Dealing with uncertainty: A novel approach to exploring industry implications of physical climate risk on General Insurers*

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Abstract

Climate risk creates uncertainty in estimating insurance losses. Insurers set capital aside to pay claims in adverse scenarios – but changing frequency and severity of weather events makes it more difficult to assess the financial impact of such events. Our research introduces a new approach to sector wide scenario testing to explore the impact of acute physical risks on general insurance firms and the wider industry. It provides a way to gauge the potential impact of a 'no additional action path' under the Bank of England's 2021 Climate Biennial Exploratory Scenario exercise, and to identify important dependencies for future industry outcomes, such as underwriting, reinsurance, and own capital.

* The views and opinions expressed within this paper do not in any way represent the official views or policies of the Bank of England or the Prudential Regulation Authority.

1 What uncertainty do insurers and regulators face in understanding and managing climate risk?

General insurers are exposed to physical climate risks on their underwriting book, primarily through physical damage to property, but they may also be exposed to business interruption and liability claims arising from climate litigation against their policyholders. Their losses are affected by physical risks that are both event driven (acute) and longer term (chronic). Implications of a changing climate on physical risks can take many years to materialise, and so the resulting financial impacts are harder to predict.

Insurers can manage climate risk in a number of ways, including: risk selection and pricing, diversification of underwriting risks, reinsurance, and own capital. Insurers may find diversification harder in a world where there is evidence that perils thought to be uncorrelated before are likely to become increasingly correlated. Insurers will therefore become more dependent on reinsurance and own capital to ensure they are still able to pay claims and meet regulatory or rating agency capital requirements. These challenges on insurer and reinsurer portfolio management may also have wider implications on the cost and availability of insurance and reinsurance.

As noted in the 2021 Climate Biennial Exploratory Scenario exercise[1] (CBES), "Projections of climate losses are uncertain; scenario analysis is in its infancy and there are several notable data gaps". This is in part evidenced by noting the significant differences in estimated peril impacts across CBES participants, as illustrated within Fig. 1.

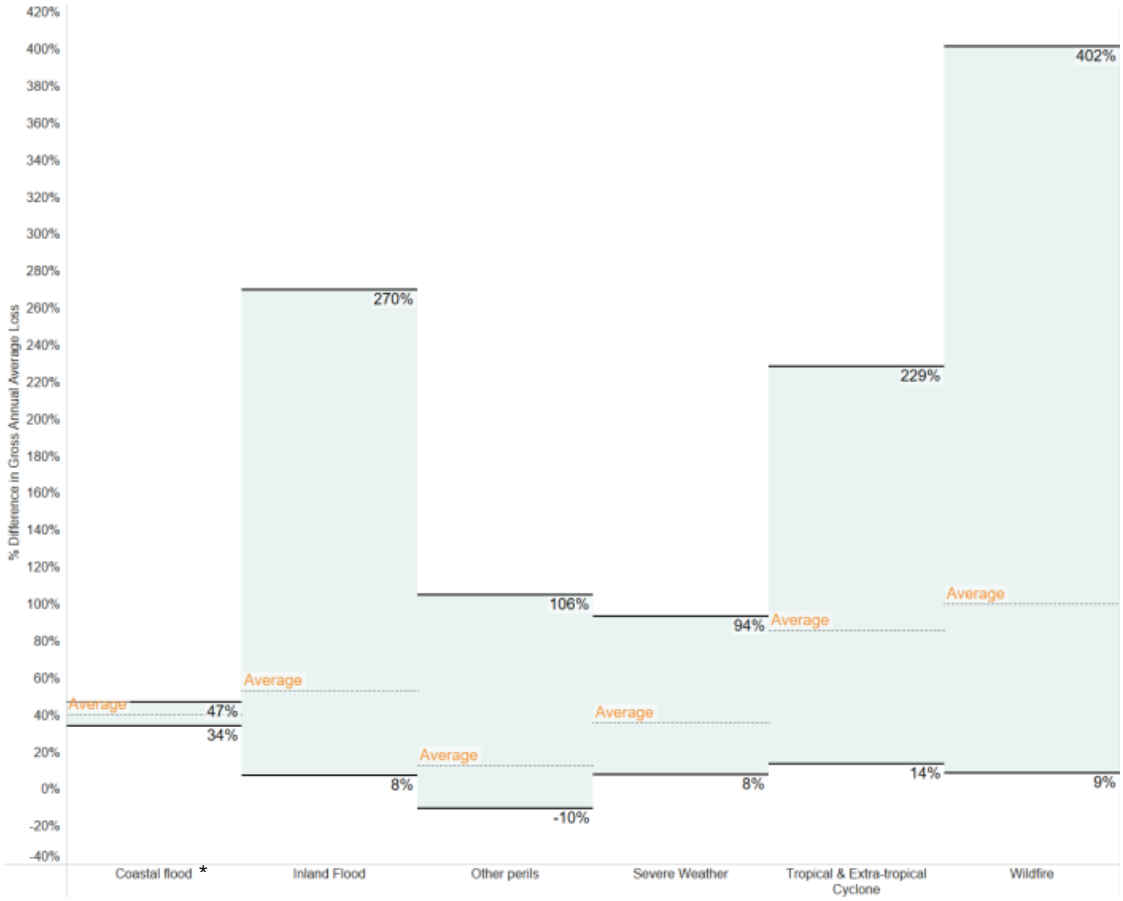
The significant uncertainty around climate change poses a challenge for insurers when estimating losses and capital for economic and regulatory purposes. Insurers typically rely on models to assess catastrophe risk. Assessing the implications of climate requires adjusting these models (parameters and structure) to account for the potential impacts on frequency, severity and the increasingly complex interactions across perils, including hurricanes, wildfires and flooding in different geographic regions.

