“There is a strong, credible body of evidence, based on multiple lines of research, documenting that climate is changing and that these changes are in large part caused by human activities. While much remains to be learned, the core phenomenon, scientific questions, and hypotheses have been examined thoroughly and have stood firm in the face of serious scientific debate and careful evaluation of alternative explanation.¹ Some scientific conclusions or theories have been so thoroughly examined and tested, and supported by so many independent observations and results, that their likelihood of subsequently being found to be wrong is vanishingly small.²” This is the judgement of the U.S. National Academies of Sciences, whose members include more than 300 Nobel laureates.

The debate about whether climate change is man-made, the result of El Niño, or a combination of man-made and natural phenomena has captivated scientists, policymakers, NGOs, and individuals across the globe for decades. With every year that passes, more record-setting hurricanes are generated, glaciers continue to melt, sea levels continue to rise, and more people are impacted by them. There is no doubt that climate change is real. The scientific evidence proving it exists in ample supply. Yet with every early snowfall or exceptionally cold winter, some constituencies in the business and government arenas deny it exists, or claim that it is a creation of tree-hugging

¹“Advancing the Science of Climate Change,” America’s Climate Choices: Panel on Advancing the Science of Climate Change, National Research Council (Washington, DC: The National Academies Press, 2010), 1.² National Research Council, Science of Climate Change, 21, 22.
environmentalists. Their reasons for doing so often boil down to the thirst for money, which has a short-term benefit, but, given the mountain of evidence to the contrary, doing so is little more than gambling with our collective long-term interests.

The battle lines that have been drawn between climate change believers and deniers could not be more distinct. However, outside of the halls of power and beyond diplomatic chatter there is a subtle, if imperceptible shift heralding a potentially more impactful climate awakening. Those favoring grandiose solutions to the very real challenges posed by climate change will find no victory with the advent of true market-based solutions to climate risk. For one, these shifts in the market are brought forth without presidential decree and signing ceremonies. Rather, they are brought about the same way each economic revolution occurs—with the inexorable drive among entrepreneurs, engineers, planners and risk managers tackling the immediacy of problems, with practical solutions for which the market is willing to pay.

The former moniker for climate change—*global warming*—which was popularized in the 1980s, failed to capture the world’s imagination and trigger significant action. As a result, opponents of climate science used the reminder of winter and imperceptibly small temperature changes as evidence that the world was not warming, but in fact remaining in an eons-long natural oscillation. The absence of evidence is not the evidence of absence, however, and the increasingly frequent climate impacts in major cities around the world is changing both attitudes and perceptions. Although more urgent action is needed to combat climate change, there is reason for guarded optimism.

When one person tries to blow up an airplane with his shoes, the whole world takes their shoes off at airports. No matter how infinitesimal the risk of a shoe-borne airline calamity, we will subject ourselves to inconvenience on a grand scale when the economic costs are linear and fear becomes real.\(^3\) One such climate change shoe dropped when New York’s emergency managers put sandbags around the floor of the New York Stock Exchange during Hurricane Sandy and had to contemplate the very real costs of building flood walls to protect New York City from once unimaginable risks.\(^4\) Sandy, and Irene before it (a near miss of Sandy’s proportions), are now part of our climate data sample and are not merely consigned to the labs or weather models.

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\(^3\) T. Connor, “Shoe Bomber has ‘Tactical Regrets’ Over Failed American Airlines Plot,” NBC News, February 3, 2015, accessed November 25, 2015, [http://www.nbcnews.com/news/us-news/shoe-bomber-has-tactical-regrets-over-failed-american-airlines-plot-n296396](http://www.nbcnews.com/news/us-news/shoe-bomber-has-tactical-regrets-over-failed-american-airlines-plot-n296396).

\(^4\) C. Marshall, “Massive Seawall May be Needed to Keep New York City Dry,” *Scientific American* (May 5, 2014), accessed November 25, 2015, [http://www.scientificamerican.com/article/massive-seawall-may-be-needed-to-keep-new-york-city-dry/](http://www.scientificamerican.com/article/massive-seawall-may-be-needed-to-keep-new-york-city-dry/).
of scientists, but on the streets of Manhattan and up and down the East Coast of the U.S. As is often the case, it takes a calamity in a center of power and influence (New York rather than the Maldive Islands) to focus attention on an issue that some people around the world live with on a daily basis.

Across the planet we are reminded just how fragile we are in the face of accelerating climate change, from super typhoon Haiyan (which wreaked havoc on the Philippines in 2013) to the monster hurricane Patricia (which hit Mexico in 2015), the two most powerful cyclonic storms in recorded history. Climate deniers would say (with a point, albeit a small one) that recorded history of these storms only dates to the 1850s for the U.S., and that, therefore, it is likely that certain weather events will be out of sample. Denial or not, it does not bode well for humanity’s future that we mostly have our heads in the sand and go about our merry lives without change. Europe has been awakened by increasingly severe storms, floods, and other weather events. Australia routinely battles drought, and California has been tormented by persistent droughts and wildfires that have triggered water rationing on a scale the state and, indeed, the U.S., has not seen since the Dust Bowl dried up much of the country during the 1930s.

As is the case with so many aspects of man-made risk, climate change, which is certainly exacerbated by man and our inexorable carbon footprint that is leaving a deep impression on the planet’s complex ecosystem, is most felt by the most vulnerable. Climate change is driving the very real specter of water wars and the rise in piracy in East Africa, which is, in no small measure, triggered by the scarcity of resources on land. Indeed, the perennial conflicts in the Middle East are not only fueled by centuries-old animus, but by control of natural resources, from fresh water in the Golan Heights to access to open water in the Mediterranean. Indeed, the casus belli for Russia’s annexation of Crimea from Ukraine in 2014 was so that Russia could regain control of its erstwhile Soviet-era access to the warm water port in Sevastopol.

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5 D. Rice, “Patricia Tops List of the World’s Strongest Storms,” USA Today, October 24, 2015, accessed November 25, 2015, http://www.usatoday.com/story/weather/2015/10/23/hurricane-patricia-strongest-hurricane/74461754/.

6 The National Hurricane Center, The Most Intense Hurricanes in the United States 1851–2004, 2015, accessed November 25, 2015, http://www.nhc.noaa.gov/pastint.shtml.

7 V. Davis-Hanson, “California is Becoming a Dust Bowl,” Newsweek, July 1, 2015, accessed November 25, 2015, http://www.newsweek.com/california-becoming-dust-bowl-349255.

8 G. Barbati, “World Water Wars: In the West Bank, Water is just Another Conflict Issue for Israelis and Palestinians,” International Business Times, July 1, 2013, accessed November 25, 2015, http://www.ibtimes.com/world-water-wars-west-bank-water-just-another-conflict-issue-israelis-palestinians-1340783.

