Advancements in Modelling and Integration of Physical and Transition Climate Risk

Core insurance business, asset management and investment applications

Background Paper

2019 Extreme Events and Climate Risk Forum

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Key messages:

1. Building on the 2015 Paris Agreement and other important developments, the climate change debate has been refocused from an environmental and social responsibility issue to a key consideration for economic development, financial stability, investment, job creation and trade.

2. Companies' investments in climate risk modelling and stress testing are driven by:
   a. Recommendations of the Financial Stability Board's Task Force on Climate-Related Financial Disclosure (FSB-TCFD)
   b. Sustainable finance initiatives to mobilize capital for sustainable growth and the transition to a resilient low-carbon economy
   c. Emerging climate change-related activities of financial and insurance regulators; and
   d. Efforts by rating agencies to include climate risk in their company, municipal and sovereign credit rating practices.

3. The priority for companies is increasingly the integration of climate risks and opportunities into governance, corporate strategy, policies, risk management, innovation and product development, capital allocation and investing, as well as disclosure and reporting. The degree of adoption differs by jurisdiction, sector, line of business and size.

4. Increasingly, main concerns are focused on the need for data, standard tools and methodologies and expertise on climate risk analysis and stress testing for informed decision-making.

5. There are initiatives underway, but the landscape of physical and transition climate risk modelling is deeply fragmented in terms of risk, sector, application and decision-making. Gaps, needs and requirements need to be identified and addressed to enable the integration of climate risk modelling at scale.

6. Advancements in climate science, climate change scenario analysis, machine learning and AI provide new opportunities for improving physical and transition climate modelling.

7. The Geneva Association, in collaboration with leading stakeholders, is building a strategy for better coordination in identifying concrete R&D priorities to enable scaling up the integration of physical and transition climate risk modelling. The strategy's focus is on insurance core business, investment and asset management applications. This initiative brings together international experts from the insurance industry, asset managers, rating agencies, regulatory bodies, FSB- TCFD, organisations involved in risk modelling, the scientific community, academia and United Nations entities.

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Context

In 2015, the leaders of the United Nations Member States adopted (i) the Sendai Framework for Disaster Risk Reduction (2015-2030), (ii) the 2030 agenda for Sustainable development; and (iii) the Paris Agreement[2]. These international framework agreements offer unique opportunities to reshape the global development pathway.

The recent report of the Intergovernmental Panel on Climate Change (IPCC) has highlighted the implications of global warning of 1.5^{o}C above pre-industrial levels and related global greenhouse gas emission pathways and the need to strengthen and align global response to the threat of climate change (IPCC, 2018). The insurance industry has recently published a report highlighting the likely effects of 1.5^{o}C - 2^{o}C climate change scenarios on the insurance industry and the impact on insurability and resilience in a changing climate (CRO Network, 2018).

Over the last few years, the climate change debate has been refocused from an environmental and social responsibility issue to a key consideration for economic development, financial stability, investment and trade. Climate change issues increasingly revolve around the integration of climate risks and opportunities into governance, strategy, policies, risk management, innovation and product development, capital allocation and investing, as well as disclosure and reporting. The degree of adoption differs by jurisdiction, sector, line of business and size. Increasingly, main concerns are focused on the need for data, standard tools and methodologies and expertise on climate risk analysis and stress testing to support decision-making.

Major developments driving climate risk modelling

The Financial Stability Board - Task Force on Climate-related Financial Disclosure (FSB-TFCD)

The FSB-TFCD has offered a framework for disclosure of climate-related disclosures, through existing reporting processes, to enable access to fundamental information for investors. Following the 2008 financial crisis, the FSB identified climate change as the highest potential threat to financial and economic stability. In September 2015, Mark Carney, then Chairman of the FSB, highlighted financial and economic risks arising from climate as one of the highest potential risks to the global economy. He stressed, "Risks of climate change to financial stability will be minimised if the transition begins early and follows a predictable path, thereby helping the market anticipate the transition to a 2^{o}C world."

