



Stability of Actuarial Assumptions: Impact of Climate Change

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INTRODUCTION

The earth has enjoyed 10,000 years of climatic stability since the most recent Ice Age. Human actions since 1750, tied mainly to fossil fuels, have increased carbon dioxide and other greenhouse gases in the atmosphere and oceans, increasing temperatures and ocean acidification. Many impacts to climate have been recorded, from expanding drought, increased strength of hurricanes, and increased damage from convective thunderstorms.

The most recent ten years have been the warmest in the global historical record, with carbon dioxide levels their highest in at least 800,000 years. According to climate modelers, the earth's ecosystem is nearing temperature tipping points. Reaching three degrees Centigrade above pre-industrial temperatures globally could stimulate an additional three degrees of temperature increase. Some have hypothesized that these triggers could be due to war-time greenhouse gas release, changes in cloud formation, permafrost melt, or a slowing ocean current. *This Time is Different!* And not in a good way. Global warming acts as a threat multiplier to nearly every other risk we encounter and impacts nearly every actuarial assumption in some way.

Assumptions for extreme weather events are unknown knowns, where we have historical data but it is not predictive for future events. Many actuarial assumptions are constant or rely on a mean reversion relationship. Meanwhile, many of today's trends are changing in nonlinear ways. For those who have mispriced these risks the tide is going out, and we may soon discover who has been swimming naked. Modelers have some tools to reflect potential trends, but uncertainty is higher and interactions with other risks are complex and can have surprising outcomes. Of interest to individuals, businesses, insurers, and other financial institutions are direct linear and indirect impacts, but also higher order impacts on assumptions from a changing climate. How will this drive changes in assumptions used by actuaries? Let's break it down by broad category, using some examples of the drivers and the impacted assumptions.

FINANCIAL

Extreme weather events damage infrastructure. This costs money and repeated events can leave a regional economy uncertain of its future path. Residents often want to stay but property insurance costs reflecting sustainable practices may become too high for those in the working class.

Goals may also include being proactive and protecting areas susceptible to damage from extreme weather, but this can be very expensive. Historically in the U.S. there has been federal funding available, but it becomes untenable as events become more frequent and widespread. By default, each event becomes a local problem, with little national coordination to improve process efficiency.

IMPACT ON ACTUARIAL ASSUMPTIONS

Climate change leads to uncertainty and financial markets need to be compensated. When the 10-year Treasury rate permanently increases, so do rates used for other loans, everything from home mortgages to commercial loans to expand a business. From a recent rate of under 5%, even an increase of 100 basis points makes a big difference to decision makers. Investors raise their hurdle discount rates by a similar amount, accepting fewer investments and projects. All asset classes are impacted in such a scenario.

Property insurance requires stability to be sustainable. If claims become more volatile, or inflation spikes, some insurers may need to exit some markets. Excess litigation and fly-by-night insurers reduce the stability of the marketplace. A region without a viable insurance market may become uninvestable.

DEMOGRAPHICS

Western economies are slowing growth or contracting their population. Developing country fertility rates remain above long-term sustainability levels of 2.1 but are slowing. There are concerns about antimicrobial resistance, microplastics, pollution (potentially tied to lower semen counts), and science skepticism. About 1900, prior to improved sanitation, maternity methods, and vaccination schedules, the total fertility rate (TFR) necessary to maintain a population was about four. Losing maternal health improvements and vaccines would increase the TFR needed to three, meaning females would need to average three children to assure that enough would live to adulthood to maintain the population size.

Increased longevity is another trend that is changing in discontinuous spurts. Life expectancy has doubled globally over the last 100 years, and research is near breakthroughs for personalized treatments based on genes and vaccines targeting specific cancers, with artificial intelligence (AI) tools progressing quickly to develop solutions.

Climate change creates uncertainty but, when combined with government debt-to-GDP levels and demographic trends, acts as a threat multiplier. High levels of government debt mean it will be hard to find the money to repair or anticipate damage from a changing climate, and a smaller and aging population means fewer taxes are collected and fewer workers are available to cultivate crops and perform needed services like aides in nursing homes.

