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EDITORIAL

A changing climate for actuarial science

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Introduction

While there is a growing interest in climate-related risks within the actuarial profession, professionals and climate scientists sometimes lack the resources to help them quantify the financial impacts of climate change. From the increasing frequency and severity of claims in P&C (re)insurance to the damage or stranding of financial assets becoming more volatile and impactful, climate policies and climate change will affect all practice areas of the actuarial profession.

To support the development and creation of innovative methods integrating climate-related risks, the *Annals of Actuarial Science* (AAS) launched a special issue entitled "Managing Climate-related Risks."

Four papers have been accepted as part of the special issue.

Jessup et al. (2023) argue that the use of model combination techniques is necessary when assessing the economic risks associated with extreme weather events. They consider various model combination methods, including inverse distance weighting, non-parametric calibration, and Bayesian model averaging, with a goal to investigate the impact of such methods on the resulting areal reduction factor (ARF) calculation. Their case study reveals that different methods lead to significantly different estimates of ARF curves, thereby suggesting that using a single model combination method may lead to overconfidence about projections.

Kiesel and Stahl (2023) propose a model to capture deep uncertainty, non-linearity, and cascading effects in climate risk. They argue that their proposed model in a wide sense provides the right structures that allow one to relate climate risk to the volatilities, uncertainties, complexities, and ambiguities approach for risk management purposes. They further argue that the framework they provided is in line with the three-pillar approach of Solvency II and fits smoothly to a hybrid approach of micro- and macro-prudential supervision.

Zou et al. (2023) consider a weather index insurance product for soybean producers. They separate the entire vegetation cycle into four phases and propose a phase-division contract that is hypothesized to yield better hedge effectiveness compared to one without any phase division. Furthermore, they argue that the division of growth cycle may also support managerial decisions, such as the timing of irrigation measures. From a modeling perspective, they suggest a generalized additive model with P-splines box product smoothers for estimating conditional yield loss functions. Their empirical work that is based on soybean production in Illinois supports the proposed phase-division contract.

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Gracianti et al. (2023) study wind derivatives that are constructed for managing uncertainty in wind power production. Specifically, they investigate how the misspecification of wind speed models may affect estimates of wind derivative prices, by comparing results generated from typical models, based on the assumption that wind speed is normally distributed, and those produced by a more general model that accounts for non-normality. Their results suggest that model risk can be highly significant for certain choices of the underlying wind speed index and payoff structure, leaving a cautionary note that model risk cannot be ignored in pricing wind speed derivatives.

This editorial is co-authored by the special issue's Guest Editors (Boudreault, Clacher, Zhou) and the responsible AAS Editor (Li), in collaboration with Catherine Pigott FIA (Head of Science & Natural Perils, AXA XL). The remainder of editorial focuses on identifying the challenges of climate-related risks for actuaries and actuarial science. Furthermore, the Editors of AAS envisage the compilation of a thematic collection of articles published in the AAS, including the articles introduced here, as well as other contributions in the area of climate-related risks.

Bridging the gap: Actuarial science, climate science, and Catastrophe modeling

As one considers the impact of climate change risks on the financial sector, both now and into the future, the need becomes apparent for bringing numerous skill sets from different disciplines together to collaborate and address the fundamental challenges that arise in tackling this constantly evolving and uncertain topic. Is there a gap in the approaches of climate scientists and actuaries that requires a change in tack? Is there enough attention paid by either discipline to developing a partnership where information and knowledge are exchanged to best understand this huge evolution of risk-taking place before our eyes?

Actuaries do not need to be climate scientists to use information coming from researchers in this field, in the same way they do not need to be medics to think about mortality and health trends. However, there is a need for actuaries to understand the approaches taken by climate scientists, the perspectives they provide, and how these might differ from the points of view of financial services and markets. Actuaries are typically required to consider the full range of possible outcomes and assign probabilities to these. This can include considering possible trends where there may not yet be a physical understanding of the cause, or the body of scientific evidence is not yet sufficient to publish literature on the subject. However, climate models often operate deterministically, rather than producing the stochastic output actuaries utilize. Nonetheless, typical actuarial techniques rely on data collection of numerous historical, repeated events. Climate change means that the past will not necessarily represent the future, and the chronic, long-term nature of the change is quite different from other risks often analyzed. Hence, it is likely that the use of climate science and development of new tools will be required to thoroughly understand this risk. Despite these differences, we believe they are not insurmountable in forging good working relationships between the two disciplines. Both are built on mathematical principles, and actuaries are extremely well placed to translate climate science into different financial contexts. Furthermore, by carefully considering the limitations and challenges of climate science along with the uncertainties that sit within climate and actuarial models, there is great opportunity for enhancing the analysis on both fronts.

An example of the need for integrating climate and actuarial science occurs in the area of mortality modeling, which has profound implications for the pricing and reserving of life insurance and annuities. Much of the existing mortality literature focuses on annual mortality rates, which do not allow for intra-annual variations in temperature and their effect on mortality. In response, a promising avenue for future research is the development of intra-annual mortality models which will facilitate the incorporation of climate change's impact in mortality modeling – such integration is difficult with current time-series-based mortality models.

Relatedly, another area of potential improvement is the collaboration between professional actuaries and catastrophe modelers. In the UK, these have usually been fairly independent groups only working together in defined areas where the disciplines intersect, for example capital modeling. We suggest that bringing these areas more closely together would be greatly beneficial, particularly as catastrophe models are often the outlet for climate science that is consumed directly in the insurance industry. While historically labeled as "black boxes," there has been a shift in the catastrophe modeling world to more transparency and flexibility in recent years, which is crucial when considering the extremely large uncertainties in understanding physical risk associated with climate change.

