Second Prize Winner

Addressing Extreme Heat Risk: A Suggested Holistic Approach

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The evidence that we are living in a world characterized by **increasing temperatures and instances of extreme heat** is numerous and persuasive. Several recent scientific and media reports have told a story marked by highest-ever-recorded temperatures, significant heatwaves, and damaging droughts and wildfires. Studies are also showing that the effects on people and property of excess heat can be enormous and frightening—including a record number of heat-related deaths in the U.S. in 2023.[1]

Although the nature of extreme heat risk is somewhat different from one-time events such as a hurricane or earthquake, it is equally imperative that we recognize this risk, and respond with an appropriate and well-thought-out **risk management plan**. As a weather hazard, excess risk naturally brings to mind the possibility of utilizing a risk management framework that might involve extensions of traditional insurance, as well as insurance-linked securities (ILS) or other financial derivatives. Indeed, the trading volumes for weather-related derivatives—futures and options—on the Chicago Mercantile Exchange increased by more than 260% in 2023,[2] and it is estimated that there is now over $45 billion in ILS-related outstanding capital.[3]

Any risk management response to a critically dangerous, widespread, and potentially ongoing risk like extreme heat will have to take the form of a serious, cooperative, and interdisciplinary effort. This effort, in all of its interrelated parts, can, should, and indeed **must, involve actuaries and actuarial skills** as important contributors to success.

This essay suggests **guiding principles for a holistic risk management effort** to effectively address the risk associated with extreme heat. Some of these have already been the subject of at least preliminary thinking; all will need to have their details significantly fleshed out. Again, actuaries should play a key role.

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[1] Cuevas and Pulver, 2024, "Heat killed a record number of Americans last year," *USA Today*, August 26, 2024. https://www.usatoday.com/story/news/health/2024/08/26/2023-heat-deaths-record-number/74937063007/. Also Howard, et al, 2024, "Trends of Heat-Related Deaths in the US, 1999-2023," *JAMA Network*, Trends of Heat-Related Deaths in the US, 1999-2023.

[2] Potter, 2024, "Worsening Weather Igniting $25 Billion Weather Derivatives Market," *Insurance Journal*, May 8, 2024. https://www.insurancejournal.com/news/international/2024/05/08/773370.htm. Also Robertson, 2023, "Use of weather derivatives surges as extreme climate events rock the globe," *Reuters*, Oct. 12, 2023. https://www.reuters.com/markets/global-markets-weather-derivatives-analysis-pix-2023-10-11/.

[3] Aon, 2024, ILS Annual Report, September

General Framework: Developing a holistic framework within which to identify, quantify, and manage the emerging and worsening risk of extreme heat is an immense task. Consequently, it will require a cooperative effort among all parties involved in order to have any realistic chance of success. In particular, a robust and mutually reinforcing structure **combining both risk mitigation and risk transfer/financing** will be necessary. In addition, public-private and local-national partnerships will be essential, both to ensure adequate coverage of all those people and institutions subject to this risk, and to facilitate the efficient and effective implementation of the risk management structure.

Responsibility: In addition to whatever high-level oversight and management of this structure is implemented, it would be useful to have a variety of regional people and/or organizations in place, to identify key issues and affected constituencies, to plan for local risk management details, and to monitor the ongoing impact of solutions as they are implemented. Several cities globally (including Miami in the U.S.) have already appointed **"chief heat officers"** who are in communication with one another to share ideas and, hopefully, eventually identify best practices.

Risk Mitigation: Mitigation of the growing extreme heat risk will be a large and enormously challenging effort. While there's insufficient room in this essay to expand much on these details, some aspects of this mitigation effort would include:

- **Statistical analysis**: Identification of those people and entities most exposed to risk, to better understand the causal relationships between excessive heat and the frequency and severity of losses. Ultimately, predictive models can be developed to help guide both risk mitigation and risk financing decisions.
- **Risk impact**: Part of this process is to thoroughly identify the wide variety of potential heat impacts on people and society, both direct and indirect. This should include potential damage to both physical items, and to persons. Indeed, even something as basic as the increase in general irritability of people in an excess heat regime could be worth trying to quantify and model.[4]
- **Special considerations**: Certain types of entities affected by heat demand specific and thorough analysis. For example, the characteristics of rural versus urban locations can differ markedly in their susceptibility to damage caused by extreme heat. Indeed, the urban heat island effect means that special consideration needs to be given to those urban and infrastructure characteristics which are known to collect and radiate heat.
- **Lessons from other times and cultures**: How have people, in other times and/or societies, dealt with heat in the ways that they have built, worked, and interacted? Explorations into such questions may provide food-for-thought regarding possible approaches relevant for us in the here-and-now.[5]

Risk Transfer: This is an area that is very open to new thoughts and innovative approaches. When considering mechanisms by which to transfer (or finance, or share, or insure) risks associated with extreme heat, a reasonable place to start would be the various solutions that have been developed and improved over the last several decades for natural catastrophes. Due to the enormous potential impact of catastrophic events (e.g., hurricanes, earthquakes)—an impact that could conceivably impair a significant

[4] Extreme heat can affect people and property in numerous subtle and indirect ways. For example, it is well-established that heat can interfere with or affect medications, a fact that has potential to impact peoples' health, certainly, but also health, workers compensation, and medical (and possibly other) insurances. See, for example, CDC, 2024, "Heat and Medications – Guidance for Clinicians," https://www.cdc.gov/heat-health/hcp/clinical-guidance/heat-and-medications-guidance-for-clinicians.html .

[5] Zuniga-Teran, 2024, "5 lessons from ancient civilizations for keeping homes cool in hot, dry climates," *The Conversation*, Aug. 30.

proportion of the property-casualty insurance industry's capitalization—an active market has evolved for catastrophe bonds, insurance derivatives, and other products that provide direct access to the capital markets. Given the wide potential impact of extreme heat risk, it seems that similar types of products should be considered here.

Some possible models on which to base an extreme heat risk transfer mechanism include the following:

- Traditional insurance and reinsurance: Insurers have begun to offer protection against various isolated and specific aspects of excessive heat risk. Example of these include insurance for impact of heat stress and drought on agricultural crops, income replacement for certain workers impacted by heat-related health issues in India, and heatstroke insurance in Japan.[6] Other extensions of traditional insurance are undoubtedly being considered, and this is an important component of an over excess heat risk management framework.
- Catastrophe bonds: Issuance and outstanding capital associated with cat bonds have reached record levels recently, largely fueled by increased demand for such bonds as a consequence of favorable hedge fund returns. Cat bonds are generally used by insurers as protection against large losses from specified natural catastrophes, and thus are basically a low-frequency high-severity form of risk management. These bonds have the benefit of engaging the financial resources of the broad capital markets (which, along with natural catastrophes representing a largely "zero-beta" investment class which can provide asset portfolio diversification advantages, was the original *raison d'etre* for these securities).
- Weather derivatives: In particular, futures and options traded on the Chicago Mercantile Exchange (CME) are quite relevant for extreme heat risk transfer. Indeed, HDD (Heating Degree Days) and CDD (Cooling Degree Days) derivatives are specifically designed to calculate the difference between actual average daily temperature and a selected threshold (generally, 65°F). These derivatives are often used by companies in various industries, especially the energy industry, to protect against the impact on a company's operations and finances of unexpectedly high or low temperatures. These securities also have the benefit of accessing the financial resources of the broad capital markets.
- A possible "Group" approach: This suggestion is inspired by group insurance and self-insurance mechanisms, and by the holistic perspective underlying enterprise risk and return management. It is also based on the fact that weather and temperature is becoming more and more volatile, variable, and unpredictable—and that, while there may be a widespread upward trend toward higher temperatures, there also can be significant differences locally and regionally in the specific weather and impact actually experienced during any given day, month, or year. By combining or pooling the risks associated with multiple geographic areas—aggregating the excess heat risks of numerous cities or larger regions—it may be possible to take advantage of these natural differences in weather conditions.

