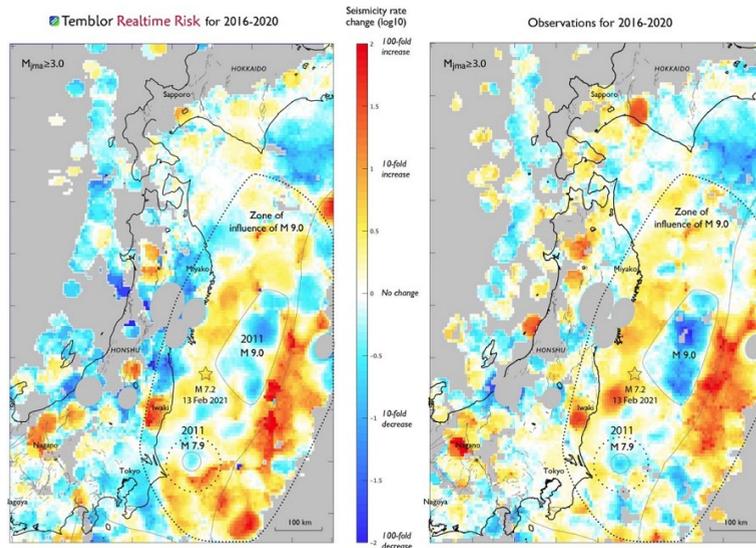


Figure 17. Greater Tokyo's 38 million residents live near a plate tectonic 'triple junction' (the intersection of the dashed red lines) where three plates meet, and so is subject to large earthquakes from the east along the Japan Trench, (as struck in 2011, taking 22,000 lives), and large earthquakes from the south along the Sagami Trough, (as struck in 1923, taking 90,000 lives).



Background Period (10 yr before M 9): 1/1/2000 - 3/10/2011 Learning Period (5 yr after M 9): All $M_{max} \geq 6.5$ from 3/11/2011 - 3/11/2016 Forecast Period (past 5 yr): 3/11/2016 - 8/31/2020

Figure 18. Toda and Stein compare the seismicity in the decade before the M9.0 Tohoku quake to the past 5 years; red indicates areas where the seismicity rate increased, blue where it decreased. The *left panel* is Temblor's retrospective **forecast** for the past 5 years; the *right panel* is the **observed** seismicity rate change during that same period. The forecast is well aligned with the observations, indicative of the robustness of their forecasting method.

Two features stand out in **Figure 18**. The site of the high slip in the M9.0 earthquake has a profoundly reduced seismicity rate today (blue) because stress there was relieved by the earthquake. But there is a massive surrounding zone into which stress was transferred (the 'Zone of influence'), about ten times larger than the zone of decrease. This zone has a much higher seismicity rate (yellow-red) than it did before the M9.0 Tohoku earthquake struck. A similar but smaller effect is seen for the M7.9 aftershock, which struck 30 minutes after the 2011 M9.0. That's because a M9.0 earthquake releases 40 times the energy of a M7.9.

So, the impact of the M9.0 Tohoku earthquake is huge and long-lasting. That means that to forecast earthquake hazard – and associated damage and loss – it is important to consider stress transfer in our view of Risk.

Use of 3D ground motion simulation to reduce the uncertainty in loss estimates, with the collaboration of San Diego State University

Tokyo is home to more than 13 million people within an area characterized by high seismic risk and exposure for the insurance industry. This high seismic hazard originates from the complicated tectonic relation and relative movements between the Pacific Plate, Philippine Sea Plate, and the continental North American plate in the triple junction setting near Tokyo (see **Figure 19**). The Japanese Earthquake Research Committee estimated a 70% probability of a M7 class event over the next 30 years, and ~11,000 fatalities and US\$1 trillion in damage in case of a M7 class earthquake scenario. It is therefore critical for societal resilience and financial stability that premiums accurately reflect expected losses in a catastrophic event

near Tokyo, exemplified by the 2011 Tohoku earthquake. But, the difficulty of quantifying the tail risk from these extreme events often pose Reinsurance, Capital and Regulatory challenges. Industry probable maximum loss (PML) estimates can sometimes be as different as \$30bn to \$300bn as in the Pacific North-West / British Columbia. When this is the case, which to trust?

simulation of 3D wave propagation to more accurately predict ground motions, whenever the earth structure and material parameters are reasonably well constrained. However, while 3D earthquake simulations have been facilitated by the emergence of supercomputers, the computational cost of the numerical approach is considerable as the resolution of the 3D models increases.

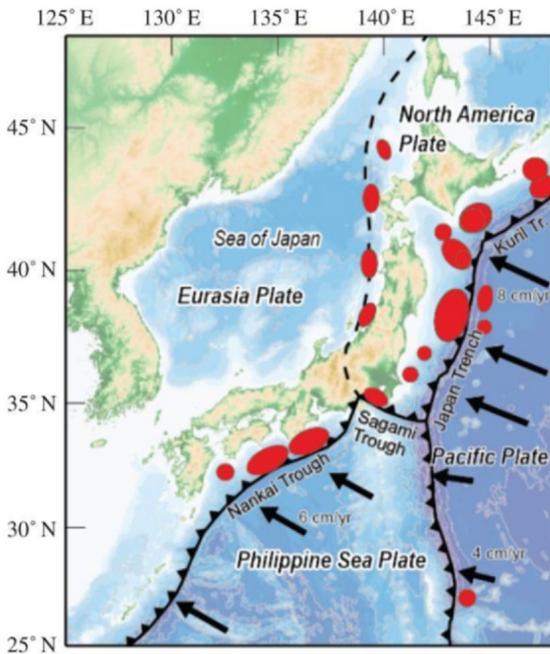


Figure 19. Plates around Japan with their convergence rates based on the REVEL model and source regions of large ($M \geq 7.5$) earthquakes since 1923 according to the JMA catalogue. From Satake (2015).

One way to reduce earthquake tail risk uncertainty is to complement traditional models with sophisticated techniques to model ground motion. Three-dimensional (3D) ground motion simulation techniques have been widely used in academia since the early 90s to assess the ground shaking resulting from an earthquake scenario. Since this early breakthrough, many studies have shown the power of numerical

The WTW Research Network has been collaborating since 2017 with Prof Kim Olsen and Dr Daniel Roten, from San Diego State University, USA, who are pioneers of this methodology since the early '90s (See Olsen et al, 1995), looking at implementing this ground-breaking research in the (re)insurance industry. To date, such advanced ground motion simulation techniques have been used in a loss framework, with a specific focus on M9 megathrust scenarios in the Cascadia Subduction Zone, Pacific Northwest, USA (**Figure 20**). These results have been presented at the WTW Research Network Seismic Seminar in 2019, where we discussed how such next generation modeling can influence loss volatility and better inform decision making.

The refined seismic footprints and resulting updated financial exposure based on the 3D simulations have already been used to inform our view of risk for the Pacific Northwest, with Chile and Peru to follow next. Considering its substantial seismic hazard and risk, the Tokyo prefecture presents itself as an additional location where 3D modeling may lead to refined estimates of financial exposure for the insurance industry. In addition, the 3D models have the potential to provide important refinements to the sea bottom displacements in a submarine megathrust scenario earthquake, potentially leading to more accurate estimates of financial losses due to tsunamis and fatalities if incorporated into separate tsunami models. Such efforts are currently underway for the west coast of Latin America between WTW Research Network, UCL, Tohoku University and SDSU.

Closing Remarks: “The whole is greater than the sum of the parts”

Helping society better prepare for and cope with the aftermath of catastrophic events such as the 2011 event is one of the aims of the WTW Research Network. These efforts go beyond natural disasters, accounting for People, Technological and Emerging Risks. Just because it has not been observed historically it does not mean it cannot happen in the future, and the current COVID-19 pandemic is testament of the need to continuously push the boundaries of our understanding of risk, to try and be one step ahead of the unforeseeable. To this extent, acknowledging the interconnectivity of catastrophic events and its global knock-on economic impact, our next generation of leading research aims to combine individual expertise from WTW Research Network members into wider, more complete collaborations, to gain deeper understanding of the risks we face. The synergy among research groups will bring us closer to understanding low probability and high consequence events, and help our clients in their endeavor to close the protection gap and create a world more resilient to catastrophes. The WTW Research Network continues its mission to support a realistic, well informed, updated, forward-looking view of risk.

With sea levels rising due to climate change, coastal communities will be facing an increasing tsunami risk, on top of greater chances of flooding during high tides and gradual loss of land. As exposure and populations in coastal areas are also increasing, the knock-on effect of this slow, chronic, irreversible change in natural capital, especially for island communities, calls for adaptation strategies and raised attention to tsunami research and related hazards. As part of the WTW Research Network we run several programs on climate related resilience initiatives. This article shows a small part of these.

Acknowledgements

This article was possible thanks to the kind contributions from Prof Tiziana Rossetto, Prof Kim Olsen, Dr Rosa Sobradelo, Dr Ross Stein, Prof Shinji Toda, Dr. Pakoksung Kwanchai, Prof Anawat Suppasri, and Prof Fumihiko Imamura.

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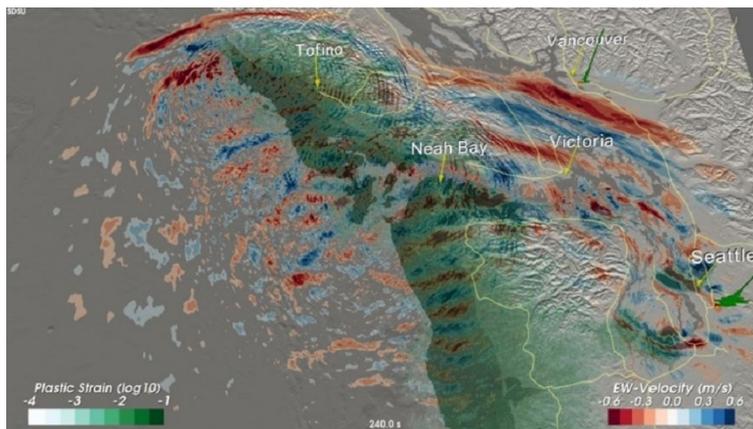


Figure 20. Snapshot of wave propagation (red-blue colors) for a M9.0 scenario megathrust earthquake as a result of the WTW Research Network-SDSU collaboration. Green colors depict nonlinear/plastic strain.



Special Feature: Risk in the Aviation Sector

Bracing for transition to a net zero and more resilient aviation sector

Towards Zero Carbon Aviation

With regards to climate change, the aviation sector is facing pressures from regulators, consumers, environmental activities, and the UN's International Civil Aviation Organization (ICAO). Its contribution to global emissions is less than often expected (2.4% in 2018), although this doesn't capture other global warming factors such as contrails.

A key challenge is that it is particularly hard to decarbonize this sector, and to do so quickly. Although there is progress with bio-fuels, aircraft redesign and fleet overhaul, there is a risk that these changes will come too late to meet the CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) aims.

Professor Ian Poll (Cranfield University) highlights the potential for operational efficiencies to save up to 30% of fuel, through a mix of measures, which would require increased collaboration within the sector: increasing the load factor for passengers and cargo; better route planning (e.g., avoiding the use of long-range aircrafts for short haul destinations) and optimizing air traffic management to reduce stacking before landing.

A science-based approach is needed to consider how the whole aviation system (aircraft manufacturers, airlines, airports...), can transition to a lower carbon footprint. The WTW Research Network is therefore supporting the Air Transportation Systems Laboratory at UCL, where Professor Andreas Schäfer and his team are using a world leading model of the aviation ecosystem (Aviation Integrated Model,

AIM) to support decisions leading to an orderly transition to less carbon-intensive technology and strategies.

Whereas simple arithmetic implies that a net zero-carbon aviation system can only be achieved through disruptive aircraft technologies and fuels, its most cost-effective composition remains unclear. Such knowledge is critical as vast investments will be required by aircraft manufacturers, fuel suppliers, airlines and airports to accomplish the transition. In addition, transitioning towards a net zero-carbon aviation system requires understanding the underlying technology roadmap, complemented by enabling policy measures and identification of early adopters. At the same time, the multiple time lags in the aviation system, from developing an early concept to fleet adoption of the final product, in addition to the long lifetime of commercial aircraft in the order of 25 years, demand swift action to generate a significant impact by mid-century. This, in turn, requires that all CO₂ mitigation options are considered, including travel demand management, which necessitates an improved understanding of travel behavior.

Over the next 3 years, the TOZCA project will develop a comprehensive tool suite to simulate the most cost-effective transition toward a net zero-carbon aviation system by 2050 and a later 2070 date. Using this tool suite, we should be able to identify the technological, economic and environmental synergies and trade-offs that result from drastic CO₂ emissions reductions through changes in technology, fuels, operations, use of competing modes and change in consumer behavior.

State-of-the-art volcanic ash cloud modeling for air traffic management

A year after the unprecedented travel disruption caused by the 2010 Icelandic eruption, EUROCONTROL, the intergovernmental organization for air-traffic management, released EVITA, a visualization tool for the volcanic-ash advisories.

Unfortunately this tool remains basic, not intended to provide operational support to an airline during a volcanic eruption, nor is it a reliable tool for designing risk-transfer financial instruments, due to its low spatial resolution, no-impact analysis, lack of validation and uncertainty quantification.

To fill this gap, WTW Research Network has partnered with Migita Solutions, an offshoot of the Barcelona Supercomputing Center (BSC), a leading institution for the development of computer applications for science and engineering, and leaders in modeling dispersal of small particles in the atmosphere.

With more than 1,500 potentially active volcanoes globally, and an average about 10 - 20 volcanoes erupting (on land) at any given time, volcanic ash in the atmosphere remains a serious threat to global aviation.

Volcanic ash particles can be transported over large distances by wind before settling on the ground. In addition to volcanic ash, sandstorms and mineral dust are also key hazards for airlines, which affect flight safety, aircraft routes, infrastructure and engine lifetime.

Mitiga Solutions has developed models and online platforms to help aviation stakeholders reduce the impact of volcanic ash, mineral dust, sea salt and other atmospheric hazards. They combine global high-resolution weather data, flight plan configuration and routes, and engine dose to aerosol contaminant intake, with impact calculator engine tools, for safer and more efficient air traffic and asset management.

These analytical tools can be used at each stage of an aircraft's operation and in ongoing emergencies, prior to an event for early warning and for efficient management during an emergency. These modeling capabilities can also be used to test and enhance preparedness. Such advances in modeling are expected to help airlines and associated organizations to mitigate their exposure, re-route planes, minimize delays and cancellations.

Unlike traditional reports provided by the Volcanic Ash Advisory Centers (VAACs) offering the aerospace community static, 2-D information at six-hour intervals, MITIGA's modeling offers a 3-D view of the present disruption at specific altitudes and is updated as information becomes available. This collaboration gives WTW the opportunity to bring airlines, airports and associated organizations in both the public and private sectors closer to state-of-the-art tools, which predict and mitigate the impact of natural hazards to air traffic management and aviation operations.

The WTW Research Network is also the sole industrial partner of MITIGA for VOLARISK. This European project aims to provide a global, high-resolution probabilistic view of the volcanic ash risk that may affect the aviation industry. Based on an assessment of volcanic risk for assets, such as flight trajectories, aircraft engines, airports, VOLARISK aims to offer index-based structuring products (parametric insurance), that would transfer the volcanic risk from the aviation industry to risk-takers.

Global airport threat analysis and risk indexing

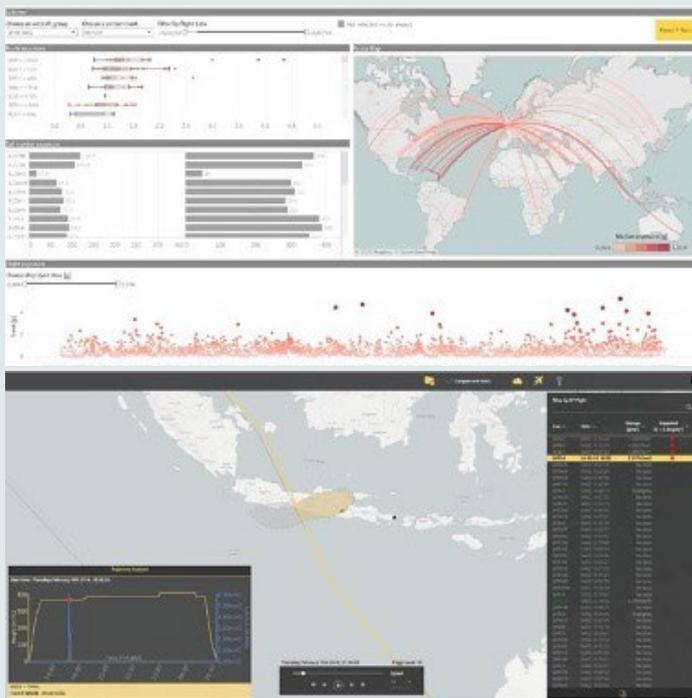
Airports face a unique set of challenges in their central role in keeping customers safe, airlines operating and trade moving. Many large organizations depend on these hubs for their business, transporting their products for international sale, obtaining supplies of goods in complex and time-dependent supply chains, and moving staff and personnel around the world to facilitate their business activities. Managing the airport risk landscape effectively requires a holistic view of the risk landscape and the collective expertise of the sector to help drive resilience.

Our Airport Risk Community (ARC) has been working with the Centre for Risk Studies at the University of Cambridge Judge Business School, long term WTW Research Network partners and world leaders in developing frameworks

for recognizing, assessing and managing the impacts of systemic threats, to develop an annual index of possible disruptors for over 110 international airports, covering current trends and emerging threats that they face.

This study takes a focused look at the range of disruptive threats that airports face as a result of global trends – geopolitical, technology, environmental, social and governance – and how prepared they are to responding. The research has explored a selection of airports (with a spread over passenger traffic, cargo, and geography) and the potential impacts from severe disruptor threats over the next 3 to 5 years.

This is particularly opportune, with airports now looking to recover from the impacts of COVID-19, the Airport Risk Index could be utilized for benchmarking and improved understanding of key risk drivers and vulnerabilities, together with supporting informed decision-making



VIEWS is a tool for operational planning, integrating volcano/fire ash/dust storm forecasts updated every 15min with real time data from the VAACs, airlines and engine Original Equipment Manufacturers.

eDOSE is an engine dose exposure assessment tool, used for safety and maintenance planning. Predictions on the impact of airborne contaminants in real time and from historic data, allows predictive maintenance analysis and optimized time-on-wing.

about building resilience to facilitate business growth. The Index will also help assess the vulnerability of organizations relying on their airports as a route for access (or for their supply chains). We look forward to sharing more insights with clients in 2022.

“We are pleased that our Airport Risk Community is bringing industry stakeholders together in a spirit of collaboration, sharing knowledge, insights and developing solutions for evolving risk trends.”

Darren Porter

Managing Director, Aerospace



*University College
London*

The Air Transportation Systems Laboratory at [University College London \(UCL\)](#) explores the interaction between air transportation, the economy, and the environment. Their work is data-driven, using physical science, econometric, and operations research-based methods. The integrating mechanism is the [Aviation Integrated Model \(AIM\)](#), a unique tool, consisting of interlinked modules simulating current and future levels of global airport-to-airport demand, flight schedules, arrival delay, technology uptake, aircraft performance, local and global emissions, aircraft noise, and the related environmental costs and economic benefits under a wide range of policy conditions. WTW Research Network is supporting Prof Andreas Schäfer and his team, in particular for the EPSRC funded project TOZCA (Towards Zero Carbon Aviation).



*University of
Cambridge*

The Centre for Risk Studies is a multidisciplinary center of excellence for the study of the management of economic and societal risks. The Centre's focus is in the analysis, assessment, and mitigation of global vulnerabilities for the advancement of political, business and individual decision makers. CCRS is part of the Cambridge Judge Business School. The group provides frameworks for identifying and assessing the impact of systematic threads, using their threat taxonomy, and are very well connected to the insurance industry, government and the World Bank.



Solutions
for natural
hazards

Mitiga Solutions

Mitiga Solutions is an offshoot of the Barcelona Supercomputing

Center which specializes in high-performance computing. It is certified by Eurocontrol, and Mitiga Fall3d is the dispersion model currently in use by the Darwin and Buenos Aires Volcanic Ash Advisory Centers. The Barcelona Supercomputing Center is also the official provider for the sand and dust storm warnings of the World Meteorological Organization. Learn more at: mitigasolutions.com



A photograph of three diverse professionals in a meeting. On the left, a bald man with glasses and a beard, wearing a grey polo shirt, looks towards the center. In the middle, a Black man with a beard, wearing a grey ribbed sweater, holds a tablet and looks towards the right. On the right, a woman with curly hair, wearing a blue sleeveless top, is seen from the side, looking towards the man with the tablet. They are seated around a wooden table with a laptop, a glass of water, and a smartphone. Large windows in the background provide natural light.