The FSB's Task Force on Climate Related Financial Disclosure (TCFD) provides the following definitions:

- *Physical risks* include economic risks that could arise from direct (e.g. destruction of property and critical infrastructure) and indirect (e.g. business interruption, affected labour force, interconnectivity of supply chains) impacts due to (i) increasing severity and frequency of extreme weather events such as cyclones and floods (acute risks); and (ii) long-term shifts in climate patterns such as changes in precipitation patterns linked to reduction of water supplies and sustained high temperatures that may cause rising sea-level and chronic heatwaves (chronic risks).

[2] - Sendai Framework for DRR: http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf
- The 2030 Agenda for Sustainable development: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf
- COP21 Paris Agreement: https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

- *Transition risks* include financial, liability and reputational risks which could result from the process of transition towards a lower-carbon economy. Changes in policy, technology, market and physical risks could prompt a reassessment of the value of a large range of assets as the costs and opportunities become apparent, leading to stranded assets.[3]

The TCFD has offered a framework for companies and other organisations to develop more effective climate-related financial disclosures through their existing reporting processes (TCFD, 2017). This report emphasized the importance of transparency in pricing climate risk to support informed and efficient capital allocation and investment decisions. It also pointed out that many companies incorrectly view the implications of climate change to be relevant only in the long-term, and thus, not necessarily to decisions today.[4]

There has been a steady increase in climate risk disclosure adoption. Nearly 800 organisations have expressed support for the TCFD and its recommendations, an increase of more than 50% from the publication of the first status report in 2018.[5] However, the following developments and insights should inform future strategies for increasing climate risk disclosure adoption:

1. Climate-related financial disclosures have increased since 2016, though it is still insufficient for investors
2. More clarity is needed on the potential financial impact of climate-related issues on companies
3. The majority of companies using scenarios do not disclose information on the resilience of their strategies and need to incorporate climate risk into their corporate strategies
4. Mainstreaming climate-related issues requires the involvement of multiple functions across companies

As the next steps, the TCFD stresses the need for detailed methodologies linked to TCFD supplemental guidelines; guidelines for introducing scenario analysis and the identification of business-relevant and accessible climate scenarios.

Finally, Carney (2019) stresses the following three critical areas to enhance information for reporting and subsequently better decision-making:

1. The need for increasing adoption rates of TCFD recommendations related to enhancing decision-relevant disclosure and strategic resilience to different climate outcomes
2. Enhancement of climate risk analysis to lead to better climate change risk management, looking at the breadth of climate risk across all business lines, sectors and geographies, magnitude of risks in the foreseeable future, dependency on short-term actions and how they impact the future and stretching beyond the traditional business planning cycles

[3] Stranded assets are defined as "assets that have suffered from unanticipated or pre-mature write-downs, devaluations or conversion to liabilities. These can be caused by a variety of factors linked to technology transformation, innovation, coal and other fossil fuels linked to the pricing of carbon and phasing out of fossil fuels. It could also refer to an asset that has become obsolete or non-performing, but must be recorded on the balance sheet as a loss of profit. In the context of fossil fuels, natural gas is considered to be relatively low carbon and is expected to be a key component of the global energy mix as the world transitions to a low-carbon economy."

[4] Participants in the GA Workshop are urged to familiarize themselves with the TCFD (2017) reports and recommendations.

[5] The List of 785 TCFD supporters include 374 financial and 297 non-financial companies, with a combined market capitalization of nearly US$9.3 trillion. Supporting financial firms are responsible for nearly US$118 trillion in assets. Supporters also include 114 other organisations, such as trade associations, financial and insurance supervisors and regulators, governments and ministries and are located across 49 countries.