9 P. N. Schwartz, Crimea’s Strategic Value to Russia, Center for Strategic and International Studies, March 18, 2014, accessed November 25, 2015, http://csis.org/blog/crimeas-strategic-value-russia.
veritable ‘land grab’ taking place under rapidly shrinking polar ice caps is a sign of how climate change is no longer a distant prognosis, but rather a current malady desperately in need of treatment. Shipping firms, as well as nations, are contemplating the impact on global trade using northern open ocean routes.\textsuperscript{10} We will derive little comfort from receiving goods faster if our cities are under water, however.

Some mega trends are working in humanity’s favor. Living in the age of \textit{homo urbanus}, with more of humanity living in dense urban environments, produces strains on the environment and intensifies resource demands, but it also exposes many more people—in whose adaptation climate resilience lies—to the line of site of extreme weather events. Just a few years ago it would have been unthinkable to see London’s ubiquitous ‘Boris Bikes’ on the streets of Washington, D.C. or New York, but for economic and business model reasons (not for the sake of being ‘green’) this mode of urban transport is now flourishing. Uber, Zipcar, and ‘hives’ of Smart cars and Cars2Go are enabling urban dwellers to forgo car ownership altogether. Hybrids and all-electric innovations are not only common place, they are also increasingly seen as ‘cool’ and part of the evolving mainstream. While diplomats and politicians grapple with not losing climate’s upcoming ‘big moment’ at the next climate change conference, a ‘climate standards war’ is being waged in the market of ideas, giving the world hope that at last we are marshaling market-driven ingenuity to make a business out of solving climate change—or at least containing its impact.

Once upon a time the words corporate social responsibility (CSR, discussed at length in Chapter \textnumero10) were shunned in corporate boardrooms, whose members naively regarded dealing with myopic shareholder interests as the only business interest worthy of discussion. Today, CSR (or, more simply, managing against a triple bottom line of economic, social, and environmental factors) is not only commonplace, it is the source of competitive advantage for many firms.\textsuperscript{11} The garment industry serves as a prime example of how quickly an interconnected and flat world can punish corporate social irresponsibility—even when it is carried out by sub-suppliers in a global chain.

As previously noted, the collapse of the Rana Plaza building in Bangladesh not only impacted share prices in the garment industry worldwide, it also triggered ‘vicarious liability’ because the garment tags of global brands were

\textsuperscript{10} B. Plummer, “Climate Change Will Open Up Surprising New Arctic Shipping Routes,” \textit{The Washington Post}, March 5, 2013, accessed November 25, 2015, \url{https://www.washingtonpost.com/news/wonk/wp/2013/03/05/climate-change-will-open-up-surprising-new-arctic-shipping-routes/}.

\textsuperscript{11} D. Disparte, and T. Gentry, “The Rise of Corporate Activism: From Shareholder Value to Social Value”, \textit{CSR Journal}, June 30, 2015, accessed November 25, 2015, \url{http://csrjournal.org/the-rise-of-corporate-activism-from-shareholder-value-to-social-value/}. 
found in the rubble. Even though these firms did not own the building or the subcontractors, they could not wash their hands of the lost lives and reputation risk. Similarly, Apple showed leadership by being among the first global technology companies to publish worker and other standards for its global supply chain. This not only defanged some of the pressures Apple had been facing from lax or nonexistent standards at Foxconn (its inextricably intertwined Chinese supplier), it also (in a rare move) used transparency as a source of competitive advantage. Transparency itself will increasingly become a source of competitive advantage in the future.

In short, just as it took about 30 years to move CSR from a ‘nice to have’ to a ‘need to have’ in business, being ‘green’ is on a similar pathway. Entire industries have cropped up, devoted to energy efficiency. Economic breakthroughs are afoot in virtually every aspect of the so-called ‘green’ economy. And while many of these micro-battles in the climate standards war may have gone unnoticed in the 2015 Paris Climate Change Summit, and other global summits to come, a whole generation of business leaders and entrepreneurs stand to create a lot of real economic value by making it a business priority for the world to stay in business. The world’s ability to tackle climate change is the tragedy of the commons of our times, and perhaps the greatest risk we have ever faced—as well as being our greatest risk management failure.

Climate change was once managed as an ‘externality’ by risk managers and quants—one so big that they could not conceivably factor it into their pricing models or risk-hedging strategies. There has also been a very dangerous remoteness to climate impacts, once seen as primarily the scourge of unfortunate and ill-prepared developing countries. Ethiopia’s dire famine, triggered by persistent droughts, claimed the lives of nearly a million people across the Horn of Africa. As recently as 2011, severe draughts revisited the region, killing at least 260,000 people, most of whom were in war-torn Somalia. Until recently, these grim images served to form so many peoples’ misconcep-

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12 J. Drennan, “Laundering the Global Garment Industry’s Dirty Business,” Foreign Policy, April 24, 2015, accessed November 25, 2015, [http://foreignpolicy.com/2015/04/24/laundering-global-garment-industrys-dirty-business-rana-plaza-bangladesh-factories/](http://foreignpolicy.com/2015/04/24/laundering-global-garment-industrys-dirty-business-rana-plaza-bangladesh-factories/).

13 Supplier Responsibility, Apple.com, 2015, accessed November 25, 2015, [http://www.apple.com/supplier-responsibility/](http://www.apple.com/supplier-responsibility/).

14 Known officially as the 2015 United Nations Conference on Climate Change.

15 D. Nuccitelli, “Is Climate Change Humanity’s Greatest-ever Risk Management Failure?,” The Guardian, August 22, 2013, accessed November 25, 2015, [http://www.theguardian.com/environment/climate-consensus-97-per-cent/2013/aug/23/climate-change-greatest-risk-management-failure](http://www.theguardian.com/environment/climate-consensus-97-per-cent/2013/aug/23/climate-change-greatest-risk-management-failure).

16 M. Wooldridge, “World Still Learning from Ethiopian Famine,” BBC News, November 29, 2014, accessed November 25, 2015, [http://www.bbc.com/news/world-africa-30211448](http://www.bbc.com/news/world-africa-30211448).

17 L. Smith-Park and N. Elbagir, “Somalia Famine Killed 260,000 People, Report Says,” CNN, May 2, 2013, accessed November 25, 2015, [http://www.cnn.com/2013/05/02/world/africa/somalia-famine/](http://www.cnn.com/2013/05/02/world/africa/somalia-famine/).
tions about the African continent, so as to relegate its massive growth potential to more astute investors and countries. Today, climate change and the urgent need to find solutions to it, is no longer being treated as an externality, but rather something for which organizations and societies must be prepared.

Global leadership, consensus, and, above all, agility are needed to begin arresting the rate of climate change and improving global resilience to it. For sensible solutions to emerge from governments around the world, the economic costs of climate risks can no longer be ‘transferred’ away by government subsidies and national catastrophe insurance programs that amplify moral hazard—which is risk taking without risk bearing. Why would anyone build a house in Tornado Alley (a wide swath of the U.S. Midwest with a propensity for frequent tornadoes) with anything other than ‘ricks and sticks’ if, following each instance of severe damage from tornadoes, the true cost of rebuilding is not carried by the communities that are affected?