People



People Risk

The emergence of the COVID-19 pandemic and its subsequent reverberations across the world have forced a fundamental rethink of how state, society, and business interact with one another. The pandemic has not only resulted in a public health crisis but as a catalyst for paradigmatic shifts in work, healthcare, education, commerce and state relations. The compounding nature of the pandemic has had deleterious effects upon goods and services and the overall international trade regime due to a more stringent regulatory environment, factory shutdowns, border closures, and supply chain bottlenecks. C-suite executives, the insurance industry, and the private sector in general must learn to adjust, innovate, and adapt to an increasingly uncertain world, a world most likely to be characterized by persistent and continued shocks. Trade, immigration, travel, technology adoption, and investment have all been unsparingly impacted by the pandemic, requiring dynamic and out-of-the-box thinking for organizations if they are to strike the proper balance between efficiency and resilience in their business models.

The importance of people risk in understanding new developments in technology, work, geopolitics, and societal resilience can be seen by assessing current problems and conflicts. While many compare our contemporary COVID-adjacent shocks to the stagflation era of the 1970s, 2022 differs drastically due to the confluence of several factors: the use and proliferation of new and emerging disruptive technologies for achieving strategic objectives, environmental degradation and natural resource depletion, and the quickening splintering of the world

into multiple monetary and technology blocs, to name just a few. To better prepare for a more volatile and uncertain world, business leaders and governments should seek to take a more holistic approach to understanding their problems, employing such strategies as scenario planning, agent-based modeling, and red teaming/adversarial simulations. Such an imaginative perspective will help organizations take a more nonlinear view of their overall strategic outlook, which will assist them in being able to minimize their operational risk across multiple contingencies.

WTW is partnering with the United Kingdom's National Preparedness Commission (NPC), whose aim is to "promote better preparedness for a major crisis or incident". Chaired by Lord Toby Harris, former Chair of the Metropolitan Police Authority, the NPC brings together some of the UK's most prominent universities, think-tanks, and companies and is made up of 46 Commissioners, two of whom are Hélène Galy, the Director of the WTW Research Network, and Elisabeth Braw, senior fellow at the American Enterprise Institute and a WTW Research Network partner. As a major partner and sponsor of the Commission, the WTW Research Network is preparing a report on the question of whether markets retain the ability to deliver resilience (later to be published by the NPC). The WTW Research Network will examine market mechanisms' contributions to real-world successes/failures and demonstrate how such market mechanisms, when paired with the appropriate institutions and culture, can contribute to market resilience and societal robustness.

Given the multiple externalities that have hit the international system of trade and commerce over the last few years, it is incumbent upon business leaders and industry executives to understand that such events do not exist in a vacuum and are not simply one-off events to be isolated from the whole. To help plug this gap, WTW has partnered extensively with Oxford Analytica to deepen its Political Risk portfolio to better understand tail risks such as China/U.S. conflict and companies' transition to a greener business model. WTW's extensive network of international clients has placed it in a unique position to gauge global business sentiment and provide exemplary advisory services to help mitigate and blunt the impact of business interruption and operational risk. Of note is WTW's risk radar, representing in-depth panel interviews with representatives from more than 30 major corporations, with risks ranging from debt/fiscal crises to the weaponization of economic relations for geostrategic purposes.

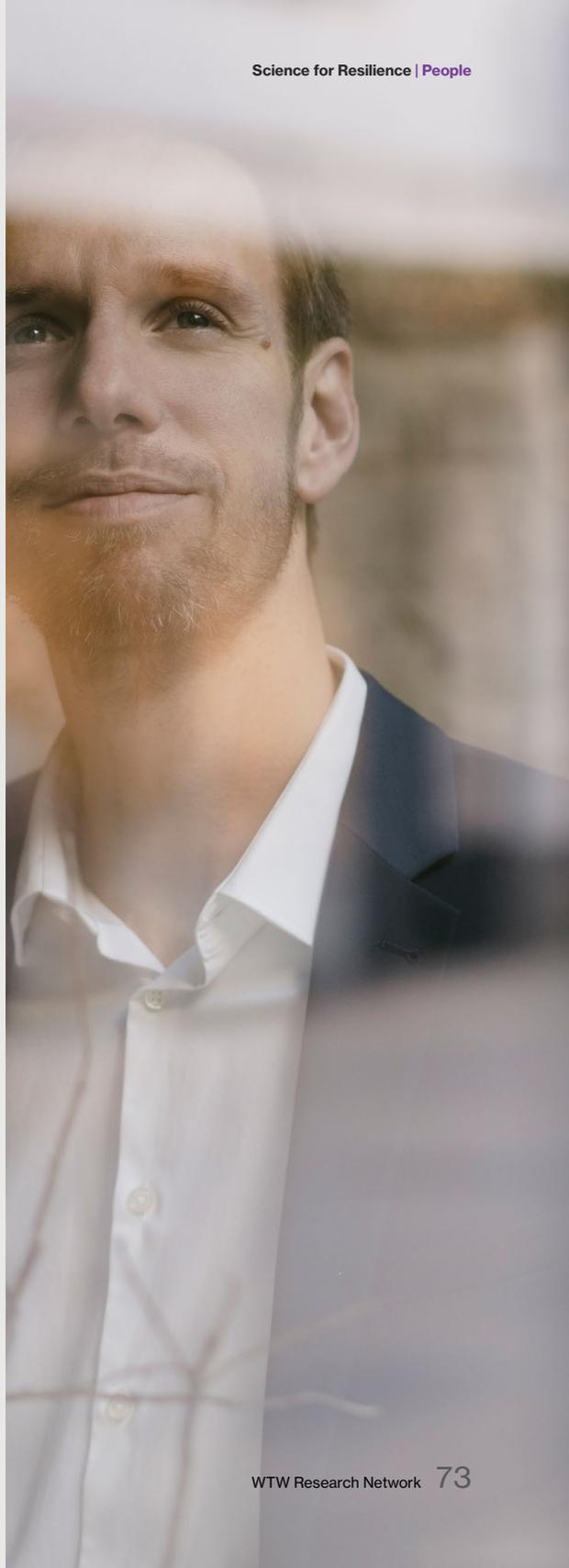
We believe that risk managers must be willing to rigorously challenge their organization's assumptions, policies, and culture, which will result in enhancing operational efficiency and structural agility. Businesses and organizations should therefore prepare for a world typified by supply disruptions, trade frictions, and greater economic, political, and social upheaval.

We will also continue our collaboration with Elisabeth Braw on grayzone aggression including the ramifications for the application of international law, insurance contracts, and economic and technological norms. While this collaboration goes back to 2019 during Elisabeth's tenure at the Royal United Services Institute (RUSI), the concepts of "gray zone", hybrid warfare and disinformation have been more in the headlines following the conflict in Ukraine.

Other complementary streams of research will be launched later in 2022.

Omar Samhan

Technology and People Risk Analyst



Understanding political risk

The threats posed to businesses by political upheavals or government action, such as expropriation, trade embargo or political violence, are difficult risks to manage as the past is often a poor guide to the future.

Political risks can emerge rapidly in societies that have enjoyed stable business conditions for years, so simple trend assessments or data analysis are inadequate in gauging the financial impact of political risk. Our partnership with Oxford Analytica complements our internal expertise to provide superior advisory services to our clients. A key example over the last year has been getting a perspective on some of those changes through our Political Risk Survey report.

The top political risks for global business

It has become an annual tradition: in January and February, the world's leading geopolitical analysts publish their lists of the top global risks for the year ahead. Each year, Eurasia Group publishes its top ten; Control Risks produces a top five. The World Economic Forum undertakes perhaps the most comprehensive effort, ranking a long set of emerging risks based on a survey of more than 1,000 global leaders.

In 2020, the novel coronavirus played havoc with these lists. Only a few weeks after the risk lists were published, countries worldwide imposed unprecedented lockdowns and restrictions on exports of food and medical products. None of the risk lists, including ours, anticipated this development, of course.

Some risk lists were updated mid-year to take account of the pandemic's impact.

That said, the top ten risks in our survey, conducted jointly by Oxford Analytica and WTW, proved to be a prescient guide to the political risk threats that the pandemic brought to the fore. The survey pulled together perspectives from more than 40 interviews with the world's largest companies, with our experts exploring the top political risks identified.

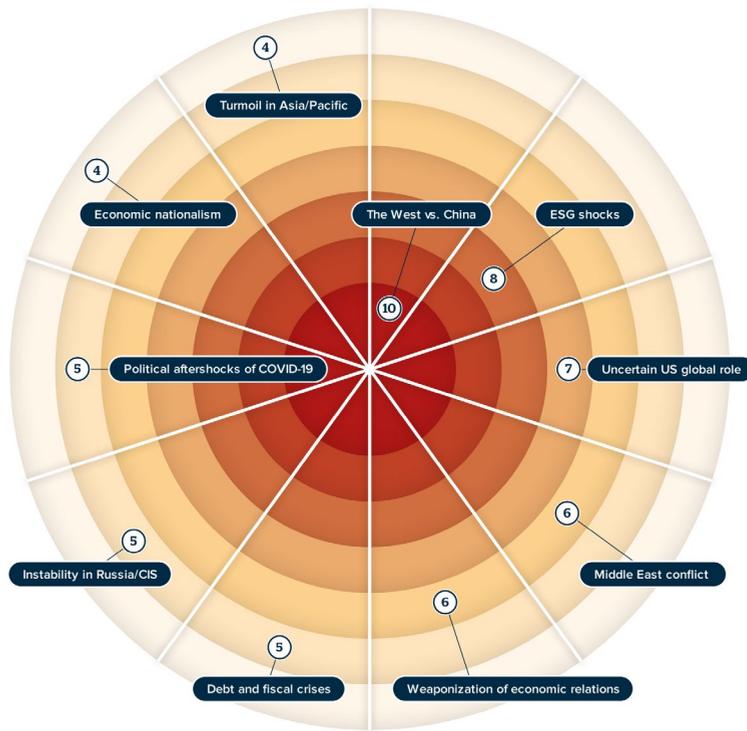
“Interconnected problems require integrated solutions, and this is where scenario-based thinking and expert partnerships can be used to explore impacts and leverage those resilience lessons to explore complex risks and decide what to do next.” Lucy Stanbrough, Head of Emerging Risks, WTW Research Network.

The survey highlighted risks from new ESG expectations for companies, and US-China strategic competition, even before the pandemic intensified each issue. Perhaps most strikingly, our risk list identified emerging markets fiscal crises as a top risk. In 2020, despite global bailout programs, there were more emerging-market debt defaults or restructurings than in 2008, the year of the global financial crisis.

Of course, the credit for this foresight goes not to us, but to the external affairs and risk management professionals who joined last year's panel. Clearly, these individuals knew their business, and demonstrated the value of opinion-based inputs alongside quantitative datasets.

“ Climate change action may have been put on the back-burner in 2020 as a result of COVID-19 but with many believing we need to rebuild our economies in a more equitable, sustainable and environmental way, it is no surprise to see 'new ESG expectations for companies' making the top ten perils list. ”

Cynthia Dugan
 Director, Financial Solutions



Source: Oxford Analytica

Note: The risk radar represents the results of in-depth panel interviews with 14 companies with a broader survey of more than 30 major corporations. Because the executives who joined the panel and survey were primarily clients of WTW and Oxford Analytica, they should not necessarily be seen as representative of typical firms worldwide. Rather, the study participants tended to represent companies that have extensive international operations and invest heavily in the management of political risk.

Since 2017, WTW and Oxford Analytica have collaborated to publish an annual Political Risk Survey Report. Recent reports are available at:

- 2019 <https://www.wtwco.com/en-GB/Insights/2019/12/2019-political-risk-survey-report>
- 2021 <https://www.wtwco.com/en-GB/Insights/2021/03/2021-political-risk-survey-report>

Additional collaborations with Oxford Analytica

Oxford Analytica has a 1,400-strong contributor network, which comprises senior faculty in first-class universities, scholars in leading research institutes, and world-class industry and sector specialists.

In partnership with WTW, Oxford Analytica has for the past decade prepared a Political Risk Index, covering political stability in more than 50 key emerging markets.

A recent edition, focusing on the topic of “pandemic debt,” is available here: <https://www.willistowerswatson.com/en-GB/Insights/2021/05/political-risk-index-summer-2021>

In 2021, Oxford Analytica and WTW have also collaborated on the production of several sector risk reports, which look forward to the key political risks facing a particular industry in the year ahead. Many of these reports include scenarios to assist companies in preparing for the potential impacts of geopolitical shocks on assets, people and supply chains:

- For technology: <https://www.wtwco.com/en-US/Insights/2021/02/managing-the-new-political-risks-in-the-technology-sector>
- For natural resources: <https://www.wtwco.com/en-US/Insights/2021/01/political-risk-in-the-natural-resources-sector>
- For renewables: <https://www.wtwco.com/en-GB/Insights/2021/07/the-top-political-risks-for-renewables-in-2021>



Oxford
Analytica

Oxford Analytica

Oxford Analytica is a global analysis and advisory company drawing on an extensive global network of experts to advise clients on strategy and performance in complex markets. We have been working with Oxford Analytica since 2006. For more information please visit their website <http://www.oxan.com/>

Whole of society approaches to improve preparedness for crises

The Covid-19 pandemic has been compared to a war on the whole population, but without the physical destruction. Beyond the obvious human and economic cost, this pandemic highlighted the fragility of the reliance on ‘just in time’ business models, and uncovered societal inequalities and tensions that threaten our resilience.

As hidden connections were revealed, the crisis reinvigorated the debate around the need for “whole of society” approaches to risk and resilience; and a search for a more concerted effort across all sectors, across government, business and civil society. WTW Research Network Director, H el ene Galy continues to explore and respond to these issues through our work with the National Preparedness Commission, and will coordinate a whitepaper in 2022 on market resilience.

The [National Preparedness Commission](#) (NPC) was formally launched on 19 November 2020 and is chaired by Lord Toby Harris. The Commission is made up of 46 leading figures – including the WTW Research Network Director – from public life, academia, business, and civil society. The aim of the NPC is to promote better preparedness for a major crisis or incident, primarily in the UK, although it has attracted interest internationally.

Although the latest edition of the UK’s National Risk Register still has pandemic flu at the top of the list, it features a further 38 other major risks facing the country, including climate change, environmental hazards, major accidents, malicious attacks (cyber-based and terrorists), risks arising overseas, and animal and human diseases.

The NPC recognizes that the UK needs to be better prepared to deal with unexpected or unprecedented shocks, but that the government is limited in its resources and bandwidth for action. This is reflected in the government’s Integrated Review, “[Global Britain in a Competitive Age](#)”, which calls for a ‘whole-of society’ approach to national resilience.

The NPC is a microcosm of UK Plc, bringing together stakeholders from public, private, academic and civil society sectors, promoting cross-sectoral debate, best practices and policy.

The Commission also holds closed roundtables for Commissioners, civil servants and subject matter experts, held under the Chatham House Rule and allowing detailed discussion of the themes contained in Commission papers or those produced by partner organizations.

While attendance of these sessions is restricted, WTW organizes a series of roundtables “[Finding your Geopolitical Feet](#)” open to our clients, focusing on those themes after a keynote from an external expert from the WTW Research Network.

A wide range of [articles and blogs](#) have appeared on the Commission's website, providing an eclectic range of thought-leadership for those interested in preparedness and resilience. The following reports (which were not directly sponsored by WTW) show the ranges of topics addressed:

- [The Data-sharing Imperative](#) – prepared by Dr Andrea Simmons looked at the lessons from the pandemic and how the perceived data protection challenges could be reduced to enable better service delivery to vulnerable individuals.
- [Enhancing Warnings](#) – prepared by Dr Carina Fearnley and Professor Ilan Kelman from the UCL Warnings Research Centre offered insights into what alerts and warning are and how they can better support effective behavioral preparedness and responses across a wide range of hazards, stakeholders and sectors.
- [Financial Foundations for Resilience](#) – prepared by Professor Michael Manelli and Lord Toby Harris provided new thinking on how insurance could be used to reduce the impact of all significant risks and hence improve resilience.
- [Learning that can Save Lives](#) – prepared by Lianna Roast of the Disaster Management Centre at Bournemouth University examined the process by which lessons identified following some major incident can be applied and embedded in practice.
- [Response to Call for Evidence from the Integrated Review](#) – this is the submission made by the Commission to the Cabinet Office in response to the call for evidence on the National Resilience Strategy, arising from the Integrated Review “*Global Britain in a Competitive Age*”.
- [Resilience Reimagined: a practical guide for organizations](#) – prepared by Professor David Denyer and Mike Sutliff of Cranfield University, with the support of Deloitte, looked at the insights of fifty business leaders from a range of sectors on the experience of the pandemic and made a series of recommendations on how organizations could become more resilient drawing on these lessons.
- [Lessons from the Millennium Bug](#) – prepared by Professor Martyn Thomas of Gresham College looked at the experience of the Y2K issue, why it was potentially so serious, how the risks were mitigated, and the lessons for future resilience.
- [Building Better Resilience](#) – prepared by Paul Martin and Jordan Giddings and looked at the difference between active and passive resilience, the role of human psychology and the significance of complex systems.
- [Independent review of the Civil Contingencies Act](#): the NPC has published its Review of the 2004 Civil Contingencies Act, led by Bruce Mann, former Director of the Civil Contingencies Secretariat, and based on over 300 interviews. It makes 117 recommendations and concludes that the Government must learn lessons from the COVID-19 pandemic and other emergencies over the last two decades if UK resilience arrangements are to be made fit for the future.

Like many other sponsors, WTW is working with the NPC on a whitepaper on a specific aspect of resilience, which will be published later in 2022. The whitepaper will look to explore where markets are effective (or not) to promote preparedness and resilience, the trade-offs between efficiency and resilience, and the incentives needed to make our ecosystems more resilient.



Lord Toby Harris was made a Life Peer in June 1998 and has been Chair of the Labour Peers since 2012. He was until recently Vice Chair of the UK Parliament's Joint Committee on National Security, having been a member for most of the last decade. He is a member of the House of Lords' Select Committee on Life Beyond COVID and was a member of the Committee on Democracy and Digital Technologies, which reported in summer 2020.

Outside Parliament, he chairs the National Preparedness Commission, whose mission is to promote better preparedness for a major crisis or incident, and is President of the Institute of Strategic Risk Management. In 2016, he conducted an Independent Review for the Mayor of London on London's Preparedness to Respond to a Major Terrorist Incident, which he was asked to update in 2021–2022.¹

¹ https://www.london.gov.uk/sites/default/files/harris_review_-_march_2022_web.pdf

Resilience to hostile activities of the grayzone

After the completion of the Modern Deterrence project at the Royal United Services Institute (of which WTW was a founding partner) in October 2022, the WTW Research Network continues its collaboration with Elisabeth Braw as she joined the American Enterprise Institute (AEI), to focus on defense against emerging national security challenges, such as hybrid and grayzone threats.

While recent events have provided us all with a vivid example of hybrid warfare, damaging grayzone aggression has been around for a long time. This aggression in the gray zone between war and peace is a daily challenge facing Western countries. While disinformation and cyberattacks are well-known forms of grayzone aggression, other, more subtle forms – including corporate coercion, gradual border changes, and subversive business practices – do equally serious damage.

Elisabeth Braw's research tracks the evolution of these different modes of aggression, and provides some insights in how western, liberal societies can counter the insidious effects of grayzone warfare, especially when so much of it resembles the bustle of everyday life. With no shortage of current – and potential future – disruptive events, and intersections across industries and geographies, WTW have been exploring some of these touchpoints with Elisabeth.

As well as being a regular contributor to our "Finding Your Geopolitical Feet", community collaborations with our Marine, Aviation and Political Risk practice, have been shedding light on the impact of current affairs on the

world of insurance and risk management, topics that feature often in her columns in the Wall Street Journal and Foreign Policy.

