"CLIMATE RISK AND ITS IMPACT IN INSURANCE INDUSTRY PART 3"

Research Paper

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"Abstract"

As we all experience in our daily life, Climate change is certainly a reality of the world. It is affecting every species in the world and is also reshaping industries and markets from a business angle. Insurance industry is affected in a unique way as climate risk impacts both sides of balance sheet namely assets and liabilities. Over many years, Insurance industry has developed many models based on past trend data including catastrophe models to handle the risk associated with uncertainties. But this is not enough as the climate risk can be handled only with a sophisticated future looking data analysis and a model needs to be developed for handling the impact of climate risk. By combining the perspectives of catastrophe and climate risk models insurance industry can handle climate risk much better. The sooner businesses and investors understand their climate related financial risks; they will be better placed to handle it and create a market differentiation to grow profitable business.

Keywords: Climate risk, Insurance Industry.

1. Introduction

In the first research paper (Climate Risk and its impact in insurance industry Part 1) presented and published by the authors on this research topic (Mannappan and Varadarajan, 2022), the topic of climate risk and its impact in insurance industry was discussed. The second research paper (Climate Risk and its impact in insurance industry Part 2) presented and being published by the authors (Mannappan and Varadarajan, 2023) discussed about one Climate model and how to make it relevant for insurance industry. In this final paper (Climate Risk and its impact in insurance industry Part 3) on this research topic, authors would discuss,

- the various climate risk models available in the world,
- challenges of the insurance industry to manage climate risk,
- how to leverage two specific climate risk models for the insurance industry and come with meaningful business inferences from it.
- also, would provide recommendations for the future research on this topic on this evolving field.

2. Models available to measure the climate risk

There are many models available to measure the Climate risk in the world today. The important ones are listed below.

2.1 Climate scenario models

Climate scenarios (Beddow, 2022) are analytical tools used to explore the potential impacts of climate change under different socioeconomic conditions, as well as to understand how human development and associated emission pathways affect the natural world. Based on the recommendation from IPCC (Intergovernmental Panel on Climate Change), organizations should use three possible future climate scenarios to explore their climate risk. Also, these risks must be analysed over a period about their ability to transform to climate hazards. IPCC suggests using the below 3 possible future scenarios:

a. Worst case scenario: Business as usual (Emissions continue to rise throughout the 21st century with no further policy intervention)

b. Most likely scenario: Emissions peak in 2040 (Emissions that do not increase beyond 2040 - the middle-of-the-road scenario)

c. Best case scenario - Paris-aligned (Emissions are reduced in line with the Paris Agreement, which aims to keep global temperature increases to well below 2ºC and preferably 1.5ºC)

By using climate scenarios to understand their physical and transition risks, businesses are better equipped to make critical decisions about where to allocate their resources to protect their bottom lines and use this knowledge to create new growth opportunities for the business.

Climate scenarios fall into two main categories, a. Climate physical risks and b. Climate transition risks and they are modelled differently.

a. The Scenario Model Intercomparison Project (ScenarioMIP) (Tebaldi et al, 2020) (climate scenarios developed by well-known science or industry experts), defines and coordinates the main set of future climate projections, based on concentration-driven simulations, within the Coupled Model Intercomparison Project phase 6 (CMIP6). Scenarios developed by ScenarioMIP, take an earth system modeling approach covering the full spectrum of climate-related outcomes. Earth systems scenarios are used to best understand the physical risk posed by extreme weather events such as flooding or heat waves, and slow-onset hazards like rising sea levels. These are widely used by major institutions like the Intergovernmental Panel on Climate Change (IPCC).

b. The second set of scenarios, such as those developed by the International Energy Agency (IEA) and the Network for Greening the Financial System (NGSF), use a simpler climate model but incorporate models of how energy markets function into their scenarios. These scenarios are designed to explore future transition risks - the disruption caused by political, social, and economic shifts arising from decarbonization.