A broad commitment among the world’s governments and businesses to quickly raise and diversify spending on research and development on energy technologies is urgently needed. While this would clearly be costly, it is important to remember three things. First, spending to reduce grave risks is reasonable. Second, some current climate policies cost a lot more than would a greatly expanded research effort. Third, battling climate change can actually raise money, the best example being well-designed carbon prices, which can boost green power, encourage energy saving, and suppress the burning of fossil fuels more efficiently than subsidies for renewables.18

While the Paris Climate Change Summit did perhaps represent a tipping point, there was a sense that, as was the case with each previous climate change summit, an opportunity had been missed, and should be tempered by the gradual climate awakening that is occurring in the market. “Thinking caps should replace hair shirts and pragmatism should replace green theology. The climate is changing because of extraordinary inventions like the steam turbine and the internal combustion engine. The best way to cope is to keep inventing.”19 The real opportunity cost is for business leaders not to seize this moment.

**De-risking Climate Change**

The first step toward financially de-risking the impacts of climate change on advanced economies is to change the economics. Shared government-sponsored risk pools, such as flood insurance, mis-price these increasingly

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18 “Clear Thinking Needed,” *The Economist*, November 28, 2015, 11.
19 “Clear Thinking Needed,” *The Economist*, 11.
commonplace catastrophes. The result is that there is little innovation in making human habitation more resilient (where financial wherewithal is not a limitation) while at the same time moving further inland from flood prone areas. The banks of the Mississippi River will brim and eventually spill over, as will the Yangtze and the various rivers along the Ganges Delta. So much of humanity live near major waterways, oceans and shorelines that they enhance our collective vulnerability. In advanced economies, while government subsidized catastrophe insurance programs help to ease the financial consequences relatively quickly, they also stem the tide of innovation and climate adaptation that could have started when the first flood programs were created in the U.S. in 1968.20 Similarly, allocating tax dollars to rebuilding flood-damaged areas takes financial resources away from taxpayers who do not live in such areas, but must in essence subsidize those who do.

During a time when the U.S. economy was largely driven by agriculture and interstate trade through waterways, and there was no extensive transportation alternative by rail or road, the need to be near major bodies of water and flood zones was an economic imperative. Today, however, with an economy that is highly diversified, coupled with multiple modes of industrial transport and global trade, the economic need to be a riparian society is no longer essential. Similarly, subsidies in wind storm insurance coverage, which would contemplate hurricanes, severe storms and tornadoes, have debased advancements in more wind-resistant or wind-proof housing. The toll from these programs, which, year after year and calamity after calamity, have reconstructed homes back to their prior state, mostly of “brick and stick” construction (the principle of indemnity in insurance holds that claimants cannot profit from a loss, thus getting the same asset they lost). This naturally begs the question, how long until the next insurance claim is filed by the same claimant in the same home, and raises the issue of how sensible it is to continue to rebuild and devote increasingly limited financial resources in disaster prone areas.

In 2013 the real toll of this perpetual weather induced creative-destructive cycle was felt by Moore, a small town in Oklahoma. In May that year a Category 5 tornado, the highest class on the Enhanced-Fujita scale, ripped through the center of town and plowed right through two poorly constructed elementary schools. The elementary schools did not have adequately reinforced walls and were hardly a durable construction class for Tornado Alley21 (no building not constructed of concrete would have withstood such

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20 National Association of Insurance Commissioners, National Flood Insurance Program, 2015, accessed November 25, 2015, http://www.naic.org/cipr_topics/topic_nfip.htm.
21 Associated Press, “Moore Schools Destroyed in Tornado Poorly Built, Civil Engineer Says,” Tulsa World, February 22, 2014, accessed November 25, 2015, http://www.tulsaworld.com/news/local/moore-
a hit). Tragically, and criminally, the buildings had no tornado safe rooms.\textsuperscript{22} At a minimum, public buildings in Tornado Alley should be mandated per the construction code to have protected basements or safe rooms sufficient to shelter the building’s occupants (this would imply a complex if impossible retrofitting process for existing structures). That there has been little financial incentive to adapt building standards to predictable natural risks is partly driven by the moral hazard created by state-sponsored programs, (to make insureds whole again). In Moore, 24 people perished and hundreds were injured with little more protection than the walls of the flimsy buildings they cowered in to shelter from nature’s wrath.\textsuperscript{23} Sadly, millions of children around the world face a similar fate from weather-related events, but so many of their governments have little or no money or resources to protect them.

Whether this type of tragedy is caused by climate change or by nature’s usual rhythms matters less than the fact that the direst of consequences—the loss of nine young lives and their future potential—were in that case entirely preventable. If the U.S. does not take leadership in confronting the impacts of climate risk at home, global admonishments about reducing emissions and protecting natural resources will continue to fall on deaf ears. Just as Tornado Alley goes through a predictable annual drama of destruction and reconstruction, the Florida Panhandle and Gulf States undergo a similar repetitive annual drama. Here too, miscalculating not only the effects but the reconstruction costs following a storm, hurricane or flood, continue to plague the region.

Just as climate risks take the heaviest toll on those who can least afford it, the entire city of New Orleans was devastated by the effects of hurricane Katrina—which was a Category 3 storm in the Saffir–Simpson scale when it made landfall in the Gulf.\textsuperscript{24} As described earlier, the entire city, state, regional and federal response apparatus froze in the face of what was an entirely predictable calamity. These government agencies did not freeze for lack of resources or knowledge of what to do and how to respond; they froze for the

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\textsuperscript{22} D. Muir and A. Castellano, “Oklahoma Tornado: 2 Devastated Elementary Schools had no Safe Rooms,” ABC News, May 22, 2013, accessed November 25, 2015, http://abcnews.go.com/US/oklahoma-tornado-devastated-elementary-schools-safe-rooms/story?id=19230427.
\textsuperscript{23} B. Brumfield, “Moore, Oklahoma, Looks Back on Tornado That Killed 24 One Year Ago,” CNN, May 20, 2014, accessed November 25, 2015, http://www.cnn.com/2014/05/20/us/oklahoma-moore-tornado-anniversary/.
\textsuperscript{24} K. A. Zimmerman, “Hurricane Katrina: Facts, Damage and Aftermath,” Live Science, August 27, 2015, accessed November 25, 2015, http://www.livescience.com/22522-hurricane-katrina-facts.html.
\end{flushright}
lack of risk agility and the capability to act with the type of speed this era requires.

Part of the failure to act is that the system, much like public bailouts of banks, is ‘internalizing’ the consequences of external events. Clearly, there needs to be a model in which aid and disaster relief work with speed—thus the reason to protect organizations like FEMA and its global counterparts. However, reducing moral hazard requires that the price of risk and its consequences are borne by those who create or take the risk in the first place. In this case, climate change is being produced and accelerated by advanced markets. Now advanced markets are beginning to feel the consequences.

**The Readiness Dilemma**

Building climate change resilience in developing and emerging countries is, of course, a much more difficult task. It combines propping up often-decrepit national institutions and financial systems, spurring infrastructure investment, and creating first-response capabilities. Above all, the development of nascent local insurance capabilities is critical, and this must be combined with greater interconnections with global insurance and reinsurance capacity. Many protectionist government policies preclude greater integration with global insurance markets, relegating many countries to offset local and regional risks with often shallow, opaque and unregulated insurance pools.