Topics investigated by Elisabeth include:

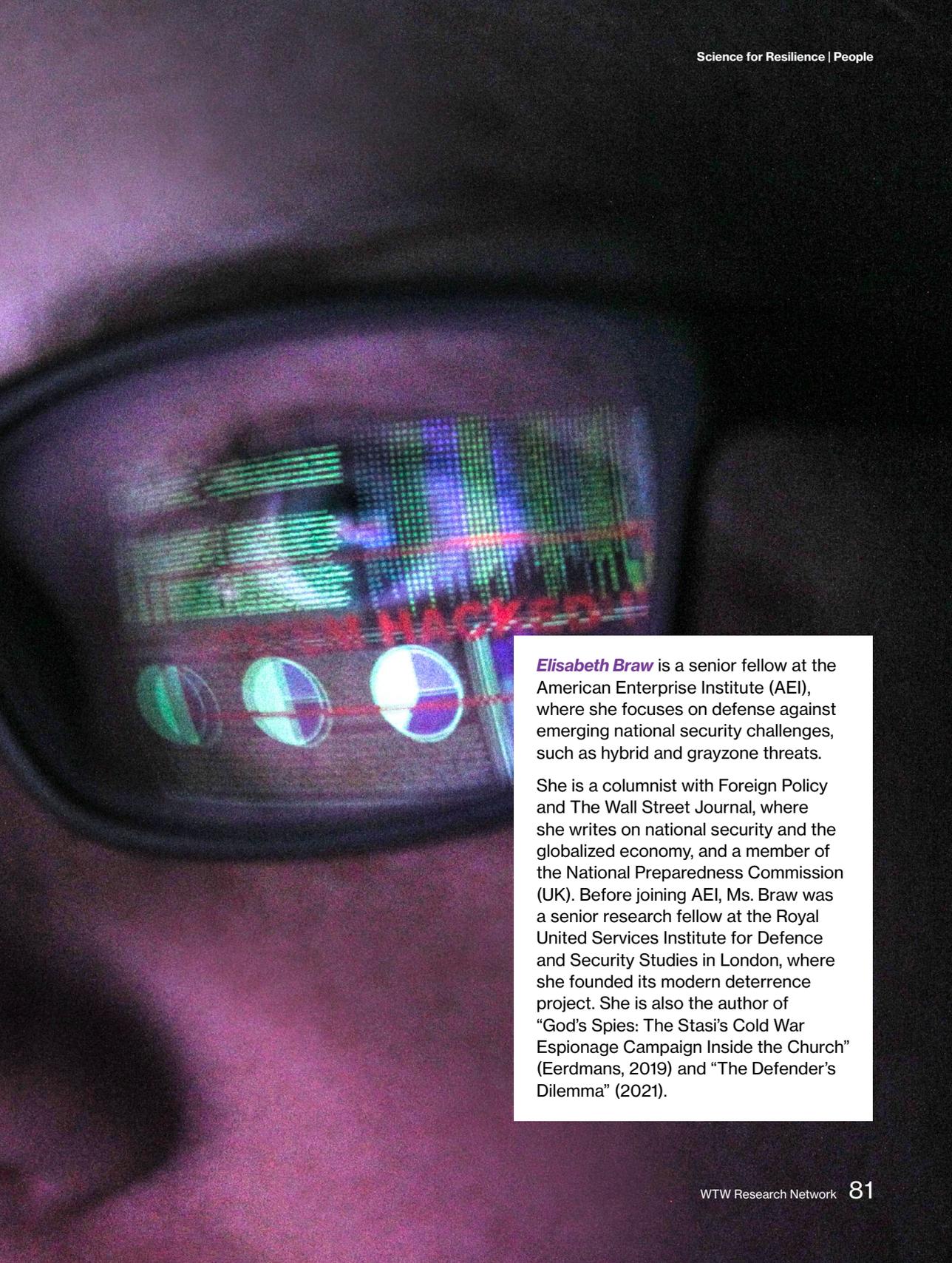
- The importance of [shipping](#) for global supply chains, and the vulnerability of [airlines](#) to geopolitics
- How private companies are seen as fair play in [geopolitical competition](#)
- The importance of [verifying](#) information and [fighting fakes](#) in our social media age
- [artificial intelligence arms race](#) and the prospect of international cooperation

Interconnected risks require an integrated response

Recent events have made it even more obvious that private organizations are not immune to geopolitics, a theme that Elisabeth has been warning about for some time. Our work with Elisabeth and our WTW Research Network partners allows us to tap into leading thinking to explore these changing dynamics and support our clients in preparing for the future.

With the world changing in more drastic and unpredictable ways than ever before, so too does the necessity for businesses to adapt in order to minimize risk and maximize opportunities as they present themselves.

The podcast series [On the Cusp](#) hosted by Elisabeth Braw, featured monthly interviews with innovative leaders on national security threats, ranging from cyber attacks, economic aggression to disinformation. The series was initially sponsored by WTW.



Elisabeth Braw is a senior fellow at the American Enterprise Institute (AEI), where she focuses on defense against emerging national security challenges, such as hybrid and grayzone threats.

She is a columnist with Foreign Policy and The Wall Street Journal, where she writes on national security and the globalized economy, and a member of the National Preparedness Commission (UK). Before joining AEI, Ms. Braw was a senior research fellow at the Royal United Services Institute for Defence and Security Studies in London, where she founded its modern deterrence project. She is also the author of “God’s Spies: The Stasi’s Cold War Espionage Campaign Inside the Church” (Eerdmans, 2019) and “The Defender’s Dilemma” (2021).



A young man with a short haircut and a nose ring is shown in profile, looking down at a tablet device he is holding. He is wearing a white long-sleeved shirt with small black polka dots and dark trousers. The background is a futuristic, dimly lit environment with prominent blue light strips and geometric patterns, suggesting a high-tech or data center setting.

Technology



Technology

The COVID-19 pandemic has laid bare many of the fragilities of our contemporary globalized world. But it has also highlighted the necessity and inevitability of the rapid adoption of technologies for the continuity of business and society. What has resulted is a more interconnected and digitized world, increasingly reliant on at-home services such as Subscription Video on Demand (SVOD) streaming abilities, edtech/medtech, and remote work. Companies have also been forced to streamline customer and business operations, positioning technology at the center of an uncertain world.

While the pandemic has brought hardship to many industries such as tourism, travel, and leisure & hospitality, the technology, media, and telecoms (TMT) sector has, unsurprisingly, fared extremely well as evidenced by the increase in segment developments and mergers & acquisitions (M&A). The pandemic has acted as a catalyzing agent for certain technologies and an accelerator for others; automation, artificial intelligence, quantum computing, digital skills in the hybrid world, and repurposing organizations to be more dynamic and nimbler have all demonstrated themselves as real world proofs of concept in a rapidly changing world. Companies and industries no longer view such methods and technologies as transient tools to increase enterprise robustness, limit liabilities, and curtail cost inefficiencies but instead as crucial strategic imperatives integral to the wider business model that will extend into the post-pandemic future.

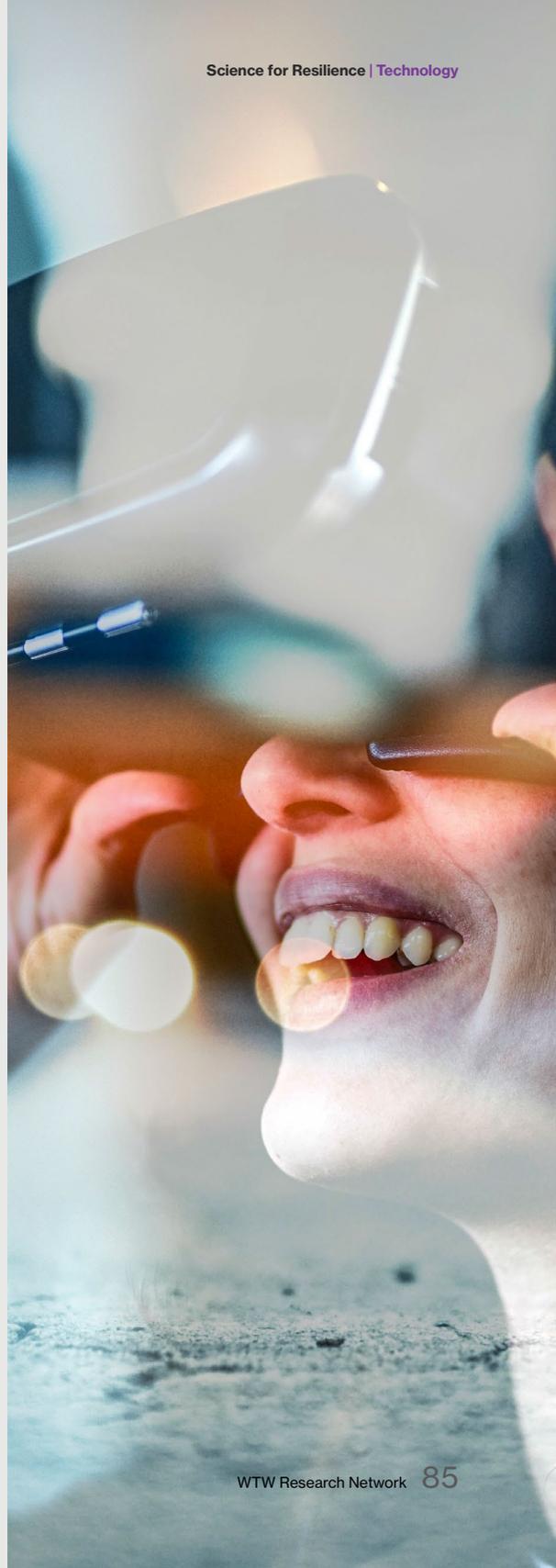
2021 has proven to be fortuitous for many companies on the bleeding edge of technology and innovation, with the trend most likely continuing into 2022 due to plentiful capital and new routes of innovation. As a result of the shift to remote and hybrid work, a paradigm shift has occurred in the cyber, Internet of Things (IoT), cloud computing, data management, direct-to-consumer, microchip, and automation sectors. Cyber security will continue to take center stage due to increased connectivity and businesses' need to safeguard client/employee confidentiality and infrastructure integrity. Cyber insurance will also be heavily impacted by the new normal of increased remote work as cyber attacks are occurring more often and becoming more damaging. The proliferation and linking of multiple devices across a multitude of platforms will accelerate IoT's centrality in the creation of smart cities and the enhancement of personal and organizational linkages. A combination of logistical bottlenecks, a shift in consumer demand, extreme weather patterns disrupting supply chains, and geopolitical tensions have all contributed to a chip shortage that will continue into 2022, affecting the automobile, telecom, and electronic device markets.

The technology, media and telecommunications industries will also play a key role in advancing the shift to a greener economy, with the environmental, social, and governance (ESG) criteria taking precedence and companies wishing to conduct proper due diligence and risk assessments, measure the ethical impacts of their investments, and analyze their fiduciary responsibilities to shareholders and society at large.

It is important that these trends in technology are linked back to tangible outcomes and understandings needed in industry. Our 2022 annual review focuses on a flagship report based on research undertaken by WTW TMT and WTW Research Network teams in collaboration with the Mack Institute's Collaborative Innovation Program (CIP) at the Wharton School, University of Pennsylvania, which provides an in-depth look at the risk landscape impacting TMT organizations and highlights issues they will need to tackle to thrive in a post-pandemic future.

Omar Samhan

People and Technology Risk Analyst



Data sharing models in the insurance industry

Data sharing between separate companies improves operational efficiency and has the strategic potential to reshape the insurance value chain. As part of the TECHNGI program, Loughborough University and WTW have been collaborating to describe some of these issues, funded from the UK Government Industry Challenge Fund's Next Generation Services program.

Christopher P. Holland, George Zarkadakis, John Hillier, Paul D. Timms, Geoffrey Saville, and Lucy Stanbrough explored how data sharing is changing across the insurance value chain, introduced four data sharing models and market scenarios, and identified the imperative strategic choices facing the insurance industry. Professor Holland also presented his thoughts on the topic during our WTW Research Network 15 Year Anniversary conference, a copy of which can be [found online](#).

Strategic change and future direction

There is a drive for efficiency in insurance markets, accompanied and enabled by changes in the way that data is captured, processed, stored and shared. Digital innovation and data sharing strategies are designed to reduce costs and develop new, innovative products, services, and distribution channels throughout the insurance value chain¹. With the competitive threats of new entrants into the insurance industry, i.e., AI start-ups and technology giants², there is a strong incentive for established firms to respond and adapt to take advantage of advanced digital technologies and Artificial Intelligence (AI) applications³. Our recent survey of industry experts expects transformation to occur in 3-5 years but the panel of experts do not perceive an immediate threat over the next 12 months⁴. This is a classic example of the innovator's dilemma for established firms in markets that are in transition, where clear benefits can be seen, but change is risky and the current markets are still profitable⁵.

1 OECD. Technology and innovation in the insurance sector. <https://www.oecd.org/pensions/Technology-and-innovation-in-the-insurance-sector.pdf> (2017).

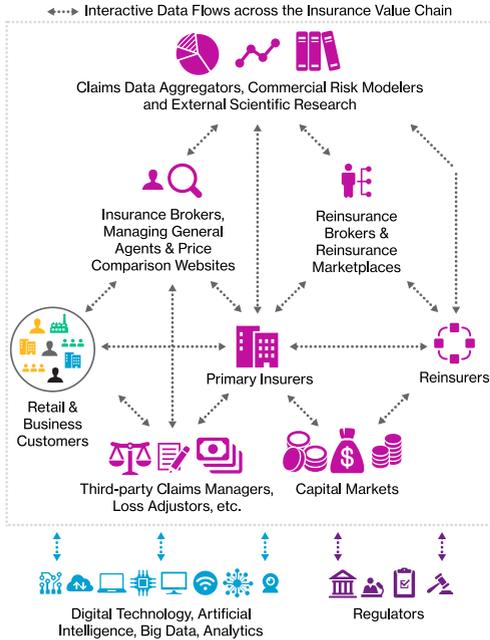
2 Ralph, O. Insurance experts put premium on start-ups reaching the big time. Financial Times (2020).

3 Deloitte. From mystery to mastery: Unlocking the business value of Artificial Intelligence in the insurance industry. <https://www2.deloitte.com/content/dam/Deloitte/xe/Documents/financial-services/Artificial-Intelligence-in-Insurance.pdf> (2020).

4 Timms, P., Hillier, J. & Holland, C. P. Increase data sharing or die? An initial view for natural catastrophe insurance. <https://eartharxiv.org/repository/view/2059/> (2021) doi:<https://doi.org/10.31223/X5K313>.

5 Christensen, C. M. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail (Harvard Business School Press, 1997).

Figure 21. Interactive data sharing in the insurance value chain



Data sharing across the insurance value chain

Insurance markets are defined by the contracts agreed between the insured and the insurance firm⁶, and the exchange of information starting from the customer and then along the insurance value chain⁷, which comprises a set of different types of organizations connected together through relationships to form a market network.

Figure 21 is a schematic illustration of how retail and business customers, insurance firms, brokers, e-marketplaces, re-insurance firms, capital markets and regulators are connected together in a complex insurance value chain.

This also includes Digital Technology, Big Data and Artificial Intelligence as well as regulators.

Incumbent insurance firms face two key questions. What are the future data sharing and market scenarios, and how soon will these occur?

6 Denenberg, H. S. The Legal Definition of Insurance : Insurance Principles in Practice. Am. Risk Insur. Assoc. 30, 319–343 (1963).

7 Eling, M. & Lehmann, M. The Impact of Digitalization on the Insurance Value Chain and the Insurability of Risks. Geneva Pap. Risk Insur. Issues Pract. 43, 359–396 (2018).

Insurance data types

Insurance policies require a diversity of data types, which vary between policies dependent on the particular insurance line, e.g., retail automotive insurance or property and casualty, and the purpose of the communication such as to share customer data, fraud prevention, or broker a deal between a customer and an insurance provider. However, some broad categories can be defined for all insurance markets:

- Customer information
- Asset being insured and related exposure
- Historical loss data
- Behavioral data from telematics, IoT in buildings and fitness trackers
- Business process definition and associated data, e.g., policy management and claims processing
- Calculated risk of the insurance (i.e., estimated losses)
- Related, non-insurance data, e.g., natural hazard, mapping, GPS data and weather information

Business benefits from data sharing in the insurance value chain

It is well established that data sharing between separate companies improves operational efficiency, increases data transparency and accuracy within a value chain, and enables a much more effective, coordinated response to external changes in the marketplace (such as changes in demand, new product designs and regulatory requirements). The recent TECHNGI survey of insurance industry experts confirms that they see numerous significant advantages to better sharing of data in the insurance

value chain. However, although there is strong evidence of innovation in bi-lateral agreements between close partners, the experts also confirm that there remain significant barriers to wider data sharing, which can be categorized into three groups⁴:

- **Commercial**, related to the protection of Intellectual Property (IP) and competitive advantage
- **Legal**, principally from data protection legislation and contractual limitations⁸
- **Technology and data costs**, e.g., the cost of data preparation, lack of technical standards, and systems integration issues

This raises the issue of how these barriers will be overcome, how quickly, and by whom.

Data sharing and market scenarios

In addition to the continuation of the current insurance value chain shown in **Figure 21**, which is a system characterized by the dominance of bi-lateral relationships, experience in other sectors suggests that four market scenarios could emerge: electronic marketplaces; smart business networks; data platforms and ecosystems (typically controlled by a single, large technology firm); and data trusts.

1. Electronic marketplace

Electronic marketplaces are digital platforms that connect multiple buyers and multiple sellers together, with fast and low cost switching between competitors⁹. In markets where the level of inter-dependency between the customer and the supplier is low, and where a strong ongoing relationship is not crucial to delivery of the service, then electronic markets are economically attractive. This is evident in the widespread

8 European Commission. What are the GDPR consent requirements? [https://gdpr.eu/gdpr-consent-requirements/\(2020\)](https://gdpr.eu/gdpr-consent-requirements/(2020)).

9 Malone, T. W., Yates, J. & Benjamin, R. I. Electronic markets and electronic hierarchies. *Commun. ACM* 30, 484–497 (1987)

use of price comparison websites for home and car insurance in the US and Europe, where a handful of dominant price comparison engines significantly influence new customer acquisition and competitor switching, which takes place at the point of renewal. A Business-to-Business (B2B) example is the insurance broker market, where Polaris' 'imarket' is an electronic marketplace that connects broker and insurer systems to facilitate real-time risk assessment and price quotes for a range of commercial insurance products from competing suppliers.¹⁰

2. Smart Business Network (SBN)

A Smart Business Network is a network of separate organizations connected together through a common set of strategic objectives and facilitated through digital connectivity and advanced data sharing¹¹. This is a network of members, who choose to cooperate closely with each other. A key role in an SBN is the 'orchestrator' or coordinating organization, which operates across the smart business network and determines the overall structure and membership of the network.

Data standards, such as Polaris' e-trading standards and ACORD's electronic standards, forms and software tools, facilitate the successful evolution of smart networks by improving operational efficiency, reducing the cost of sharing data with economic partners and define common business processes along the value chain. Importantly, SBNs are more flexible than vertical integration in supply chains, because new organizations can be switched into the network and organizations that are no longer needed or choose to leave, can be disconnected. They offer more stability

than an electronic market, so trust and continuity can be built into the relationships. New technologies such as blockchain could be used as part of the digital infrastructure to build a smart business network and there is early evidence of this happening with companies such as b3i facilitating close ties between insurance and re-insurance firms for the secure exchange of risk data, which is based on a common language.

In insurance markets, the candidates for the role of orchestrator are primary insurers, brokers and re-insurance firms. The role requires a combination of influence and prestige arising from an organization's existing position in the insurance value chain, combined with a high degree of expertise and capacity for digital innovation and leadership.

3. Data platforms and insurance ecosystems

A data platform shifts the center of gravity for insurance data to a data platform, which might be managed by an e-commerce or automotive company, or a technology giant such as Tencent, Google or Apple. In this scenario, insurance data would be a part of a much larger ecosystem¹², and the insurance service would be subsidiary to other services such as transportation and mobility, health, property services or e-commerce. Technology giants potentially have significant data and analytics advantages over incumbent insurance firms and could use them to embrace and integrate InsurTech companies into their platform, which would offer the specialized industry expertise.

¹⁰ Polaris UK Ltd. Products.

¹¹ Heck, E. V. & Vervest, P. Smart business networks: how the network wins. *Commun. ACM* 50, 28–37 (2007).

¹² Tanguy Catlin, Lorenz, J.-T., Nandan, J., Sharma, S. & Waschto, A. Insurance Beyond Digital: The Rise Of Ecosystems And platforms. McKinsey Co. 16 (2018).