IMPACT ON ACTUARIAL ASSUMPTIONS

One could argue that demographics move slowly and impact all actuarial assumptions, but some vary by product. An older population drives interest rates higher as retirees decumulate their assets, decreasing values of assets and liabilities. Fewer children reduce the incentive to fund research on their behalf, increasing the price of health insurance for families. Payout annuities, especially those that are single premium focused and competitively priced, are susceptible to longevity increases and mismatched assets and liabilities. Scenarios should be developed to determine how additional improvement in retiree lifespans and ALM mismatches impact profitability and solvency.

FEEDBACK LOOPS

Global warming drives ice caps, permafrost, and glaciers to melt. Reduced sea ice slows the ocean currents, impacting keystone species like krill that feed on plankton that use the nutrients pulled to the surface by the normal uplift function of the current. Permafrost melting is another feedback loop, releasing long frozen carbon along with diseases today's species have no immunity against. Glaciers provide fresh water to several billion people. As this water source becomes sporadic, the remaining resources will be fought

over in regional conflicts. The loss of ice cover expands the albedo effect as sunlight that had been reflected back into space is now absorbed by the darker land and water that was underneath.

Extreme weather continues to interact in ways that make some areas less sustainable. Repeated cycles of drought and heavy rain due to atmospheric rivers have led to landslides and wildfires on the U.S. west coast, also leaving the areas impacted more susceptible to earthquakes. In the south and plains states convective storms with tornados and hail have become more prevalent.

Global tensions are high today, challenging the rules-based international order put in place after World War II, and a large war would release fossil fuels with a rebuild using carbon generating cement processes. Melting ice makes it easier to access fossil fuels and rare earth minerals in locations like Greenland and Alaska, creating another feedback loop.

IMPACT ON ACTUARIAL ASSUMPTIONS

Property insurance is becoming more expensive in many parts of the U.S. Repeated hail damage in the plains doubled homeowner premiums and limited the number of carriers willing to offer coverage. Some states have added government run insurers with taxpayer backing, but they often are subsidized and do not help create a sustainable marketplace or economy. Higher volatility of extreme weather could lead to a change in the way private insurers operate. They could require roofs to be fire resistant or expect community-based fire repressant strategies to be implemented. Property insurance could become an unsustainable product and life insurance susceptible to bouts of deflation and hyperinflation as temperatures rise, impacting the value of both assets and liabilities.

FOOD

Populations are naturally controlled through war, disease, and famine. Ben Franklin and Thomas Malthus expressed concerns 300 years ago about the ability of agriculture to increase yields quickly enough to meet a growing population's needs. They asserted that yields grow arithmetically and populations exponentially. So far fertilizer pivots and aquifer depletion have kept this from happening, but concerns have arisen about soil nitrates and monoculture concentration risks. Pollution and microplastics are present in the soil and enter the food supply, eaten directly by humans and indirectly by animals in the food chain.

Temperature changes that are too rapid for natural evolution to keep pace with have led to research about phenology, where alignment of cyclic and seasonal natural phenomena are studied. Many crops now require traveling bee populations for pollination. Climate change has made the farmer's job even harder, with stability already under pressure due to prices, market volatility and uncertainty, politics, bugs, diseases, and regulations. They are market takers and deal with incredible mental stress continuously. Stress may be the greatest cause of instability for the general population as we worry about our impact on climate change in addition to family, food, money, and relationships.

IMPACT ON ACTUARIAL ASSUMPTIONS

Healthy and plentiful food is a prerequisite for a population to succeed. Contaminants in our food supply and pollution lead to a reduced ability to learn at an optimal level, creating mortality and morbidity rates that vary by socioeconomic class. It becomes harder to access the American dream and comes to resemble the caste system found in other cultures. If small farms become impossible to maintain profitably the economy across these regions will suffer, leading to slowed growth.

TECHNOLOGY

The rapid rollout of artificial intelligence and the race for intelligent and autonomous agents have led to a construction bonanza for data centers. Backlogs of natural gas generators will slow this process, but reliance on fossil fuels is likely to add to the feedback loops already under way. This surge in electricity demand is inflationary in the short-term and risky as new technology could increase efficiency and leave additional electrical generation unnecessary. Electrification using renewables will be challenged to keep up with demand, but the short-term impact is being felt by consumers.

IMPACT ON ACTUARIAL ASSUMPTIONS

Technology tends to be deflationary to economic assumptions, making it cheaper to accomplish specific tasks. The interaction with climate change is a mixed bag as AI will present solutions while releasing greenhouse gases. It probably depends on how close we are to various tipping points, and that is uncertain at best due to complexity and lack of historical data sets.