Following a natural disaster, developing and emerging countries most often depend on global aid, development agencies, and their disaster relief response. As climate change becomes increasingly severe, developing regions of the world are facing the most consequential impacts. Few developing regions are spared—and fewer still are able to go it alone. Much like an individual U.S. state’s resources will be strained following a crisis, organizations like FEMA help coordinate a whole-of-government response. As is the case with so many of the topics addressed in this book, effective international and regional responses are needed.

In Pakistan in 2010, record-breaking floods triggered by unseasonably heavy rains caused widespread damage, claimed thousands of lives and affected 18 million people (more than one-tenth of Pakistan’s population). The hardest-hit regions were in the Swat Valley and the disputed Kashmir region, a tradi-

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25 *Pakistan Floods*, Thomson Reuters Foundation information website on Pakistan flooding, April 8, 2013, accessed November 25, 2015, [http://www.trust.org/spotlight/Pakistan-floods-2010](http://www.trust.org/spotlight/Pakistan-floods-2010).
tionally restive region and safe haven for separatist and terrorists. As a result, the Pakistan government has a deep distrust of international aid efforts, fearing that international intelligence agency operatives may be embedded among relief workers, and that the groups it opposes may take advantage of relief operations to pursue their own agendas. In Pakistan, as well as the Indian-controlled side of Kashmir, disaster relief efforts were led by the military, the strongest institutions in each country.

Similar to how the world only gained the upper hand on the Ebola outbreak that started in West Africa and eventually affected 11 countries when its response was militarized, militarizing aid and disaster relief quite literally has a double-edged sword. On the one hand, military intervention is most often associated with armed conflict or a takeover, and people in developing countries have long memories of occupation. On the other hand, many of the worst disasters (man-made or naturally occurring) can only be tackled with the superior logistics and personnel capabilities controlled by the military. Duplicitous actions blurring humanitarian neutrality—such as Colombian paramilitary units posing as Red Cross workers to free Ingrid Betancourt from the Fuerzas Armadas Revolucionarias de Colombia—severely hamper global relief efforts, especially when there is no other choice but to bring in the cavalry.

From the desertification of already arid lands caused by persistent droughts to torrential downpours and a record-breaking El Niño weather phenomenon, the worst impacts of climate change are being felt south of the equator. Latin American countries, such as Panama, which did the right thing by the renewable energy ‘manual’ of the 1980s with its reliance on hydropower, is now facing energy shortages and a head-on collision course with climate change. This confluence of events comes at a time when the country’s growth and energy needs are outpacing its capacity to produce sufficiently diversified energy. The adoption of greener energy alternatives the world over is partly suppressed by persistently cheap oil prices and a standard ‘war’ that is being waged by the alternative energy market. There is no “one size fits all” approach to powering economies.

The unbalanced impacts of climate change are heavily weighted against emerging and developing countries. Not only are most developing countries’

26 I. Khan, “Flood Brings Chaos Back to Pakistan’s Swat Valley,” New York Times, August 19, 2010, accessed November 25, 2015, http://www.nytimes.com/2010/08/20/world/asia/20swat.html?_r=0.
27 “Ebola: Mapping the Outbreak,” BBC News, November 6, 2015, accessed November 25, 2015, http://www.bbc.com/news/world-africa-28755033.
28 M. Tran, “Colombia Apologizes Over Use of Red Cross Symbol in Betancourt Rescue,” The Guardian, July 16, 2008, accessed November 25, 2015, http://www.theguardian.com/world/2008/jul/16/colombia.
net contribution to climate change lower, but their ability to respond and rebuild stricken communities is, as we have noted, greatly impaired. While climate change invariably deals with large-scale science and phenomena, micro-climate impacts are increasingly commonplace. China’s smog crisis (caused by severe industrial pollution and coal-fired power plants) is linked to major respiratory ailments and a dramatic rise in lung cancer.\footnote{C. Larson, “Rates of Lung Cancer Rising Steeply in Smoggy Beijing,” Bloomberg.com, accessed November 25, 2015, \url{http://www.bloomberg.com/bw/articles/2014-02-28/rates-of-lung-cancer-rising-steeply-in-smoggy-beijing}.} Similarly, the temporary ban of vehicle traffic in Paris due to lingering noxious smog that affected the city in 2015, serve as reminders of just how fragile our ecosystem is.\footnote{E. Izadi, “Paris Tries to Fight Smog by Banning Half its Cars From the Roads,” \textit{The Washington Post}, March 23, 2015, accessed November 25, 2015, \url{https://www.washingtonpost.com/news/worldviews/wp/2015/03/23/paris-tries-to-fight-smog-by-banning-half-its-cars-from-the-roads/}.} Adverse micro-level changes like these provide case studies on both the consequences and societal responses to climate change. Affected cities adopt ‘a life goes on’ attitude and people and commerce proceed at a slower pace, while donning a surgical mask, popularized as a low-cost adaptation to air pollution and communicable respiratory diseases in Asia.\footnote{J. Aleccia, “Flu-fighting Masks May Help, But Don’t Bet on It,” NBC News, April 30, 2009, accessed November 25, 2015, \url{http://www.nbcnews.com/id/30464365/ns/health-cold_and_flu/t/flu-fighting-masks-may-help-dont-bet-it/#.VIYQg_mRtRX8}.} In European cities, where people are already used to pedaling to work, bicycle use has skyrocketed and alternate forms of mass transit are available.

Facing hotter temperatures during summer months, colder winters, drier and longer droughts, and soggier monsoons, the world is being profoundly tested by what scientists would call the ‘climate change little league’. The dire consequences of rising sea levels and a world beyond a rise of 2° Celsius promise to make it an increasingly unpleasant place—a veritable hot, flat and crowded hellscape.\footnote{R. Leber, “This Is What Our Hellish World Will Look Like After We Hit the Global Warming Tipping Point,” \textit{New Republic}, December 21, 2014, accessed November 25, 2015, \url{https://newrepublic.com/article/120578/global-warming-threshold-what-2-degrees-celsius-36-f-looks}.} According to a consensus that has clearly formed among the scientific community, a ‘Gladwellian’ tipping point is nigh.

Winter storms are now named in the U.S. to raise public awareness and improve safety against increasingly severe winter storms.\footnote{T. Niziol, “The Science Behind Naming Winter Storms at the Weather Channel,” The Weather Channel, October 13, 2015, accessed November 2015, \url{http://www.weather.com/news/news/science-behind-naming-winter-storms-weather-channel-20140121}.} Terms like ‘snowmageddon’ have become a part of the weather-watching vernacular, and cities like Boston find no mirth in being snowed in on an epochal scale. Through the winter of 2014/2015, the northeastern U.S. faced a monster...
snow storm named Juno.³⁴ Boston was particularly hard-hit throughout the winter, with a record shattering 108.6 inches of snowfall,³⁵ resulting in massive snow drifts. The economic impact of this calamity, preceded by Super storm Sandy, and Irene before it, served as a stark reminder of the GDP at risk in cities, where climate-risk is one of the chief perils.