4. Data trust

A data trust is a legal and technological construct that enables the compliant, ethical and secure sharing of sensitive data among a network of data providers. WTW is actively exploring this concept and has piloted its use in the insurance sector¹³. A data trust can remove much of the friction from the commercial, legal and technological barriers identified in the TECHNGI survey. This is achieved through privacy-by-design as well as by identifying use cases with compelling commercial and social advantages from data sharing, e.g., the sharing of industry-wide claims data for fraud prevention and the sharing of loss data from natural catastrophe to build more robust risk models. The insurance industry is clearly advancing towards digital, data-driven products and services that personalize and disintermediate, while reducing cost and increasing expediency and value to customers. Some of the biggest challenges on this digitalization journey are the scarcity of inter-operable, high-quality data, and the technology skills of data science and machine learning skills. The WTW pilot demonstrated that a Data Trust incentivizes members in a “Minimum Viable Consortium” (MVC) of data providers to share data and resources to solve a common problem, as long as there are clear policies for data governance, technologies that protect privacy (such as federated learning and differential privacy), as well as commercial agreements between MVC members that ensure the equitable sharing of value generated through collaboration.

Discussion of insurance industry scenarios

In the TECHNGI survey, the panel of industry experts were asked about how and when data sharing in re(insurance) would change and over what time frame. The majority expected significant change in a time horizon of 3–5 years, but not within 12 months. They felt that the outcome is likely to be a mix of the scenarios outlined above. It is not clear which, if any, will dominate though the participants' favored electronic marketplaces. The time-lag of 3–5 years is significant in illustrating some reticence towards change, supported by a notable minority of survey respondents still seeing the status quo in 3–5 years. Our interpretation, however, is that there is a much higher level of urgency to change and that the inertia of incumbent firms is typical of the innovator's dilemma and understates the disruptive effects of data platforms and ecosystems.

Imperative strategic choices for incumbent insurance firms

Existing bi-lateral data sharing agreements are valuable but do not fully exploit the strategic value of data from a market-level perspective. Vertical integration, i.e., common ownership of the insurance value chain, is not a viable option for insurance firms because it is too expensive and inflexible. Insurance firms should therefore embrace new market scenarios and develop strategies that take advantage of their existing knowledge and expertise, relationships, and data – this will entail a re-evaluation of core competencies and a new approach to business models that takes an external or market network perspective rather than being internally focused. The strategic focus for an individual insurance firm should place much more emphasis on building product

13 Zarkadakis, G. “Data trusts” could be the key to better AI. Harv. Bus. Rev. (2020).

differentiation through analytics, rather than from the proprietary ownership of raw data. This implies a need for increased data sharing and investments into data science and Artificial Intelligence (AI) skills.

Electronic markets work effectively in those areas where products are standardized and there is no need for close collaboration between buyers and sellers. Electronic markets will therefore continue to be successful in consumer markets where insurance services are standardized and well understood, e.g., comparison websites for automotive and house insurance. There are also standardized marketplaces in B2B markets where the concept of open data is likely to thrive. This is where the industry as a whole agrees to share information and not use data ownership as the basis for competition. For example, OASIS is an open hub that facilitates the free sharing of environmental and risk data, supported by a common modeling language. The common good and the need for a better global understanding is more important than the competitive advantage of a single firm.

In specialized consumer markets such as health, and B2B relationships between insurance firms and reinsurance, and in the capital markets, smart business networks will come to the fore. SBNs require close alignment between their constituent members, and the role of the 'orchestrator' is therefore crucial. This is a principal organization that builds the network around a set of common strategic objectives and provides leadership in areas such as technology strategy, innovation and the continuing evolution of the network, including its membership. Incumbent insurance firms are the natural contenders for this role though reinsurance firms and brokers could also have legitimacy in this role. SBNs offer an interesting opportunity for

InsurTech firms because SBNs are inherently flexible in terms of new relationships, including technology partnerships, and are therefore more likely to embrace InsurTech services.

Data platforms and insurance ecosystems require huge scale. Ping An's success in this area is built upon expansion into other market sectors, including healthcare and banking, and a large user base of over 500 million customers¹⁴. For European and US insurance firms, which do not have this scale or cross-sector presence, a data platform strategy would require a transformation of the existing insurance industry position and extensive cross-sector collaboration and integration. If a technology giant attempts to use its scale to enter the insurance market with a platform strategy then the incumbents would be forced to respond, either by attempting to block the move through superior offerings or by embracing the initiative and becoming an integral component of a much larger ecosystem.

Data trusts have significant potential to be applied to highly sensitive data such as loss and claims data between direct competitors. For example, in health insurance markets it may be necessary to combine genetics, insurance data and patient information to build AI-powered services. The synthesis of the data is necessary for the development and refinement of the AI algorithms, but the individual data owners may be unwilling or unable to share the data with other organizations, so a separate fiduciary body in the form of a data trust can overcome what may appear to be insurmountable barriers. A simpler example would be the combination of claims data from competing insurance firms to combat fraudulent claims.

14 Ngai, J. Building a tech-enabled ecosystem: An interview with Ping An's Jessica Tan. McKinsey Q. (2018)

A viewpoint of the future

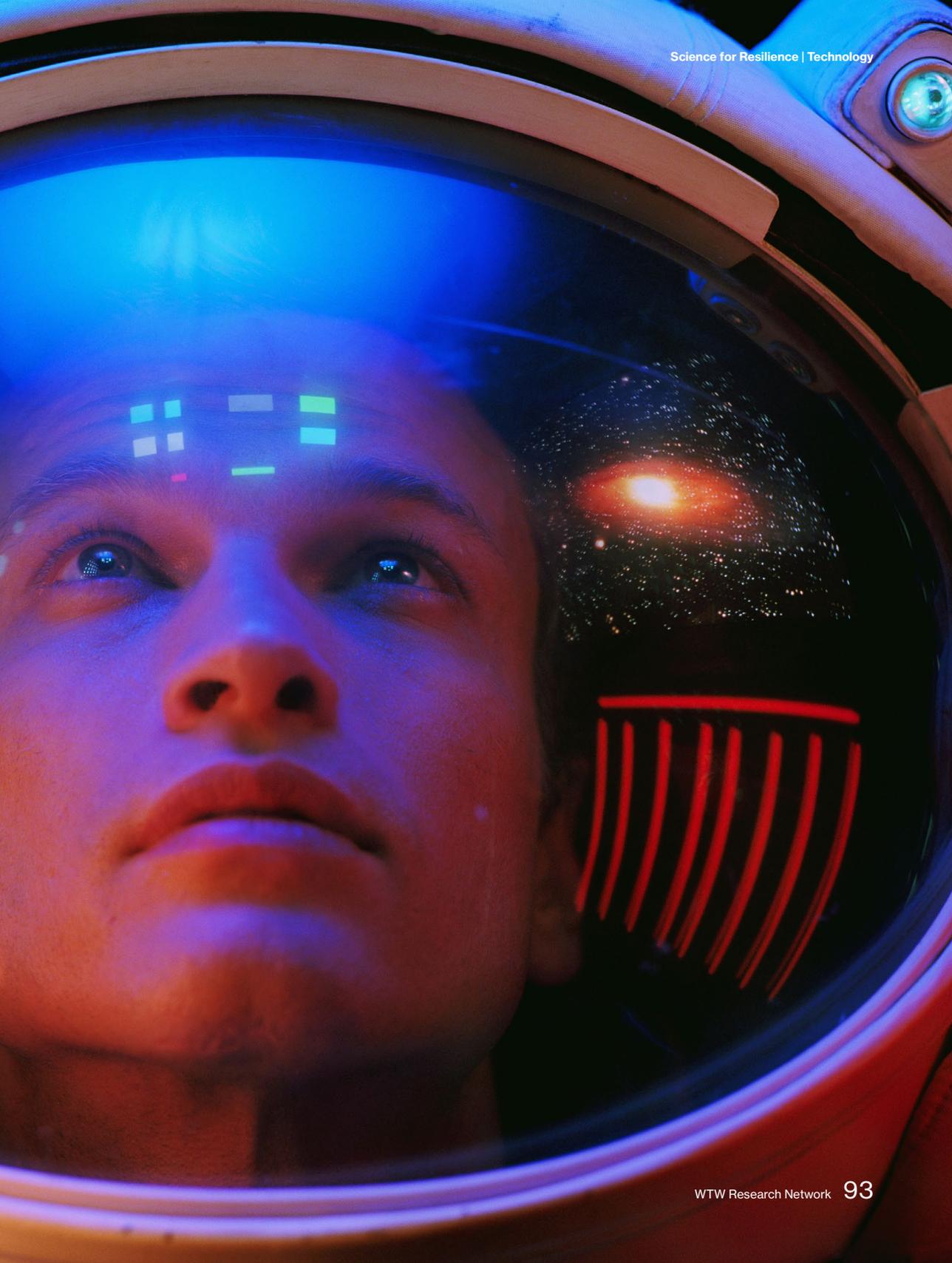
The current ad-hoc and incremental approach to data sharing that is based principally on bilateral agreements and partnerships impedes the ability of the insurance industry as a whole to improve its profitability. The relatively slow uptake of data standards to overcome the barriers to sharing make insurance increasingly attractive to radical change from a new entrant such as a technology giant and the myriad of AI start-ups launching novel products and services. A combination of smart business networks orchestrated by incumbent insurance firms, electronic markets, and data trusts, combined with leading use of digital technology and data standards will enable a way forward for the insurance industry to successfully evolve from its current position, and build competitive and technology barriers to new entrants.



School of Business and Economics, Loughborough University

The TECHNGI project is part of the Centre for Information Management (CIM), which is an inter-disciplinary research group in the School of Business and Economics at Loughborough University. Academics in CIM are engaged in a variety of applied research and consultancy projects with industrial partners focused on the digital transformation of business firms, public sector organizations, and markets. These include the topics of Artificial Intelligence (AI), big data analytics, FinTech, industry 4.0, social media analytics, digital ecosystems, competition in online markets, new technology start-ups, smart cities, and digital marketing.





Loss prevention technologies

The emergence of new technologies, and ways in which they can transform our exposure and vulnerability, provides the insurance industry with new factors to consider when evaluating risk. However little is currently known about the quantitative effect loss prevention technologies can have on property risk and what economic net benefits the asset owner can gain by investing in this area. This project, in conjunction with the University of Southern Denmark, seeks to reduce the gap in the literature and gain in-depth insight into how underwriters respond to the use of loss prevention technologies under premium determination. In addition, it will look at what quantitative effect can be observed in retrospect by estimating the future effect of using such technologies. The project will help insurance buyers determine the extent of loss prevention needed to gain a positive economic net-benefit when risk is transferred to an insurance company.

Technological advancement in methods for loss prevention presents novel ways for people to cope with the risk. From typical scenarios such as fire, crime, natural catastrophes and cyber risk, the technical installations present within the building influence the potential exposure. However, technology advancements in helping manage risks have been occurring more rapidly than the existing insurance market, and insurance systems have not been able to adapt to them fully. Whilst various loss prevention technologies, e.g. fire alarm systems, sprinkler systems, burglar alarms, access control, CCTV, water leaks detection systems etc., are commonly recognized in

the industry, little is actually known about the economic net benefit for the property owner or the quantitative effects on property damage.

In order to understand these economic net-benefits, a collaboration between WTW, fourteen clients, two insurance companies and the University of Southern Denmark was established in 2019. This collaboration has enabled the research to provide a deeper understanding of the market's response to loss prevention technologies and the quantitative effect said technologies can have on property damage.

The WTW Research Network will present the research in a series of articles through 2022.

- The first article will address how property damages can be influenced by the use of loss prevention technologies when there is no risk transfer. Data on recorded losses, the use of loss prevention and building characteristics was collected for approximately 5,000 buildings owned by Danish municipalities from 2014 to 2018. The article will add to the quantitative understanding of how automatic fire alarm systems, sprinkler systems, burglar alarms, access control, CCTV, automatic water leak detection systems are influencing property risk.
- The second article will report on the challenges the insurance market has when pricing risk due to the heterogeneous use of loss prevention technologies, and will challenge the current understanding of when loss prevention is beneficial for



policyholder. The article will be based on data from 40 Danish municipalities' insurance purchases and will include information on building characteristics, use of loss prevention, claims history and insurance bids over the period from 2008 to 2019.

- In the third and last article the project will be operationalized, and a framework for a decision making model will be presented. The model is expected to support a policyholder's future investments in loss prevention including the need for property loss prevention and level of deductibles.

Whilst the initial work leverages access to data and the Danish market, it is expected that this research can provide useful insights for other regions.

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works purposefully
to create dialogue
between the

university's researchers and the surrounding society. The answers to societal challenges are often found in the interaction between highly specialized academic environments. When these environments collaborate, perspectives are expanded, and new insights emerge. The University of Southern Denmark welcomed the first students onto its campus in September 1966. It now has five faculties with more than 32,000 students, almost 20% of whom are from abroad, and more than 4,000 employees distributed across its campuses in Odense, Slagelse, Kolding, Esbjerg and Sønderborg. Several international studies document that SDU conducts world-class research and is one of the top 50 young universities in the world.





Special Feature: TMT Risks on the Horizon



Risks on the Horizon

Technology, Media and Telecommunications Futures Report

The technology, media and telecom (TMT) industry has faced an extraordinary range of risk and uncertainty in recent years. Risks surfacing from tectonic shifts in technology have been compounded by rising geopolitical tensions, regulatory complexity and a never-ending talent shortage. And of course, inevitably, COVID-19.

In an effort to assist our clients' understanding of the full business and risk landscape, the WTW Research Network and TMT practice established a new research project collaboration with the Mack Institute's Collaborative Innovation Program (CIP) at the Wharton School, University of Pennsylvania.

We set out to examine changes to the risk landscape that have surfaced over the past five years, as well as to identify emerging industry risks. In this new report – 2021 Technology, Media and Telecommunications Futures Report – we share ideas to help executives and their Board of Directors move beyond a “risk list” into a more holistic risk management approach to better address emerging risks and capitalize on opportunities.

The research includes observations, insights and recommendations from key executives in the TMT and broader risk management space.

We identified five risk megatrends that form the overall framework.

5 megatrends



Business model & strategy pressures



Global talent & skills race



Digitalization & technological advances



Regulatory & legal risks



Operational complexity & vulnerability

The following sections share key insights from each trend, and a full copy of the research can be found [online](#).



Wharton
UNIVERSITY OF PENNSYLVANIA

The Mack Institute for Innovation Management

at the Wharton School is the hub of a global learning network for scholars, business leaders and students. The Institute joins rigorous research with practical applications to help established firms navigate the risks and rewards of innovation. Each year, it hosts several major conferences and workshops; funds student, PhD, and faculty research; and sponsors student initiatives relating to innovation and emerging technologies.



“ Companies must continuously innovate to stay ahead of the curve and manage risks effectively. ”

Sara Benolken

WTW TMT Global Industry Practice Leader

Business model and strategy pressures

TMT business models and strategies have been forced in recent years to accommodate sudden shifts in the macro business environment, including disruptive technological change, geopolitical stresses, a global pandemic, and climate change.

New or rapidly evolving TMT business models and strategies are having a hard-to-measure impact on revenues, return on investment and other key performance indicators. However, to remain viable, many businesses have few options but to look at alternative ways of doing business.

In a 2020 Ernst & Young survey, the professional services network found that 34% of its media industry respondents said their companies would not survive in five years if they didn't "reinvent" their business. Half had doubts about their business models and have made major restructuring a short-term priority.

Telecom and media companies, in particular, have felt pressure to expand outside their core businesses to diversify revenue streams and look for synergies across different segments. Mergers and acquisitions continue to reshape the industry. Other companies have in effect adopted "two-speed" business models as they shift to the cloud while having to rethink investments into existing IT assets with implications for sales, operations, and company culture.

Our research also highlighted the pressure to update, automate and digitize business.

A Boston Consulting Group (BCG) survey found that 70% of digital transformations fall short of objectives – a big blow to potential earnings. BCG found that earnings grew 1.8 times faster among digital leaders than among digital laggards.

TMT respondents tended to agree that the price tag for full digitalization might be a challenge for companies already under margin pressures. Others need to balance the cost of full digitalization with investor expectations of strong quarter-to-quarter financial results at the risk of underinvesting in future operations.

WTW's research confirms the vital role played by a company's culture and leadership. (WTW Insight: [The Change Management Imperative](#).) This is certainly true around digital transformation. Digital-savvy leadership can ensure that the organization accepts digitalization as a strategic necessity and are given the resources and structure to leverage data for decision making.

Nick Dunlop, a WTW managing director, has concluded that for most companies climate change is the [next big challenge](#) after COVID-19, and that tech companies will play a big role in applying big data and machine learning to help both financial services and corporates address their climate risk.

"Climate change is what many of us consider a 'grey swan' event," he says. "Unlike an unpredictable black swan event, climate change is perfectly predictable. It's something that we've known about for decades – the human role in atmospheric CO2 concentration has been accurately measured since the late

1950s. Yet, despite the existential threat, we as a society are not doing enough to address the climate change problem.”

Many financial institutions and other companies increasingly understand their exposure to climate risks and are reducing their carbon footprint. The pace will pick up as more companies find themselves in a four-way squeeze among regulators, institutional investors, consumers and employees, and risk management that faces a growing “protection gap.”

Risk management basics, of course, come into play across the full spectrum of risks that will force companies to rethink and frequently modify their business models and strategies. For this reason, it is vital that CROs engage with other senior managers to see that enterprise risk management is fully aligned with broader business objectives. .

A **business model risk analysis** by the Kelley School of Business, Indiana University, identified 28 categories of risk and uncertainty organized into four internal risk categories, including customer risk, value proposition, infrastructure (e.g. supply chains and operational risks) and financial viability. The analysis added an external risk category that includes political, environmental, economic, and competitive risks, such as those identified in our conversations with TMT business leaders.

A takeaway message for senior management is the study's ominous conclusion:

“**Business model risks have not been sufficiently addressed.**”



Global talent and skills race

Although we have identified the global talent and skills race as a risk megatrend in its own right, TMT executives say that inadequate or poorly trained talent can contribute to the full spectrum of risks, including operational vulnerabilities, regulatory and legal exposures, and even business model and strategy shortcomings.

In previous WTW research, risks associated with the talent and skills race ranked below regulatory and legal risks, digitalization and technological advances, business model and strategy pressures, and operational complexity

and vulnerability. Now many companies see talent and skill gaps as a top risk.

Our latest research reveals that talent concerns have climbed up the risk ladder as companies take a broad view of how enterprise success depends on the recruitment, training and effective deployment of talent. This assessment fits with findings in our [Flexible Work and Rewards Survey 2021](#). This survey highlights the impact of accelerated automation focused on talent as critical factors in the re-organization of the workplace in the post-pandemic era.



What talent-related risks lie ahead?

TMT executives share these concerns:

- Traditional talent pipelines are limited or obsolete, and companies need to deploy more creative and effective solutions to identify, attract, and retain key talent.
- Compensation is important but hardly enough as potential hires often are more concerned about skills development and personal satisfaction.
- Brand matters: Your company's values, image and culture can be an asset or a liability.

This need for talent has been described as a “war” for talent by one executive, forcing new approaches to finding or developing the talent necessary in the age of digital transformation, including an enhanced role for technology. (WTW Insight: [Innovating around talent risk.](#))

Despite this dependency on specialized talent and skills, WTW finds that comparatively few companies feel they have found the secret to effectively identify, attract, recruit and retain key talent.

Upskilling is also emerging as important. Some companies have begun recruiting employees without a digital pedigree, instead seeking employees who exhibit such traits as curiosity, creativity, and a willingness to innovate. [Disney](#) and other companies are finding that these employees can be trained to gain digital skills while adding a higher level of creativity and innovation to the enterprise.

Technology employees are also being given opportunities to better integrate with other functions. CompTIA, in its [Cyberstates 2020](#) report, noted: “Beyond technical skills, businesses are also looking for technology professionals that can speak the language of the business, collaborating with other departments in order to drive technology-fueled business results.”

Employee satisfaction must be part of the equation. It's important that companies expand their digital talent pipeline. But this produces a short- term value – and an [costly mistake](#) – if TMT companies fail to recognize that employees want more interesting work, better opportunities, and have little patience if they feel badly managed or unchallenged.

Consequently, forward-looking TMT companies are taking new approaches to employee retention. These actions include offering the professional experience of “moving around”, but within the business. The employees enjoy the experience and employers are reaping the benefits of the creativity dividend as they find these rotational programs are a good way to spread new ideas throughout an organization, ideas that might lead to product and service innovations, as well as operational efficiencies.