2.2 Global climate models

A global climate model (GCM) is a complex mathematical representation of the major climate system components (atmosphere, land surface, ocean, and sea ice), and their interactions. Earth's energy balance between the four components is the key to long-term climate prediction. They are three-dimensional in that they represent physical processes in three dimensions, including the atmosphere, oceans, land, and the cryosphere, or sea ice and glaciers on land. Compared to the other types, these models can predict climate over longer time scales of several 10,000 years or glacial years. There are Five basic types of climate model

i. Energy Balance Models (EBMs)
ii. Radiative-Convective (RC) or Single-Column models (SCMs)
iii. “Dimensionally Constrained” models.
iv. Global Circulation Models (GCMs)
v. Earth System Models (ESMs).

There are many examples of successful implementation of Global Climate models. For ex,

- Using six HighResMIP multi-ensemble GCMs (both the atmosphere-only and coupled versions) at 25 km resolution, the Tropical Cyclone (TC) activity over the Bay of Bengal (BoB) is examined in the present (1950–2014) climate (Akhter et al, 2023).
- performance of a set of regional high-resolution simulations of the 1982–2005 seasonal mean climatology of daily precipitation and precipitation distribution over land are compared to observations from different sources (i.e., in situ-based and satellite-based) (Nguyen et al, 2022).
- Historical simulations of 15 Global Climate Models (GCMs) of the Coupled Model Intercomparison Project phase 6 (CMIP6) in replicating annual and seasonal rainfall climatology, their temporal variability and trends in Bangladesh for the period 1979–2014 is evaluated (Kamruzzamman et al, 2022).
- Three generations of global climate models (GCMs), Coupled Model Intercomparison Project version 3 (CMIP3), CMIP5, and CMIP6, are evaluated for performance simulating seasonal mean and annual-to-decadal variability of temperature and precipitation in the Upper Colorado River Basin (Pierce et al, 2022).
- Skill of 28 GCMs and 16 RCMs, and more importantly to assess the ability of RCMs relative to parent GCMs in simulating near-surface wind speed (WS) in diverse climate variable scales (daily, monthly, seasonal and annual) over the ocean and land region of the South Asian (SA) domain is evaluated (Lakku and Behera, 2022).

2.3 Coupled model intercomparison project (CMIP)

CMIP (Tebaldi et al, 2020) is a project of the World Climate Research Programme (WCRP)’s Working Group of Coupled Modelling (WGCM). CMIP has led to a better understanding of past, present and future climate change and variability in a multi-model framework. CMIP has developed in phases, with the simulations of the fifth phase, CMIP5, now completed, and the planning of the sixth phase, i.e. CMIP6, well underway. Based on the CMIP many regional based models are developed. For ex,

- The ability of 42 global climate models from the Coupled Model Intercomparison Project Phase 6 (CMIP6), consisting of 20 low resolution (LR) and 22 medium resolution (MR), are evaluated for their performance in simulating mean and extreme precipitation over Indonesia (Kurniadi et al, 2023).
- The ability of 11 climate models from Coupled Model Intercomparison Project Phase 5 (CMIP5) and Phase 6 (CMIP6) to simulate the sea ice seasonal cycle in Antarctica in terms of area (SIA) and concentration (SIC), as well as the

improvements in the most recent models' version, submitted to CMIP6 (Casagrande, Stachelski and de Souza, 2023).

- Precipitation variability (Sein et al, 2022) over Myanmar at the annual and seasonal scales was compared against 12 model outputs from the Coupled Model Intercomparison Project Phase 6 (CMIP6) with gridded observational data provided by the Global Precipitation Climatology Centre (GPCC) from 1970 to 2014.
- The concurrence of the two extremes, compound wind and precipitation extremes (CWPEs), may cause even larger impacts than the univariate counterparts. Using Coupled Model Intercomparison Project (CMIP6) models, changes of CWPEs in the mainland of China in the future were assessed (Meng et al, 2023).
- Performance of global climate models (GCMs) from the family of the Coupled Model Intercomparison Project Phase 6 (CMIP6) in the historical simulation of precipitation and select the best performing GCMs for future projection of precipitation in Pakistan (Abbas et al, 2022) under multiple shared socioeconomic pathways (SSPs) was evaluated.
- How rainfall may change in the future over the Sahel, Savannah, and coastal zones of the Volta River Basin (VRB), the trends and changes in rainfall between 2021–2050 and 1985–2014 under the Shared Socioeconomic Pathway (SSP2-4.5 and SSP5-8.5) scenarios were analyzed after evaluating the performance of three climate models from the Coupled Model Intercomparison Project Phase 6 (CMIP6) using Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) as observation (Dotse et al, 2023).