Models that rely on data from past losses may inaccurately predict the future as perils are both increasing in frequency and scale, and becoming increasingly correlated. Therefore,

[1] https://www.bankofengland.co.uk/stress-testing/2022/results-of-the-2021-climate-biennial-exploratory-scenario

capital requirements imposed by regulators may be insufficient in both design (not capturing the risks) and calibration (undervaluing the risks).

Figure 1: Expected change to average expected loss per year (AAL[2]) under the No Additional Action Scenario*



*CBES 2021. The above graph represents US perils only. The narrow range in relation to coastal flooding reflects the fact that most insured losses will fall to the National Flood Insurance Programme, not the CBES participants.

Scenario testing is an essential tool to explore the impacts of climate risks, on both insurers and the wider industry. It can also be used to understand and assess climate risks that may not be adequately captured in standard catastrophe models, such as changes in precipitation. Scenario testing can take many forms, for example, the Economics of Climate Adaptation methodology uses annual expected losses to estimate the value at risk by combining stresses from different climate change scenarios against distribution of economic asset value[3]. In addition to stress testing, Central Banks can also perform qualitative assessments to reveal

[2] AAL: average annual loss, which is the average expected loss per year.
[3] Souvignet, Maxime and Wieneke, Florian and Mueller, Lea and Bresch, David N. (2016). Economics of Climate Adaptation - Guidebook for Practitioners.

key change agents and feedback loops[4]. Qualitative assessments may include challenging firms' own capital adequacy assessments and conducting further research on individual economic transmission channels.

Although the actual climate related risks are not fully known, sector wide scenario testing can allow us to better explore risks to business model sustainability, and financial stability. Whilst scenario analysis may not be able to fully address all the uncertainties noted above, they remain a useful tool to enhance our understanding of potential impacts of climate risk.

[4] Golnaraghi, Maryam and the Geneva Association Task Force on Climate Change Risk Assessment for the Insurance Industry. (2021). Climate Change Risk Assessment for the Insurance Industry.

2 A novel approach to exploring industry implications

Our approach

Regulators can adapt existing stress test data to test capitalisation under climate risk stress. This calibration can address two of the challenges that insurers face in understanding and assessing the impact of climate risk: extrapolating future losses and estimating heightened tail correlations of perils. These challenges can be explored through the extrapolation of existing data. This can be achieved, for example, using physical or statistical methods[5] – physical methods rely on a 'General Circulation Model' to simulate key aspects of the climate system, and statistical methods apply direct correlations between perils. To date, the lack of available data, exacerbated by climate and demographic changes rendering past data less relevant, have impaired the development of widely recognised approaches.