As is noted in Illustration 8.1,³⁶ according to the U.S. National Oceanic and Atmospheric Administration (NOAA), the trend line since the beginning of the twentieth century shows a slow and steady increase in average land and ocean temperatures, rising more than one full degree Celsius during

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³⁴T. Ghose, “Why Monster Storm ‘Juno’ Will be So Snowy,” LiveScience, January 26, 2015, accessed November 25, 2015, http://www.livescience.com/49571-northeastern-snowstorm-juno-causes.html.

³⁵D. Abel and N. Emack-Bazelais, “Boston’s Winter Vaults to the Top of Snowfall Records,” Boston Globe, March 15, 2015, accessed November 25, 2015, https://www.bostonglobe.com/metro/2015/03/15/parade-day-snow-but-snowiest-winter-record-unlikely-today/BCxfh7yPr1rxtHVzty5sPM/story.html.

³⁶National Oceanic and Atmospheric Administration, National Centers for Environmental Information, Weather Time Series, 2015, accessed November 25, 2015, http://www.ncdc.noaa.gov/cag/time-series/global/globe/land_ocean/ytd/7/1880-2015.
this period, with a noteworthy rise since the 1960s. The first seven months of 2015 were the hottest in recorded history, and July 2015 was the hottest month ever recorded. It is hard to argue with facts, and the fact is that average temperatures on land and in the oceans have risen consistently for more than a century.

Scientists differ on the projected rise in average temperatures for the remainder of this century, but there is a growing consensus that the projection of a 2° Celsius rise now appears inadequate, given the already observed impacts on ecosystems, food, livelihoods, and sustainable development. According to scientists from the Inter-governmental Panel on Climate Change, a 2° Celsius increase in temperature would result in greater risk of a rise in sea level, shifting rainfall patterns and extreme weather events, such as floods, droughts, and heatwaves, that would severely impact the polar regions, high mountain areas, and the tropics. This would pose a significant danger to disadvantaged populations in many of the world’s largest coastal cities, people whose livelihoods are dependent on natural resources, and those at risk from conflicts over scarce resources.

Three reports produced by the World Bank in its *Turn Down the Heat* series warn that, in the absence of concerted action, temperatures are on pace to rise to 4°C above pre-industrial times by the end of this century. The reports paint a dire picture of what the world could be like should such a temperature rise occur, including the inundation of coastal cities, increasing risks for food production (potentially leading to higher under and malnutrition rates), more extremes in temperature and precipitation, unprecedented heatwaves, substantially exacerbated water scarcity in many regions, an increased intensity of tropical cyclones and irreversible loss of biodiversity.

One of the more insidious effects of climate change is the impact it is having on the spread of communicable, warm-weather diseases, and on human health more generally. The spread of mosquito-borne illness across parts of the mid-Atlantic U.S., such as West Nile Virus, which is inexorably spreading

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37 “Two Degree Celsius Climate Change Target ‘Utterly Inadequate’, Expert Argues,” *Science News*, March 27, 2015, accessed November 25, 2015, [http://www.sciencedaily.com/releases/2015/03/150327091016.htm](http://www.sciencedaily.com/releases/2015/03/150327091016.htm).

38 “Celsius Climate Change,” *Science News*.

39 *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience*, Worldbank.org, accessed November 25, 2015, [http://www.worldbank.org/en/topic/climatechange/publication/turn-down-the-heat-climate-extremes-regional-impacts-resilience](http://www.worldbank.org/en/topic/climatechange/publication/turn-down-the-heat-climate-extremes-regional-impacts-resilience).

40 “New Report Examines Risks of 4 Degree Hotter World by End of Century,” Worldbank.org, accessed November 25, 2015, [http://www.worldbank.org/en/news/press-release/2012/11/18/new-report-examines-risks-of-degree-hotter-world-by-end-of-century](http://www.worldbank.org/en/news/press-release/2012/11/18/new-report-examines-risks-of-degree-hotter-world-by-end-of-century).
north, is being attributed to climate change, which will provide little comfort to northern cities when anti-malaria cocktails and mosquito repellents become a part of daily life. While the so-called maladies of affluence continue to be the leading killers in developed countries, climate change poses a serious setback to the world’s efforts to combat the maladies of poverty. From diarrheal diseases to water and food supply challenges exacerbated by forced migration, all development goals are inextricably connected. Other diseases that fester in warm, densely populated environments continue to mutate and spread. While there may be a spurious linkage to climate change, a globally connected world with a new variety of dread diseases, such as H5N1, SARS, Zika, Ebola and vector-borne diseases, pose grave threats to humanity. As noted in Illustration 8.2, the potential impacts of climate change on human health are numerous and serious.

Illustration 8.2  The impact of climate change on human health (Climate effects on health, Centers for Disease Control and Prevention, accessed November 25, 2015, http://www.cdc.gov/climateandhealth/effects/)

41 Centers for Disease Control and Prevention, Climate and Health: Diseases Carried by Vectors, December 11, 2014, accessed November 25, 2015, http://www.cdc.gov/climateandhealth/effects/vectors.htm.
42 Centers for Disease Control and Prevention, Climate Effects on Health, accessed November 25, 2015, http://www.cdc.gov/climateandhealth/effects/.
Undoubtedly, climate change is most visibly affecting the world’s food supply chains and agricultural output. From droughts and wildfires in California (one of the largest agricultural suppliers in the world\textsuperscript{43}) to $1.25 billion in lost rice production in Thailand, climate change is not only disrupting output, but is also disrupting and potentially eradicating entire crops—and the lifestyles that go with them.\textsuperscript{44} Our insatiable appetite in developed countries for a perennial supply of out-of-season fruits and vegetables is pushing agricultural production to new, dangerous limits of industrialization. A year-round bounty of meat, fish, and poultry harvested in massive industrial complexes is having unintended consequences on CO\textsubscript{2} emissions and the world’s fish stocks.

Climate-related impacts on food prices and staple crops translate quickly into urgent political and security challenges. Indeed, observers have linked the effects of the rising costs of grain to the spark that ignited the Arab Spring in Tunisia in 2010.\textsuperscript{45} One act of self-immolation in protest to the oppressively prohibitive cost of living and the arc of history changed throughout the Middle East, and indeed the world. The security and refugee crisis plaguing Europe and much of the rest of the world are an indirect consequence of this climate-linked spark. Looking ahead, as war-ravaged countries throughout the Middle East face the confluence of low oil prices, desertification, food supply chain pressures, and mass migration caused by sectarian violence, peace and stability face potentially insurmountable odds.