2.4 Third party climate model tools

There are also third party climate models like EarthScan (Cervest, 2023). EarthScan’s on-demand climate intelligence gives you an unprecedented view of historical, current and predictive climate risk on your physical assets, enabling you to baseline, monitor and forecast risk across your entire portfolio.

2.5 Catastrophe risk models

Businesses and investors are already experiencing increased financial losses from catastrophic weather events. To help understand and mitigate these losses, the insurance industry has depended on sophisticated catastrophe risk models (Pielke et al, 1999), but these do not currently take into account the threats from a changing climate. Catastrophe model (Based on historical and past data) (Grossi, Kunreuther and Windeler, 2005) – which are already in use for many years, matured and are widely used by insurance industry.

2.6 Climate risk models

Climate Risk models have emerged to estimate how temperatures will evolve in the future. Rather than rely on historical, backward-looking data, climate models provide forward-looking simulations of the interaction between energy and matter in the ocean, atmosphere and land based on levels of greenhouse gas emissions. There is a phenomenal book on which covers the climate model in depth (Gettelman and Rood, 2016) We (Authors of this research) are strongly recommending anyone who is trying to create a climate model for any industry to understand this book before they start their work, as it captures many of the nuances of climate model in depth.

3. Climate risk – challenges of the insurance industry

Critics of the insurance say that insurance places the bulk of the economic burden on communities responsible for the least amount of carbon emissions (Russell, 2018). For low-income countries, any insurance program can be expensive due to the high start-up costs and infrastructure requirements for the data collection (Warner et al, 2013). It is theorized that high premiums in high-risk areas experiencing increased climate threats, would discourage settlement in those areas (7 things you need to know, 2017). These programs are also usually timely and financially inadequate, which could be an uncertainty to national budgets (Warner et al, 2013). A considerable problem on a micro-level is that weather-related disasters usually affect whole regions or communities at the same time, resulting in a large number of claims simultaneously (Hermann, Koferl and Mairhofer, 2016). This means that it is needed to be sold on a very large, diversified scale. However, a well-designed climate risk insurance can act as a safety net for countries while improving resilience (Surminski, Bouwer, and Linnerooth-Bayer, 2016) (Kreft et al, 2017).

The international community invested in developing further support for this kind of insurance through the InsuResilience Global Partnership launched at COP23 (Russell, 2018). That group, supports regional programs such as Climate Risk Adaptation and Insurance in the Caribbean (CRAIC) and international organizations like the Munich Climate Insurance Initiative. The ACT Alliance published a guidebook for equitable and climate justice-oriented model for climate risk insurance in 2020 (Alliance, 2021).

There are several changes that are expected in insurance industry to manage the climate risk. Key ones are listed below.

- On the technology side, insurance industry is very slow to adopt to the new technical advancements (de Ferrieres, 2021). This study points on the opportunity/need for the Incumbents in insurance industry to collaborate with new entrants (InsurTechs) to speed up their digital transformation and help adjust their organization and governance to embrace new technologies fully. Digital transformation would also pave way for newer approaches to handle climate risk in insurance industry.
- Insurtechs should partner with incumbent insurers to gain insurance and climate risk know-how and leverage incumbents years of knowledge in the insurance industry to scale up faster. Until then, the industry will transform slower than other industries, and the incumbents will remain the leaders of such transformation.
- Methodological approaches currently applied to study climate insurance reach their limits when applied independently (Will et al, 2022). Hence a proper synergy among these can make climate insurance products more effective under changing climatic conditions.
- To manage climate risk, insurers need to increase their focus, attention and their spending on capital and human resources. Capital and human resources availability will continue to be a problem as more and more scrutiny would be placed and various parties will continue to seek climate risk disclosure from insurers – both on the underwriting and asset management side (Mills, 2009).
- High-stakes liability exposures will be scrutinized more and hence Enterprise Risk Management (ERM) will increasingly be seen as a valuable framework for addressing climate risks.