Employees will always value compensation and benefits. But it doesn't all boil down to money. Many of the more talented employees might be lured to another company where they will feel they are making an impact on the business or find more opportunity for movement and growth.

Sensitivity to employee needs and expectations deserves at least as much attention as investment in a new technology. As one of our respondents noted, “It is a mistake when people management is less important than managing technology.” As new generations move into the workforce, they are expecting this as a standard, not a nice-to-have.

Diversity & inclusion

Our latest research confirms that most companies care about workplace diversity and inclusion (D&I), but D&I implementation and execution varies widely. The very definition of D&I differs from company to company and among countries. We find that, for many TMT companies, workforce diversity and inclusion are blind spots.

At the risk of overstatement, we find that U.S. companies too often apply simple metrics to measure the success of D&I programs. The thinking goes like this: “About half of our workers are women, and we have 20% minority employees. So, we’re done.” Companies in Europe and Asia are less likely to apply specific metrics. They often take less formal steps, such as encouraging hiring managers to have an open mind about diversity and inclusion.

We offer extremes to illustrate a point: Neither approach guarantees the operational and financial benefits and competitive advantage of a genuinely diverse workforce.

“Leaders should focus on the business results of diversity and inclusion rather than see it as a moral thing or something that amounts to window dressing,” noted one TMT executive. “Diversity gives better business results. It’s that simple.”

There are many TMT standouts in the D&I space. For example, Microsoft puts its full corporate backing into a vigorous D&I program. Microsoft reports modest, but steady progress while leaving no doubt about its D&I commitment in the company’s [Global Diversity & Inclusion Report 2020](#).

SAP, a leading software company, started its Autism at Work program in 2013 as one way to foster innovation by lowering barriers of workforce entry for a qualified but often overlooked skill base. (WTW Insight: [SAP’s](#)

[Autism at Work program](#) leverages the unique abilities and perspectives of people on the autism spectrum to foster innovation.)

Unfortunately, too many TMT companies - and technology companies, in particular - allow a ‘bro culture’ that many women and minorities find uncomfortable. We’ve seen this culture up close and find that “tech bros” are oddly limited by their strong ideas and a preference for working with people who share similar views and prejudices. There is a correlation, to our thinking, between a lack of gender or racial diversity and a lack of innovative ideas.

WTW has [described D&I this way](#):

- Innovation doesn’t happen in a silo. If inputs are limited, then outcomes are also limited.
- To solve critical problems, we need to foster an inclusive culture that encourages diversity of thought, ensuring visibility for ideas and innovation on a global scale when faced with global challenges.
- An inclusive culture is achieved when all colleagues have the chance to contribute.



“Diversity of opinions really helps to improve basic operations and efficiency,” a member of our TMT advisory group noted. “Different perspectives bring together different ideas. The worst thing a company can do is to have the same people with the same background coming to the same answers each time. This creates a flywheel effect.”

There are, to be sure, reputational benefits to be gained from a D&I commitment. Some companies leverage forms of diversity to define the brand. For example, Verizon has made a substantive commitment to equality and social justice. Apple has taken a strong public stand for the U.S. immigration program known as Deferred Action for Childhood Arrivals, or DACA.

While D&I is not a “metrics only” program, some metrics are highly illustrative. Women remain underrepresented in most technology jobs at TMT companies. One estimate puts female workforce participation at only about 25% of technology positions. A Disney-type CODE: Rosie program is one way to deal with the disparity and gain the business advantages of diversity.

As the TMT sector embraces the advantages of D&I, they should also consider the broader landscape and direction of travel. Many of these issues cannot be dealt with in isolation and considering D&I as part of the ESG strategies will be an important step to ensure ongoing commercial success.



Digitalization and technological advances

Long before the COVID-19 pandemic, TMT executives had learned to expect disruptive digital and technological change. Now they sense that disruptive change – and related risk and uncertainty – will intensify with the growth of artificial intelligence, 5G, the Internet of Things, and other innovations.

To prepare their companies for the next wave, business leaders are shaping more resilient, enterprise-wide cyber cultures. TMT executives say they can mitigate digital and innovation risks by instilling cultural values that welcome and leverage change. This is something we have seen ourselves through our work around cybersecurity-focused organizational and cultural transformation. (WTW Insight: [Cybersecurity organizational and cultural transformation.](#))

More robust data analytics can help companies better assess their own risks and shape optimal insurance and risk financing

strategies for themselves as well as with third parties and other business partners. Contractors and other outside business partners need to be held to the same high risk management standards that a company would apply to itself.

For their part, insurers are using data, including client data, to provide rates that reflect a company's risk profile rather than a broader industry grouping. For companies that have an effective risk management program, this opens the door to more cost-effective insurance and risk management programs. (WTW Insight: [How data can inform risk decision making.](#))

Talent and workforce issues surface throughout the exposures linked to digitalization and technological advances. Organic or in-house talent is being developed and nurtured at many companies with upskilling programs such as courses or workshops for employees. In the most



effective settings, these programs are combined with broader efforts to build employee satisfaction and create new routes to career development.

A good example can be found in the AT&T University and the AT&T Aspire programs, employee development efforts that support AT&T's position as a diversified provider of high-speed connectivity, software-based entertainment, premium content, and tailored advertising.

(This topic is discussed at greater length in the [Global Talent & Skills Race](#) section.)

A confusing mix of data protection and privacy laws is likely to challenge TMT companies for years to come, especially as financial penalties and sanctions toughen. But related risks and uncertainty may be tempered if European GDPR standards, continuing to inspire regulators globally, become a de facto global standard.

Technology, media, and telecom companies should expect a rough ride if they are perceived to engage in anti-competitive practices, either in terms of market dominance (a bigger problem for technology companies) or mergers and acquisitions that might be seen as anti-competitive or against consumer interests.

Meanwhile, all TMT companies need to be alert to environmental, social and governance (ESG) issues with regulatory and legal implications highlighted in the earlier trends. In combination, how TMT companies handle these issues will have a profound impact on corporate brands and reputations, according to TMT executives. (ESG's impact on the TMT industry, particularly from climate change, will be examined in a separate WTW study.)

Reputational risk is in some ways harder to measure and harder to define. It can come from any direction. Consumers, supported by regulators, are rightly concerned about how

their data is gathered and used, and sloppy data protection and privacy practices can cause serious long-term damage to an image – or a balance sheet. Regulatory regimes, such as for example GDPR, are expanding or being mirrored across the globe with heavy fines likely if there is a failure to comply. If a merger is seen as a move to jack up prices or limit consumer choice, the parties may pay a heavy cost both in terms of reputation and in dealing with new barriers to a transformational strategic shift.

There is at least one area of appetizing risk and opportunity that is seen through a haze of uncertainty shared by nearly every TMT company: Finding ways to further monetize the huge mounds of data collected in the course of normal business operations through relationships with customers and business partners.

The financial stakes are high. A 2021 [Accenture global study](#) found that digital adoption – defined to include artificial intelligence and data analytics – could release more than \$5 trillion in profitable growth. The professional services company said that “future-ready” organizations are more than 10 times as likely to use analytics at scale with diverse data sets to yield actionable insights and inform decision-making.

While corporate performance and profitability is top of mind for all TMT companies, it was more likely to be cited as a concern among telecom executives. The pace of change requires ongoing and growing investments in digital transformation and technology. A good example is the transition from 3G to 4G to 5G broadband networks. Each generational shift has demanded new investment.

[PwC's Strategy&](#), a strategy consulting team, has estimated that TMT companies will be investing billions to build up equipment, network density and spectrum. But Strategy& notes that monetization of a large-scale

investment proved to be a problem in 4G's wake. After 4G's 2012 introduction, for example, conventional telephone services plummeted, driving industry diversification and the application of new business models.

The growth of 5G looks to be much more disruptive than 4G, but TMT companies may have little choice but to make heavy 5G investments to remain competitive. Business models will no doubt change again with 5G and widespread use of artificial intelligence, the internet of things (IoT) and other developments that are likely to accelerate.

Some telecoms plan to better understand and to mitigate 5G risks by rigorously modeling various technical and business scenarios, including the identification of new revenue sources.

To a great degree, the ability to adjust to change and embrace innovation is influenced by the size of the company and the nature of its leadership. Bigger companies typically have greater financial and technological resources, but size may work against them for reasons that include:

- A large customer and shareholder base that may resist far-reaching strategic and operational change, slowing innovation.
- Corporate bureaucracies or siloed operations that resist change or thwart effective implementation.

TMT executives say they can mitigate the failure-to-innovate risk by instilling cultural values that welcome and leverage change. In the short term, organic options can include formation of small teams in which effective leaders have senior management support to plow through internal barriers to change. Other companies are finding that it's easier to acquire outside talent – a team, perhaps, or even talent through corporate mergers and acquisitions. Business partnerships can also boost innovation if accompanied with good system and process design.

Whether TMT companies have out-performed expectations or not, nearly all are finding that their business models and risk profiles have changed significantly amid the rush of technological change. Risk management must change, too. This is something we have seen ourselves through our work around cybersecurity focused organizational and cultural transformation. The section below is provided to provide further insight to this type of work.

In our work with TMT business leaders, there was one overarching theme: Without constant innovation, they fear being left behind by their TMT rivals or pushed aside by nimble, growth-hungry start-up companies backed by ample capital. They don't see innovation as simply improving existing products and services. They also look for innovations that might leapfrog existing products or services.

A classic example of innovation failure is a one-time market leader in cell phones that was pushed aside when it didn't anticipate the smartphone revolution. Post-mortems point to a culture that discouraged innovation, poor strategic planning, and what might be called a form of institutional lethargy.

“There are a lot of examples of companies that become obsolete by not anticipating or promptly reacting to technological change that threatens their existing business model,” one executive said. “We don't intend to be among them.”

Regulatory and legal risks

The uncertain direction of data protection and related privacy laws and regulations is among the top risk management issues that face technology, media and telecom companies, according to WTW research and interviews with TMT executives.

TMT business leaders also find themselves increasingly wary of regulatory and reputational risks associated with environmental, social and governance (ESG) criteria as well as fears of an unpredictable global political environment and changes to international trade agreements that may disrupt manufacturing patterns and even content development and distribution.

Most companies are making whatever technical accommodations are necessary to ensure that the gathering and use of data occur within legal and regulatory guidelines. At the same time, consumers are more attuned to privacy and data protection issues, fueling further regulation and consumer protection laws.

“It’s fair to ask what TMT businesses are doing wrong to be hit with so many financial penalties or face reputational damage related to data protection and privacy,” said Lay See Ong, divisional TMT director at WTW. “TMT companies need to do a better job anticipating regulatory developments and moving proactively to deal with them.” (WTW Insight: [Privacy: A Willis Towers Watson Perspective](#).)

A global data and privacy model is the European Union’s [General Data Protection Regulation](#) (GDPR). The EU is in the process of significantly expanding its body of regulations as it considers a new Digital Services Act and Digital Markets Act. The regulations, among other things, will carry the EU deeper into the realm of content moderation and add additional user safeguards.

Until recently, the U.S. has taken a comparatively relaxed approach at the national level with privacy laws covering identifiable individual financial or health data. California and other U.S. states have begun adding tougher legal and regulatory regimens with the threat of financial penalties.

Asian and Latin American countries are taking similar actions with emphasis on cross-border data flows and rising interest in establishing more consistent data and privacy standards across the region. The Asian Business Law Institute acknowledges that many companies find it difficult to follow local laws and regulations that change too frequently for translations to keep pace. Compliance risk is an obvious outcome.

Rising ESG-related risks can surface if regulators, investors and other stakeholders conclude that a company is falling short of ESG obligations that may range from workforce diversity to ethical outsourcing or carbon emissions. One area of exposure, for example, could involve the use of [forced or underaged labor](#) in supply chains. (WTW Insight: [The ESG Basis for Commercial Success](#).)

Reputational risks could be more costly than a regulator's heavy hand. Twitter, Facebook and other social media platforms can spread damaging information (accurate or not) at light speed. As one of our research participants noted, "Reputational risk is challenging to manage because it's not always fact-based."

Intellectual property infringement is another risk that isn't going away. In our latest research, IP infringement risks have expanded into two relatively new areas. The first is connected to the [remote working arrangements](#) that many companies adopted to help control the spread of the COVID-19 pandemic.

Improvised technical arrangements and isolated, often less-supervised workers can open the door to IP loss or theft. The larger problem of IP infringement, some TMT executives say, surfaces when companies find it necessary to work with third party organizations that might be infringing on IP rights for their own business objectives.

Mergers and acquisitions remain in favor with TMT companies that need to shift their business models or improve profitability. But antitrust concerns are increasingly common if a company is seen as squeezing out competition. In the United States, federal agencies and various states have targeted the tech companies with what the Wall Street Journal describes as "competition-focused probes".

Antitrust actions are not confined to the United States. The European Commission is taking a hard look at TMT M&A for any trace of anti-competitive behavior, as when it concluded in a 2020 "preliminary view" that Amazon might be using non-public business data of independent sellers "to the benefit of Amazon's own retail business." In China, the government launched an antitrust action against the Alibaba Group, among other actions.

WTW, in a recent [political risk survey](#), also finds political risks arising along with trade tensions.

“ When thinking about the ‘unknown’ risks, don’t just look at what’s regulated. Ask yourself, ‘What could be regulated?’ Especially in an M&A situation, you have to consider what’s on the horizon of regulation. ”

Sara Benolken,

WTW Global TMT Industry Leader.



Operational complexity and vulnerability

Asked to identify major exposures associated with operational complexity and vulnerability, TMT executives identified four broad risk categories:

- Operational continuity, including supply chain shocks.
- Rise of pandemic-related virtual operations.
- Cyberattacks, data privacy and related operational security.
- Workforce wellbeing and flexibility of work styles.

For many TMT executives, operational continuity risks are increasingly seen connected with supply chain disruption and related geopolitical friction, particularly on the hardware and semiconductor side of the industry. They point out that their supply chains are complex webs to start with. It doesn't help to see growing resistance to free trade agreements. They also see geopolitical risk as a long-term exposure as countries jostle for competitive advantage.

Trade disputes also have revealed an overconcentration of suppliers – and even customers -- adding to the checklist of TMT action steps. Excessive dependence of technology companies on a single country's manufacturing facilities was brought into sharp focus by recent trade conflicts as well as security concerns raised around the possibility of intellectual property theft or even fear of government-backed spying.

Supply chain concentration is a factor in the thinking about globalization versus localization. Several TMT executives with whom we spoke noted that it's tricky to strike a balance: Globalization with supply chain concentration had significant cost-and-delivery advantages, but trade stresses are prompting many companies to think about looking at alternative solutions, including bringing production closer to home.

The MIT Sloan Management Review, in a Summer 2020 article, asked, "[Is It Time to Rethink Globalized Supply Chains?](#)" The author, Willy Shih, a professor at Harvard Business School, wrote, "For many companies, the combination of lean production and global multistage supply networks is leading to crises. This should be a wake-up call for managers who need to understand their supply chain's strategic vulnerabilities."

"Procurement teams and risk management need to work jointly to better identify and mitigate supply chain risks," according to Frederic Lucas, WTW Regional TMT Industry Leader, Western Europe. "Procurement naturally will focus on costs and efficiencies, while the risk manager would think about location, third party risk, and so on. It's vital to get the risk manager involved."

There also is a disturbing lack of supply chain visibility, as one executive told us. Some supply chain managers have no clear idea of the full range of suppliers and sub-contractors, much less the risks that might be found in a big supply chain network.

“Supply chains are complicated and changing them isn't easy,” he said. “You have to start with improving supply chain visibility. If you can see it, you can get your hands on it. If you get your hands on it, you can better manage it and mitigate the risks.”

Politics aside, TMT executives say they intend to concentrate on supply chain resiliency and the need for what a 2020 IDC survey describes as a general “lack of digital competencies” at a time when virtual operations have become standard.

TMT executives interviewed for our 2021 study also say that operational risks are rising as cybercriminals adjust tactics to exploit pandemic-related vulnerabilities. For example, with so many people working at home, cybercriminals have stepped up phishing attacks. This technique relies on, say, bogus emails with attachments that, when opened, can introduce ransomware into a company network.

Research sponsored by [Baker McKenzie](#), a law firm, found that the threat of IT disruption “owes as much to insider threats from disgruntled employees – those on notice or paid leave who still have access to systems and controls, for instance, or sensitive data – as it does longstanding worries over outages and overloads.” (See the [Global talent & skills race](#) megatrend.)

Early last year, in the first stages of the pandemic, COVID-19-related cyberattacks had already ensnared nearly half of the companies in a [Tenable Inc. survey](#) of more than 800 business and security executives. Alarming, about 75% of the respondents said that business and related security efforts were not fully aligned.

“Our financial investment in raising technology barriers against cyberattacks will be wasted if our employees aren't alert to phishing and other security threats,” noted one executive. “This is hard to achieve when so many of us are working in remote locations and, our network is already stressed by the workforce fragmentation that we're seeing with COVID-19.”

One lesson learned among many TMT executives is that technology leaders must embed cybersecurity and privacy processes into business and technology initiatives from the start.

The importance of a strong cyber culture is also being recognized as key. (WTW Insight: Cybersecurity organizational & cultural transformation.)

To underline the point, a 2020 WTW [Cyber Claims Analysis Report](#) found “high average severity” of business disruption events related to data breaches. Together with ransomware events, the report noted, both types of losses can severely affect productivity and “end up being very costly.”



Observations and next steps

Finance executives, risk managers and other TMT business leaders have learned much from today's complicated risk landscape, but they are left now to brace for emerging risks that will include, perhaps above all, the global implications of climate change.

Climate change, in our view, will profoundly reshape each of the five risk megatrends that we have examined in this report, from risks surrounding business models and geopolitical uncertainty to more exacting regulations, technological advancements and talent.

(For a detailed discussion of climate change risk, see WTW's ["Why climate change is a particularly challenging risk for strategic CROs."](#))

Climate change is not the only risk that will spill over each megatrend. For one thing, our work with TMT business leaders confirms that the global talent and skills race sends a similar jolt across other risks. It's clearly not enough to have digital wizards on staff when talent also is needed for developing an effective business model or strategy, or even meeting ESG criteria.

The organizations that will succeed tomorrow must ensure the development of resilient operations and workplace cultures. They must ensure that employees keep pace with the evolving workplace (which in many cases will become a [hybrid home-and-office arrangement](#)), adopt new technology and processes, update their skills and competencies and stay engaged and productive.

COVID-19 and its disruptive impact on business will accelerate corporate resilience

efforts. Although the idea of resilience has been kicked around corporate offices for years, the virus has added a greater sense of urgency. We therefore expect to see new efforts by TMT companies, many of which are already leaders in their field, to continue to build genuine resilience into business strategies and operations in 2021 and beyond.

From a risk management perspective, it will be more important for insurance and other risk financing decisions to flow from a risk management program that begins with a clear understanding of a company's risk tolerance and appetite. This will require unprecedented use of data. Although data is "king" in a heavily digitalized business, TMT data savvy often falls short when applied to risk management, beginning with defining risk tolerance.

This was a lesson learned by some companies in early stages of the pandemic; imagine when climate change engulfs the global economy from many more directions with even greater intensity on operations and assets, including the workforce.

More effective data mining and analytics will enable companies to build a model for the total cost of risk. This involves identifying exposures and risks while modeling the loss frequency, severity, and volatility of each. Risk modeling outputs can then be examined within the context of risk appetite, cost of capital and the cost of transferring risk. This way you define the optimum balance between risk retained on the balance sheet or captive and risk transferred to insurance or capital markets. TMT companies will need to continue

to re-examine their risk finance strategies with the aim to create savings in total cost of risk, with dual renewal and risk financing strategies. What constitutes “material” risk must include also include any new risks emerging from the current risk landscape.

In our experience, senior company management must assert responsibility for the development, communication, monitoring and updating of the risk appetite framework and risk mitigation within an enterprise business context that brings together risk, financial and technology leadership.

Hardening insurance market conditions are going to continue in major lines of coverage. Organizations should prepare by detecting, analyzing, and managing both existing and emerging risks by using all the necessary analytical and advisory tools. Alternative risk transfer solutions and captive insurance

strategies will no longer be a luxury but, under certain risk circumstances, a necessity.

Every organization purchases insurance for a particular reason, or as part of a particular strategy. Consequently, each insurance policy should be evaluated based on its own merits within an enterprise context that supports your current business strategy and protects stakeholders from income statement and balance sheet shocks.

