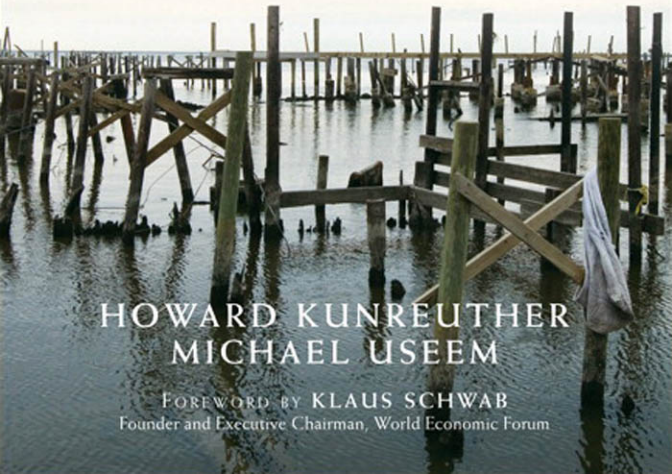
LEARNING FROM CATASTROPHES

Strategies for Reaction and Response



HOWARD KUNREUTHER
MICHAEL USEEM

Foreword by KLAUS SCHWAB
Founder and Executive Chairman, World Economic Forum

Praise for *Learning from Catastrophes*

"What an extraordinary range of experiences and what an experienced array of authors! This book is actually exciting to read, whether or not you are professionally concerned with anticipating or coping with catastrophes or their aftermath. But if those are your concerns, this book will not only inform you but stimulate your own thinking."

—**Thomas Schelling**, Emeritus Distinguished University Professor at the School of Public Policy of the University of Maryland, and recipient of the 2005 Nobel Prize in Economic Science

"*Learning from Catastrophes* brings together the expertise of two distinguished academics, Howard Kunreuther and Michael Useem, and other prominent thought leaders to shed light on a provocative topic of our times—risk. Kunreuther is a leading expert on the economic impact of large scale catastrophes and brings a well-honed perspective to the risk sciences. Useem is a driving force in studying leadership attributes, incorporating leadership studies into business curriculum and applying them in business. Together, the two professors of The Wharton School, University of Pennsylvania have presented a thoughtful analysis of extreme events and recommendations for mitigating their impacts. Spawned by discussions at the 2009 World Economic Forum, this book is a must read for those whose careers touch on the prediction of and response to catastrophes."

—**Jay Fishman**, Chairman and Chief Executive Officer, The Travelers Companies, Inc.

"The first decade of this century has seen natural disasters, acts of mass violence, and a severe financial crisis; but also increasing global integration and growing prosperity in many areas. *Learning from Catastrophes* is a most timely look at how we can use the latter to be better prepared for the former. The richness of ideas in this book reflects the diversity and expertise of the contributors. There is, however, a single thread that runs through it—that the answer lies in communication and collaboration and that we have a shared global responsibility to harness technology, intellectual resources, and financial capital to prevent recurrence of these events and mitigate their impact."

—**K. V. Kamath**, Chairman, ICICI Bank, and former President, Confederation of Indian Industry

"In this volume, Howard Kunreuther and Michael Useem have gathered together a cast of brilliant thinkers to impart lifesaving knowledge for successfully navigating the hazards of the twenty-first century. This deeply optimistic book not only equips the reader with the intellectual tools for confronting our worst fears head-on, but teaches us that we can become a better, more compassionate, and prosperous global society in the process."

—**Stephen E. Flynn**, Senior Fellow for Counterterrorism and National Security Studies, Council on Foreign Relations

This page intentionally left blank

Learning from Catastrophes

This page intentionally left blank

Learning from Catastrophes

Strategies for Reaction and Response

Edited by Howard Kunreuther and Michael Useem

Alan Berger
Case Brown
Séan Cleary
Arnold Howitt
Bridget M. Hutter
Michel Jarraud
Carolyn Kousky
Herman "Dutch" Leonard
Geoff Love
Thomas Lovejoy
Michele McNabb
Erwann Michel-Kerjan
Suzanne Nora Johnson
Kristine Pearson
Harvey Rubin
Jiah-Shin Teh
Detlof von Winterfeldt
Lan Xue
Richard Zeckhauser
Kaibin Zhong

In Collaboration with
the World Economic Forum
Global Agenda Council on
the Mitigation of Natural Disasters

Vice President, Publisher: Tim Moore
Associate Publisher and Director of Marketing: Amy Neidlinger
Editor: Steve Kobrin
Executive Editor: Jeanne Glasser
Editorial Assistant: Myesha Graham
Operations Manager: Gina Kanouse
Senior Marketing Manager: Julie Phifer
Publicity Manager: Laura Czaja
Assistant Marketing Manager: Megan Colvin
Cover Designer: Chuti Prasertsith
Managing Editor: Kristy Hart
Project Editor: Jovana San Nicolas-Shirley
Copy Editor: Keith Cline
Proofreader: Apostrophe Editing Services
Indexer: Joy Dean Lee
Compositor: Jake McFarland
Manufacturing Buyer: Dan Uhrig

Publishing as Prentice Hall
Upper Saddle River, New Jersey 07458

Printed in the United States of America

Second Printing September 2010

ISBN-10: 0-13-704485-2
ISBN-13: 978-0-13-704485-6

Pearson Education LTD.
Pearson Education Australia PTY, Limited.
Pearson Education Singapore, Pte. Ltd.
Pearson Education North Asia, Ltd.
Pearson Education Canada, Ltd.
Pearson Educación de Mexico, S.A. de C.V.
Pearson Education—Japan
Pearson Education Malaysia, Pte. Ltd.

