DEALING WITH DISASTERS

From hurricanes to asteroids, how should we determine what steps to take to avert catastrophe?

BY TIM SABLIK

When Hurricane Hugo struck Charleston, S.C., in September 1989, it became the first natural disaster in the United States to cause more than $1 billion in insured losses. Today, after adjusting for inflation, it doesn't even make the top 10 costliest U.S. disasters eight of which have occurred since 2000 alone. Indeed, disaster costs have been trending up worldwide over the last three decades (see chart).

This may partly be explained by growth in coastal areas, which are at greater risk of damage from recurring natural disasters like severe storms and flooding. Development of these areas is not necessarily a bad thing, as Stéphane Hallegatte, senior economist in the World Bank's Climate Change Group, explained in a 2011 paper. Coastal cities are popular tourist destinations and are natural hubs for industry and trade thanks to their access to waterways. As a result, greater development in those areas is to be expected as a country's GDP increases, despite the risks.

"The challenge is not to reduce risk-taking at all costs," says Hallegatte. "It's about good risk management."

But are households, cities, countries, or the world as a whole doing enough to manage disaster risks? Through an economics lens, deciding the right level of spending on disaster risks seems straightforward: Just compare the marginal costs of disaster mitigation to the marginal benefits to determine which measures are worth undertaking.

While this is true in theory, the uncertainties surrounding disasters make such calculations anything but simple. And in the wake of such uncertainty, coordinating a response locally — let alone globally — can be a monumental challenge.

An Ounce of Prevention

Should individuals or communities take steps to prepare for possible disasters or wait until after disaster strikes to respond? Investment in prevention or mitigation can be particularly attractive for areas where disasters are statistically somewhat predictable over the long term, especially areas exposed to repeated disaster risks from natural phenomena. Indeed, the bulk of disaster-related damage worldwide is caused by reoccurring weather events, like hurricanes or tornadoes.

In many cases, preventing or blunting disaster — for example, building levees in New Orleans to prevent flooding or designing buildings and bridges in San Francisco to withstand earthquakes — can be much more cost effective than picking up the pieces after the fact. The Federal Emergency Management Agency (FEMA) estimates that every $1 spent on mitigation saves $4 in disaster relief spending.

Despite such attractive cost savings, federal spending in the United States leans heavily toward the latter. In 2014, FEMA spent $25 million on its pre-disaster mitigation fund, compared to over $6 billion spent on its disaster relief program. The 2016 budget proposes increasing funding for mitigation to $200 million, but that is less than the anticipated increase for the relief fund.

This allocation of resources may be questionable economics, but it seems to be consistent with the desires of the electorate. A 2009 article in the *American Political Science Review* by Andrew Healy of Loyola Marymount University and Neil Malhotra of Stanford University found that voters were much more likely to reward politicians who responded by offering relief after a disaster than those who invested in preventative measures in the first place.

The fact that people are reluctant to take precautions to avert costs that may occur in the future could partly reflect cognitive biases. Psychologist Daniel Kahneman shared the 2002 Nobel Prize in economics for his research on how people make decisions. When confronted with uncertain future events like a disaster, people tend to rely on their own experiences or heuristics rather than actual probabilities. This is true of preventative measures as well as taking steps to insure against bad outcomes. An experiment conducted by Howard Kunreuther, co-director of the Wharton Risk Management and Decision Processes Center at the University of Pennsylvania, Christian Schade of Humboldt University of Berlin, and Philipp Koellinger of Erasmus University Rotterdam, found that individuals purchased disaster insurance based on their own subjective level of worry, even when the probability of disaster was clearly stated.

Kunreuther says that many people view disaster insurance as an expensive investment with uncertain payoffs. In some cases, governments have subsidized disaster insurance, in part to make it more palatable. The National Flood Insurance Program (NFIP) provides insurance to homeowners living in floodplains at below actuarial rates. But economists have argued that this subsidy masks the true flood risks of those areas, leading to more development than would otherwise occur and actually increasing flood-related damages.

"There's a real trade-off," says Carolyn Kousky, a fellow at Resources for the Future, a nonpartisan think tank devoted to natural resource and environmental issues. "If you want people to buy, then you don't want it to be too expensive. But if you're not pricing it at a risk-based level, then it's not going to be a fiscally sound program." Indeed, the NFIP was forced to borrow roughly $18 billion from the U.S. Treasury to cover claims from Hurricane Katrina.