In 2021, the Bank of England created a new desk-based approach to examine plausible impacts if there is 'no additional action' on climate risk under the CBES 2021 exercise (see Fig. 2).

Figure 2: Summary of risk impacts in the CBES scenarios. Our approach uses the modelled output from insurers under the No Additional Action scenario.

We used two building blocks of data available to the Bank to explore industry implications under physical risk stress.

[5] Foote, Matthew and Hillier, John and Mitchell-Wallace, Kirsten and Jones, Matthew. (2017). Natural Catastrophe Risk Management and Modelling : A Practitioner's Guide, Available at: https://ebookcentral.proquest.com/lib/boe/detail.action?docID=4850320.

- **Internal Model Output (IMO):** Under the UK Solvency II regime, insurers are required to hold capital that would be sufficient to meet losses in a year to a 99.5% (1/200) confidence level. The Internal Model Output (IMO) data is reported by those insurers that have been given approval to assess these risks using their own internal model. The IMO provides regulators with relevant data points such as: catastrophe losses at key return periods relating to specific perils (natural and man-made), the distributions of non-catastrophe losses and other risks, as well as the correlations between various risk elements. In aggregate, the IMO data contains the industry's current view of all perils (including those impacted by climate change), which forms the starting point of the climate risk stress.

- **Information from 2021 CBES:** The CBES included climatic pathways for a number of perils and territories. Participating insurers reported the potential impact of this scenario on average expected loss per year (AAL[2]) and the total aggregate annual loss representing a 1% likelihood that this loss amount will be exceeded in any given year (i.e. 1-in-100 tail loss, or 1/100 AEP[6]). This information formed the basis for some of our assumptions.

We then constructed two scenarios:

Scenario 1 is based on the unadjusted CBES dataset, and assuming no or low correlations across perils, which is a common assumption within firms' internal models.

Scenario 2 is designed to address two potential shortcomings of Scenario 1 – specifically i) the lack of correlation between perils and ii) the CBES implied reductions in volatility. We expand on these below:

i. Adjusting for the lack of correlation between perils

We have drawn upon the research on the correlation between UK windstorm and flood published on Bank Underground in 2020[7], which showed that this correlation

[6] AEP: annual exceedance probability, which is the likelihood of annual aggregate loss exceeding a certain size. 1-in-100 AEP loss gives the size of annual aggregate loss that will be exceeded in any given year with a 1% chance.

[7] Hadzilacos, Giorgis and Li, Ryan and Harrington, Paul and Latchman, Shane and Hillier, John and Dixon, Richard and New, Charlie and Alabaster, Alex and Tsapko, Tanya. (2021). It's windy when it's wet: why UK insurers may need to reassess their modelling assumptions. Weblink: https://bankunderground.co.uk/2021/04/08/its-windy-when-its-wet-why-uk-insurers-may-need-to-reassess-their-modelling-assumptions/

does exist and the level can be between 20% and 50%. Further research in 2022, 'Co-Occurring Wintertime Flooding and Extreme Wind Over Europe, from Daily to Seasonal Timescales'[8], supports the conclusion that UK windstorm and flood are correlated; and that 40% correlation is not an overestimation, and that similar correlation exits in many EU countries too.

Consequently, in Scenario 2 we increased between peril correlation to 40%.