Since any effort to address extreme heat risk will require coordination of many different activities involving ongoing public funding, a pool of public entities would form a group. Each entity would provide promissory funding commitments, and the funding pool would be distributed to the various pool members periodically, according to a pre-designed actuarial allocation formula based upon actual relative temperature measures associated with each group entity. Either in combination or as a separate matter,

[6] Clark and Uranaka, 2023, "5 ways insurance is working to de-risk extreme heat," PropertyCasualty360, May 8, 2023. https://www.propertycasualty360.com/2023/05/08/5-ways-insurance-is-working-to-de-risk-extreme-heat-globally/?slreturn=2024090591602.

broader financial resources could be engaged through a reinsurance-oriented special purpose vehicle that potentially transfers the group risk to the capital markets.

Risk Metric: Any allocation or payout of risk-transferred funds would depend upon a metric or index that measures relative exposure to excessive heat risk. The metric would also objectively indicate a basis for identifying the potential impact and damage severity of a period of abnormally high temperatures. This metric would ideally be **readily and unambiguously calculable**. There are numerous metrics proposed and available, some of which include:

- **Heat Index**: A commonly used meteorological measure combining temperature and humidity.
- **Excess Heat Factor (EHF)**: A metric for heat intensity, based on a three-day-average of mean daily temperatures.[7]
- **Universal Thermal Climate Index (UTCI)**: An index combining temperature, humidity, wind, and solar radiation.[8]
- **Wet-Bulb Globe Temperature (WBGT)**: An index combining temperature, humidity, wind, and solar radiation;[9] often used in decisions regarding outdoor activities for sports and military purposes.

While much data analysis and assessment of the appropriateness of these, and many other, metrics has been done, more work on the historical correlation of these metrics with potential loss severity would help to better understand their ability to constitute an effective excess heat exposure measure.

Loss Trigger: Any insurance or financial security designed to provide protection against extreme heat losses will need to have a "trigger" that determines when and if a payout occurs. Historically, there have been at least three types of triggers employed by cat bonds and insurance-linked securities: indemnity (or company loss); industry loss; and parametric[10] triggers.[11] These different triggers vary in their relative exposure to both basis risk and moral hazard. Because of the nature of excess heat risk—including the difficulty of measuring the impact, and its potential to have a cumulative and widespread effect—a **parametric trigger** is likely to be the preferred type in any relevant risk transfer mechanism.

Data: A **well-defined, thorough, and ongoing approach to data** will be necessary throughout this entire process, providing for initial analysis, identification and evaluation of possible solutions, and monitoring of performance and impact. There will need to be very specific and consistent data reporting requirements, possibly with some type of incentive structure implemented to encourage quick, clean, and complete data reporting.

Incentives: Behavior of all parties that is **consistent with the overarching mission and goals** of the excess heat risk management process will need to be incentivized as much as is reasonable financially. The

[7] Nairn and Fawcett, 2015, "The Excess Heat Factor: A Metric for Heatwave Intensity and Its Use in Classifying Heatwave Severity," *Int J Environ Res Public Health*, Jan; 12(1): 227–253.
[8] Spengler, et al, 2023, "Does choice of outdoor heat metric affect heat-related epidemiologic analyses in the US Medicare population?" *Environmental Epidemiology*, Aug; 7(4).
[9] ibid
[10] A parametric trigger uses a pre-determined "parameter"—such as windspeed, or the Saffir-Simpson rating of a hurricane—to trigger a payout.
[11] One might add to this list a "model" trigger—i.e., a trigger based on a cat model projection—or include such triggers as a sub-type of the three mentioned.

clearest example of an incentive is tying the cost of a risk transfer mechanism for an entity, to the amount and quality of risk mitigation pursued by that entity.

Regulation: In many industries and areas, regulation often lags behind the innovative technical and strategic strides made by the market participants. For the kind of interdisciplinary and cooperative process necessary to address extreme heat risk, **regulatory authorities and rules must be embedded and involved** in the creation and implementation from the very beginning.

A holistic perspective for the entire risk management effort will be necessary to adequately address the risk of extreme heat. **Actuaries should be an integral part of this effort**.

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