Underwriting discipline is back with a vengeance, and it is a trend that will likely continue for the foreseeable future. Insurers increasingly will pay close attention to the nature and quality of each risk as hard market conditions continue. More scrutiny will be on businesses to show, for example, that engineering recommendations are being satisfied, and that they are supplementing the loss control recommendations that insurance companies put forth.

In this environment, companies will need to step up efforts to better collect and interpret data around risk exposures and loss experiences. These actions should include data-mining solutions that will enable risk managers and their advisors to identify, prioritize and manage exposures that may have material impact on operations and revenues. Insureds will have to demonstrate that they are a compelling risk and that they have proactive risk management in place.

As recent events have demonstrated, no risk can be considered in isolation. The pandemic increased geopolitical tensions, climate change and other developments have highlighted the need to future proof the corporate infrastructure against risk extremes.

New challenges and risks will unfold as the world emerges from the worst COVID-19. If not managed correctly, these exposures will threaten the very resilience and long-term profitability of the business.







Organizational Resilience



Organizational Resilience

Catastrophic risks are increasing in multiple dimensions, e.g. correlated climate change induced losses from natural catastrophes, technological change resulting in potential industry-wide capital stranding or resource/supply chain pressures, and externalities of globalization, including biodiversity loss, wars, pandemics, and related systemic shifts. It is now clear that we will have to face a continuous adaptation to the extremes in the years to come. We must all prepare, both society, organizations and individuals, and mitigate efficiently the risk we face.

Organizational resilience is a strategic choice that will give a competitive advantage when needed, yet, the effect and advantage depend on the efficiency of the actions taken. As complexity increases and adjustments to the future are required, it is essential to increase organizations' ability to understand uncertainty, foresee risk to allow a continued adaptation to the risk landscape as well as maintain a necessary focus on cost allocation. Consequently, risk quantification is key if prioritization of actions is to be based on facts and allow investments in resilience to be efficient yet effective to ensure the required adaptation to risks and continued development of the commercial interest of the organization.

The Organizational Resilience hub continues to support and foster a broader understanding of risk quantification and quantified understanding of risk mitigation. With the help of our WTW Research Network partners, we develop research focused on risk quantification, insurance policies, loss prevention, and applications that may enable preliminary and early detection of risks.

The research themes in 2022 are:

- Rethinking insurance as the next generation resilience
- Supply chain risk quantification
- Artificial intelligence and insurance risk estimation
- Application of knowledge management and expert systems to support risk assessment

We are proud to work with some of the best scientists around the world to create multiperil research projects on risk mitigation. The aim is to increase understanding of how society and individuals most efficiently mitigate their risk in the future. In the following chapter, we illustrate the most relevant achievements of the past year and we are already now looking forward to presenting an existing pipeline of new project next year in 2022.

Simon Sølvssten

Head of Organizational Resilience Research



Modeling exposure in commercial property insurance

To ensure correct and efficient calculation of insurance coverage, correct estimation of risk exposure is important for both insurers and policyholders. However, exposure is versatile, difficult to quantify, and is often subject to individual and subjective assessment. A variety of methods and practices are currently used within the insurance industry, and it is found challenging for the industry to agree on which models to use. The challenge of finding a uniform way to calculate exposure begins with the definitions and guidelines for models and methods themselves. There is no common standard in the insurance industry as a whole; thus, the industry uses a whole spectrum of definitions and methods to determine expected loss potentials.

The magnitude of consequences following inaccurate calculations can be severe; yet, property risk estimation is still, to a high degree, influenced by subjectivity and lack of standardization. As the insurance industry begins to introduce new and more objective methods, there is a need to identify the gaps in existing models and methods to provide a clear understanding of what is needed to be strengthened.

With a growing need for more objective methods to estimate financial exposure, this project seeks to clearly identify the challenges with current models used for estimation of exposure with the aspiration of understanding the variation to provide guidance for future research that may improve and automate property risk exposure and development of new methods.

The project consists of in-depth literature review focusing on fire risk exposure and the use of estimation of Catastrophe Loss, Maximum Possible Loss, Possible Maximum Loss, Maximum Amount Subject, Maximum Credible Loss, Probable Maximum Loss, Estimated Maximum Loss, Maximum Foreseeable Loss and Normal Loss Expectancy.

The project will be concluded at the beginning of 2022. Following a public available insight piece on the global webpage, WTW Research Network will host a webinar presenting the finding and allow colleagues and clients in-depth access to the research team and give participants the possibility to ask questions directly.



The University of Southern Denmark works purposefully to create dialogue between the

university's researchers and the surrounding society. The answers to societal challenges are often found in the interaction between highly specialized academic environments. When these environments collaborate, perspectives are expanded, and new insights emerge. The University of Southern Denmark welcomed the first students onto its campus in September 1966. It now has five faculties with more than 32,000 students, almost 20% of whom are from abroad, and more than 4,000 employees distributed across its campuses in Odense, Slagelse, Kolding, Esbjerg and Sønderborg. Several international studies document that SDU conducts world-class research and is one of the top 50 young universities in the world.

The use of AI to automate estimation of exposure in commercial property insurance

AI image analysis is increasingly be applied in a variety of insurance applications, for example for rapid claims assessment following natural catastrophes. Other forms of AI, for example natural language processing, are also being used to reduce manual processing in other insurance applications, such as fraud prevention and regulatory compliance.

Assessment of property risks and property damage scenario estimation still absorbs substantial amounts of time from experienced risk professionals. The question therefore arises to what extent some of the more routine aspects of their responsibilities could be automated, allowing them to focus on higher value-added tasks. Specifically, much of the standard information for risk-profiling and damage assessment is taken from building blueprints.

The project aims to understand what the potential for applying AI technologies to building blueprints is in order to automate the assessment of exposure and vulnerability in property insurance. Thus, the research project seek to understand to what extent it is realistic, with currently available AI technologies, to automate the processing of blueprints by risk professionals; and what further research and development will be required for developing this application first as proof of concept and then in subsequent commercial application.

The research is made with a combination of desk review and interviews/ focus group discussions to understand the requirements for such an application of AI to work in practice, propose the requirement modeling for AI-aided insurance risk assessment, and finally examine the potential and applicability of AI technologies to satisfy such requirements.



*School of Business and Economics,
Loughborough University*

Loughborough University is proud of its long history as an institution of further and higher education. Thanks to the vision of its founding father, Dr. Herbert Schofield, it has been able to grow and develop into one of the country's top universities. Today it is one of the country's leading universities, with a reputation for excellence in teaching and research, strong links with business and industry and unrivaled sporting achievement. Research is at the very heart of the school, which is committed to leading the way in advancing knowledge across the full range of business disciplines. The research centers and interest groups provide clusters of expertise recognized internationally for the quality of their research.



A person wearing a white protective suit is seen from behind, looking out a large window. The window reflects the city skyline, including a prominent tower and construction cranes. The scene is bathed in a warm, golden light, suggesting sunrise or sunset. A black rectangular box is overlaid on the image, containing the text "Emerging Risks".

Emerging Risks



Emerging Risks

The pandemic has shone a light on the variety of existing societal pressures and exacerbated many of the tensions inherent in the current economic system, including income, generational, racial and other forms of inequality. These tensions create long-term risks to business, consumers and wider society, by changing customer bases, longevity, insurability, access to finance, and increasing the numbers of those most vulnerable to protection gap issues. This increased volatility challenges all aspects of our global economy and society, highlighting the imperative to expand traditional risk management to address classes of risks that are increasingly relevant, but lack comprehensive solutions that address risk mitigation, incident response and compensation for loss.

Reviewing emerging risks and being future ready is about more than maintaining a risk register, or scoring acceleration, impact and severity. Our research themes in the Emerging Risks hub link closely with the work underway across the wider WTW Research Network portfolio, but they all focus on core topics that support resilience building – identifying the change, dealing with uncertainty, and taking into account the interconnected interplay of risks, themes and global trends.

Today, future-seeking leaders accept that risk has become a mainstream element of business and likely will remain so for the balance of their careers. The frequency and simultaneous occurrence of high-impact risks require both enhanced day-to-day management and agile planning for a “portfolio” of risks, supporting a culture of adaptability to incorporate new information that arrives daily or hourly, and being ready to act decisively when events happen.

Over the last year the Emerging Risks hub has been supporting clients with their emerging risk frameworks; offering a challenge perspective that brings stakeholders together to discuss risks and their interconnections. The ability to drill down into different risks offers an ideal opportunity to challenge your processes, ask questions, and ensure emerging risk thinking is not just a list-based or ‘one and done’ process. For example, Pandemic Flu was at the top of the UK National Risk Register, however this did not mean that the country was well-prepared. Registers have their place but to help decision-making engaging storylines are more effective and this new risk map could form the basis to consider interconnected and multi-risk scenarios.

Our partnership with the Cambridge Centre for Risk Studies at the Judge Business School, University of Cambridge continues to explore the application of their rigorous scenario framework to a wide range of principal and emerging risks to businesses, with a particular focus on resilience with our Airport Risk Community and Ports and Terminals Forum. We are also continuing to build on our partnership with the Mack Institute for Innovation Management to explore the emerging issues raised in our Futures report for the Technology, Media, and Telecommunications industry.

Other areas of research continue to be explored over 2022 including the complexity of global supply chains, industry focused dives into emerging risks, and the role of warning research for future pandemics.

Lucy Stanbrough

Head of Emerging Risks and
Business Engagement



Emerging risks survey: putting uncertainty under the microscope

Climate change, Cyber risks / Cyber business interruption, and Antimicrobial resistance are the top three emerging risks that are most underappreciated and in need of greater understanding. Run as part of our WTW Research Network 15 year anniversary conference, the survey saw 144 insurance and corporate executives, academic researchers and policy makers take part – providing a snap-shot of views on the emerging risks on their radars.

If the recent past has done anything it has emphasized the need to reconsider the risk landscape and look with fresh eyes at our never normal. This is especially important as there is no shortage of risks where planning may be out of date for our current society, impacts are not fully recognized, or potential for threats compounding each other.

This thinking provided the backdrop for the survey – to draw down into those knowns and unknowns, gauge uncertainty and provide a starting point on thinking about interconnectivity. This has been a key driver of activity from the Emerging Risks hub over the last year.

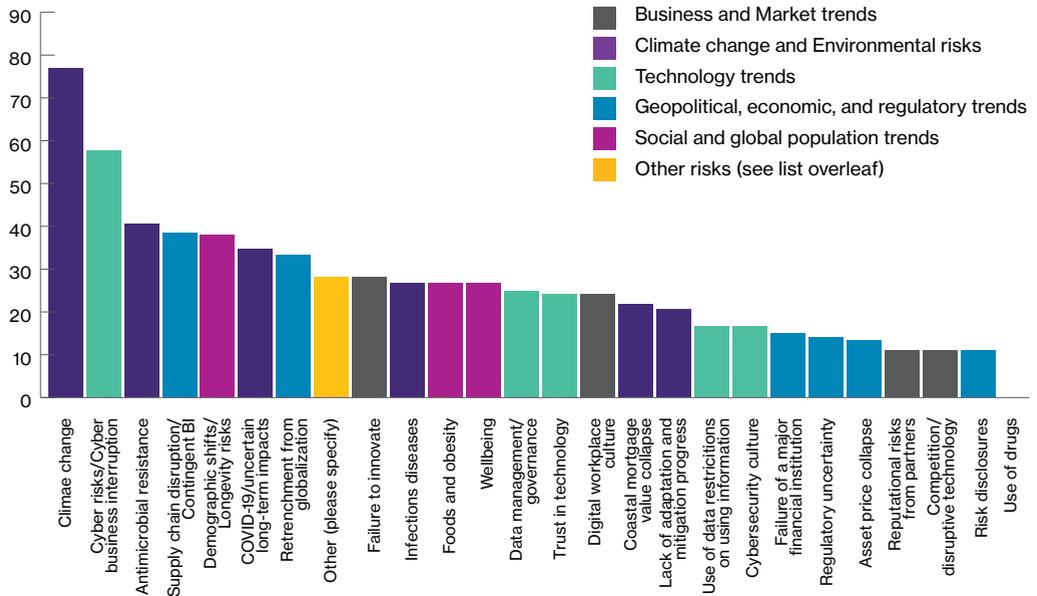
Which 5 emerging risks do you believe are most underappreciated, and in need of greater understanding?

Here we asked participants not for their top emerging risks, but where they felt risks might be under appreciated and in need of greater understanding. Highlighting areas of uncertainty is the first step towards reducing it and deciding what to do next. Should risks remain on a watch list? Is a new scenario needed, or do you engage with new partners or experts to raise awareness? Are we tapping into the right teams around the organization? If you're having a conversation around people driven risk, are your talent and reward teams in the room?

Out of 672 risk votes Climate Change was the most underappreciated risk, followed by a range of risks across the five categories (Climate change & environmental risks, Technology trends, Geopolitical, economic and regulatory trends, Social and global population trends, and Business and market trends):

1. Climate change (78)
2. Cyber risks/Cyber business interruption (58)
3. Antimicrobial resistance (41)
4. Supply chain disruption / Contingent BI (39)
5. Demographic shifts / Longevity risks (38)
6. COVID-19 / Uncertain long-term impacts (35)
7. Retrenchment from globalization (33)
8. Other risks, Failure to innovate (28)
9. Food and obesity, Infectious diseases, Wellbeing (27)
10. Data management / Governance (25)

While climate change it is now well recognized as a risk and subject to increasing reporting,

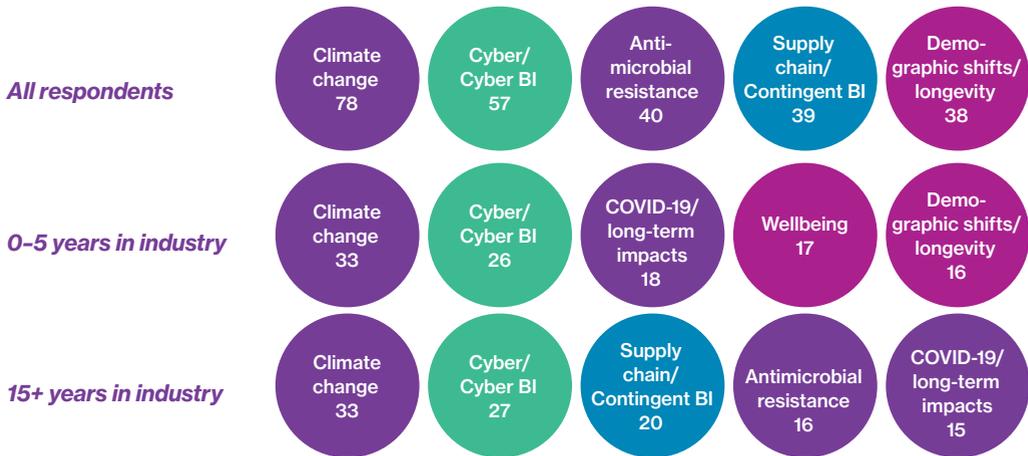


many others are at different points in their journey and these results highlight the need to keep sharing knowledge and advancing science to level up understanding. This will be increasingly important as more countries bring forward mandatory climate reporting, and boards are challenged to explain how their strategy supports a sustainable world.

The results also highlights the COVID-19 effect of increasing recognition around issues such as antimicrobial resistance and longevity, which as flagged by Metabiota in our [October 2020 webinar](#), and the need to maintain curiosity and action beyond this news cycle.

Just before the COVID-19 pandemic hit, our [WTW survey of risks that insurers](#) perceived as the most dangerous to their business were led by cybercrime and the effects of disruptive technology. Those won't have dissipated, but they are likely to have been joined and indeed colored by the lessons we've learned and are still learning from the impacts of the pandemic on public health, economies, ways of working and buying patterns.

While climate and cyber were consistently the most underappreciated risks across all time spent in industry, the other risks in the top 5 varied, with social risks making up half of the top six risks for those newest industry, and supply chain of more concern to those longest in their posts.



Respondents were also able to put forwards “other” risks, and here only one respondent said it was the interconnections risks they were most uncertain of. This list provides a set of risks to consider and challenge yourself with.

How many of these are on your risk register, and if not, has a decision been made around why – or does the question need to be asked? Could a process like red teaming help with risk maturity? Red teaming is the practice of rigorously challenging plans, policies, systems

The interconnected nature of many risks and their systemic implications

Climate change and environmental risks	Social and global population, trends	Geopolitical, economic and regulatory trends	Technology trends
<p>1. Climate risks</p> <ul style="list-style-type: none"> ▪ Breakdown of the global conveyor belt ▪ Collapse of entire, multiple ecosystems ▪ Biodiversity collapse <ul style="list-style-type: none"> ▪ Soil degradation, pollinator extinction, etc. ▪ Threats to eco-system services ▪ Infusion of natural catastrophe losses arising from human factors <p>2. Space weather</p>	<p>1. Generational shifts</p> <ul style="list-style-type: none"> ▪ Cultural movements i.e. protests for BLM, climate change, anti-lockdown, farming rights, political activists ▪ ‘Culture wars’ caused by political shifts ▪ Generational wealth disparity ▪ Socio-political unrest from fed-up young people <p>2. Mental health</p>	<p>1. Political risk</p> <ul style="list-style-type: none"> ▪ Collapse in democratic structures, frameworks and institutions ▪ Failure of politics through inappropriate individuals in power ▪ Inequality-driven social unrest ▪ Security ▪ War (China/Russia) ▪ US/China tensions <p>2. Financial risks</p> <ul style="list-style-type: none"> ▪ Central bank collapse ▪ Social inflation ▪ Inflation ▪ Under-pricing and externalization of risk in the financial system 	<p>1. Crypto-currency impact on Flat Currency</p> <p>2. Space debris/orbital sustainability</p> <p>3. Trust in government and media</p> <p>4. Fragmentation of the internet</p> <p>5. Cyber</p> <p>6. Machine Learning/AI Governance failures</p> <p>7. Reinforced autoclaved aerated concrete (RAAC) collapse</p>

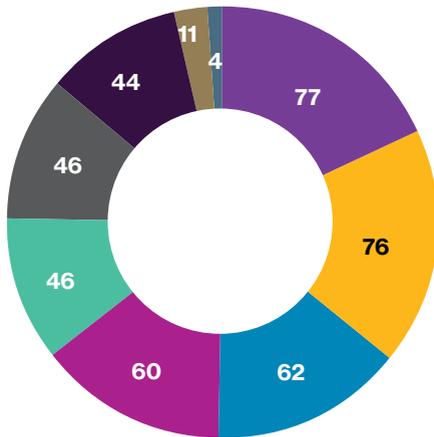
and assumptions by adopting an adversarial approach. This challenge process has been seen in organizations such as insurers like Beazley Group and luxury brands like Gucci as they make use of initiatives like shadow boards¹, or find new ways to tap into wider pools knowledge – something we've been helping our clients do with the WTW Research Network network – to use science for resilience.

What top 3 business and market drivers have the greatest impact on the ability to manage emerging risks?

Yet risks are just one part of the puzzle. As organizations and members of markets and sectors we often experience drivers that impact our ability to manage them. Here respondents highlighted the barriers – perceived or real – that are getting in the way. There's no one silver bullet or target to aim at. Disruptive technology, human factors, culture, and data management are all factors.

¹ https://finance.yahoo.com/news/companyneeds-shadow-board-young-133005280.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ-29vZ2xiLmNvbS8&guce_referrer_sig=AQAAADKCx-5MHUnAqVknSI92HmAC0I4LveDqj-ar0zaUKF7WFsl241Py6XK-lwWvd2HIWsRU1_gcyoQ3-PVM9FJVDoVHqZcaT4Mqd_G1Tp0FSQD2UTnepjQPT_Fxyox7fFKVX-4Kg-WrRufXrgQX-yumGR8MZSYEAWQyVtlmvC9X3TszP9





- Lack of adaptation and mitigation progress
- Diversity of thought
- Poor understanding of resilience culture
- Failure to innovate
- Data management/governance
- Changing talent and skills
- Competition/disruptive technology
- Other (please specify)
- Reputational risks from Partners

Also, from our 'others' category we can see there's a whole series of issues acting as barriers, from a lack of time due to busy business-as-usual activities, to a lack of incentive to act ahead of the market:

- Challenging BAU / Everyone is too busy: focus on their day job
- Externalization of risk in all financial transactions (IFRS, IAS, credit reserves, ratings, etc.)
- Fear of failure, underlies risks like failure to innovate
- Lack of incentive to act ahead of the market
- Open data and standards
- Operational processes around risk mitigation
- Regulatory uncertainty
- Credibility of the process at the senior management/board level
- Lack of experience / empirical evidence constrains business case for investing in research / mitigation / resilience
- Short-termism, too much focus on single year time horizons, weak incentives for long-term value creation / risk management.
- Businesses being judged on a quarterly basis are circumventing this outlook and much needed funding in areas which will not give an immediate return

These factors will need to be challenged and are being explored in our work with the National Preparedness Commission (NPC), the aim of which is to promote better preparedness for a major crisis or incident. The NPC's program of work is intended to be both strategic, (recognizing that what is needed to be better prepared for many shocks is the same whatever the initiating crisis or incident), and practical to encourage comprehensive actions so as to get away from merely "admiring the problem". It will look holistically at what needs to be done to improve societal preparedness and national resilience.