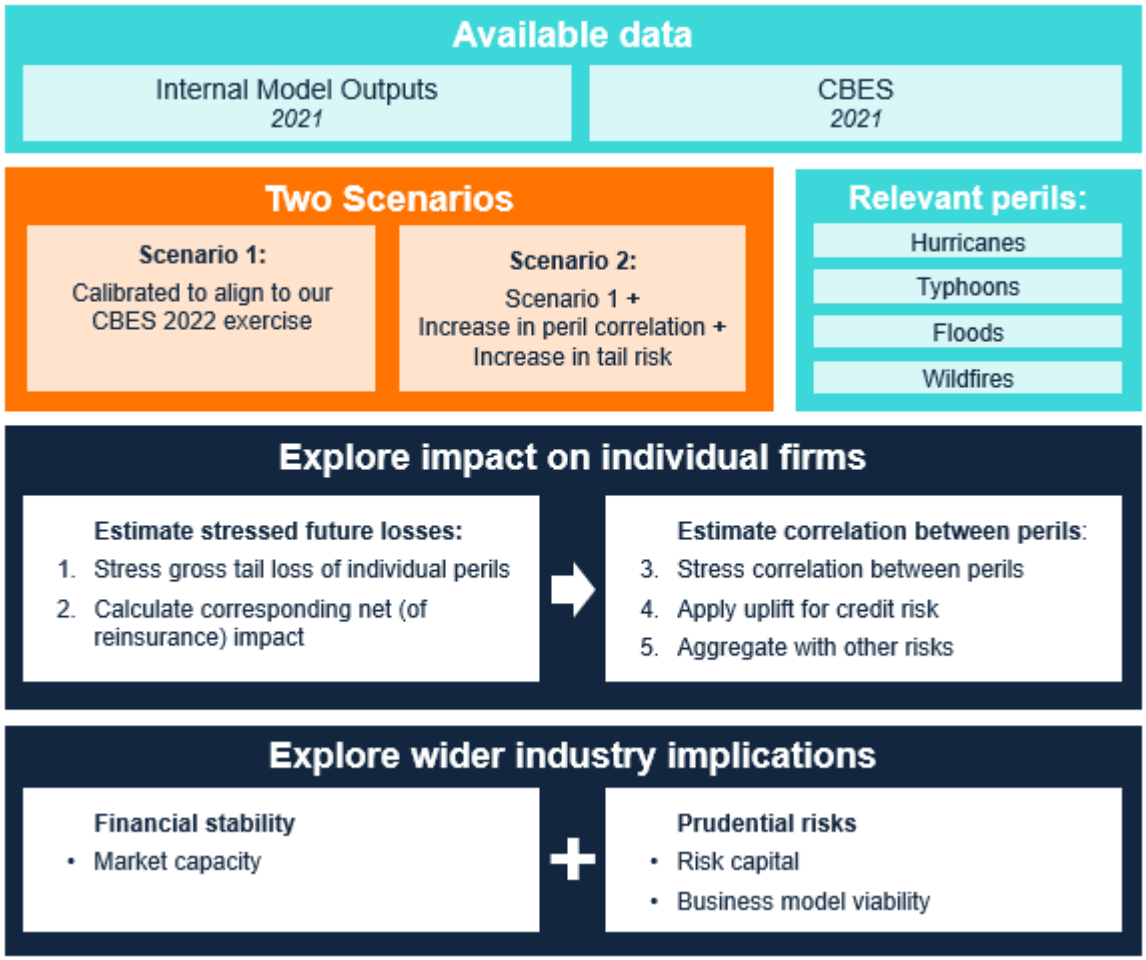
ii. **Adjusting for the implied reduction in volatility from the CBES results**

For most perils, CBES implies a bigger impact on AAL than on 1/100 AEP (i.e. the extreme losses), statistically that indicating losses would increase because of climate change, but the overall distribution would be less dispersed. Such a result, even if statistically plausible, is somewhat counterintuitive as it suggests that current uncertain climate trends will make the prevalence and severity of extreme events more predictable. In the spirit of a "what-if scenario" and without asserting a higher level of credibility, we also adjusted **Scenario 2** to instead consider the implication that the volatility of losses will increase instead of the implied trend under CBES. We achieve this by increasing the coefficient of variation of the loss distributions for each of the climate expose perils by 30%.

Figure 3 provides an overview of our methodology.

