

Insurance Products for Climate Change: Probability Distributions and Adaptation

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It should be admissible to concede that mitigation of climate change has been less successful than optimists have hoped. Without surrendering entirely on mitigation efforts – a 2-degree Centigrade increase in mean global temperature is better than a 3-degree increase, and a 3-degree increase is better than a 5-degree increase – the immediate task that is now ahead of the world is finding adaptations to substantially altered and now unavoidable if not fully known climatic and geophysical conditions. Obviously, less costly adaptations are to be preferred to more costly ones. The world's insurance and re-insurance industries are positioned to reduce the avoidable costs of these adaptations and cushion the unavoidable costs.

This note outlines some templates for the role of insurance in mitigating costs of adaptations to climate change. Modifications to contemporary homeowner's insurance policies are likely to be the most important components of adaptation from aggregate and macroeconomic perspectives. Adaptations to insurance policies available for businesses face quite varied situations depending on details of businesses' activities and locations. Limitations on data for calculating actuarial probabilities will force reliance on models, which can be improved continually. The alternative would be reliance on outdated event data which are known to portray current and near-future event probabilities inaccurately, in some cases grossly so.

A Context for Climate Change Insurance Policies

Insurance policies are bets on whether undesirable events will happen within a certain period of time. Nobody bets on a sure thing. Some if not many of the untoward events attending climate change will happen for certain but others involve a shift probability distributions. The nature of previously well-understood events such as flooding and forest fires is changing not just in frequency but in fundamental structure – altering where and when they occur. Consider flooding as an example: Flooding as we've understood it comes from precipitation or snow melting, or from coastal storm surges. While sea-level rise surely will alter the probability distribution of damages from hurricane storm surges, sea-level rise also will change ground-water levels well inland from coasts, creating the possibility of sub-surface flooding such as has begun to affect septic systems in some inland parts of the United States.

A Template for Coastal Regions

A well-known type of insurance exists that bets on certain events with uncertain timing – life insurance, whole life and term. Term life insurance probably is a better model than whole life for designing insurance policies for assets that certainly will be damaged or destroyed by climate change events such as sea-level rise and coastal recession, which we know will occur by certain dates within certain statistical confidence intervals – although elements of whole life policies can operate in climate change policies. In the case of either type of life

insurance, a payment, if one is made, is not to one of the two contractual partners, but to a designated survivor of the policyholder. The price of the policy – the premium payment – typically depends on characteristics of the policyholder, characteristics which are currently immutable although they are partially the result of previous behaviors and which determine the actuarials underlying the insurance contract.

Using this term life insurance model as a template, consider the possibilities for insurance of real property, a single-family home, a multi-family structure, or an office building (which might be better covered with a commercial property insurance policy) against damages from specified events deriving from climate alteration. The policy will exclude wind and flood damages from hurricanes or lesser tropical cyclones because those damages can be insured against through provisions in conventional catastrophe policies – with actuarials based on expected probabilities during the contract period rather than historical probabilities which may no longer be accurate predictors of damages during the contract period. What other event drivers exist? Sea level rise is an obvious candidate, with the uncertainty residing in centimeters of level change at specified dates and the attendant damages, including the possibility of complete and irreparable failure of the structure resulting within a specified time period. Certifiable measurement is necessary. A deductible clause would affect the periodic premium payment. The anticipation for the insurer in the contract is that its premium structure and time period would allow the insurer to invest the payments in safe (“safe”) financial vehicles and earn enough over the contract period to make any required payments and a target rate of return. Multi-year contracts, such as exist for term life insurance, would be better suited to the longer-term changes anticipated from climate change than single-year contracts typically governing homeowner’s policies. The anticipation for the policyholder is that the payment in the event of irreparable damage during the contract period would be compensated with a target amount that would serve much as a pay-as-you-go savings account. The insurance contract has allowed – or forced – the owner of the property at risk of damage from changing climate to put aside some “rainy day” savings, avoiding total financial loss and permitting relocation.

The contract would contain clauses encouraging the property owner to make periodic investments to prolong the economic life of the property. What types of events driven ultimately by climate change and proximately by sea-level rise should be covered by such a policy? Some suggestions: soil subsidence, corrosion and weakening of structural elements caused by rising groundwater or saltwater infiltration from sea-level rise. Coverage of hurricane damage, both wind and flooding, during the contract period should be orthogonal to the coverages offered by the pure climate-change (CC) policy – changes in hurricane damages attributable to changed climatic conditions should be incorporated into hurricane policies and should not be duplicated in pure CC policies.