- Green projects in insurance would flourish. Any insurance company that brings in innovative green products and services to scale, would be the leader in the industry and hence conformance to green initiatives would become hygiene for the insurance industry in the future.
- Any company which is doing Green Projects just as a tick in the box would be exposed soon and they would lose prominence. They also will be subject to more scrutiny in the future.
- New players will continue to enter the insurance market. Some of the new players (with innovative climate risk solutions) can enter from outside insurance sector also.
- Non-insurance entities – governments, non-governmental organisations, energy companies, etc. – will continue to seek innovative partnerships in delivering climate change solutions.
- Insurers need to spend more money on research activities on climate risk including regional based climate risk models, insurance sub-domain based climate risk models, integration of various climate modelling, Go Green initiatives, efficient underwriting and asset management policies.
- Sustainability and disaster-resilience are linked initiatives and one cannot exist without the other. Insurers are perfectly placed to make the case for unifying “green” and “disaster-resilient” practices across many domains (construction, energy, agriculture, land use).

4. Research purpose and questions

Insurers face a complex challenge because climate change risk affects both sides of the balance sheet, namely assets and liabilities (Climate change, 2022). Only recently, financial and economic impacts of climate change have been defined under physical risks, liability risks and transition risks and this is enabling quantification and monitoring of these risks and integrating these into core business (Constructing Climate Pathway, 2022). Also, like many industries the focus is shifting from looking at these risks not as just a cost but as a revenue generating opportunity. As such, those insurers who are better able to adapt their business models for these new risks are most likely to capture these growth opportunities. This is the key purpose of this research. Also, the purpose of this research is to obtain data on transition risks for sectors and insurers, and then deploying capacity and expertise into sectors that are likely to benefit from the transition to a low-carbon economy.

Businesses and investors are already experiencing increased financial losses from catastrophic weather events. To help understand and mitigate these losses, the insurance industry has depended on sophisticated Catastrophe risk models, but these do not currently take into account the threats from a changing climate. Climate risk models have emerged to estimate how temperatures will evolve in the future. So, the question at hand is to how to leverage both these models to estimate the climate risk better.

5. Research design

The impact of climate is analyzed by two widely accepted models here.

5.1 Representative concentration pathways (RCP) based model:

What the climate looks like in the future depends on expected levels of greenhouse gas (GHG) emissions. Intergovernmental Panel on Climate Change (IPCC) scientists developed four Representative Concentration Pathways (RCP), which model the projected temperature increases and atmospheric warming expected by the end of the century. The below chart shows how the high emissions scenario, RCP8.5, might lead to an increase in temperature of more than five degrees Celsius (Wolf, 2020).