[8] Bloomfield, Hannah and Hillier, John and Griffin, Adam and Kay, Alison L. and Shaffrey, Len C. and Pianosi, Francesca and James, Rachel and Kumar, Dhriendra and Champion, Adrian and Bates, Paul. (2022). Co-Occurring Wintertime Flooding and Extreme Wind Over Europe, from Daily to Seasonal Timescales. Available at SSRN: https://ssrn.com/abstract=4197062 or http://dx.doi.org/10.2139/ssrn.4197062

Figure 3: Our model approach to exploring industry implications under climate risk stress



Our approach provided us with a view of plausible firm level implications under a scenario of climate risk stress. Using the data contained in the IMO, we were able to fit 'stressed' distributions of climate exposed perils under CBES, model how much of the climate stress is absorbed between firm's own capital and reinsurance and approximate the increase in capital requirement after diversification for both insurers and reinsurers. We then applied two additional assumptions on insurer and reinsurer cost of capital and eventually estimated how much the premiums will have to increase to account for the increase in expected loss and cost of capital of both insurers and reinsurers. This was designed to reflect a dynamic element of insurer/reinsurer response following climate stress, in order to better explore the wider industry implications.

Model assumptions and limitations

Before discussing our results, we highlight a number of key assumptions in our desk-based model, which are detailed within Fig. 4:

To explore the impact of climate stress on individual firms

- We approximated a single compound distribution for frequency and severity of perils based on the IMO and extrapolated the impact from the two data points of CBES (AAL and 1/100 AEP) to other percentiles using statistical methods
- We assumed reinsurance behaved in line with today's extreme percentiles
- We assumed the same correlation between perils on gross and net loss
- We assumed distributions were elliptical to approximate the diversification benefit, and then applied a correction factor to partially mitigate the approximation error

To explore wider industry implications

- We made two additional assumptions to better explore wider industry implications, namely: insurer and reinsurer cost of capital, and reinsurer diversification.

We recognise the assumptions and limitations of our desk-based approach. In particular, we believe climate change may have material implications on the cost and availability of catastrophe reinsurance, which means our analysis is likely to have underestimated the capital impact. However, we believe the limitations arising from an accumulation of modelling assumptions are less material when compared to the uncertainty around climate change itself, and therefore that our model results are able to give a plausible indication of the potential impact of the 'no additional action' path on the General Insurance industry.

Figure 4: Summary of key assumptions applied

Assumptions to explore impact of climate stress on individual firms

	Core Parameters	Assumption	Basis / rationale
Stress Model Inputs	Impact on AAL (ie mean losses)	Different by peril	Derived from CBES 2021
	Impact on 1-in-200 peril loss (AEP)	Different by peril	CBES stress at mean and 1 in 100 AEP, extrapolated to 1 in 200 using Translated Gamma approximation.
	Benefit of Reinsurance	In line with current programme	Ability to use current IMO data to estimate recoveries in the tail of the distribution
	Correlations across perils	40%	2020 Bank research paper on the correlation between windstorm and flood in UK
IMO Data	Natural and Man-made Cat	No change	Diversification benefit reduces if climate related perils become more dominant
	Non Cat Losses and Reserve Risks	No change	
	Other Risks (market, credit and operation)	Credit risk increased in line with increase in recoveries; Other risks unchanged from IMO	Credit risk is dominated by reinsurance recoveries in the tail. Assume same risk charge from IMO.
	Correlation across risk types	Unchanged from IMO	Overall diversification reduces if premium risk becomes more dominant after stress