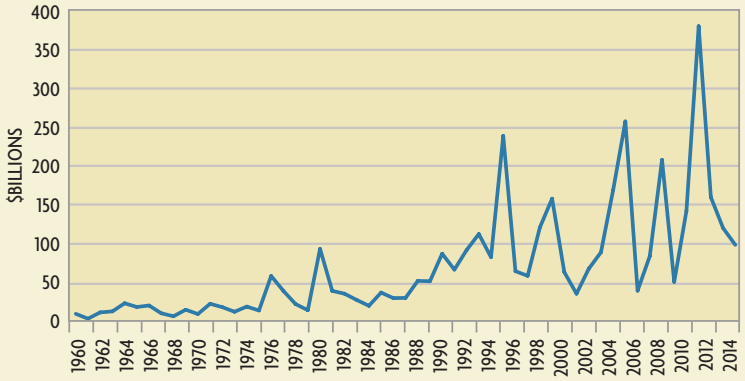
Insurers have looked for ways to make disaster insurance more affordable while also encouraging individuals to reduce their exposure to risk. For example, FEMA offers discounts on flood insurance for homeowners who elevate their homes above expected flood levels. But the core problem seems to be that, for better or worse, most people simply do not worry too much about disaster risks. Kousky found that even the spike in demand for insurance that usually follows disasters is largely driven by a requirement that individuals purchase insurance to receive federal disaster aid rather than a sudden feeling of vulnerability.

Even disaster experts are not immune to this mentality. During a recent blizzard that struck Washington, D.C., Kousky's family lost power at their house and she was forced to borrow a neighbor's generator. "And I thought, I study disasters for a living! Why haven't I gotten my family a generator?" says Kousky. "But it's just a classic example of how human behavior works. When it's a sunny day and there are other things to do, you don't think about it."

Coordinating Global Action

Convincing individuals to take steps to prepare for a disaster when the costs and timing are fairly well understood can be hard enough. Adding more uncertainty and more people to the equation only makes it that much more difficult.

Total Economic Damages Caused by Natural Disasters Worldwide

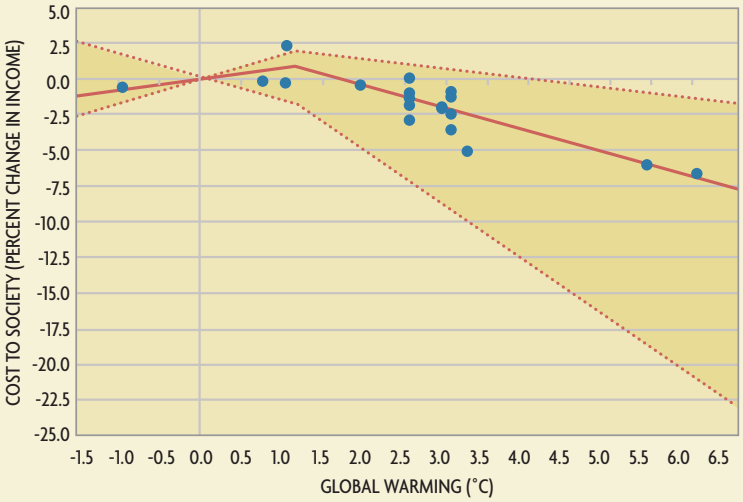


NOTE: Damages are in 2014 dollars.

SOURCE: D. Guha-Sapir, R. Below, Ph. Hoyois, EM-DAT: The International Disaster Database, Centre for Research on the Epidemiology of Disasters, University Catholique de Louvain, Brussels, Belgium

The Challenge of Estimating Disaster Costs

Predicting future events is fraught with uncertainty. This is particularly true in the case of rare disasters like climate change, where there is little prior experience to draw from. This chart depicts estimates of the economic damages from global warming taken from different studies. The solid line represents the best-fit for these estimates, or the most likely outcome given available data. The shaded region is a range of possible scenarios based on these estimates. For more extreme warming scenarios, it becomes much more difficult to estimate the likely effects. That uncertainty is depicted by the widenening shaded region.