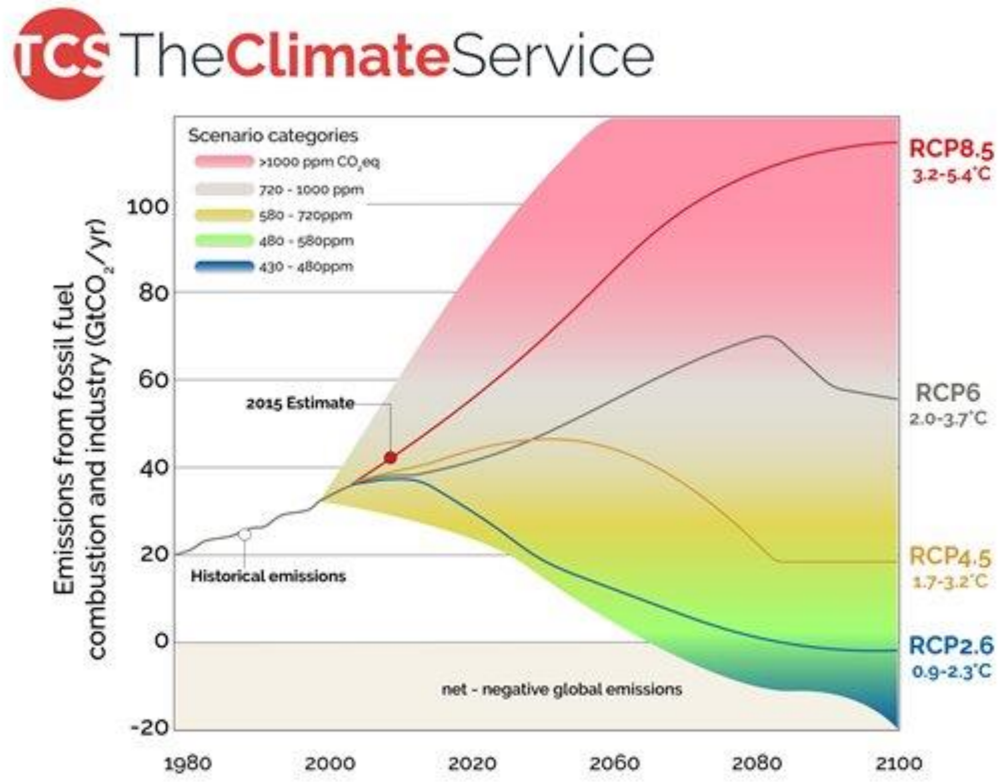

Fig 1: Global Carbon Budget - Source: Fuss et al 2014; CDIAC; Global Carbon Budget 2014

Using these RCP scenarios, climate risk analytics providers like TCS (The Climate Service), model the financial impact of physical hazards including extreme temperature, wildfire, drought, water stress, riverine flooding, coastal flooding and tropical cyclones, given the uncertainty and assumptions that climate change presents.

5.2 Physical laws-based model

Climate models can also be based on known physical laws. Basic processes describe the source and loss terms in equations, subject to basic laws of conservation. Uncertainty lies in how processes are represented (parameterized) and coupled. The energy in earth's climate system comes from the sun. Greenhouse gases (Water vapor, Carbon dioxide, Methane etc.,) alter the flow of energy in the atmosphere (Sensoy and Demircan, 2010).

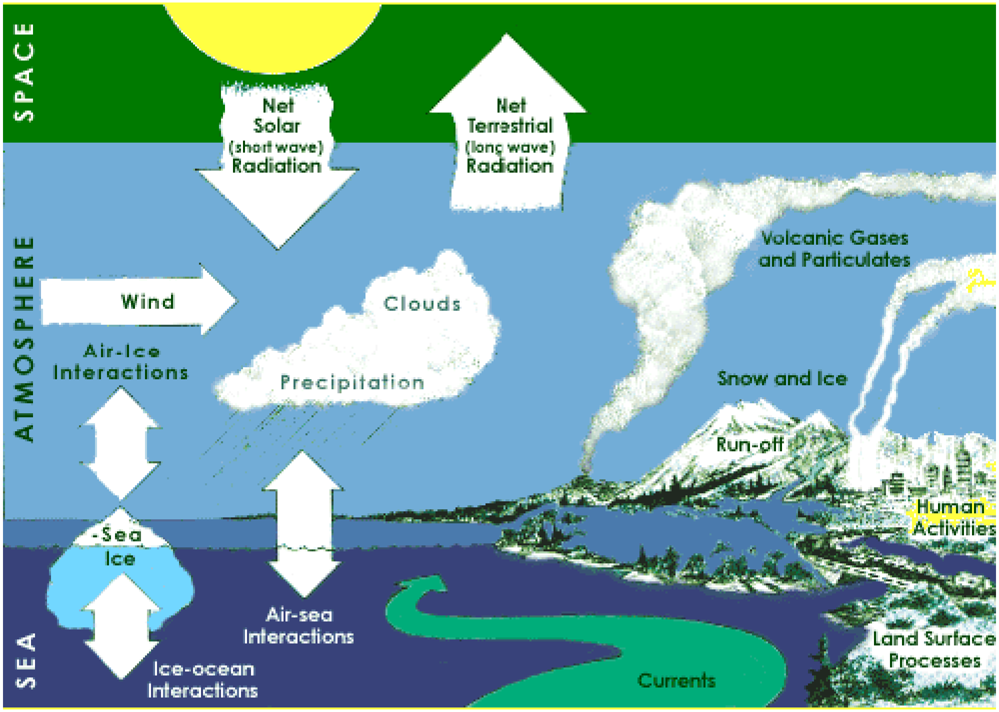

Fig 2: Major elements of the climate system (Sensoy and Demircan, 2010)

A climate model is a computer program (Fahys, 2019). Generally, each component, such as the atmosphere, can be run as a separate model, or coupled to other components: often as a coupled climate model. Simple to complex physical laws based models exist. Climate models complexity would continue to evolve with the development of more advanced computers.