Additional assumptions to explore wider industry implications

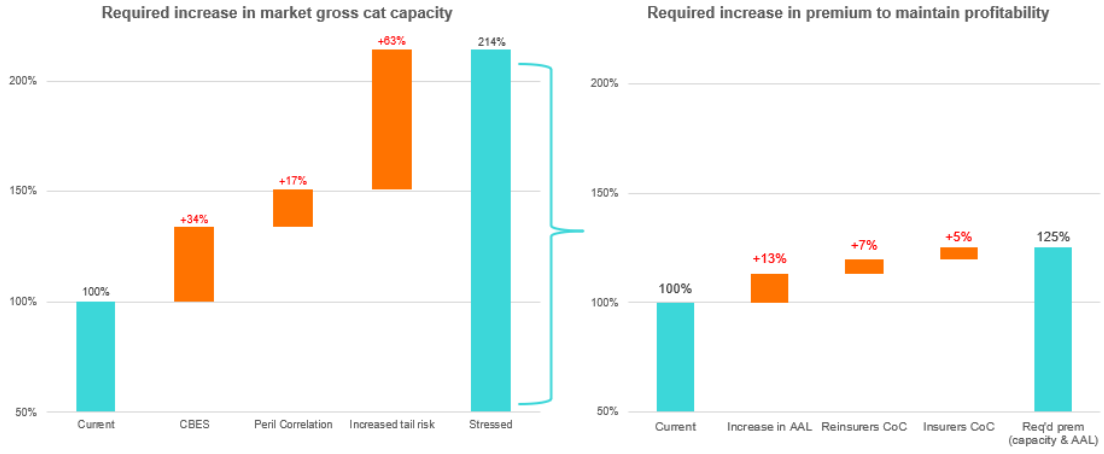
	Core Parameters	Assumption	Basis / rationale
Industry asm.	Insurers Cost of capital	10%	Assumed target return on capital
	Reinsurers Cost of Capital	10%	Assumed target return on capital
	Reinsurers Diversification of nat cat risk with other risks	25%	We assume reinsurers are more dominated by concentration of nat cat risk

3 Results and key conclusions

Using our model, we have been able to explore the potential impact of climate risk on financial stability and for assessing business model viability.

The left-hand side of Fig. 5 shows the expected increase in market capacity for gross catastrophe risks under climatic assumptions set out in Scenario 2. On the right-hand side, we illustrate the implications of the increase in capacity on average premiums charged to policyholders. This indicates that the overall increase in costs are manageable. However, it is important to remember that the general insurance market is heterogeneous when it comes to firms' business models, for example, the concentration in certain perils and regions, and the reliance on reinsurance, etc. As a result, some insurers will need to increase premiums significantly more than others.

Figure 5: Financial stability under Scenario 2 – If market capacity can comfortably expand, increases in average cost of insurance appear manageable. However, this average does not provide an individual firm's view of impact, which could be significantly more material.

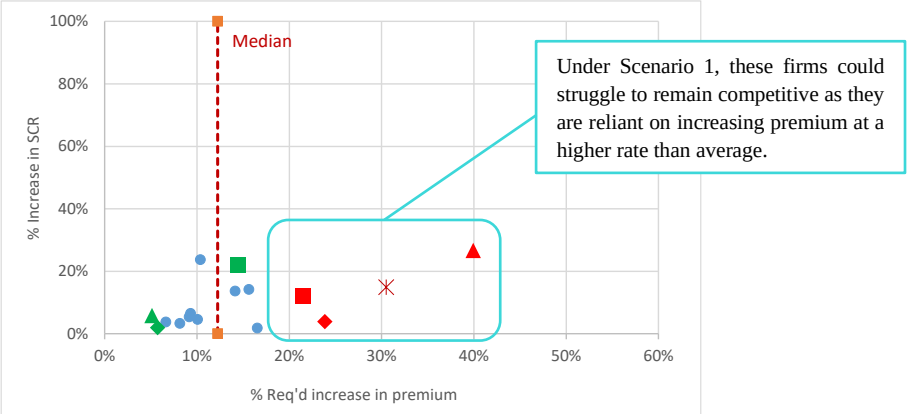


We also used our model to explore the impact on regulatory capital and on business model viability. Fig. 6 illustrates the potential impacts on regulatory capital and insurance premium pricing on an individual firm basis under our two scenarios – the upper chart is fully aligned to the assumptions used in the CBES 2021 (Scenario 1), and the lower chart has applied additional correlation between risks and additional tail risk to the CBES baseline assumption (Scenario 2). Firms may have difficulties maintaining their business