SOURCE: Richard S. J. Tol, "Economic Impacts of Climate Change," University of Sussex Working Paper Series No. 75-2015.

Disasters like climate change, asteroid strikes, or pandemics of new infectious diseases have occurred rarely in human history, making it hard to estimate the benefits of action versus the costs of inaction.

Climate change, for example, is characterized by deep uncertainties. Last December at a climate change summit in Paris, 195 nations pledged to take measures to limit overall warming to less than 2 degrees Celsius. Many scientists argue that crossing that threshold would result in a great deal of harm, but "it's also a threshold in terms of how much we know," says Hallegatte. "We have been through 0.8 degrees of climate change in the last century. So we have experience, in a way, for limited climate change. But when you go beyond 2 degrees, you get into a very different climate, and the uncertainty increases a lot."

For levels of warming below 2 degrees Celsius, some economists estimate that global warming would actually have net positive effects, due in part to the benefits of longer growing seasons in some parts of the world. But beyond that point, estimates diverge wildly, with models forecasting anywhere from "moderate" losses due to more frequent flooding in coastal regions, more severe weather phenomena, and greater prevalence of tropical diseases, to more extreme events, like a shift in the Gulf Stream that warms Western Europe (see chart).

Avoiding catastrophes like the latter scenario means coordinating preventative steps on a global level. Such mitigation is a "public good," which means it is impossible to exclude people from enjoying its benefits and their use of it does not diminish its availability to others. This means every participant will have an incentive to contribute less and "free ride" on the contributions of others. The "correct" action from the perspective of society as a whole might be for everyone to contribute to preventing a disaster, but if you suspect others may contribute enough on their own to avert the worst-case scenario, you have less incentive to act.

"If I know everyone else has contributed, I'm probably going to be tempted to free ride if doing so is only going to increase the probability of disaster by a tiny bit," says Scott Barrett, an economist at Columbia University who studies international cooperation to prevent disasters.

Governments can sometimes address this free-rider problem at a local level by collecting taxes to pay for disaster defenses. But Barrett notes that international institutions have historically had a much more difficult time doing the same thing on a global level. The Paris Agreement and the Kyoto Protocol that preceded it both relied on voluntary action from participants to reduce greenhouse gas emissions. And that opens the door for free riding.

There are some exceptions. For example, Barrett says that the Montreal Protocol agreement to ban the use of ozone-depleting chemicals was a success partly because it identified a specific, easily attainable goal (the costs of shifting away from those chemicals were relatively low). The agreement also reduced uncertainty regarding participation by threatening trade sanctions against countries that failed to take action.

"Our ability to avert disaster depends very heavily on the characteristics of the disaster itself and how they relate to our institutions," says Barrett. One solution for dealing with the uncertainties of something like climate change, he says, is to focus global efforts on achieving a single goal, like adopting a specific technology that will reduce emissions, rather than attempting to gain cooperation on a set of nebulous long-term policies.

Choosing a Global Response

Getting countries to agree to address global disasters is one thing; choosing the right course of action is another.

This is especially important if a disaster-related measure at the national level makes a global response less likely. In the case of infectious diseases, for example, countries often stockpile vaccines or treatments for their residents to receive in the case of an outbreak. While this allows individual countries to mitigate damages to their citizens, it could be more efficient from a global perspective for those same countries to instead form a shared stockpile of medicines to treat outbreaks at their source. The National Academy of Medicine recommends such a plan in a 2016 book, blaming the haphazard nature of the international response to the 2014 Ebola outbreak in Africa for "economic costs that were far greater than they could have been."

A preventative approach to global disasters may often seem like the most efficient response in hindsight, but it is not always so clear beforehand. Prevention of some global threats,

like climate change, may demand serious sacrifices or lifestyle changes. Curbing worldwide greenhouse gas emissions, perhaps indefinitely, would entail long-running productivity costs. In developed nations, that has implications for the wealth of both current citizens as well as future generations, possibly making them poorer in return for uncertain benefits. Future generations have also historically been wealthier than their parents, suggesting that they might be in a better position to afford costly mitigation efforts — provided that there is still enough time for them to act.