Choose up to 3 combinations of risk pairs where respondents feel there is the potential for unexplored but significant consequences.

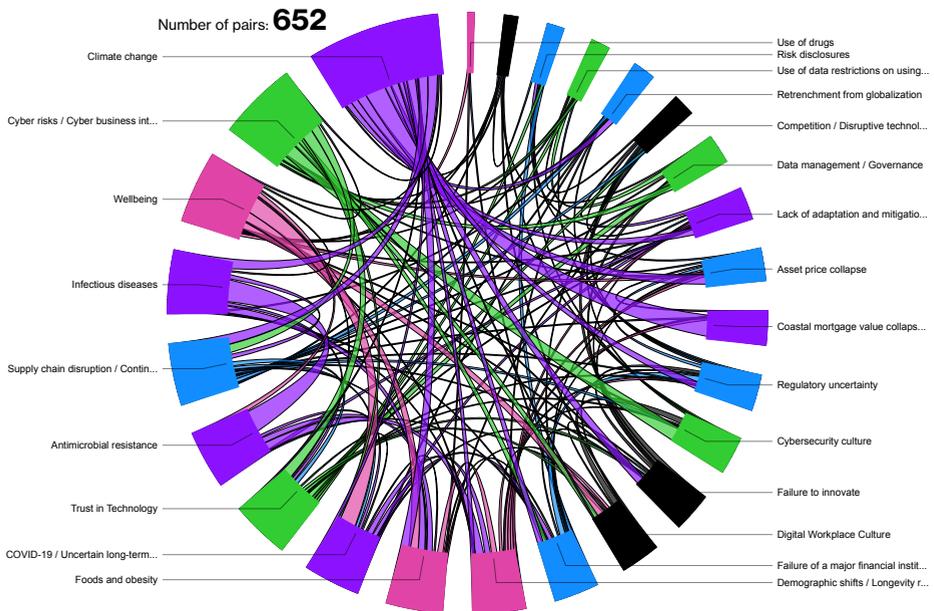
The final survey question looked at the interconnections between risks and levers explored in the first part of the survey. Risks don't happen in isolation and more needs to be done to surface these connections, raise awareness, and identify further modeling and research needed to fill knowledge gaps.

652 connection points were put forwards with no categories lacking connections. This new way to explore risks – created by the Emerging Risks hub – and provides a starting point for those who raised the uncertainty around specific risks to find and challenge connections to explore consequences. This holistic view will be increasingly important for many industries looking to build forwards from the pandemic, so that when investments are made, they consider wider risks and reduce the potential of solving one problem and making others worse.

There are also deeper stats within this view that are valuable to consider. The trap is often to focus on those risks found at the top of lists. If we look again, not at the counts but the diversity of risk connections (how many other risks it is connected to) the top 4 looks different:

- 17: Climate change has connections to 17 of our other risks
- 16: Wellbeing, Supply chain disruption / Contingent BI, Trust in Technology 16

This is why it is essential to challenge your processes, ask questions, and ensure emerging risk thinking is not just a list-based process, and a one and done.



Over the last year we have been supporting clients test this by providing a challenge perspective to their emerging risk frameworks to develop strategies and models that enable them to take advantage of market opportunities. Our process of bringing risks and stakeholders together – from across their organization and our WTW centers of excellence – to discuss impacts and interconnections, is designed to stress test thinking.

Pandemic flu was at the top of the UK risk register, however it didn't mean that the country was well-prepared. Registers have their place but to help decision-making engaging storylines are more effective and this new risk map could form the basis to consider multi-risk scenarios.

This is something we have been exploring and welcome discussion on. Businesses need to be ready for multiple scenarios and be flexible when the exact situation doesn't unfold as scripted or risks have fallen between the cracks of formal risk registers. Some of those are called "grey rhinos" (a cross between elephant in the room and black swan): you see them, but you're not sure how to tackle them, as they weave together lots of issues. If you missed the conference session, our panel walked through two rich narrative scenarios

that considered workforces of the future and critical infrastructure dependencies. These scenarios formed the basis of discussion between panel members representing key perspectives to highlight risks, opportunities, and how science can be used to support awareness and understanding.

Recording to be found [here](#).

In 2022 we will be taking deeper dives into some of the risks, uncertainties and connections raised through the survey. For example, only 7/144 respondents highlighted reputational risks from partners an area of uncertainty and yet findings from our [Global Reputational Risk Management Survey Report](#), saw almost 80% of the risk managers and executives we spoke to felt the focus on reputational risk in their business would only increase in the coming five years. Is this an area where further work is needed to highlight the art of the possible?

The WTW Research Network will also be looking to repeat the survey across sectors to build wider insights into risks. If there is an aspect you would like considered, please reach out.



Into the metaverse: Emerging risks in the leisure and hospitality sectors

Leisure and hospitality industries have faced an extraordinary range of risks and uncertainty in recent years. Change driven by accelerating shifts in technology have been compounded by rising interest in sustainability, regulatory complexity, and a never-ending talent shortage. And of course, inevitably, COVID-19. Risk managers need to examine this changing environment with curiosity and fresh eyes, because while the risks we're facing in many cases aren't new, the landscape has shifted and continues to shake. Against this backdrop, it's often too easy to fall into the trap of focusing on the risks at the top of lists and minds and miss the related opportunities.

Companies must continuously innovate to stay ahead of the curve and manage risks effectively. Further change is brewing on the horizon and, as the last 18 months have shown us, acceleration can come at any time and force through changes many thought they would have a decade to plan for.

This article provides some context to the changes afoot before exploring three key trend areas for the industry, namely, technology and digitalization, talent and workforce, and sustainability. We then offer perspectives for businesses to consider as they plan for the future.

“Companies must continuously innovate to stay ahead of the curve and manage risks effectively.”

Kelvyn Sampson

GB Industry Lead – Retail and Leisure and Hospitality, WTW



Dish of the day: Change

Without a doubt, COVID-19 has been a major factor for the leisure and hospitality industry in the UK, with an estimated £220m of sales lost every day since April 2020 to March 2021¹. Yet change has been deeper than the headlines or balance sheets suggest. Business models have been tossed out the window due to operational complexity and vulnerabilities changing and taking new forms, and that's even before considering changes on the horizon from key megatrends and their components.

These major drivers for the industry include rapid innovation and the increased proliferation of technology, including digitalization of products and services, industrial and mobile technology solutions, demand for on-demand delivery, industry competition with new entrants disrupting traditional business models, and the expansion of connected infrastructure enabling virtual and digital transformation to name a few.

Looking forward: Potential implications for growth and resilience

At the heart of all of this is the desire to deliver a memorable customer experience. As a sector, operators are united by the fact their products are an experience and it is the ability of a company to successfully manage and deliver this experience that can determine its success.

Customers have new expectations, assets need to be re-evaluated, and sustainability is now a business essential, not a nice-to-have. These changes, paired with uncertainty over when the sector will reach pre-pandemic levels of sales, require businesses to look past COVID-19 and at more emerging risks and opportunities to ensure greater resilience in the future.

By understanding the key megatrends of technology and digitalization, talent and workforce, sustainability and their components, businesses operating in the leisure and hospitality sectors can start tailoring their strategies to remain competitive in an evolving world, moving from 'prepare for one', to 'prepare for all'.

Technology and digitalization

In an industry undergoing unprecedented change, it is unsurprising many of the trends impacting retailers are interlinked and underpinned by technology. The last year has changed business models and radically accelerated digital transformation as companies strive to serve homebound consumers with new products, such as home gym experiences, and as consumers accelerate their on-demand experiences, whether shopping, entertainment, or dining.

Hospitality business leaders have been focusing on accelerating technology adoption and transition to online service model. In 2021, 65% of UK hospitality business leaders have implemented or invested in app ordering systems, pay-by-phone (41%) and online booking systems (41%)². Examples of this include:

- Contactless guest experience: Global roll-out of 'Accor Key', a digital room key accessed via a guest's smartphone. As well as providing a seamless experience, the initiative also allows Accor to reduce the amount of plastic used for traditional key cards and cardboard holder.³
- Investing in experience: 2021 saw the acquisition of PlacePass by Hopper – one of the world's largest activity aggregators – into

1 <https://view.publitas.com/ukh/future-shock-9/page/3>

2 <https://cgastrategy.com/business-leaders-survey-2021/>

3 <https://group.accor.com/en/Actualites/2021/02/digital-key-solution>

their Hopper Cloud solution⁴. This marks Hopper's first entry into the experience business, and a key example of the trends of partnerships with proprietary tech developers to allow white-label portals for companies aspiring to sell travel with a differentiated consumer experience and offering.

Arguably, COVID-19 has accelerated the inevitable move to digitalization with an increased reliance on technology and this has further highlighted the need to embed these within business models. These have now become our new normal, but what might be next on the horizon?

The rise of the metaverse – a virtual 'white space' that acts as a blank canvass where people can interact with computer-generated environments, objects and scenarios, as well as other users⁵ – raises questions around the future of location, and how to subsequently deal with areas like regulation and compliance, travel security, and incident management if businesses need to plan for truly virtual worlds.

While Facebook CEO Mark Zuckerberg put the concept of the metaverse in the headlines earlier this year⁶, the concept has been around for some time. The use of metaverse features like virtual reality could provide customers with the ability to experience distant locations from the comfort of their own home, allow insurers to evaluate sites to gain comfort in risks and controls, and train staff against potential scenarios before they arrive for their first day. Tomorrow's winners are the

ones taking these changes very seriously, considering future technology and how it could be implemented and using it to multiple and integrated advantages.

Talent and workforce

A wicked nexus of COVID-19 plus Brexit has transformed the workplace with consequences affecting companies, employees, investors, and other stakeholders. From an operational perspective, the UK hospitality industry has lost more than 660,000 jobs over the pandemic and currently faces a shortfall of 188,000 workers, with the shortage of front-of-house staff and chefs being 'particularly acute'.⁷ There also a rising risk of skills gaps and skills fades in the hospitality industry. This is due to the large break many employees experienced as a result of lockdown keeping them away from day-to-day activities and training, paired with the change in the work environment on their return⁸.

The COVID-19 pandemic has accelerated a shift to new ways of working, prompting companies to reimagine how, where and by whom work gets done. This shift was already under way with the technological changes of the Fourth Industrial Revolution⁹, and businesses' responses need to be integrated across risk management and HR.

Inadequate or badly trained staff can contribute to operational vulnerabilities, regulatory and legal exposures, and even business model and strategy shortcomings. As companies look to reset for the new world

4 <https://media.hopper.com/news/hopper-acquires-placepass-to-lead-its-travel-experiences-offering>

5 <https://www.techradar.com/uk/news/the-metaverse-is-coming-but-what-does-that-even-mean>

6 <https://about.facebook.com/meta/>

7 <https://www.bighospitality.co.uk/Article/2021/06/01/UKHospitality-warns-of-staffing-crisis-as-sector-faces-shortage-of-188-000-workers>

8 <https://aim-museums.co.uk/returning-work-safely-business-considerations/>

9 <https://www.gov.uk/government/publications/regulation-for-the-fourth-industrial-revolution/regulation-for-the-fourth-industrial-revolution>

of work emerging from the pandemic, they would benefit from an approach that values talent as a key asset that contributes to an organization's sustained value creation.¹⁰

Where many businesses have embraced technology, a key aspect of this is the need to consider workforce skills and the future of work in an increasingly competitive market. Industries around the world will be bidding for the same small pool of talent. A global talent and skills race – already a big concern a few years ago – has become more of a war today, with one technology media and telecoms executive telling us as they are now competing with sectors like leisure and hospitality for talent.

Organizations need to concentrate their efforts on attracting, developing, and retaining talent to develop a sustainable talent pipeline. It is now incumbent on hospitality and leisure employers to promote their sector to ensure as many individuals as possible are enthused about working in hospitality and for it to become a career of choice.

Sustainability

Running parallel to this is the increasing awareness and demand around sustainability, which has moved from a 'nice to have' to a business essential. As UK Hospitality pointed out in their Future Shock issue on sustainability¹¹, those who don't will run the risk of being isolated by consumers and investors.

Consumer preferences are changing, and individuals are seeking more environmentally

sound options. Consumers now expect to see ethically sourced food and drink, evidence of reduced carbon footprint and, increasingly, awareness and action on social issues¹². In response, many online travel agencies and search aggregators have developed filters highlighting 'green' characteristics to emphasize their commitment to sustainability and accommodate the needs of consumers who rely on their services¹³.

From 6 April 2022, over 1,300 of the largest UK-registered companies and financial institutions will have to disclose climate-related financial information on a mandatory basis – in line with recommendations from the Task Force on Climate-Related Financial Disclosures. This will include many of the UK's largest traded companies, banks and insurers, as well as private companies with over 500 employees and £500 million in turnover.¹⁴

With COP26 and the path to net zero being driving forces, more is now expected from businesses, employers, and the government to tackle the global climate emergency and the progression towards wider environmental social and governance (ESG) issues. These need to be priority at board level, and go beyond reducing plastics and encouraging customers to support their schemes by bringing reusable cups.

It also encompasses designing and building new sites, retrofitting existing assets in

¹⁰ https://www3.weforum.org/docs/WEF_NES_HR4.0_Accounting_2020.pdf

¹¹ <https://www.ukhospitality.org.uk/page/FutureShock-IssueSix>

¹² <https://www.axa.com/en/magazine/2021-future-risks-report>

¹³ <https://tnmt.com/sustainability-drives-commercial-impact/>

¹⁴ <https://www.gov.uk/government/publications/uk-joint-regulator-and-government-tcf-d-taskforce-interim-report-and-roadmap>

a sustainable way after loss events, and ensuring there are ESG metrics in executive compensation packages. These actions can drive competitive advantage and improved financials. Industry research suggests energy and sustainability certification can reduce operating costs and property risks and increase the value of commercial property by an average of nearly 15%¹⁵.

From an operational perspective there are clear lines in the sand where action is needed. UK hospitality businesses have been challenged to improve their energy productivity by 20% by 2030, as set out by the government's Clean Growth Strategy.¹⁶

At the risk transfer end, to comply with financial regulator reporting, financiers, investors, and insurers will increasingly require transparent disclosures through TCFD reporting from 2022 – this covers aspects like business strategy down to metrics and targets.

In many ways, sustainability is not something new to the leisure and hospitality sectors as actions are often centered around operational efficiencies; however, it has deepened and those who embrace it will have a competitive advantage in the years ahead.

Interconnected thinking

What's clear from each of these trends is that asking the right questions of your policies and practices is essential for making sure you're ready for any eventuality. That starts with building awareness of the coming trends and having the right risk management in place to mitigate against changing risks. Both moves can help businesses face an uncertain future with more certain confidence.

Interconnected problems require integrated solutions, and this is where scenario-based thinking and expert partnerships can be used to explore changing risk landscape, learn from the last 18 months, and leverage those resilience lessons to explore complex risks and decide what to do next. This will be essential to provide comfort to insurance carriers that your organization understands the risks and is acting before capacity is questioned.

How can WTW help?

To support the industry in its journey, we will be undertaking research on new trends over the next year with the WTW Research Network. Our aim is to support understanding, outline risks and highlight opportunities. We believe access to research is essential to building resilience, which is as much a culture challenge as an operational one. Businesses need to be ready for multiple scenarios, and reactive when the exact situation doesn't unfold as scripted, and awareness of the art of the possible through research partnerships is a key way to explore the challenges businesses are facing.

This kind of approach can support businesses as they consider how their risk registers should change to account for the new world we find ourselves in. For many leisure and hospitality organizations, now is the time to put their risk registers under the microscope in the context of not only the 'new normal', but the 'never normal'.

If you need support reviewing your risk register, or any element of how your business needs to adapt in light of emerging trends, please get in touch.

¹⁵ <https://www.mdpi.com/2071-1050/12/7/2729/pdf>

¹⁶ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/726711/Call_for_Evidence_-_helping_businesses_to_improve_the_way_they_use_energy_.pdf

Emerging, converging and evolving: geopolitical risk and cyber threats

Over the last 12 months we've seen the ripples of natural, man-made and political upheaval spread far and wide; and environmental, technological and political changes continue to highlight new uncertainties as global trends set new domino chains in motion.

All of these have highlighted the need for organizations to create stronger links between their c-suites, operational managers and partners to produce the required integrated and rehearsed responses.

At the beginning of 2021, key geopolitical risks on the radar included fragile global supply chains, ongoing US-China tensions, climate and sustainability, and the deepening web of cyber risks and digitalization. As the risk landscape continues to evolve, the risk advisory and insurance industries are increasingly reliant on better risk insights and innovation. No single institution has the resources or breadth of knowledge to single-handedly answer all of the questions around the quantification and management of risk and opportunities. Understanding risk and driving resilience are still best met working in partnerships and embracing the talents of people across the globe.

Earlier this year the WTW Research Network team joined forces with WTWs' cyber and geopolitical risk experts to explore the emerging, converging and evolving world of geopolitical risk and cyber. With the emergence and importance of cyber risk increasingly accelerating, the opportunities and threats of the risks of cyber increase for businesses of all sizes.

Converging, emerging and evolving

The world is sitting on the cusp of, if not already immersed within, a 4th industrial and digital revolution, and there are clear business benefits and opportunities associated with the continued emergence and advancement of technologies within the cyber space. According to the UK Government's own website, 'technological breakthroughs in areas from artificial intelligence to bio-technologies are heralding a revolution with the power to create, reshape and change almost every sector within the global economy'.

Undoubtedly these will and are transforming and evolving the way we live and work, and with the continued and increased convergence of technologies and operating environments across the virtual, physical and cognitive domains, will also bring new and emerging opportunities for businesses and economies. However they will also bring new opportunities for a wide range of global cyber threat actors. Cyber space is already considered a fifth war fighting domain by multiple nation states, joining the likes of Air, Land, Maritime and Space – however unlike those other environments, the cyber space is really the one that offers a foreign state or threat actor a high degree of deniability, anonymity and increasingly blurred lines when it comes to attribution, prosecution and potentially, retaliation.

For businesses, the current geopolitical and cyber risk landscape means that organizations are at heightened risk of being caught in the 'virtual cross-hairs' of what

could be considered a global game of cyber 'chess', a seemingly endless and strategic game of testing an adversaries defensive (and offensive) capabilities whilst at the same time pushing to the boundaries the very definition of precisely what constitutes hostile or malicious nation state activity - a grey area that remains to this day, and a topic being explored by Elisabeth Braw through her work at the American Enterprise institute.

Key insights shared during the session included:

1. Operational precedence

"Cyber impacts on every aspect and level of business, there is responsibility and accountability at every level, it can not be viewed in isolation. Turn a blind eye and it will bite hard, surprise, deceive, paralyze and even destroy a good business. BUT, we have great opportunity to tackle the threat, optimize technology and better understand the cyber and geopolitical relationships, its emergence, convergence and evolution. Most of our actions boil down to knowing and controlling what is connected into our operational systems, optimizing our threat intelligence capability, keeping our technology up to date and regularly rehearsing and testing the whole organization. Preparing for one crisis should be preparation for all potential crises" Andrew Hall, WTW Global Client Relationship Director, Strategic Risk Team.

2. The threat landscape

"The industries that are at greatest risk are the ones that don't take this seriously and invest both in prevention and resilience. Cyber threats are twofold: data loss (theft of IP, personal data, or \$) or system availability (disruptive attacks) – with ensuing financial, regulatory and reputational risks. Cyber actors can be politically motivated (State or

hacktivist) or financially motivated, or both. If your industry is critical national infrastructure - in the widest sense - then the direct destructive threat from State actors is clearly greater. The range of targets is wide and opportunistic."

Before 9/11, the dots went unjoined and the warning signs were ignored. While we might discount the self-interested alarms from the cybersecurity industry, we are in the same place with cyber. Offense trumps defense. The trends are clear. Former Director of National Intelligence Dan Coats was clear: "the lights are blinking red." – Steve Hill, Visiting Senior Research Fellow at Kings College, London.