3. New opportunities and their returns that follow a transition to a low-carbon economy, in areas such as energy and infrastructure, with consideration for how advances in risk analytics and reporting are paving the way for investors to realize the opportunities in climate-friendly investments by re-orienting their approach to more sustainable long-term value generation

Emergence of sustainable finance initiatives

***S*ustainable finance frameworks are emerging in a number of jurisdictions to mobilize finance for sustainable growth, and transitioning to resilient low-carbon economy.** The European Commission (EC) and countries such as the U.K. and Canada are advancing the concept of sustainable finance to address challenges and realize opportunities to mobilize finance for sustainable growth. A critical focus of these initiatives is the need to mobilise capital for the transition to a climate resilient and low-carbon economy. The TCFD recommendations and incorporation of climate risk (physical and transition) and opportunities into investment strategies are also key considerations.

Building on the recommendations of the High-Level Expert Group on sustainable finance (HLEG 2017), the EC launched a strategy in 2018 for a financial system that supports the EU's climate and sustainable development agenda. The EC has defined a roadmap to boost the role of finance in achieving a well-performing economy that delivers on environmental and social goals. Around €180 billion of additional investments per year are needed to achieve the EU's 2030 targets agreed in Paris, including a 40% cut in greenhouse gas emissions. This action plan on sustainable finance is part of the Capital Markets Union's (CMU) efforts to connect finance with the specific needs of the European economy to the benefit of the planet and society. It is also one of the key steps towards implementing the Paris Agreement and the EU agenda for sustainable development.

Following these developments the EC set up a Technical Expert Group on sustainable finance (TEG) to assist it, in line with the EC's legislative proposals of May 2018, in developing the following:[6]

- An EU classification system – the so-called 'EU taxonomy' – to determine whether an economic activity is environmentally sustainable
- An EU green bond standard
- Methodologies for EU climate benchmarks and disclosures
- Guidance to improve corporate disclosure of climate-related information

Furthermore, the EC considers the need to require insurance and investment firms to advise clients on the basis of their preferences on sustainability (EC 2018a-d, 2019).

Similarly, other jurisdictions such as the U.K. and Canada have established task forces to guide their governments in these areas, i.e. the U.K. Green Finance Task Force and the Canada Expert Panel on Sustainable Finance. Developing climate risk analytics capabilities and leveraging them to support informed decision-making is at the core of these initiatives (Green Finance UK, 2018, Canadian Expert Panel on Sustainable Finance, 2018 and 2019).

Financial and insurance regulations and climate change

A number of initiatives are underway through supervisors and regulators to strengthen their understanding of and responses to sustainability issues, including climate change. These developments

[6] The TEG has made extensive progress on all four topics. For more information see: https://ec.europa.eu/info/publications/sustainable-finance-technical-expert-group_fr

are at their early stages.[7] The Sustainable Insurance Forum (SIF) is a forum of insurance supervisors and regulators with specific focus on these topics. In 2018 the SIF and the International Association of Insurance Supervisors (IAIS) released a joint *Issues Paper on Climate Change Risks* to the insurance sector, also recognising the importance of the *Recommendations and Supplemental Guidance* of FSB-TCFD (IAIS-SIF revised paper 2018). At the 2018 IAIS annual conference, the IAIS requested that the SIF conduct further work in partnership with the IAIS on climate change risks. At the fifth meeting of the SIF, member supervisors agreed to engage with the industry on climate risk issues through a global survey on the implementation of TCFD recommendations.[8]

The Bank of England (BoE) issued a paper on potential impacts of climate change on the UK insurance sector (BoE, 2017) and two documents (2019a-b) providing further guidance. BoE (2019a) is a supervisory statement for enhancing banks' and insurers' approaches to managing the financial risks from climate changes, setting out the Prudential Regulation Authority (PRA)[9] reviews concerning the strategic approach for embedding climate risk in governance, financial risk management practices, strategy-setting and risk identification and assessment, and development of approaches to disclosure.

BoE (2019b) offers a framework for assessing financial impacts of physical climate change, as a practitioners' aid for the non-life insurance sector. The framework offers six stages: (i) identify business decisions; (ii) define materiality, e.g., where the physical risk from climate change could have a material impact on business decisions; (iii) conduct background research, such as scientific publications; (iv) assess available tools (e.g., Cat models); (v) calculate impacts, including output and uncertainty; and (vi) reporting and action.