In developing nations, forgoing cheap fossil fuels may inhibit their ability to industrialize and pull themselves out of poverty. An alternative approach could be for countries to make more short-run investments to prepare for eventual climate change. This might include measures like building levees to protect against rising sea levels or developing new agricultural methods to cope with higher temperatures. Developing nations are more exposed to these damages, as their economies tend to be more reliant on agriculture. But Nobel Prize-winning economist Thomas Schelling has argued that instead of focusing entirely on prevention, developed nations could devote resources to helping boost the economies of their less-developed neighbors, making them more resilient to climate change-related disasters.

"One way to make people less vulnerable to disasters is to make them richer," says Hallegatte.

As with regularly reoccurring disasters, determining the most efficient measures for rare or theorized disasters that might occur on a global scale is largely a cost-benefit exercise. But the infrequency of these types of disasters

Asteroid Defense and Types of Public Goods

In 1908, an asteroid roughly 60 meters in diameter exploded over Siberia with a force a thousand times more powerful than the nuclear bomb dropped on Hiroshima. Fortunately, the event occurred over a largely uninhabited forest; had it happened above a major city, the losses would have been catastrophic.

While intercepting deadly asteroids seems like something from a movie, the idea is not confined to the realm of science fiction. The National Aeronautics and Space Administration (NASA) has successfully landed a spacecraft on an asteroid and used another to intercept and collide with a comet. These open the possibility of developing spacecraft designed specifically to deflect asteroids. Thanks to the great distances involved, diverting an object in space by just a small amount would generally be enough to prevent impact — provided the intervention occurs far enough in advance.

Both the United States and the United Kingdom have made some efforts at tracking "near Earth objects" (NEOs) that could pose a threat. But to date, scientists have discovered only a fraction of the asteroids in our solar system. As recently as 2013, astronomers were caught by surprise when an asteroid roughly 20 meters in diameter exploded as it entered the atmosphere over Russia, damaging thousands of buildings in six cities and injuring as many as 1,500 people.

"People tend to think about the really big asteroids that would destroy everything, like in the movies," says Scott Barrett, an economist at Columbia University. "But the much bigger risk is the medium-size asteroids because they're more common."

Like other types of disaster defense, protection against asteroids is a public good. Indeed, George Mason University economists Tyler Cowen and Alex Tabarrok devoted an episode of their popular online economics program, Marginal Revolution University, to asteroids as a case study in why markets tend to undersupply public goods.

In the early 1980s, economist Jack Hirshleifer at the

University of California, Los Angeles proposed categories for public goods. One type is "summation" goods, which depend on the collective effort of all participants to succeed. An example would be reducing greenhouse gasses in the atmosphere: Action taken by one country to cut emissions would not be sufficient if other countries continue to pollute. This is the classic public good, and economic theory predicts that it will be underprovided by voluntary participants due to the presence of free riding.

In contrast, what Hirshleifer calls a "best-shot" good can be successfully provided by one party acting alone. Asteroid defense is an example of this; only one successful interception is necessary to protect everyone. In theory, this could make the provision of such a good more likely. Wealthy nations have the most to lose economically from an asteroid strike and are in a better economic position to fund defensive measures unilaterally. Other factors certainly play a role in such decisions, but developed nations like the United States and the United Kingdom and the broader European Union have been the most active in funding efforts to track and defend against NEOs.

On the other hand, free-riding problems could be even more pronounced with best-shot goods, as Hirshleifer found in experiments conducted with Glenn Harrison of Georgia State University. But in a bit of good news, Hirshleifer and Harrison also found that individuals contributed more to all classes of public goods than simple theory would have predicted.

— Tim Sablik

makes the calculation even more difficult. Economists "discount" the expected costs of disasters that could occur in the distant future to compare them in real terms with the costs of response measures undertaken today. If the costs of taking action today are less than the expected cost of a future disaster (taking into account the probability of its occurrence), then taking action is economically preferable.

Of course, such calculations are highly sensitive to the chosen discount rate. Lower rates will make future benefits seem larger in present value, making costly responses today more attractive. For the very long time horizons involved in phenomena like climate change, even small changes in the discount rate can result in very different recommendations. Traditionally, economists have used the rate of return on an alternative investment, like bonds or private capital, as a discount rate. But in the case of climate change, economists have proposed using discount rates ranging from as low as about 1 percent to nearly 5 percent.