3. People

"We know already that the cyber employment stream is vastly under-resourced, there are reportedly over 3m vacant posts globally - for businesses and national agencies that is a huge problem, it's a problem right now and I expect is going to be a problem going forward: how and from where can businesses build sufficient talent to not only develop these new technologies, but also protect and monitor them, and then respond to incidents when they occur? Going forward I think governments and businesses must look at how we can better share and develop the talent, the resources, and the technologies, available to us." Dean Chapman, Cyber Lead, WTW.

"a lot of the US tech talent comes from China – you can't cut that off. It's something we've been looking at with one of our WTW Research Network partners – Elisabeth Braw who started the modern deterrence research stream at RUSI and now continues it at the American Enterprise Institute - investigating how societies can tackle new national security threats without closing themselves off from globalized markets. And that starts with awareness of the risks so you can balance

and make decisions on the opportunities.”
Lucy Stanbrough, Head of Emerging Risks,
WTW Research Network.

4. Scenario-based thinking

“Every organization will have their own version of what’s critical to their operations. Is theirs a key supplier, a critical location, the failure of their strategy, a node of a transport chain? This is something we’ve been exploring in the WTW Research Network through the use of narrative storylines that weave together risks and trends that are often considered in isolation. We find the process of considering these futures helps move the narrative from prepare for one, to prepare for all. For example, critical infrastructure blackouts were recognized as increasingly important by the CRO Forum in 2020, whether through the risk of natural catastrophes, solar storms or geopolitically-motivated cyber attacks. Stressed global supply chains, geopolitics, and the failure to adequately invest in infrastructure networks could impact continuity of services, especially in a remote working environment.” Lucy Stanbrough, Head of Emerging Risks, WTW Research Network.

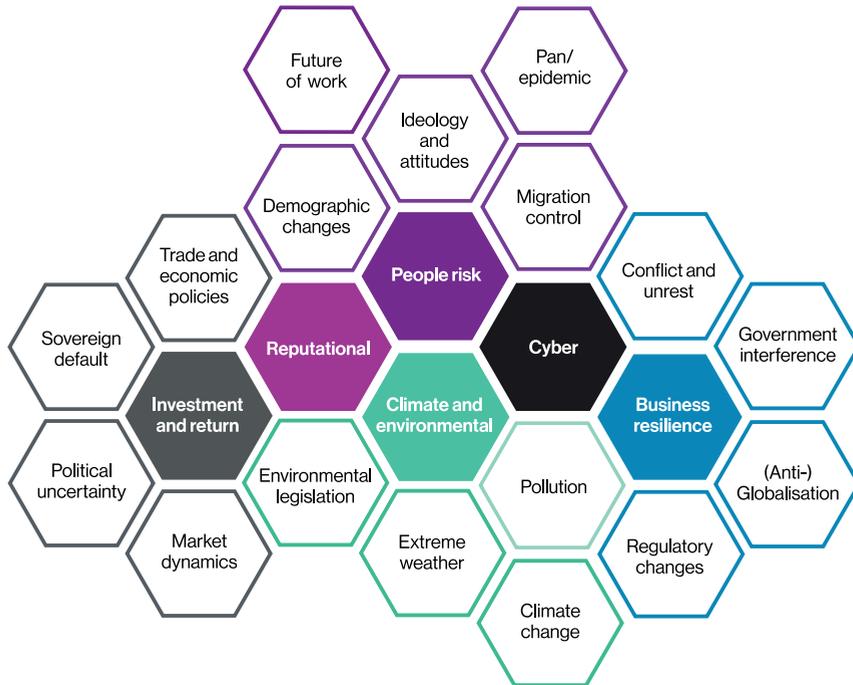
“Tail-end risks are becoming more common – pandemics, weather events, crowds storming The US Capital or the European Championship final, IT outages, geopolitical crises – or some combination thereof. Boards will never eliminate these risks, but have a responsibility to mitigate and enhance their resilience to bounce back when they happen. Governance and culture matter more than technology. The best money that a Board can spend is to bring on someone with the right experience who sits outside the bureaucracy and internecine politics of an organization to provide 1) a strategic intelligence-led and risk-based perspective and 2) a two hour Board level cyber simulation that will bring home the reality of a major attack in terms not

of the technical solutions, but of Board policy decisions and judgements around reputational external communications.” Dean Chapman, Cyber Lead, WTW.

Continuing the research journey

As organizations continue to embrace the digital capabilities, boards and their risk managers should remain proactive in reviewing their risk profiles and appetites and in identifying the relevant tipping points. Successful organizations will be those that are able to understand, assess and quantify the connected risks taking advantage of the opportunities and to mitigate or manage the risks associated with the geopolitical developments.

Businesses should continue to stretch their thinking, and where possible embrace intelligence led capabilities that help to reduce the surprise and shock of regional, national and global events. Using a range of tools and scenario planning, organizations can gain a holistic view of their risks and drivers, bringing more clarity to complex risk landscapes, and thereby gain competitive advantage. The WTW Research Network, Cyber and Geopolitical forums have a track-record of bringing together diverse expert panels, customized to our clients’ needs, to help in this process.

Figure 22. The six lenses within the context of geopolitical risks

“Cyber risk stands alone as the operating environment that will offer and enable an unrivaled opportunity for business innovation and both competitive and strategic advancement... but it is also, perhaps, the one that could cause us the greatest harm from an enterprise risk and threat standpoint.”

Dean Chapman
Cyber Lead, WTW

Zoonotic risks on the horizon

Pandemic threats have never been more visible with COVID-19. Now is the time to raise awareness of Zoonotic pathogens, and build global resilience.

With COVID-19 continuing to dominate the headlines and board agendas, it can be easy to lose focus of the wider risk landscape. However, if you are involved in pork or poultry production or any of the associated industries, the spread of African Swine Fever virus (ASF) and Avian Influenza – two Zoonoses – and their potential impact on global markets¹ is a growing global concern.

A zoonosis is an infectious disease that has jumped from a non-human animal to humans.² Zoonotic pathogens may be bacterial, viral or parasitic, or may involve unconventional

agents and can spread to humans through direct contact or through food, water or the environment. They represent a major public health problem around the world due to our close relationship with animals in agriculture, as companions and in the natural environment. Zoonoses can also cause disruptions in the production and trade of animal products for food and other uses, making their potential a key concern for those involved in supply chains.

Over the last year the Emerging Risks hub has been working with our Bloodstock, Estates, Livestock and Aquaculture team to support them in understanding the potential impacts to their clients.

¹ <https://www.rabobank.co.nz/media-releases/2020/200623-nz-red-meat-sector-to-benefit-as-asf-continues-to-weigh-on-global-animal-protein-markets/>

² <https://www.who.int/news-room/fact-sheets/detail/zoonoses>

“ We are seeing an increasing turbulent landscape at the moment when it comes to notifiable diseases. African Swine Fever has now crossed the Atlantic and Avian Influenza seems to be more rampant than ever. We are pleased that we can share best practices in bio-security measures with our clients, to ensure that the worse doesn't happen to their livestock. ”

Archie Horne

Head of Bloodstock, Estates, Livestock & Aquaculture, WTW

In the case of African Swine Fever it is a highly contagious viral disease that impacts swine, with a high mortality rate. The disease is 'Notifiable' and the veterinary services within countries are responsible for its control'. Severe cases of virus can cause death between 2 – 10 days of infection and, with no cure, can devastate entire supply chains. Disease control normally consists of culling infected herds and imposing strict quarantine procedures; there are no vaccines or treatments available.

These disruptions cascade beyond the farm boundary into the supply chain, with consequences ranging from those growing crops to feed herds, to the transport companies moving the world's stock. As pig production is an important source of human dietary protein in many countries, particularly in areas where beef production is difficult, a threat to this source can weaken food security and limit pig production within the effected countries. These are issues that cascade beyond the exposure of individual businesses, and into discussions around country and regional resilience, which is why you will find national security agencies at the forefront of funding research into the disease.

Link to the full article <https://www.wtwco.com/en-GB/Insights/2021/08/avian-influenza-on-the-horizon-the-wolf-in-the-hen-house>

1 https://www.pirbright.ac.uk/files/quick_media/ASFV%20Fact%20Sheet%20DL%20Leaflet_FINAL.pdf

Avian influenza (AI) viruses, commonly known as bird flu, infect a wide range of hosts, including humans and swine. The natural reservoir lies in populations of wild aquatic birds such as ducks and shorebirds whose global migratory patterns are a key factor in being able to limit the global spread. Wild birds normally carry AI viruses in their respiratory or intestinal tracts, but they do not usually get sick, which allows them to carry the viruses long distances.

New AI virus strains are created frequently which means there is a constant risk one of the new strains may spread easily among people². This risk is not unfounded. The viruses responsible for all four of the worldwide human influenza pandemics seen in the last 100 years have originated from birds, and most recently the virus hit the headlines in June 2021 with China reporting the first human case of the H10N3 strain³.

Link to the full article <https://www.wtwco.com/en-GB/Insights/2020/12/african-swine-flu-on-the-horizon>

2 <https://www.pirbright.ac.uk/viruses/avian-influenza-virus>

3 <https://www.wsj.com/articles/what-is-going-on-with-bird-flu-china-reports-first-human-case-of-h10n3-strain-11622658667>

Science for resilience

Building resilience to risks associated with both requires a holistic approach, and scenarios, technology, hiring staff from the veterinary sector, and multi-stakeholder engagements are some of the tools available, all guided by scientific best practice. This is a threat no farmer can afford to ignore, and one they cannot act on alone. Beyond the farm fence and the associated feed industries, supply chains using products need to be aware of potential risks and opportunities. There has never been a better time to understand the disease dynamics, build awareness in supply chains, and learn from those who are experiencing it first-hand.

The cascading effect on the supply chain from one outbreak of either African Swine Fever or Avian Influenza can have a devastating impact. For example, China's domestic pork production already has been disrupted by the domestic spread³ of ASF virus, which has recently reached the doorstep of the U.S., after affecting many countries in Europe⁴. With cases recently confirmed⁵ in the Dominican Republic, alarm bells of concern are certainly ringing in American states such as Iowa, where hog production, slaughtering and processing contributes⁶ more than US\$40 billion to local economies each year. A recent study⁷ by Iowa State University suggested

3 https://www.fao.org/ag/AGAInfo/programmes/en/empres/ASF/Situation_update.html

4 https://ec.europa.eu/food/animals/animal-diseases/diseases-and-control-measures/african-swine-fever_en

5 <https://www.pigprogress.net/Health/Articles/2021/7/After-40-years-ASF-is-back-in-the-Dominican-Republic-775973E/>

6 <https://www.agriculture.com/news/business/iowa-secretary-of-agriculture-responds-to-asf-in-dominican-republic>

7 <https://www.feedstrategy.com/animal-feed-manufacturing/top-2022-us-animal-feed-industry-issues-to-watch/>

that, if the ASFV entered the U.S., it could cost the state, the country's No. 1 producer of pigs, up to US\$50bn in lost revenue and 140,000 jobs in the next decade.

Due to the potential threats, once one of these zoonotic pathogens is found at a farm, the system goes into overdrive. The animals are humanely destroyed and the carcass have to be incinerated to ensure that the disease is destroyed as well. A number of deep cleans of the site have to be carried out to make certain the disease is no longer present. This means that a farm can be out of action for up to six months, which presents a significant impact financially which rolls on through the supply chain. With no livestock to be delivered (impact on logistic companies) to processing plants (impact to food distributors) the cost of meat rises (impact on end consumer).

Understanding the risk landscape

By modeling environmental events and physical assets, risks to property and people can be quantified and managed. This will be increasingly important as land-use changes bring more animals into contact with people through habitat disruption. The goal isn't predictions, it's preparedness. As we have seen with COVID-19, despite best efforts to contain infectious diseases, global supply chains always carry a risk of transmission; response requires sustained biosecurity practices, reporting, and cooperation efforts.

To support understanding the Emerging Risks hub conducted research into:

- How the diseases work: including infection vectors and disease progression
- The scale of the problem: highlighting the spread of the diseases across different regions
- Where next: using available scenarios from academic research groups that set out industry impacts

- And how risk management and insurance markets are responding

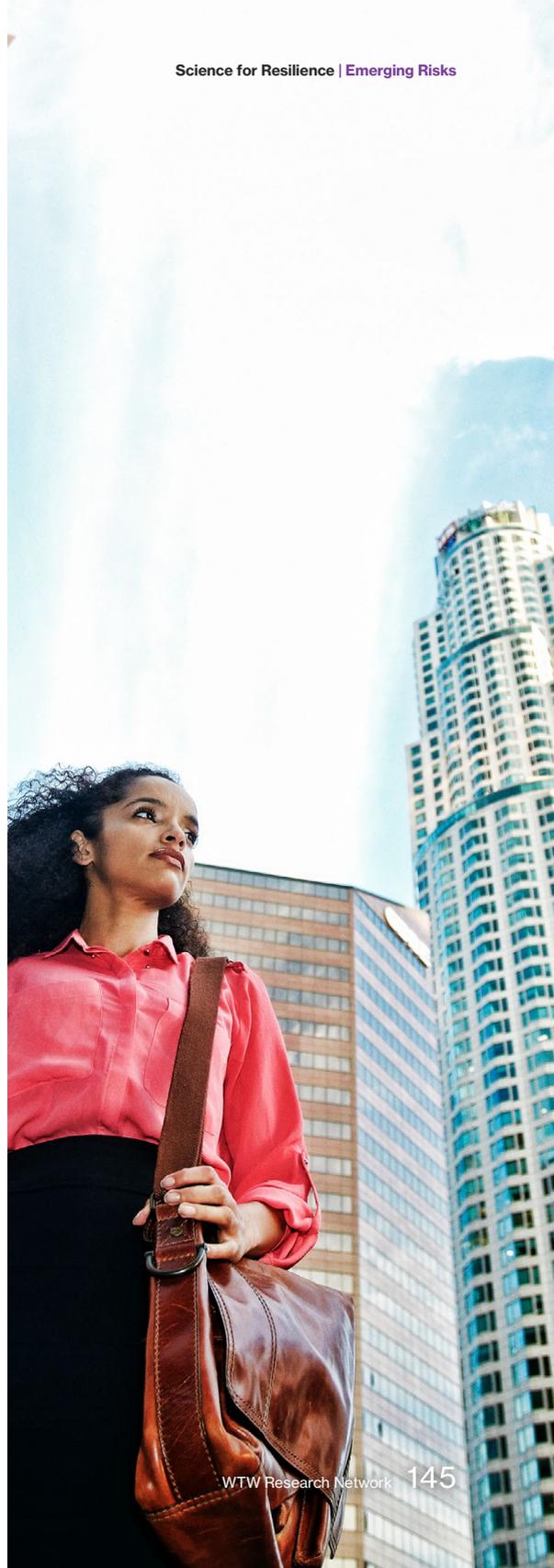
Interconnected problems require integrated solutions, and this is where scenario-based thinking and expert partnerships can be used to explore the impacts from those already experiencing the virus, and leverage those resilience lessons to explore complex risks and decide what to do next. This will be essential to provide comfort to carriers that the risks are understood, and that action is being taken before capacity is questioned.

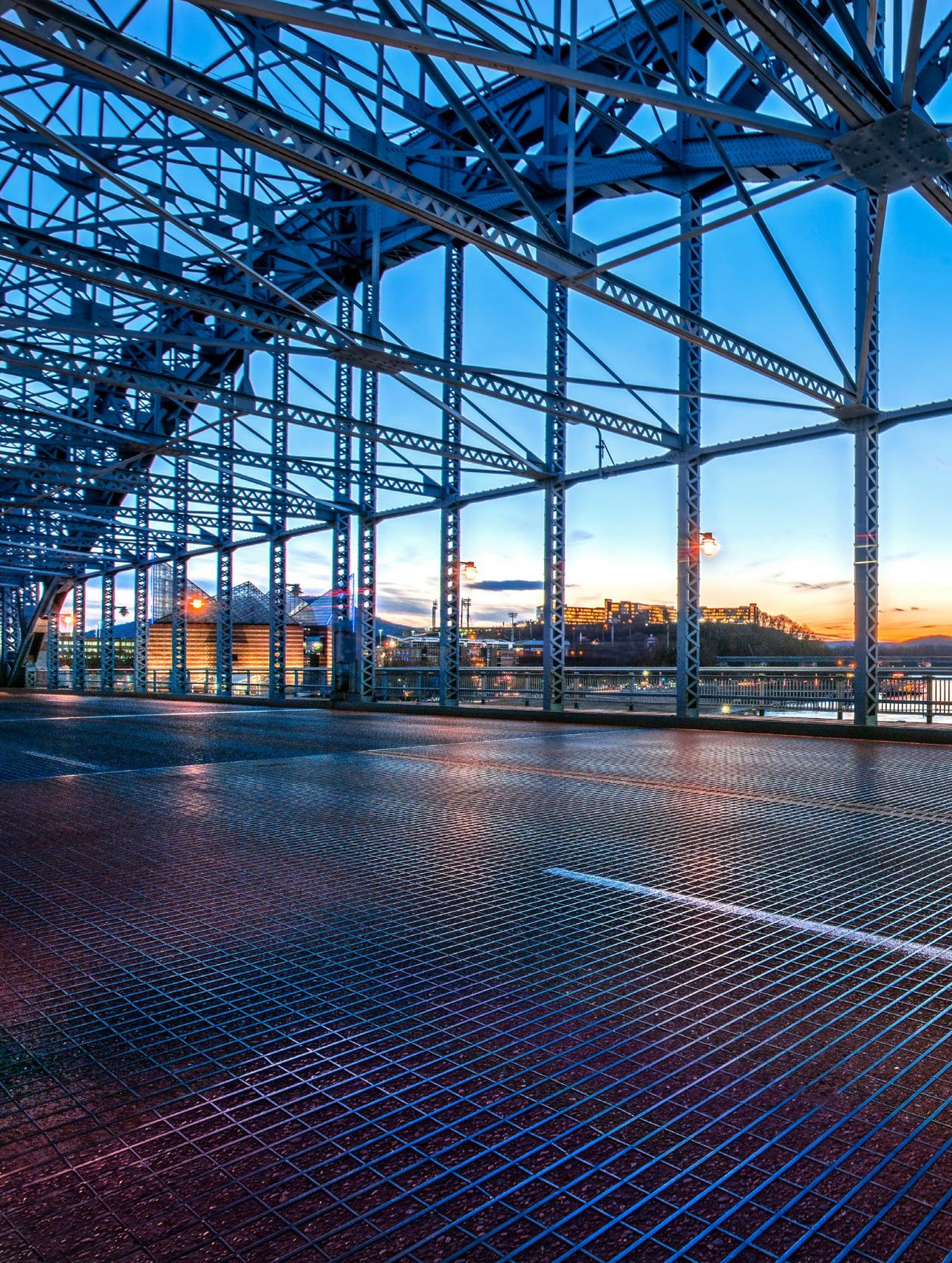
The important lesson from COVID-19 is that not all pandemics will look this like one, which highlights the importance of building understanding about the risk landscape, and ensuring that any investments made in combatting African Swine Fever and Avian Influenza will have holistic benefits against future animal diseases and consumer trends. If you are looking at new technology investments or hiring choices, considering these could uncover new challenges before you face them.

Supporting business decisions

In 2022, we will continue to explore ways to leverage Metabiota's epidemiological data analytics capabilities to improve understanding of pandemic risk, build better pandemic risk models, and support mitigation and risk transfer decision making for increased resilience.

Our partnerships will also look to support the global community across both public and private sectors to manage the next pandemic in a more informed and pre-planned way once the current crisis has passed. In the private sector, we will continue to assist our clients as they improve their structural resilience to pandemics and navigate human resources, insurance, business and investments issues more effectively.



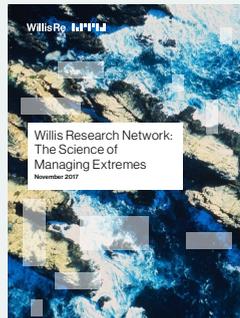


Learn more about the WTW Research Network

To view previous brochures and for upcoming WTW Research Network events and communications please visit our website at <https://www.wtwco.com/en-GB/Insights/research-programs-and-collaborations/wtw-research-network>



2016



2017



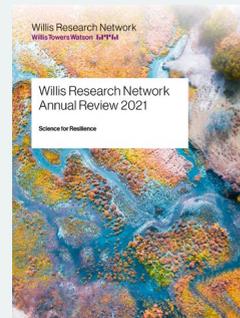
2018



2019



2020



2021

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