In June 2019, the PRA issued the Insurance Stress Test (IST 2019), an exploratory request to the largest regulated life and non-life insurers to provide information about the impact of a range of stress tests on their business. At a sector level, this exercise aims to provide PRA with information to assess market resilience and to be better prepared in the event similar scenarios were to occur. At a firm level, IST 2019 aims to provide the PRA with the firm's risk management systems. It will not be used to set capital requirements. In addition, the PRA is asking all participating firms to undertake an exploratory exercise in relation to climate change. General insurers are asked also to complete exercises relating to cyber underwriting and commercial liability exposures. These are designed to explore emerging risks so that the PRA could improve its shared understanding of sector exposures. For non-life insurers, PRA will be co-ordinating some of the scenarios with the Bermuda Monetary Authority. Many London market insurers are exposed to similar risks to those based in Bermuda; U.K.-based insurers cede a significant proportion of risks to Bermuda-based reinsurers. This exercise is also designed to enhance understanding of the interconnectedness between our jurisdictions in the event of a stressed scenario. As in the previous stress test exercises, firms are invited to participate on a voluntary basis. The PRA will publish a summary of the overall results but no individual firm results will be made public (PRA, 2019).[10]

[7] For more information see: www.sustainableinsuranceforum.org

[8] https://www.sustainableinsuranceforum.org/insurance-supervisors-launch-survey

[9] PRA is a financial services regulatory body of the U.K.

[10] More information about the details of the stress test and templates can be accessed at: https://www.bankofengland.co.uk/prudential-regulation/letter/2019/insurance-stress-test-2019

A fragmented landscape of climate risk modelling

The current landscape of climate risk modelling (physical and transition) initiatives is deeply fragmented across various sectors, applications, and decisions. Gaps, needs and requirements need to be addressed to enable the development and integration of climate risk modelling at scale for applications such as core insurance, asset management and investing. Increasingly, financial institutions (e.g., banks, asset managers, rating agencies, life and non-life insurers) are considering expanding their physical and transition climate risk analytics capabilities to support their decision-making. However, these developments are at an early stage and remain fragmented.

Driven by TCFD recommendations and emerging sustainable finance initiatives, organisations have launched initiatives working with insurers, banks, and asset managers to develop methodologies for the incorporation of physical climate risks (e.g., extreme events and trends) and opportunities in their core business, investment, lending and portfolio analyses (Geneva Association 2018b, UNEP-FI 2018, ClimateWise 2019a-d, Benedetti, et al 2019).

The Geneva Association (2018b) provides insights on catastrophe (Cat) risk modelling for core insurance business and other sectors. It offers recommendations for innovating Cat risk modelling for physical climate risks modelling and management for core insurance business and other areas such as investment and asset management. The report explores a number of key considerations for development and utilization of risk models, including standardization, interoperability, open framework and open source versus proprietary, model validation, uncertainty estimation, and regulatory issues. Specifically, it offers opportunities for improving physical risk modelling with a forward-looking approach by embedding the latest climate science and climate change scenarios in Cat models.

ClimateWise (2019a-b) is focused on how investors and lenders can use Cat risk models, tools and metrics to improve their management of some of the physical risks of climate change for real estate lending and related investment portfolios.

UNEP-FI and Oliver Wyman (2018) engaged 16 banks to develop a methodology for integrating transition-related risks and opportunities in credit assessment and corporate lending portfolios. Their paper also offers a number of recommendations for addressing gaps and developing the next generation of transition risk analysis, including (i) building out climate scenario models to support financial risk analysis; (ii) developing data and analytics for borrower-level climate risk analysis; (iii) methodology enhancements to the portfolio impact assessment; (iv) integration of transition risk assessment in the organisations, also including physical risks, incorporation of climate risk in underwriting and credit ratings, limits and exposure monitoring portfolio management and structuring and business planning and strategic planning.