Because of this uncertainty, trying to choose one optimal response may not be the best approach. In the case of climate change, Hallegatte and his colleagues at the World Bank have argued that developed nations can help developing countries grow their economies in a way that makes them resilient to climate change while also helping reduce global emissions. By using more efficient, greener technologies from the start, developing nations can "leapfrog" over older means of industrialization in much the same way that many of them skipped landlines and went straight to cellphones.

"These countries have a fantastic opportunity today to build things right in the first place and avoid the type of difficult retrofits that we're considering in developed countries at the moment," he says.

Robert Lempert, director of the Frederick S. Pardee Center for Longer Range Global Policy and the Future Human Condition at RAND Corporation, a policy think tank, has also advocated flexibility. He and his colleagues at RAND developed a model for disaster response that flips the typical approach on its head. Rather than start from an intractable problem and attempt to determine the best solution, their model tests different solutions under a variety of possible scenarios to find the one that performs the best across a wide range of possible futures.

"It becomes easy to get hung up on not knowing the shape or timing of potential disasters and getting locked into a discussion over these uncertainties as opposed to focusing on the actions that one can take to make the system more robust, more resilient, and tuning it to do the best job possible of handling a wide range of even extreme disasters," says Lempert.

Preparing for (Possible) Doomsday

Just how much should we worry about really extreme disasters? The extinction-level asteroid (see sidebar), the climate change so severe it cripples world food production, or the new infectious disease that becomes a worldwide pandemic? These events might seem to belong more in the realm of summer blockbusters than serious policy discussion, but some, like Harvard University economist Martin Weitzman, argue they are not as rare as many people assume.

Disasters in general suffer from what economists call a "fat-tail" problem. In a normal statistical distribution, a classic bell curve, divergences from the mean in either direction are both increasingly rare and do not differ too drastically from the average. This is not true of fat-tail distributions. While extreme events are still rarer than the average, they can deviate from that average by much larger amounts, meaning that the next event could be orders of magnitude worse than the record holder up to that point. In extreme cases, there is essentially no limit to how bad the next disaster could be. Under such conditions, Weitzman says traditional cost-benefit analysis breaks down. It could be correct to spend any amount of resources on prevention if doing so means averting a true catastrophe.

That doesn't necessarily provide a useful framework for making decisions, though. Weitzman allows that such large uncertainties may make it impossible to obtain agreement on an optimal solution before the risks become more apparent — at which point it may be too late to implement those solutions. With climate change, for example, cutting carbon emissions is not an effective plan to reduce global temperatures once they have already risen significantly. Given the reluctance to devote significant resources to avert theoretical future catastrophes, accepting suboptimal responses after the fact may be the best we can hope for, Weitzman has written.

"We tend to be unwilling to take strong steps to avert a crisis, but then after the crisis occurs we are more willing to do what we should have done all along," says Barrett. In the case of global threats, "you need to convince the whole world to do what it wouldn't want to do normally. And that is unprecedented." **EF**

Readings

Barrett, Scott, and Astrid Dannenberg. "Negotiating to Avoid 'Gradual' versus 'Dangerous' Climate Change: An Experimental Test of Two Prisoners' Dilemmas." CESifo Working Paper No. 4573, January 2014.

Hallegatte, Stéphane. "How Economic Growth and Rational Decisions Can Make Disaster Losses Grow Faster Than Wealth." World Bank Policy Research Working Paper No. 5617, March 2011.

Harrison, Glenn W., and Jack Hirshleifer. "An Experimental Evaluation of Weakest Link/Best Shot Models of Public Goods." *Journal of Political Economy*, February 1989, vol. 97, no. 1, pp. 201-225.

Kousky, Carolyn. "Informing Climate Adaptation: A Review of the Economic Costs of Natural Disasters." *Energy Economics*, November 2014, vol. 46, pp. 576-592.

Schade, Christian, Howard Kunreuther, and Philipp Koellinger. "Protecting Against Low-Probability Disasters: The Role of Worry." *Journal of Behavioral Decision Making*, December 2012, vol. 25, no. 5, pp. 534-543.