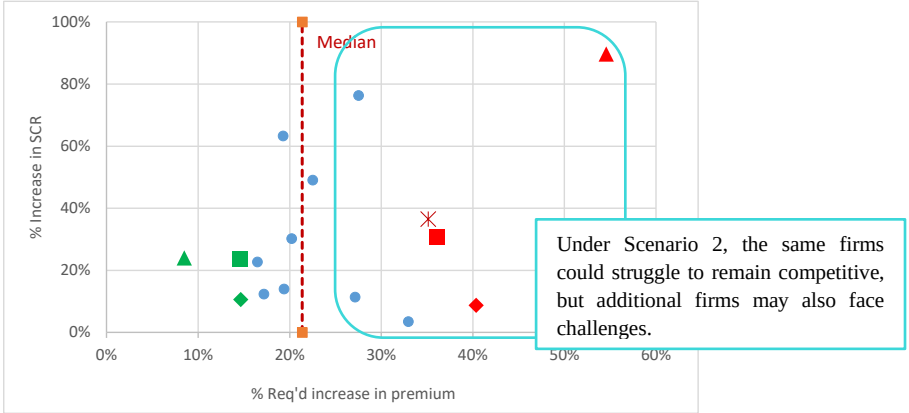
model if they have to increase capital and premium rates much higher than market average. In other words, these firms may have to adapt in order to remain competitive.

Figure 6: Prudential risks under Scenarios 1 and 2 – impact on regulatory capital and required premium repricing on an individual firm basis is more pronounced under circumstances with increased correlation between perils and heightened risk at the tail.

*Impact on insurer business model under Scenario 1**



*Impact on insurer business model under Scenario 2**

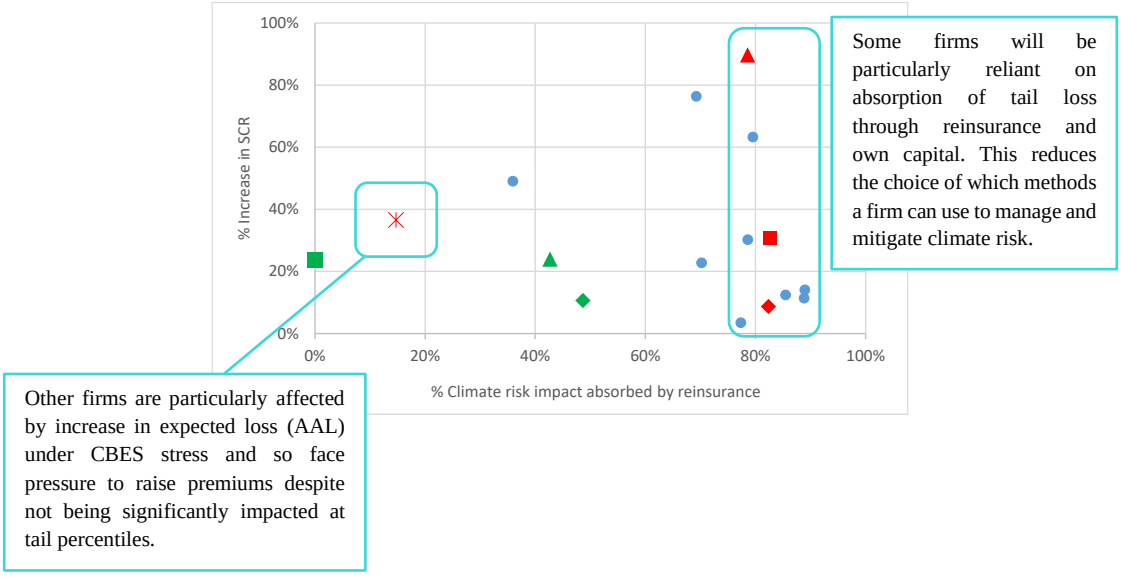


*Markers represent individual firms and the red and green icons used are consistent between both graphs across Fig. 6 And Fig. 7 to illustrate the variability of dependence and impact of different drivers, such as peril volatility and correlation, on individual firms.