ClimateWise (2019c-d) is focused on methodologies to assess the impacts of the low-carbon transition on infrastructure investments. The proposed transition risk framework is designed to help investors (i) to assess the breadth of asset types exposed to transition risk and opportunity across an investor's portfolio (sub-sectors, regions and time frames); (ii) define the potential financial impact from the low-carbon transition down to the asset level; and (iii) incorporate transition impacts into their asset financial models. The report focuses on applying this framework to infrastructure portfolios.

Benedetti et al. (2019) offer a model to capture the potential impact of carbon pricing on fossil fuel stocks and inform Bayesian portfolio construction methodologies.

Academic centres of excellence are also advancing the development of such methodologies, e.g., the Cambridge Institute for Sustainability Leadership, Oxford Sustainable Finance Programme, and the Centre for Climate Finance and Investing of the Imperial College Business School.

Finally, a number of asset managers are teaming up with academic institutions and private modelling firms to integrate physical and transition climate risk modelling into their pension fund strategies.

Leveraging advancements in climate science, climate change scenario analysis, AI and machine learning[11]

To model transition risks associated with the move towards low-carbon and sustainable futures, the implications of the various socio-economic pathways for staying within the Paris Agreement of 1.5-2°C—not only in terms of business evolution, but also in terms of the response of the regional/local climate system to those pathways—need to be explored. The TCFD (2019) has identified the need for identifying business-relevant and accessible climate-related scenarios as a high priority for its future work. A number of jurisdictions, as part of developing their sustainable finance initiatives, are investing (or planning to invest) in R&D for developing base climate-change scenarios. Furthermore, the response will depend on how sensitive the climate system is to changing levels of greenhouse gases and other factors, such as aerosols. New Earth System science is constantly emerging that is changing our understanding of climate sensitivity and possible pathways to stay within 1.5-2°C target. The IPCC issues its coordinated reports every 7-8 years, and it is important for the industry to stay abreast of the latest scenarios and assessments of climate sensitivity. For example, in the run-up to the sixth IPCC Assessment Report (AR6), due in 2022, several of the leading modelling groups are reporting much higher climate sensitivities than in previous ARs.

Advancement in climate research and modelling, rapidly expanding computational capabilities, explosive expansion with big data combined with other engineering and technological innovations are providing unprecedented opportunities to innovate modelling of physical risks and develop the next generation of Cat risk models (Geneva Association, 2018b). Weather and climate science is built around two fundamental capabilities: (i) Earth Observation, which increasingly gives us a very detailed view of the health of the planet and of extreme events and their impacts, and (ii) Earth System Simulation and Prediction, which provide insights into why our climate varies, how it is changing and it might be like in the future.

Annex 2 highlights a number of recent advances in weather and climate science as relevant to insurance and financial services in the context of the changing landscape of physical and transition climate risk.

These advances are critically important because at the root of any assessment of current and future climate risk must be the best possible assessment of the characteristics of the drivers of these risks. More often than not, these are extreme weather events. Yet the observational record is far too short to characterise extreme events with confidence and provide robust estimates of return periods. At the same time the statistics of observational extremes are non-stationary due to both low frequency natural variability (e.g. Atlantic Multi-decadal Oscillation (AMO)) and, more importantly, anthropogenic climate change.

Earth System Simulation (or climate modelling) is fundamentally different from the other modelling tools used within the risk modelling, insurance and financial sectors. Whereas those models are empirically based, Earth System Simulation computes the evolving weather, and thereby the climate, from first

[11] Contributed by Professor Julia Slingo

principles using fundamental physical equations, which have to be solved using sophisticated numerical techniques on a supercomputer. The Earth's atmosphere (and oceans) is divided into millions of volumes each with its own meteorological variables, and these are integrated forward in time by solving the physical equations to produce a simulation of the evolution of the weather and climate over the coming minutes, hours, days and decades. The simulation produces all the weather and climate phenomena (e.g., jet streams, storm tracks, tropical cyclones and El Niño) which drive the varying and changing landscape of weather and climate risk. The output is a time-evolving set of meteorological and oceanic variables, which can be analysed the same way as a set of observations.