The climate-related risks to food supply chains underscore just how far societal adaptation must go to decelerate the rate of change and eventually establish a new normal, albeit a hotter and more austere normality. Humanity must change its diet, its mobility, modes of transport and, above all, its industrial and residential energy consumption. Policymakers, in turn, must embrace greater diversification and efficiency in energy production and distribution. Governments must implement financial systems that accurately price for the externalities of dirty fuels, following a “polluter pays” principle. Additionally, building up risk hedging that funds crisis and post-crisis reconstruction efforts as if climate change were not a surprise event is key. Perhaps

\textsuperscript{43} A. Bjerga, “California Draught Transforms Global Food Market,” Bloomberg Business, August 11, 2014, accessed November 25, 2015, http://www.bloomberg.com/news/articles/2014-08-11/california-drought-transforms-global-food-market.

\textsuperscript{44} J. Kawasaki and S. Herath, Thailand’s Rice Farmers Adapt to Climate Change, Our World, United Nations University, November 19, 2010, accessed November 25, 2015, https://collections.unu.edu/eserv/UNU:1581/journal-issaas-v17n2-02-kawasaki_herath.pdf.

\textsuperscript{45} I. Perez, “Climate Change and Rising Food Prices Heightened Arab Spring,” Scientific American, March 4, 2013, accessed November 25, 2015, http://www.scientificamerican.com/article/climate-change-and-rising-food-prices-heightened-arab-spring/.
the most important step governments can take is to let the thousand flowers of efficiency and climate readiness bloom in the private sector and let the market pick winners and losers.

A Private Sector Response

The internal combustion engine has been in use globally since the 1800s. Over this 200 year period, the basic technology and its basic output—pollution—has been largely unchanged. That the Volkswagen Group, the crestfallen global automotive major claiming the fastest production car in the world, still needed a cheat device to meet regulatory emissions standards speaks to need to leave an old technology to a bygone era. In moving urban dwellers from pestilent horse-drawn carriages, the internal combustion engine and its early mass produced carriage, the Ford Model T, heralded a new era—an industrial renaissance. Mobility over long distance is as essential to economic development as water is to survival. Herein lies the challenge of an antiquated form of mobility: who among the world’s advanced countries has the right to dictate the development pathway of emerging and developing countries when they are themselves merely playing a game of ‘catch up’?

As in some areas of the economy, people are waiting with baited breath as innovations continue to leapfrog old systems that seem increasingly ill-equipped. Brick and mortar banking, for example, is increasingly being consigned to the history books in countries like Kenya, where the advent of mobile money through the ubiquitous M-Pesa program jump straight to a cash-free and banking branch-free future. Can any ‘developed’ country say that? Technologies such as Elon Musk’s groundbreaking Tesla vehicles serve as a hopeful guidepost for the future of mobility.

Climate change resilience goes far beyond how we get around over long distances and whether we evolve from the internal combustion engine. It also includes our financial readiness and the penetration of insurance and other hedging mechanisms, such as insurance-linked securities. Lloyd’s research shows that a 1 percent rise in insurance penetration translates into a 22 per-

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46 “The History of the Automobile,” About.com, accessed November 25, 2015, http://inventors.about.com/library/weekly/aacarsgasa.htm.
47 S. Edelstein, Hold Onto Your Butts: These are the 10 Fastest Cars in the World, Digital Trends, May 5, 2015, accessed November 25, 2015, http://www.digitaltrends.com/cars/fastest-cars-in-the-world-photo-gallery/.
48 J. Bright and A. Hruby, The Next Africa: An Emerging Continent Becomes a Global Powerhouse (New York: Thomas Dunne Books, 2015).
cent decrease in the burden shouldered by taxpayers following a large loss.\textsuperscript{49} While some classes of insurance are seemingly more ubiquitous than gravity in advanced economies, underdeveloped or non-existent insurance markets in developing countries greatly hamper post-disaster recovery efforts. Moreover, the lack of insurance penetration across all categories of coverage provides no financial backstop as families that grapple with losing economic breadwinners inevitably slide into hardship or poverty. Increasing insurance penetration, from property programs to life and health, cannot only price climate risk more accurately, it can also help shore up redevelopment and individual household resilience.

Indeed, part of the reason the VW emissions-rigging scandal had such a swift punitive response is that attitudes and enforcement about climate change have evolved the world over. While there remains an unsurprising lag in attitudes among the worst CO\textsubscript{2} emitters, generally the tendency globally is both an acceptance that climate change is real and that the time for action is now. In a compelling read of public sentiment, the Pew Research Center has conducted a global survey on climate change (see Graph 8.1), showing different attitudes worldwide, as well as a dangerous partisan schism in key

\textsuperscript{49}C. Edwards, C. Davis, \textit{Lloyd’s Global Underinsurance Report}, Lloyd’s of London, August, 2012, accessed November 25, 2015, https://www.lloyds.com/~/media/files/news\%20and\%20insight/360\%20risk\%20insight/global_underinsurance_report_311012.pdf.
countries, such as the U.S., Germany, and the UK, among others.\textsuperscript{50} The more conservative or right-leaning on the political spectrum the less likely one is to believe that climate change is a serious problem that is harming people right now. This schism widens when looking at the partisan difference on climate change among Democrats and Republicans in the U.S., creating a dangerous environment of climate inaction and denial.\textsuperscript{51} Political gridlock in the face of such a stark global risk is the very antithesis of risk agility. Therefore, it is largely up to the market and individual households (and voters) to drive change. The more climate impacts are felt in advanced markets, the more likely attitudes will change.

A Return on Misfortune

The global insurance industry is among the most resilient business sectors in the world. Its \textit{raison d’être} is to provide financial coverage against the misfortune visited upon policyholders. The industry is increasingly responding to climate change with innovative financial products that at a minimum provide economic security in the face of more frequent climate-related risks. While financial innovations can mitigate some of the economic consequences of climate change (for a premium), they will, of course, not stop adverse impacts from occurring. Insurance is merely a mechanism for financing unforeseen losses. Risk management is the art and science of stopping (or minimizing) losses in the first place. We need a true climate risk management strategy, for the collision course we are on with the planet’s most complex system (the environment) is untenable.

Weather-related crop failures have been a persistent threat since our earliest ancestors gave up their wandering lifestyles in favor of more sedentary farming societies. Today, crop failure insurance has expanded to include other weather-related risks to global food supply chains. Coverage based on specific predetermined rain volumes can help farmers and buyers alike offset some of the economic consequences triggered by weather. Supply chain disruptions continually affect world trade. From the flooding in Thailand that stopped much of the global production of semiconductors in its tracks to disruptions

\textsuperscript{50} B. Stokes, R. Wike, J. Carle, \textit{Global Concern about Climate Change, Broad Support for Limiting Emissions}, Pew Research Center, November 5, 2015, accessed November 25, 2015, \url{http://www.pewglobal.org/2015/11/05/global-concern-about-climate-change-broad-support-for-limiting-emissions/}.

\textsuperscript{51} Stokes et al., \textit{Global Concern}.  