Climate-Change Adjustments for Other Types of Insurance

Insurance is a hedonic good, varying in as many characteristics as there are personal and business activities and covering just about every imaginable contingent event. The industry is well developed and, with the possible exception of health insurance, highly competitive, with policies tailored for individuals and households almost certainly over-regulated in light of the industry’s competitiveness. Nevertheless, it is well-known – in fact screaming from

business and general newspaper headlines weekly – that homeowner’s insurance is in danger of collapse in the United States – and possibly worldwide – because of the combination of climate change and jurisdictional regulation.

State regulators are attempting to shield homeowners from the increased costs of these changed probability distributions, partly out of altruistic motivations but at least equally to maintain current tax bases that climate change otherwise could erode. The probability distributions of damages from fire in Western North America have changed from patterns close to those of automobile crashes to distributions characterizing catastrophic events such as hurricanes, earthquakes or floods, in which most policyholders in an area covered by an insurance company experience damages simultaneously. Risk pooling of damages from auto crashes and incidental house fires can be absorbed by the population in a defined geographical area, typically a state or group of counties within a state subject to a common regulatory authority, because such a small percent of the policyholders experiences the event in a contractual time period. Risk pooling over large, reasonably similar populations keeps premiums low and widely affordable. Not so with catastrophic events. The similarity of outcome within the contractual time period across covered policyholders drives up premiums, although many state insurance regulators strive to keep catastrophe homeowner’s policy premiums below what many insurance companies can afford to offer and stay in business.

Actuarial probabilities of damages derived from long-standing, historical data are no longer as accurate as they have been. The past several years in the North American West have witnessed earlier and more extensive wildfires that have been more difficult to contain. These fires have been occurring in widely, if not necessarily densely, inhabited areas. Some fires have resulted as combinations of electric utility negligence – to put it bluntly – century-long forest management policies and, voilà! changed probability distributions of temperature and humidity – climate change. Insurance companies are declining to renew homeowner’s policies throughout wide swaths of some western states because the approved risk-pooling premium structure is inconsistent with the catastrophic character of the incidence of damages in the wildfire-prone areas.

In other parts of the country, damages from hail and wind have increased beyond the historical pattern, exceeding the damages if not the death tolls from tornados, partly but only partly because of life-style changes in hail-prone areas. The probability distribution of tornado damage also is changing: Tornado Alley appears to be moving east. In some cases, the risks of damages from these categories of events are combining. A state the size of Iowa or Nebraska or Missouri can absorb the pooled risks of these events without the new meteorology forming catastrophic risks, but individual insurance companies may not offer policies across the full extent of a state, leaving them facing circumstances with some catastrophic characteristics. In any event, homeowner’s policy premiums will rise if the insurance industry is to remain solvent.

Pooling the meteorological risks of different parts of the country into a single risk pool may sound superficially appealing, but it would involve homeowners facing hail or tornado risks paying for (subsidizing) wildfire risks whose damages are riddled with moral hazard

problems while the magnitudes of the damages from the wildfires and hailstorm-tornado events differ greatly. This said, wildfire catastrophe bonds covering larger geographical areas than individual insurers' operational areas to mitigate tail risk are being explored, at least among insurance scholars if not among insurance and reinsurance firms. Tinkering with homeowner's policies in wildfire-prone areas by offering premium breaks for mitigating actions such as clearing trees away from houses, installing metal roofs, and other investments in fire-resistant components is nice ("nice"), but these actions involve externalities among neighboring homeowners which reduce every homeowner's incentives to install mitigants to the optimal extent. The publicity value of offering such codicils could exceed the value of the damages they avoid. It's empirically unknown (at least to the public, if not necessarily to insurance companies offering such incentives) how effective these incentives are.

Each area of the United States will experience some idiosyncratic damage exacerbants (a new word? English is an efficiently flexible language) along with some common consequences of changing temperature and precipitation regimes. Homeowner's premiums will rise or homeowner's policies will cease to exist. The macroeconomic consequences of such an outcome are difficult to contemplate. Renting would not be a solution because the costs are the same, regardless who the middleman is.

The worrisome scenario for real property insurance in the United States today is the wholesale withdrawal of homeowners' insurers in particular parts of the country and the quandary for lenders who would be foolish enough to lend hundreds of thousands of dollars on the chance that the property could go up in smoke or be reduced to rubble by hail, tornado, flood or hurricane without insurance protection. With state insurance regulators striving to protect homeowners from having to pay actuarially fair prices, something like a game of chicken between insurance companies and homeowners, with regulators as intermediaries, is playing out. An important question for the outcome of those state-by-state games is whether the actuarially fair rates will be affordable – or might homeowners purchasing more expensive insurance have to retrench on other expenditures. With the model of the 20th century discriminatory concept of redlining, which had no rational basis in risk actuarials, a new concept of blue lining is emerging which is rationally based in the actuarials of new environmental conditions. Insurance companies will decline to write homeowner's policies in areas scientifically predicted to be at especially high risk of damage from environmental events, at least under current rate restrictions. State insurance regulators and city and town fathers and mothers can be expected to cry vociferously because of impacts on tax revenues if residents are forced to relocate.