In the past, the coarse granularity/resolution of the simulation system (due to lack of supercomputing power) has been a limiting factor in the uptake of weather/climate simulation and prediction by the insurance and financial sectors. However, recent advances in Earth System Simulation with higher resolution (e.g. EU PRIMAVERA: https://www.primavera-h2020.eu) now provide opportunities to produce large synthetic events sets—orders of magnitude larger than observational records)—of meteorologically plausible extremes for the current (and future) climate; in other words, pseudo-observations that act to 'fatten up the tails'. They allow estimation of return periods (e.g. 1 in 100 years) more robustly than using empirical methods based on the short observational record, and have been used to explore correlated extremes and clustering of extremes, such as windstorms. Furthermore, these event sets have already shown that there is the potential for unprecedented extremes, even without climate change, due to the natural volatility of weather systems.

At the same time these increases in resolution have delivered substantial improvements in the skill of monthly to decadal forecasts, beyond El Niño, to include other drivers of extreme events (e.g. weather regimes, North Atlantic Oscillation(NAO)). In addition, latest attribution science, based on these advances in Earth System Simulation, is providing stronger evidence that the characteristics of extreme events (frequency, intensity) are already changing as a result of global warming; in other words, the observational record is no longer representative of the future.

The impacts of extreme events are invariably felt at the regional and local level, but global simulations still have limitations in providing the fine detail that often defines the degree of risk. In the last few years the development and implementation of kilometre-scale regional simulation systems within weather forecasting has demonstrated that, at this scale, they are remarkably realistic. They can reproduce intense local rainfall events that lead to flooding, as well as very strong winds linked, for example, to sting jets. This class of simulation is now being used within climate risk assessment, such as the latest UK Climate Projections (UKCP18), to provide more robust estimates of changes in local extreme events. The information emerging from these high-resolution simulations is substantially changing our perceptions of future risks.

Finally, the emergence of Machine Learning (ML) and Artificial Intelligence (AI) is offering new opportunities to exploit the latest developments in weather/climate science. As noted above, synthetic event sets from simulation provide a rich data resource which can be used to explore the links between extremes and weather/climate regimes, for example, and can act as learning data for ML and AI algorithms.

Research activities of The Geneva Association in climate risk modelling

The insurance industry plays a critical role as risk managers and investors in enabling the transition to a resilient and low-carbon economy (Annex 1). The Geneva Association (2018a) has examined the contributions of the insurance industry in addressing climate change and identified critical actions that need to be undertaken by governments, the industry and through public-private partnerships.[12]

Building on the developments highlighted above, three years of research in the area of risk modelling and extensive consultations with stakeholders, The Geneva Association's *Extreme Events and Climate Risk Working Group* (EE&CR WG) and its *Task Team on Linking Climate Risks to Investing*, have proposed to the Association's Board to build a strategy with key stakeholders, to identify high priority R&D and to coordinate efforts to scale up the development and integration of physical and transition climate risk modelling. As part of this initiative, the 2019 EE&CR Forum of The Geneva Association is dedicated to 'Advancements in Modelling and Integration of Physical and Transition Climate Risk - Core insurance business, asset management and investment applications.

[12] With approximately US$ 35 trillion in assets under management (FSB, 2019), insurers rank alongside pension funds as the world's largest long-term investors. The valuation of investments and assets are significantly impacted by climate risks.

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Annex 1 – Foundations of the insurance business model[13]

Understanding the insurance business model is fundamental to leveraging the industry's contributions to achieving global climate change goals and targets.

Risk transfer

Transferring and carrying risk is at the heart of the insurance business. Insurers assess, price, assume and transfer risk on behalf of their policy-holders.

As risk underwriters, insurance companies offer protection to people, businesses and governments in return for a premium. The insurance industry's value chain includes policyholders, (primary) insurers, reinsurers, brokers and the financial market. Traditionally, from an underwriting point of view, there are three basic ways of classifying insurance: social versus private, life versus non-life and commercial versus personal. The insurance policy is a mutual agreement whereby the insured transfers the risks of an uncertain loss to the insurer by paying upfront a certain fixed amount. Subsequently, in the occurrence of a covered event, the insurance company indemnifies the policyholder. The insurance product is not the payment in the event of a covered loss; it is rather the guarantee that losses will be indemnified if the policyholder suffers a loss. The guarantees of the insurance mechanism rely on three methods: pooling of risks, retrocession and securitisation.