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caused by natural disasters, offsetting economic risks and enabling firms and countries to reposition is a key facet of building resilience.52

One of the more promising aspects of financial innovation in building a societal response to climate change borrows from behavioral economics—although many of these innovations are still in their nascent stages. John Hancock, a U.S. subsidiary of the Manulife Financial Corporation, unveiled an innovative whole life insurance policy in partnership with Vitality, a pioneering South African wellness program.53 In this solution, traditional life insurance customers combat longevity risk by wearing a Fitbit device that rewards a healthy lifestyle with a combination of incentives and real savings on premiums, which for a whole life insurance policy can range in excess of $50,000.

This type of behavior-based solution is also occurring in the highly commoditized auto insurance market, where drivers install a device in their car that monitors driving patterns, thereby rewarding good road conduct with reduced premium and other benefits. Further incentives for hybrid or all-electric vehicles add to government-sponsored tax incentives, spurring the adoption of efficient vehicles. Following total loss claims, some homeowner’s policies require rebuilding houses with environmentally friendly materials and systems, such as use of natural light and solar panels, among others.54

Options for harnessing insurance and financial incentives beyond the traditional indemnification offer a compelling, if underexplored, area for innovation. Similar possibilities also abound to hedge large-scale losses. Harnessing the depth, liquidity, and actuarial capabilities in the private sector will help not only an individual household vis-à-vis climate change, but also highly exposed industries and society writ large. Clearly, the scale of the potential economic consequences are such that it will require true cross-sector collaboration. Bringing government resources to bear, along with global reinsurance and insurance capacity, would create an unbroken chain of financial control that can help communities rebuild following a loss, while helping others gain resilience by incentivizing behavioral change. For developing and emerging

52 S. Mydans, “Flood Defenses are Overrun in Bangkok,” New York Times, October 25, 2011, accessed November 25, 2015, http://www.nytimes.com/2011/10/26/world/asia/flood-waters-in-bangkok-shut-domestic-airport.html.

53 John Hancock Life Insurance, Johnhancockinsurance.com, accessed November 25, 2015, https://www.johnhancockinsurance.com/life/John-Hancock-Vitality-Program.aspx.

54 Green Insurance, Insurance Information Institute, November, 2015, accessed November 25, 2015, http://www.iii.org/article/green-insurance.
countries alike, the opportunity lies in creating basic insurance industry capabilities while strengthening ties and access to international markets.

For Rising Tides, Deeper Pools

In the face of climate change—a risk so large that people wrongly believe they cannot have an impact—harnessing all aspects of the capital markets is key. While most climate-related financial innovations are quite sophisticated, insurance-linked securities, such as catastrophe bonds (so-called “cat bonds”), are still underutilized in the world’s climate risk management strategy. Given the scale and potential city-wide and broad regional impacts natural disasters can have, catastrophe bonds were developed to bring greater financial liquidity following a large-scale loss, while at the same time giving sophisticated investors an important source of diversification. While catastrophe bonds themselves come with a series of intrinsic risks, they nonetheless offer a compelling approach to improving financial resilience.

While a novel investment vehicle, catastrophe bonds and their constituent funds, like other insurance-linked securities, are prone to a number of risks. Some are inherent in the underlying insurance exposure they are attached to—for example, natural disasters—while other risks may be common to the investment class. The first order of risks materialize if the underlying claim trigger (or covered event) occurs during the maturity of the bond, which is typically three years. This would result in a payout from the special purpose vehicle (SPV) to cover certain portions of the loss that have been transferred to the capital markets. In effect, these specialized financial instruments are the reinsurance of the reinsurance industry.

One of the most attractive features of catastrophe bonds is that they are largely decoupled from the fluctuations of the economy. While it shields investors from potential economic contagion in other asset classes, these bonds expose insurers to highly concentrated regions that are prone to natural disasters, which, as the evidence suggests, are occurring with greater frequency and severity, and are affecting more densely populated/built-up areas. Hurricane Katrina, which decimated the Gulf Coast and inundated New Orleans, Hurricane Sandy, the March 2011 Tohoku earthquake, and the ensuing tsunami and nuclear fallout in Japan, highlight the perils intrinsic in these instruments.

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55 World Economic Forum, Global Risks Report 2015.
In other words, while seeking diversification from economic risks, investors in catastrophe bonds are largely putting all their proverbial eggs in only a few highly concentrated regions exposed to natural perils, such as East Coast hurricanes, Japanese earthquakes, and European weather events. In short, only those regions that are prone to natural disasters that can be modelled and have a confluence of insurable assets are in the pool—therefore there may be a case of limited gains from diversification. Broadening the geographic scope and the types of natural perils covered in a catastrophe bond will not only help to diversify risks, adding coverage to woefully under-insured regions, but will also help mitigate the effect of adverse selection.

Rating agencies (not necessarily the paragons of accurately rating risk) have noted this so-called ‘peak peril’ attribute of catastrophe bonds. Consequently, most rating agencies give these bonds low marks in terms of investment grades.  

In fact, approximately 90 percent of the cat bonds tracked in Swiss Re’s Cat Bond Index receive a BB rating or lower. Where other investment instruments have a property of ‘slow degradation’ and can quickly turn around with the advent of new market information, cat bonds are not dissimilar from a game of Russian roulette: if the event occurs, albeit remote, an investor is likely to lose everything. This feature of being uncorrelated to the ‘noise’ in the financial markets give cat bonds the quality of being an investment vehicle that is not speculative in nature, but rather associated with the advent of a pure risk.

While climate change is a man-made risk, people will have a hard time gaming the acuity of these claim triggers, which can be an important source of stability against Adam Smith’s invisible hand. Outside of the ‘all or nothing’ risk inherent in cat bonds, they face a host of what can be deemed operational risks, which are exacerbated by the fact that there is a limited secondary market for these instruments and many investors do not totally understand this market, as evidenced by its small comparative size, at $24 billion. In addition to potential exposures resulting from issuer insolvency or financial distress, returns to investors are subordinated to other potential obligees. Additionally, reductions in interest rates due to early redemption or extensions in the notes can potentially hamper investor returns.

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56 Swiss Re, *Insurance-Linked Securities: Market Update Volume XVI*, July 2011.
57 Swiss Re, *Cat Bond Indices: Year in Review 2012*, February 2013.
58 National Association of Insurance Commissioners, *Insurance-linked Securities: Catastrophe Bonds, Sidecars and Life Insurance Securitization*, September 3, 2015, accessed November 25, 2015, [http://www.naic.org/clpr_topics/topic_insurance_linked_securities.htm](http://www.naic.org/clpr_topics/topic_insurance_linked_securities.htm).
59 Swiss Re, *Insurance-Linked Securities: Market Update, Volume XIX*, July, 2013.
Cat bonds are unequivocally appealing in that they are one of the few investment vehicles that can help diversify away business cycle exposures in a portfolio. While in turn this exposes investors to the often misunderstood peril of natural catastrophes and the opacity of risk modelling agencies, the trade-off is nonetheless attractive. Empirically, cat bonds have performed well in terms of holding their principal and delivering returns to investors that are often superior to other benchmarks. At the same time, there appears to be inherently less volatility in cat bond returns as evidenced when comparing returns to more volatile equity markets. In addition to being uncorrelated to the business cycle, cat bond pricing and returns are relatively straightforward spreads, with returns being a premium spread on treasuries and pricing typically pegged as a spread on LIBOR.