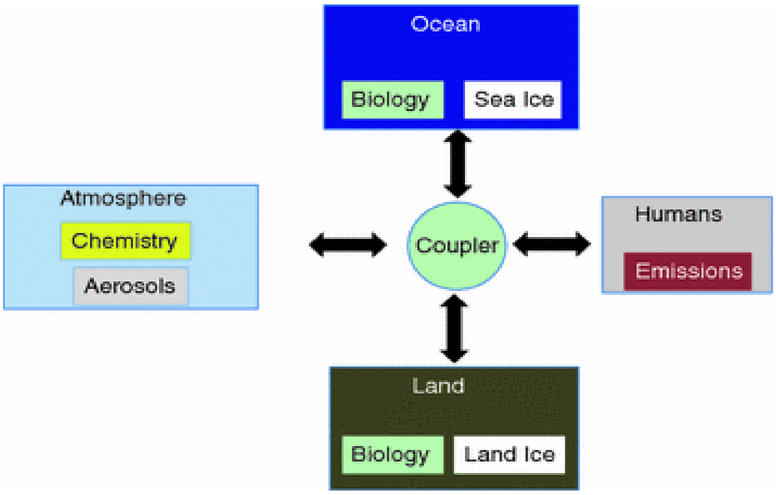

Fig 3: Coupled climate model - Schematic of the component models and subcomponents of a climate model program. (Fahys, 2019)

The process of modeling climate risk involves coupling climate model data with a vulnerability assessment of assets to produce a quantified estimate of financial loss for any asset at any location on the planet. By aggregating dozens of climate models, forward-looking hazard data is estimated, interpreted and managed by climatologists, expert data scientists, engineers, and financial analysts.

5.3 Climate model in insurance industry

- In the insurance industry, since climate models are in it earlier stages, it is better to start with integrating physical laws based base models with Catastrophe based models and expand it to more complex models later.
- In every region, certain aspect of the climate would be predominant. It would be more appropriate to look for these regional based climate models and integrate them with Catastrophe models for better results.
- In places where climate risk is more, climate risk itself can be a new product for the insurance industry generating a new revenue stream. New climate models and products can be developed in line with vertical and horizontal integration of services in the insurance industry.
- Underwriting and claims specialists must be trained more on climate risk with associated models for them to serve this industry better. Specific recommendations must be developed for selling Property and Casualty insurance and Life and Annuity insurance.
- Also, Private insurance plays a role in addressing long-term risks. A public–private partnership, where government intervention contributes to overcoming both the supply and demand barriers of long-term insurance development, would be an optimal choice in practice (He and Faure, 2023).

5.4 Research design limitations

When this research work was started not many work related to climate models were available in the public research domain. Now, there is growing evidence of more and more work related to climate risk are being developed across many industries with active participation and funding by specific Countries, Industries and top institutions. Some are getting published now more as an approach document. Still the work related to Climate risk in insurance industry is not much in public domain yet. Any advancements in it may pave way for more Climate models than the two discussed here in this paper. Hence this research work is giving an approach on how to integrate the existing risk models with a few available Climate Risk models to have better prediction on the impact of climate risk in insurance industry and this research design is limited by the fact that it is in no means an exhaustive analysis of all the available or potentially to be available Climate Risk models.

6. Summary of findings

To Summarize, insurance companies need to develop more consistent and comprehensive strategy on ESG-C and implement models that would address the climate risk. Climate models which are Regional based and product lines which are aligned to integration of services in insurance industry are the need of the hour and hence more future research work is expected in this area. Climate models need to start as simple models and mature to a more complex models with the evolution of the insurance industry to handle the climate risk.

Insurance industry has many gaps to handle climate risk. Key ones are listed below.