Liability-driven investment strategy

The investment (asset management) strategy of insurance companies is liability-driven, constrained by regulations and driven by a number of internal and external factors (Asset-Liability Management, ALM).

Insurers invest conservatively; they need to remain solvent so they can make pay-outs to policyholders with the highest probability at any time. Insurers have a fiduciary duty to enhance the value of their 'policyholder' assets. These fiduciary duties can constraint the industry's investment strategies. On the other hand, insurance regulators impose risk-based capital charges on investments to ensure adequate capital levels to cover insurers' liabilities; the riskier the investment, the higher the capital charge. These vary by country and region. Further, different lines of business are exposed to different risks. This dictates how financial risks associated with assets and liabilities are managed by life and non-life insurers (Asset Liability Management, referred to as ALM). Specifically,

(i) Life insurers are typically 'buy-and-hold' investors. They aim to generate predictable and stable income to match cash flows of long-dated and generally predictable liabilities. Life insurance contract duration can range from ten years to several decades, involving payout patterns of 20 to 30 years.[14] Life insurers are deeply concerned about the asset-liability mismatch, with interest rate risk being a key issue.

(ii) Non-life insurers are geared towards more liquid investments with shorter time horizons, typically one to three years in duration.[15] However, in some instances (e.g. asbestos-related) claims are paid out many years later, exposing them to interest rate risk.

13 Source: Geneva Association (2018a)

14 Duration is a term that qualifies the sensitivity of cash flows to interest rate. That is why it is usually shorter than the pay-out patterns.

15 Liability business is usually longer than one year, typical P&C portfolios have a duration of two to three years. One year is typical for NatCat risks.

Typical investment patterns

The nature of liabilities determines how the financial risks associated with the assets and liabilities are managed, given that different lines of business are exposed to different risks. In order to fulfil their fiduciary responsibility and to guarantee credit-worthiness, insurance companies often select secure investments with slightly lower return on investment (RoI).

Life insurers are typically 'buy-and-hold' investors seeking to generate predictable and stable income to match long-term and generally predictable liabilities that must be paid when claims become due (life insurance contract durations are 10 years and more with pay-out patterns of 20 or 30 years or more). Life insurers are deeply concerned with the asset-liability mismatch, and the focus of ALM is often interest rate risk. The longer the duration, the more sensitive the liabilities are to changes in interest rates.

Non-life insurers' investment categories are geared towards more liquid investments with shorter investment horizons in order to be able to compensate policyholders quickly and efficiently (non-life insurance contracts are typically one year in duration).

Large insurance conglomerates usually maintain their asset management divisions in-house, while smaller companies tend to outsource asset management to third party asset managers.

Insurance regulations

To ensure that insurers have adequate capital, regulators impose risk-based capital charges on insurers' investments; the riskier the investment, the higher the capital charge. Regulatory capital requirements are designed to ensure that insurers can honour future claims.[16] Regulators will intervene if an insurer does not have sufficient capital to meets its regulatory requirements. The asset allocation is restricted to a high degree by regulatory requirements targeted at consumer protection, which are enforced in the insurance industry through complex regulatory systems. These vary by region.[17, 18]

Regulatory capital charges and the associated formulas vary by type of insurance company and asset class. For example, assume that the baseline charge for an investment in common equities by a non-life insurer is 15 per cent of the asset value; for every dollar invested in common equities, a non-life insurer would be charged USD 0.15. As such, insurers might be more drawn towards asset classes with lower capital charges (e.g. long-term, high quality fixed income investments).