Another attractive feature of cat bonds is that they typically abate counterparty exposures, such as insolvency or financial distress, by being managed through SPVs and collateralized with strong paper. This property makes cat bonds attractive to issuers as well, as SPVs are often off-balance sheet instruments that tend to be bankruptcy remote. Cat bonds aided the broader insurance industry with standardized contracts, a move away from ad hoc reinsurance agreements, providing the vital liquidity of the capital markets following Hurricane Andrew. While many insurers had difficulty coping with this, investors clearly benefited from a degree of harmonization. Finally, with the advent of multi-peril cat bonds, investors have been able to secure an added layer of “natural” diversification, by not being exposed to a single natural catastrophe in a single region, but rather to be invested in a basket of natural perils. While the dominant force majeure in cat bonds are U.S. wind-related exposures, the multi-peril approach adds an additional layer of protection.

In terms of disadvantages, cat bonds have largely remained the remit of large institutional investors and insurance and reinsurance firms wishing to tap into the capital markets. This is a by-product of their issuing complexity and costs, combined with their relative novelty. Additionally, cat bonds are heavily dependent on third-party modelling firms, who use historical loss information and various payment trigger approaches (i.e. modelled loss and parametric modelling, among others), thus exposing cat bonds to substantial model risk, as many natural catastrophes, by default, are out of sample.

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60 G. Chacko, V. Dessain, A. Sjoman, A. Plotkin, and P. Hecht, Bank Leu’s Prima Cat Bond Fund, Harvard Business School, December 2004, accessed November 25, 2015, http://www.thecasesolutions.com/bank-leus-prima-cat-bond-fund-10452.

61 Swiss Re, The Fundamentals of Insurance-Linked Securities, June 2011.
This is particularly true when dealing with something as vastly complex as nature and weather systems, which operate on a millennial scale. Another drawback of this asset class is that they are, by design, prone to adverse selection. More clearly, only those regions that are prone to natural disasters and have exposed assets will enter the pool. While this exposure is abated by the various underlying layers of insurance (e.g. underlying insurance limits perform like a deductible, thus they need to be exhausted before the cat bond is triggered), cat bonds offer something of an ‘all or nothing’ proposition to investors. It should be noted that one major disadvantage of this asset class, to the extent one can rely on rating agencies, is that none receives an investment grade.

Cat bonds are an important financial instrument that are here to stay. As such, they are well placed in large, well-diversified portfolios. In fact, this may be their only home, for the reasons of size and complexity cited earlier. The property of being decoupled from the business cycle is an attractive one. However, fund managers would be well advised to tread carefully into cat bonds, for their ‘all or nothing’ properties can wreak havoc on an imbalanced portfolio. Crucially, cat bonds not only offer some respite from economic volatility compared to other assets classes, but also tend to demonstrate superior risk-adjusted returns.\textsuperscript{62}

A limited secondary market is a business risk that fund managers have to contend with for cat bonds, leaving few exits in instances of investor remorse. Nonetheless, cat bonds offer another avenue in the pursuit of investment yield, with spreads averaging between 300 and 600 basis points over treasuries. There is also evidence, following the Tohoku earthquake in Japan, that even in the face of unforeseen calamity, cat bonds are a surprisingly resilient asset class.\textsuperscript{63} This resilience, and, thus, their attractiveness as a source of diversification, is increased with the advent of multi-peril instruments.

Undoubtedly, the risk–return trade-off provided by cat bonds is appealing to investors. While they largely remain an investment vehicle for sophisticated institutional investors, cat bonds offer an attractive value proposition. Multi-peril cat bonds overcome some of the concerns of being exposed to specific regions that are prone to specific natural hazards. Thus, in a given year or over multi-year periods, wherein investors are typically locked into the bond, it is unlikely that a confluence of natural catastrophes will occur. The property of being shielded from the economic cycle lowers the overall volatility of cat

\textsuperscript{62} Chacko et al., \textit{Prima Cat Bond Fund}.

\textsuperscript{63} Swiss Re, \textit{Insurance-Linked Securities: Market Update Volume XVI}, July 2011.
bonds, making them a favorable addition and a potentially stabilizing force in a portfolio.

As investors seek yield, cat bond primary issue yield spreads have stood up reasonably well during the last decade. A period that was both naturally tumultuous—with Katrina, the Tohoku earthquake and Sandy, among others—and financially turbulent, with the Great Deleveraging of 2007–2009 and a historically low interest rate environment. Against this backdrop, and with the evident resilience of cat bond returns, the risk–return trade-off appears to be in balance. This being the case, it is striking how comparatively small the cat bond market is, perhaps signaling that they are only attractive to “practitioners” or those whose investment mandates permit them to dabble in the below investment grade “no-go zone”.

Nonetheless, there are encouraging signs that these instruments are being cleverly applied to bring liquidity into other areas of the insurance market. For example, life and health insurers are using cat bonds for the ‘longevity’ calamity that has the potential to upend actuarial models around life expectancy. Likewise, governments are turning to this vehicle as a way of creating a backstop in the event of a natural disaster. Innovative applications in man-made disasters, such as war and terrorism, which already enjoy a vibrant insurance and reinsurance markets, appears to be a logical next frontier.

Financing climate change and natural disasters through a broad-based approach can help improve pre-crisis readiness and post-crisis reconstruction. No matter how innovative pure claims-based solutions are, there is no climate risk management substitute to stopping the accident in the first instance. In order to do this, leveraging financial markets to change behavior through incentives and penalties can have a positive impact on the worst-performing advanced market consumers. Globally, the disequilibrium of impacts from climate change weigh heavily against underdeveloped countries. Calibrating this imbalance through public–private approaches will help stem the tide of forced migration, terrorism, and other global threats in the era of man-made risks.

A 2015 poll found that just 3 percent of Americans viewed climate change as the most important issue facing the U.S. Given the short-term orientation of so many people, perhaps this is unsurprising, but it should be alarming, coming from the world’s top producer of carbon dioxide. In the face of overwhelming scientific evidence proving that climate change exists, there is

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64 Fox News Poll: 2016 Matchups, Fox News, November 20, 2015, accessed November 26, 2015, http://www.foxnews.com/politics/interactive/2015/11/20/fox-news-poll-2016-matchups-syrian-refugees/.

65 World Bank, CO₂ Emissions, 2015, accessed November 26, 2015, http://data.worldbank.org/indicator/EN.ATM.CO2E.PC.
little that can be said to someone who continues to deny this fact. However, much of the world’s population clearly believes climate change is here to stay. Whether the result of their own personal experience or their understanding of the science supporting the climate change argument, people around the world are beginning to recognize both the adverse effects of climate change, and the need for urgent action. Reversing the paralysing effects of partisan politics that is stalling serious action on climate change is vitally important. Broad-based resilience on the part of individuals, organizations, and governments will collectively determine our agility in responding to this looming threat.