Actuaries have a vital role

Beyond modeling, actuarial research can play a vital role in fostering climate adaptation, building climate resilience, and helping to close the protection gap. Insurance is a fundamental tool for managing risk and is one of the key areas where actuaries can contribute to climate adaptation strategies. This includes developing new insurance or financial products for climate-related risks, for example flood and crop insurance, and pricing these risks appropriately, or improving product design to incentivize risk mitigation. There are also innovative areas around parametric products, nature-based solutions, and carbon capture insurance, to name a few, that lend themselves to supporting the transition to net zero.

It is important to remember that the consequences of climate change are not restricted to catastrophe insurance products, with physical risks having impacts on more chronic risks including healthcare and mortality. Secondary effects, such as population migration and impacts on geopolitical risks, could also have long-lasting societal consequences. Transition and litigation risks could have significant impacts on the general insurance market, across many product lines, offering another area where academic research combined with actuarial input would be beneficial. In addition, many of the economic implications of climate change are currently poorly understood, and this provides opportunities for actuaries, who have expertise in understanding both sides of the balance sheet. Climate change poses a broad range of impacts to risk categories from underwriting, reserving, and investments, to operational and strategic areas. Given the very transversal nature of climate change effects, it is important that a holistic approach is taken to managing this risk and that subcomponents are not considered in isolation. While this is a complex task, given the interactions at play, collaborative research between actuaries and others can start to rise to this challenge to give better information to decision-makers.

In addition to examining the impact of climate change on financial service companies, it is essential that consideration is given to the impact that financial service companies have on the environment. This concept of double materiality requires much more investment from the financial services sector to enhance newly developing techniques to quantify emissions. Strategic decisions around items such as investment policies will have knock-on impacts on the economy and future carbon emissions. Financial organizations are part of investor sentiment as well as being impacted by it. This is an area where actuaries could have a bigger influence and help to steer the ship towards greener decisions.

Finally, actuaries have professional responsibilities, and we would argue that it is profoundly unethical to ignore risks on the grounds that they cannot currently be quantified with the precision that other risks can be. Raising awareness of unquantified risks in a qualitative manner is a first step, but striving for solutions and communicating the nature of the uncertainties should be the goal to address these developing risks. Personal beliefs about the most likely outcome should not influence or prevent discussion of possible outcomes, even if they are not popular. For example, those doing scenario analysis should seek out critical feedback but not come under pressure to accept "that's impossible" lines of argument. Actuaries are well-respected risk professionals and can be a powerful voice in communicating the risks they perceive even if these are uncertain.

Areas of future research

Although our understanding of the impacts of climate change on climate extremes such as floods, tropical cyclones, and wildfires has improved significantly over the past 2 decades, it is still very challenging to relate climate policies to economics, which is at the core of transition risk assessment. Life insurers and pension plans manage financial assets over a very long-time horizon and research as to how climate policies and climate extremes affect GDP growth, inflation, interest rates, and returns in various sectors of the economy is therefore essential to actuaries.

As well as these long-term impacts, which may seem remote and distant to many actors in the market and may therefore lead to inertia, actuaries have a key role in helping the pensions and insurance sectors in particular understand near-term risks such as floods, extremes of temperature, all of which are increasing in severity and frequency and are impacting portfolios and pricing now.

Global warming and more frequent climate extremes will make certain areas of the world uninhabitable, uninsurable, or very costly to live therefore leading to significant climate migration or a widening of the already sizeable protection gap. Climate migration will put pressure on social services (e.g., healthcare, education, etc.), demand for housing, and may even create political instability. A growing protection gap could add significant debt to governments as the insurer of last resort further putting pressure on social services and economic stability. How this is going to affect the economy is also a potentially impactful area of research.

Improving access to insurance worldwide is key to improve resilience to climate change. As such, parametric solutions for weather risks, including weather index insurance and weather derivatives, are well-established. Despite advances in the actuarial community regarding developing index-based insurance for the agricultural sector, there is a notable gap when it comes to the renewable energy sector, including areas like solar and wind energy. This gap exists not just in covering physical damage to infrastructure but also in potential reductions in energy production due to adverse weather events. As such, there is a pressing need for increased actuarial research to develop standardized parametric coverage with low basis risk for the renewable energy sector.

Conclusion

Actuaries and actuarial science can contribute to better understand the financial impacts of climate change to improve access to insurance, the long-term viability of social security systems and, in turn, accelerate adaptation plans and mitigation strategies. But to achieve these objectives, actuaries and actuarial science have to work with climate scientists, as they are the leading experts to provide detailed information on historical weather patterns, ongoing climate changes, and future climate predictions. A notable challenge in applying climate science to actuarial modeling is the uncertainty surrounding long-term climate forecasts. Climate scientists can provide tools and methods to measure and convey these uncertainties, assisting actuaries in enhancing their models. But as climate change is quickly being integrated into economics, climate science will also have to provide adapted tools and models for long-term economic projections, balancing the predictability of long-term climate trends with the uncertainty of climate projections, and actuaries are arguably one of the best-placed professions to help with that translation piece between climate science and the real economic impacts of climate change.

Further reading

- International Actuarial Association papers on climate issues
- Institute and Faculty of Actuaries climate-related publications

- Task Force on Climate-related Financial Disclosures publications
- United Nations Disaster Risk Reduction publications
- Intergovernmental Panel on Climate Change publications
- United Nations Environment Program – Finance Initiative publications

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