16 Even if the future loss experience is worse than assumed when the liabilities are calculated.

[17] *Prudence Regime:* The idiosyncrasy of insurance cash flows is that their magnitude and timing are random. Actuaries calculate the capital requirements in order to be able to serve these contingencies with very high probability. Unless regulations explicitly prevent it, diligent actuaries assume a prudent position, i.e. it is better for the insurance company to reserve slightly too much capital than too little.

[18] *Risk Appetite*: According to the general economic theory, risky investments tend to have more volatile returns. This involves the upside potential of risky investments being higher.

Annex 2 - A preliminary list of potential contributions of weather/climate science to business decisions

Business Function	Natural Hazard	Potential Contributions from Weather/Climate Science
Core Insurance Life Insurance	• Increased mortality from poor air quality • Increased mortality from heat stress • Increased risk of pandemics, new vector-borne pathogens, food contamination, due to higher temperatures and climate shifts	• Fully coupled chemistry-climate scenarios of future air quality e.g. CORDEX, IPCC AR6. • Copernicus Atmospheric Monitoring Service (https://atmosphere.copernicus.eu) for current air quality assessments • Copernicus Climate Change Service (https://climate.copernicus.eu) for latest climate assessments • Current and future climate assessments of changes in clustering of hot days, warm nights.
Non-Life Insurance	• Quantifying increased exposure to extreme flooding, wind, wildfire, landslide and storm surge events under a changing and varying climate • Influence of natural climate variability (e.g. ENSO) on extreme event statistics for setting annual premiums	• Current and future climate assessments of changes in extremes including use of weather regime analysis to assess likelihood of extremes. • Use of Earth System Simulation to provide Synthetic Event Sets of unprecedented extremes – Narratives/Scenarios • Advances in extreme event attribution methods • New kilometre-scale regional climate scenarios with more robust assessments of changes in regional/local extremes (e.g. UKCP18 https://www.metoffice.gov.uk/research/collaboration/ukcp, US NCA4 https://nca2018.globalchange.gov)
Re-Insurance	• Extreme insured losses due to unprecedented extremes, more intense, or more frequent extremes, or more clustered or correlated extremes	• Seasonal forecasting with baseline risk set by large synthetic events sets from seasonal/decadal 'hindcasts'. • Latest monthly-to-decadal prediction systems showing improved skill in forecasting major climate modes beyond ENSO e.g. NAO. • Using decadal forecasting to estimate longer term (1-5 years) risks from natural variability and climate change. • New understanding of how modes of natural climate variability set the context for extremes. • Attribution of extremes using Earth System Simulation to identify contribution of climate change and potential changes in return periods
Asset management	• Changes in severity, frequency of extreme events leading to damage to infrastructure assets • Impacts of sea-level rise on coastal assets • Exposure of assets to transition risk including 'stranded assets'	• Use of synthetic events sets from Earth System Simulation to 'fatten up the tails' and to explore clustering and correlated hazards • New kilometre-scale regional climate scenarios with more robust assessments of regional/local extremes and impacts on infrastructure (e.g. UKCP18 https://www.metoffice.gov.uk/research/collaborati

	related to oil/coal intensive industries • Impact of climate change on international trade routes • Risk of international violent conflict arising from climate change • Risks to business from disruption to supply chains and distribution networks	on/ukcp, US NCA4 https://nca2018.globalchange.gov) • Attribution of extremes using Earth System Simulation – contribution of climate change – changes in return periods • New assessments of sea level rise based on latest evidence of glacial melt • New assessments of climate sensitivity and mitigation pathways – accelerating the pace of transition?
Investment decisions, portfolio management and structuring	• Abrupt shifts in climate policy leading to change in pace of transitions to low carbon, sustainable futures • Impact of abrupt shifts in public perceptions on investment portfolios e.g. ethical, sustainability issues • Climate exposure of investments in renewable energy infrastructures, smart cities etc.	• New assessments of climate sensitivity and mitigation pathways – accelerating the pace of transition? • Shifting weather/climate patterns and impact on renewables • Exposure of city infrastructure to more severe, frequent or correlated extremes. • Impacts of sea level rise on coastal cities