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Homeowners' insurance policies could be modified with codicils that might help adjust to longer-term deterioration in sustainable environmental conditions as suggested above. Whether such policy adjustments as rate reductions for installation of flame-resistant roofs, removal of proximate vegetation, dispersal of structures, etc., can preserve the insurability of properties in locations that have undergone or are undergoing rapid environmental changes, as contrasted with longer-term changes such as sea-level rise, has not been put to empirical test. Can entire small towns be rendered uninsurable and consequently uninhabitable without funding from other people's money? Archaeologists have found entire, abandoned cities that

housed over one hundred thousand residents, and continue to find smaller abandoned settlements, typically abandoned by changing geographical circumstances, sometimes social, sometimes environmental. Currently parts of the Middle East, North Africa and the Sahel have already experienced such environmental changes, and the American Midwestern experience of the 1930s Dustbowl remains in evidence in abandoned farmsteads and remains of destroyed farm fields. There's no reason other American towns cannot experience the same sort of environmental obsolescence, regardless of insurance support.

The next step in the interaction of insurance and lending begins with the willingness of homeowners to take advantage of such codicils – whether because of overall expense and the magnitude of price offsets or homeowners' assessments of risks. There should be no need for legislation or regulation requiring the purchase of such policies. Lenders' reluctance to offer uninsured or otherwise unsecured loans of the magnitude of a dwelling would go a long way toward enforcing the purchase of insurance suitable to lenders' requirements for recoverability. Without such guarantees to lenders of recovery of the value of a loan in the event of damage to or total loss of a mortgaged property, households living in such properties are effectively living on other people's money, a relationship most economic systems are unable to support.

Problems with such a non-legislative, mortgage-homeowner's insurance arrangement: Proof of insurance for opening a mortgage is easy. Assuring maintenance of insurance over the life of a mortgage would be more difficult, even if maintaining insurance was a term in the mortgage. Annual submission of proof of insurance to the lender sounds simple, but could prove to be more costly. Mortgages frequently are sold. Monitoring compliance with a mortgage term other than payment through changing ownership of a mortgage would add an administrative cost of currently unknown magnitude. Experimental programs administered by a large lender and a comparably sized insurance provider would yield information on administrative costs and reliability of monitoring. A program like this surely involves new business practices, but adapting to climate change will require that we do lots of things differently.

Beyond Property Insurance

The discussion so far has used the example of private residences and homeowner's insurance, but the structure of contractual agreements between insurers and insured that eliminate as much scope for emerging moral hazard as can be anticipated and verified applies to every type of business-related insurance in which covered outcomes are subject to either short-term or long-term changes in environmental conditions. Consider an example of business income insurance against losses imposed by environmental conditions: a Colorado brewery advertises its use of pure, Rocky Mountain snow-melt water in its beer. Snow has been erratic for the better part of a decade. The brewery has the option of diversifying its water supply – or stockpiling – with the possibility of modifying its advertisement, which combination of actions could reduce its losses in the event of an extremely low snow season – all at some cost, of course. If its business income insurer was satisfied that the brewery had done its environmental due diligence regarding the supply of this key ingredient, the insurer could offer a reduction on its business insurance premium.

Does the brewery have the resources to conduct such analysis of its options under a variety of contingencies? Probably not. Options: if such environmental due diligence premium breaks became widely available, an assessment-and-advisory industry would emerge either outside the insurance industry or within some of the larger insurance firms. Whether the present value of the premium reductions was greater than the cost of the due diligence would determine the industry and firm distribution of the uptake and offering of such premium breaks. Clearly some time would be required to develop the template and proof of principle sufficiently to encourage insurers to formalize such environmental due diligence rate reductions as standard options. But the direction of environmental challenges to business incomes is not going to change, so time is on the side of innovation.