Library of Congress Cataloging-in-Publication Data

Kunreuther, Howard.

Learning from catastrophes : strategies for reaction and response / Howard Kunreuther, Michael Useem.

p. cm.

Includes bibliographical references and index.

ISBN-13: 978-0-13-704485-6 (hardcover : alk. paper)

ISBN-10: 0-13-704485-2

1. Risk management. 2. Emergency management. I. Useem, Michael. II. Title.

HD61.K86 2010

363.34—dc22

2009032585

Contents

Part II: Linking Risk Assessment, Risk Perception, and Risk Management

Part III: Applications to Catastrophic Risks

Foreword

In late autumn 2008, more than 700 experts gathered in Dubai for the inaugural meeting of the World Economic Forum's Global Agenda Councils. Initiated less than 12 months earlier, the idea behind the Councils was to bring together some of the best minds from business, academia, and government to focus on the most pressing questions of our times. From that gathering emerged fresh thinking, sometimes provocative, sometimes pragmatic, as to how to mobilize the combined forces of the public, private, and nongovernmental sectors around issues ranging from global economic imbalances to ecosystems and biodiversity. One of these councils, the Council on the Mitigation of Natural Disasters, under the chairmanship of Howard Kunreuther and Michael Useem, left Dubai with an even stronger vision of the need for a holistic approach to this issue, a vision they explore in this book.

The initial focus of the council members was on natural catastrophes, which wreak havoc on lives, communities, and economies. These events occur across countries, climates, and economic sectors, and only mitigating strategies, preparedness, and response readiness can make a difference. What emerged from the council's thinking was how much the principles and operational elements relevant for natural catastrophe mitigation and management can be applied to other incident-driven risks. In their discussions with experts and practitioners from fields as diverse as terrorism prevention, pandemic preparedness, and technical or even nuclear accident avoidance, the council's principles were unanimously deemed applicable.

Thus, the focus of *Learning from Catastrophes* is on improving our ability to identify and manage events that are perceived to be highly unlikely, but which, if they do occur, can have catastrophic impact at both the national and global levels. Left to our own devices, we tend to underappreciate such low-probability, high-consequence events. Our minds often turn them into "no likelihood"—although sometimes into the opposite and equally pernicious prescription of

"near certainty." As a result, those who are responsible for leading major institutions have a special and specific calling to recognize and guard against these human shortcomings.

The empirical evidence presented in this book points to the value of building an effective forecasting capacity and persuasively communicating information on high-consequence risks to everybody potentially affected. The authors also recommend drawing upon economic and other incentives to encourage individuals, firms, and public agencies to work together in undertaking protective measures for reducing losses from disasters and in building a culture of resilience and sustainability.

To avoid and mitigate both natural and unnatural calamities in the future, you will want to incorporate this book's directives into your strategic and operational planning processes and leadership programs. Leaders from business and the public and nonprofit leaders could do a lot to protect their organizations and communities by putting the principles highlighted in *Learning from Catastrophes* into practice. This book provides a useful set of principles for guiding decision making and leadership so essential for averting and overcoming those future risks that are sure to threaten yet again our global prosperity.

—Klaus Schwab
Founder and Executive Chairman
World Economic Forum

Preface

According to the 2008 *World Disasters Report*, natural calamities in 2007 affected more than 200 million people. Their direct cost in 2007 totaled more than $60 billion; the financial impact of the Sichuan earthquake in 2008 alone has been estimated to exceed $70 billion. The cost of the 2008–09 global financial crisis reached hundreds of billions of dollars in many countries. A widespread outbreak of swine flu could wreak havoc on a comparable scale.

This book offers critical lessons for those who are most responsible for avoiding the worst, whether natural calamities or unnatural catastrophes ranging from financial crises to terrorist attacks.

All are low-probability but high-consequence events. By examining what worked and what did not in prior disasters, we can be better equipped to prevent and mitigate future disasters. One cannot fully learn to effectively manage extreme risk without looking to the lessons from both natural and unnatural disasters.

If New Orleans had well-maintained levees and evacuation plans, land-use management programs, and well-enforced building codes, and if insurers could charge premiums that reflected risk and could reward with price reductions those who adopted loss-reduction measures, the devastation from Hurricane Katrina would have been far less. But in fact, short-term savings trumped long-term safeguards.

If federal regulators had required transparency in credit-default swaps, if bank CEOs had insisted that quarterly windfalls be balanced against future earnings, and if loan officers had to live with the subprime risks they were foisting on others, we would be talking about market correction, not credit calamity. But in fact, private greed trumped collective good.