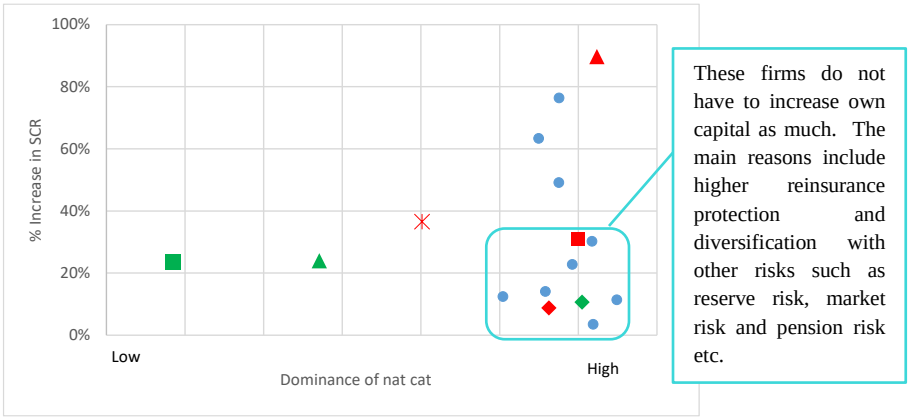
Fig. 7 provides more details under Scenario 2 about why certain firms are more affected. Note the red and green markers represent the same firms as Fig. 6.

Figure 7: Prudential risks under Scenario 2 – the influence of reinsurance and cross-product diversification.

In general, higher reliance on reinsurance reduces the need to hold more capital. However, some insurers in our sample will experience a sharp rise in capital regardless of their high reliance on reinsurance *



*Cross-product diversification away from natural catastrophe risk can mitigate capital impacts, but currently a large portion of our sample are mitigating climate related risks via reinsurance and diversification with other risk types, such as market risk**



*Markers represent individual firms and the red and green icons used are consistent between both graphs across Fig. 6. And Fig. 7 to illustrate the variability of dependence and impact of different drivers, such as peril volatility and correlation, on individual firms.

Overall, the results show that the impact of climate could be dramatically different between firms. Firms with less diversified portfolios (e.g. firms specialising in property catastrophe

risk) are likely to face the greatest challenge. Reinsurers will inevitably raise prices or reduce coverage in cases where they are ceded with increasing amounts of risk, and so insurers that are reliant on both big increases in own capital and reinsurance to absorb climate risk are likely to face challenges to their business model. Firms that are less able to cross subsidise against non-catastrophe risks will have to increase their premiums more significantly, which may reduce their ability to compete.

Our desk based model has allowed us to explore how climate related risks could materialise and the impact on both individual firms and the industry as a whole. Below are the key conclusions we are able to draw from our exercise.

- Both scenarios indicate that the sector as a whole should be able to continue to provide coverage.
- However, the analysis has also indicated insurer business models that are more vulnerable to climate-related changes. These firms will need to adapt to remain competitive.
- The estimated increase in overall market capacity is not insignificant and cannot happen overnight. Further action may be required to ensure that capacity will be available as physical risks materialise.
- The analysis has also highlighted climate uncertainty, and the extent to which key assumptions can change industry implications and which business models could become vulnerable.

4 What next? Implications for regulators

Both firms and regulators face at least two types of challenges when assessing the impact of climate: data quality (including availability, reliability and comparability); and validity of assumptions in a continuously changing environment.

The financial impact of physical risks is forward looking and long term. Historical loss data may become less relevant in assessing future risk, which shifts the focus on e.g. modelled information. The reliance on modelled information exposes firms and regulators to increased risk of modelling errors and assumptions.

Physical risk exposure will not increase linearly relative to the increase in global average temperature. Once climate change passes a certain threshold, the impact of physical risks could increase in both frequency and severity at an accelerated rate, and this adds an additional dimension of uncertainty that regulators need to account for. Impacts are likely to be lumpy and so there could be material implications on reinsurance availability and pricing following a significant upwards reassessment.

While this uncertainty cannot be reduced, our approach provides a framework for considering broader consequences that could help regulators and other stakeholders to explore the implications for the general insurance market. As this paper has illustrated, this work has helped us to identify and assess some of the key dependencies, such as future capital requirements, pricing, and reinsurance programmes.

Given the challenges above, it is important for regulators and firms to regularly perform sensitivity testing on the potential impacts of climate on business model viability, by considering the implications on required capital and pricing of risks. Our approach has leveraged the CBES results and the latest academic research to consider potential medium to longer term implications for the general insurance sector. Development of additional methods to explore industry implications under climate risk stress can be used as part of a regulator’s toolkit to support and, where necessary, challenge the market’s ability to consider and adapt to climate risk.