Changes in the probability distributions of interruptions to business incomes will be industry-specific and contingent on both geographical location and individual business. Will a Rocky Mountain brewery that depends on snowmelt for its water fail to anticipate changes in the probability distribution of snow in the Rockies and see its output fall by half in some year? The U.S. Department of Agriculture has extensive farm income insurance programs, and agriculture is experiencing crop-specific losses due to meteorological changes. New seed varieties and rediscovery of some old ones may help farmers adapt to changed growing conditions, even if crop insurance retards adaptation, but a new Dustbowl from excessive withdrawal of groundwater throughout the Upper Midwest can't be ruled out. Will battery and chip makers discover short- or long-term interruptions to their supply chains, less repairable than those imposed by the Covid-19 Pandemic, possibly related to water supply, for either manufacturing processes or workforce sustenance? Will technological changes be able to anticipate and compensate for natural developments? Insurance can provide bridges tailored to specific issues although actuarial probabilities underlying Betweening policies most likely will have to come from modeling.

If business income insurance policies adopt provisions for premium breaks to firms with well-conceived and executed operational risk management plans and procedures, they can facilitate adaptation to changed meteorological conditions.

Employees will become subject to changed probability distributions of health risks, depending on their occupation and location. Outdoor construction workers, large-vehicle operators, other occupations which work largely or to a great extent outdoors, will be especially affected. Businesses that cover employees' medical costs for injuries or other health conditions incurred on the job will face rising insurance premiums. Lawsuits will add to premium increases. Firms that respond quickly by changing their operating procedures for employees will keep their premiums down. Between declining productivity of, particularly, outdoor workers and rising, heat-and-humidity-related personal injury lawsuits, business demands for specific types of climate-related insurance policies. Trade and business associations are likely to be well positioned to provide risk information to firms in their industries . . . if they notice changes and decide to investigate them, which certainly will involve their member firms.

Adaptation, Mitigation, and Probability Distributions

Insurance provides partial – not full – cushioning of undesirable outcomes whose allocations across individuals and dates are defined by probability distributions. Just about all possible outcomes of every conceivable event are or can be put under a protective contract with an insurance policy. The outcomes of many events throughout our economy and society are being and will continue to be affected by changing climatic and geophysical conditions – climate change for short. Since insurance is designed to mitigate the costs of experiencing undesirable outcomes – to the mutual benefit of the insured and the insurer – the insurance and re-insurance industries will participate in the world’s adaptation to these changing circumstances. The interaction of insurance and lenders’ security requirements eliminates or greatly reduces requirements of any kind of public mandate regarding property insurance in particular.

Without fanfare – not even a serious requiem – we have transitioned from mitigation of climate change to adaptation to what we did not and will not stop. Adaptation will be costly, and although some parts of our economies and societies will reap benefits from new business, we can make adaptation more or less traumatic. Insurance, hand in hand with capital market lending, is a device that can mitigate some of the costs of adaptation. This note has offered some ideas of varying specificity about how insurance policies can be designed to soften some serious bumps on the paths into our new world and how lenders rationally and efficiently can provide non-governmental enforcement of participation at least in property insurance.

References

Boomhower, Judson, Meredith Fowlie, and Andrew J. Plantinga. 2023. “Wildfire Insurance, Information, and Self-Protection,” *AEA Papers and Proceedings* 113: 310–315.

Collier, Stephen J., and Savannah Cox. 2021. “Governing Urban Resilience: Insurance and the Problematization of Climate Change,” *Economy and Society* 50:275–296.

Doncaster, C. Patrick, Alessandro Tavoni, and James G. Dyke. 2017. “Using Adaptation Insurance to Incentivize Climate-Change Mitigation,” *Ecological Economics* 135:246-258.

French, Karina. and Carolyn Kousky. 2023. “The Effect of Disaster Insurance on Community Resilience: A Research Agenda for Local Policy,” *Climate Policy* 5: 662-670.

Gatzert, Nadine, and Philipp Reichel. 2022. Awareness of Climate Risks and Opportunities: Empirical Evidence on Determinants and Value from the U.S. and European Insurance Industry,” *The Geneva Papers on Risk and Insurance - Issues and Practice* 47:5–26.

Hornbeck, Richard. 2012. “The Enduring Impact of the American Dust Bowl: Short- and Long-Run Adjustments to Environmental Catastrophe,” *American Economic Review* 102:1477–1507.

Jørgensena, Sisse Liv, Mette Termansen, and Unai Pascual. 2020. “Natural Insurance as Condition for Market Insurance: Climate Change Adaptation in Agriculture,” *Ecological Economics* 169: 106489.

Kousky, Caroline. 2019. “The Role of Natural Disaster Insurance in Recovery and Risk Reduction,” *Annual Review of Resource Economics* 11:399–418.

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Lueck, Dean, and Jonathan Yoder. 2016. *Clearing the Smoke from Wildfire Policy: An Economic Perspective*. PERC Policy Series No. 56.