- Net zero strategy and Sustainability policies are not consistent in Insurance companies. They need to take quick steps to achieve it so that there won't be any anomalies in a regulated industry like insurance.
- Financial and economic impacts of climate change have to be integrated into core insurance business.
- ESG-C need to be incorporated into insurers decision-making process, particularly for their investment portfolios.
- Reporting of ESG performance, measured against a set of globally consistent standards, to become a mandatory requirement across insurance companies.
- Green infrastructure and renewable energy projects which support the transition from a high carbon to low-carbon economy should present new opportunities for insurers and have to be encouraged more.
- Deploying capacity and expertise into sectors that are likely to benefit from the transition to a low-carbon economy is a topic to consider in insurance world.

7. Recommendations for future research

- More focussed work on climate models for each climate risk zone needs to happen which can help to plan for the climate risks better.
- Global communities on climate risk to be formed to promote knowledge sharing on this topic which would be evolving in the coming years.
- Technical advancements like computing power and Gen AI can help to accelerate the models to get refined further without causing too much cost for the company or additional premium for the consumers. Focussed research on the technical disruptions to be encouraged by Governments and insurance companies.
- Many under privileged who are in climate risk zone need to be provided with climate insurance coverage so that they don't lose their livelihood. Private Insurance (He and Faure, 2023) has a role to play in it.
- Combining climate risk analysis with catastrophe modelling and risk management can yield a more robust understanding of the financial implications of climate-related hazards in the future, under different climate scenarios. In turn, this enables more holistic preparation for the threats and opportunities that the future may present.
- Insurance industry need the below data and models to handle climate risk.
- Data on transition risks for sectors and insurers is an opportunity to improve
- Climate risk models have emerged to estimate how temperatures will evolve in the future. Development of more and more climate models is important
- In the insurance industry, since climate models are in it earlier stages, it is better to start with integrating physical laws based base models with Catastrophe based models and expand it to more complex models later.
- Regional based climate models development is critical to handle the variations associated with regions.
- In places where climate risk is more, new climate models and products can be developed in line with vertical and horizontal integration of services in the insurance industry.

8. Conclusion

In a world rocked by turmoil and disruption, climate change remains one of the biggest challenges facing humanity and is already reshaping industries and markets. Based on the research done on this topic by the authors the following can be concluded,

- Catastrophe and climate models both have unique and valuable attributes. Based on the research conducted on Climate risk in insurance industry it can be concluded that while Catastrophe based models are well matured and integrated with insurance business there are opportunities to improve in managing climate risk. Models associated with Climate risk can be developed and integrating them with Catastrophe model would bring in the desired results for the business and the consumers. Combining climate risk analysis with catastrophe modeling and risk management can yield a more robust understanding of the financial implications of climate-related hazards in the future, under different climate scenarios. In turn, this enables more holistic preparation for the threats and opportunities that the future may present.
- Blending catastrophe risk and climate risk outputs can unlock a range of analytical opportunities.
- Expand investor understanding of risk over a longer time horizon. Catastrophe risk models typically provide a sophisticated understanding of potential insured loss over the next 12 months, while climate risk models can project economic losses decades into the future.
- Insurance community has to raise awareness and conduct policy-industry relevant forward looking research to help shape future policies and regulatory dialogues.
- Empower strategic investments in adaptation measures such as green roofs to mitigate building-level extreme temperature impacts, or stormwater best management practices to mitigate riverine flooding, via cost benefit analysis.
- Enable corporations to identify locations with lower climate risk profiles for the future placement of key facilities or personnel.
- Hone a longer-term return on investment perspective. With a better understanding of the ultimate terminal or sale value of real estate assets, investors can model the expected return on investment and incorporate climate risk into investment decision making.
- Identify the broader impact of climate change on markets. For instance, the availability and price of insurance for physical perils, the implications for credit and the cost of capital, and how to best navigate the regulatory journey toward mandatory climate risk disclosures.
- Insurers need to spend more money on research activities on climate risk including regional based climate risk models, insurance sub-domain based climate risk models. This includes the integration of climate modelling and catastrophe modelling, exploring the comparative risk profiles of “low-carbon” technologies to help inform underwriting as well as public policy.
- The sooner businesses and investors understand their climate related financial risks, the better placed they will be to weather the gathering storm and seize opportunities to growth their business as they emerge.

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