Actuarial assumptions should always be reviewed by those qualified to provide oversight. Artificial intelligence today provides a black-box solution that must be justified to meet the transparency expectations established by actuarial standards. Processes need to be developed that work with AI tools and self-document the result.

TIME HORIZON

Climate change due to global warming occurs slowly, imperceptibly at first until some people start to notice surprising results. Perhaps the Galveston hurricane in 1900 was such an event, a Category 4 storm that killed up to 12,000 people and encouraged development to move to Houston, deemed to be a safer location. Now hurricane Harvey, among other storms, struck Houston. If we project out another 100 years will Austin or San Antonio be at risk?

Historically liability assumptions were conservative, but often by luck. Smoking became less prevalent as the life insurance market grew, so fewer people died than expected. Interest rates fell during the era of whole life and universal life coverages. Property insurance could reprice frequently enough to remain profitable, absent a spike in inflation, increase in convective storms, and higher wildfire risk. Some states did not allow insurers to price using anything except historical data, driving some out of those markets. Many products require reinsurance to be sustainable, but counterparties are not guaranteed forever, and many forms of reinsurance can be pulled.

Asset assumptions face similar uncertainty. A mortgage written in south Florida is likely to face tidal flooding as faraway ice melts and sea level rises. The region's porous limestone allows sea water to infiltrate neighborhoods from below. A wall is ineffective and saltwater intrusion contaminates the freshwater supply.

A short time horizon mindset assumes that the economic pie is fixed in size. Infrastructure spending is delayed because circumstances don't change quickly enough to make it worthwhile.

A long time horizon mindset seeks to grow the economic pie in total, recognizing that a new location may be more sustainable in the long run than a current one susceptible to sea level rise, subsidence, storm surge, aquifer depletion, and ocean currents (examples include Norfolk and New Orleans).

IMPACT ON ACTUARIAL ASSUMPTIONS

Property insurance that is allowed to frequently reprice and does not guarantee coverage for longer than a couple of years should be sustainable. These insurers should collaborate on updating building codes and a regulatory environment that takes into account local needs.

It is important that actuarial assumptions consider longer time horizons for products where liabilities are being written with option adjusted durations (OADs) longer than available asset OADs and uncertain cash flows that could extend to the end of the current century and beyond. Products like structured settlements and pension risk transfers should be priced in ways that reflect this. These are single premium products that have no ability to adjust outgoing cash flows in the future. Regulators have expressed concern that some owners and asset managers of insurers have increased the risk of their firms by being aggressive with assumptions and strategies. Actuarial assumptions can be strategically tested using AI tools accompanied by a risk manager to find concerns and risks over longer time horizons. Emerging risks are inevitable and they will not always have a positive influence on results.

STABILITY IN A COMPLEX SYSTEM

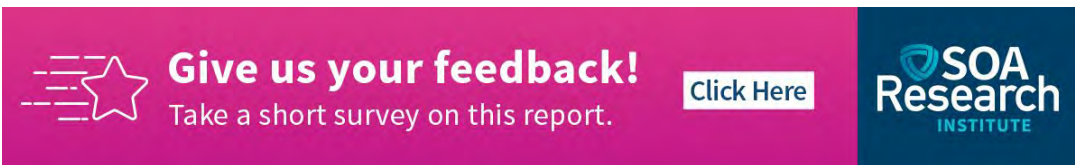
Financial institutions, including insurers and asset managers, along with pension plans, operate best in a simple and certain world. Today's environment is a complex adaptive system. Climate change, the global financial systems, geopolitics, and demographics all face growing uncertainty.


One way the insurance industry is unique is a reliance on state guaranty associations to protect policyholders from insolvency of the carrier. Historically the industry has been run conservatively with insolvencies due mostly to concentrated positions, either liabilities sold in one location that were mispriced or suffered from a weather or seismic event, or concentrated asset positions that went bad. But now regulators around the world are concerned with the entrance of private equity to the insurance industry as owners, asset managers, or both. These investors aim to optimize results.

Stability requires oversight that considers the higher order impact of interactions between various risks. Optimization techniques make the system more uncertain, increasing fragility. At the same time as extreme weather events are increasing, the need for stability to have a sustainable insurance marketplace also increases. The financial and risk management focus needs to be on solvency. Insurance serves its customers when it is available to pay a claim. Regulations should focus on principles and push back on rules that weaken the industry.

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