If we know that we will predictably underpredict—and thus underanticipate the next catastrophe—we can do something about it in advance. Now is the time for all of us to appreciate the importance of recognizing risks and preparing for them before they result in

another Katrina washout or credit tsunami. Above all, leaders need to remember that *a low risk is not no risk*.

Drawing on the knowledge of a select set of leading experts on natural disasters and other extreme events, this book takes stock of what we know about decision making, risk reduction, and strategies for encouraging preventive actions. *Learning from Catastrophes* provides a framework and a core set of principles for designing strategies for managing risks that have a relatively small chance of occurring—but could create severe consequences if they do.

Learning from Catastrophes is intended for readers with a general or professional interest in understanding behavior and developing more effective strategies for reducing losses from low-probability, high-consequence events. These events include large-scale natural disasters, financial crises, industrial accidents, rogue trading, corporate bankruptcies, pandemics, and terrorist attacks. The book should be of interest to policy makers, risk managers, and business leaders; those directly engaged in preparation for, mitigation of, and recovery from catastrophes; and decision makers in organizations ranging from insurance firms and financial companies to emergency preparedness agencies and other governmental organizations concerned with the risks from disasters.

We owe a great debt of gratitude to World Economic Forum Executive Chairman Klaus Schwab for his leadership in creating and supporting the Global Agenda Councils. We are extremely grateful as well for the assistance of Matthias Caton, Martina Gmür, Stéphane Oertel, Fiona Paua, and Sheana Tambourgi of the World Economic Forum in supporting our Global Agenda Council on the Mitigation of Natural Disasters. It was through a number of wide-ranging discussions with members of this council and a meeting of all the councils in Dubai in November 2008 that this book took shape.

We also want to thank Carol Heller of the Wharton Risk Management and Decision Processes Center, for her careful and comprehensive guidance of this project from its inception to the completion of this book. Jeanne Glasser, Russ Hall, Steven Kobrin, Timothy C. Moore, Teresa Regan, and Jovana San Nicolas-Shirley of Wharton School Publishing provided unstinting support in bringing this book to completion so that it would be available in time for the Annual

Meeting of the World Economic Forum in Davos, Switzerland, in 2010. We hope, in time, that lessons from this book will help to reduce the potential impact of future catastrophes.

—Howard Kunreuther and Michael Useem
The Wharton School, University of Pennsylvania
October 2009

This page intentionally left blank

1

Principles and Challenges for Reducing Risks from Disasters

Howard Kunreuther and Michael Useem
The Wharton School, University of Pennsylvania

Overview

This chapter provides a framework and a set of guiding principles for designing alternative strategies for reducing losses from low-probability, high-consequence events. This framework highlights the importance of expert assessment of the risk, as well as the importance of understanding how the public perceives the risk. These two elements should serve as a basis for developing and evaluating strategies to manage risk. Seven principles provide guidance to leaders in designing measures that will reduce losses in advance of a disaster and in developing efficient and equitable means to aid the recovery process following a catastrophe.

The past decade has been particularly devastating on the natural disaster front, especially in developing countries. The tragic tsunami of December 2004 killed more than 280,000 people in Southeast Asia. Cyclone Nargis in May 2008 killed an estimated 140,000 in Myanmar. A 7.9-Richter-scale earthquake in the same month killed nearly 70,000 and left some 5 million homeless in China. Widespread flooding in Mozambique following a tropical storm in February and March 2000 displaced more than a million residents.

Even in a developed country like the United States, which has extensive experience with natural catastrophes and ample resources to prepare for them, the 2004 and 2005 hurricane seasons proved devastating. Hurricane Katrina, which hit Louisiana and Mississippi at the end of August 2005, killed 1,300 people and forced 1.5 million to evacuate—a record for the country. Economic damages were estimated at more than $150 billion.

The world experienced comparably catastrophic shocks in 2008. The subprime mortgage crisis of mid-2008 overwhelmed dozens of financial companies in the United States, from Fannie Mae and Freddie Mac to Lehman Brothers and AIG. The stock market crash in the autumn destroyed more than a trillion dollars in investor wealth worldwide. The great credit squeeze directly impacted Main Street in developed countries and "No Street" in emerging economies, leading to worldwide recession in 2009.

This book provides experience-based and research-informed insights into how individuals engaged in disaster mitigation can better manage the risk associated with both natural and unnatural calamities. Here we provide a framework that highlights the importance of linking risk assessment and risk perception in designing strategies for managing risks in our increasingly interconnected world. The framework also outlines a set of guiding principles for the role that leaders can take to mitigate those risks and effectively respond when the possibility of an extreme event turns into reality.

Framework for Analysis

Systematically investigating the impacts of natural and unnatural disasters requires input from many disciplines. Engineering and the natural sciences provide data on the nature of the risks associated with disasters of different magnitudes and the uncertainties surrounding them (*risk assessment*). Geography, organizational theory, psychology, sociology, and other social sciences provide insights into how individuals, groups, organizations, and nations perceive risks and make decisions (*risk perception and choice*). Economists and policy analysts examine various strategies for reducing future losses and for dealing with recovery problems (*risk management strategies*).

Risk Assessment

The science of estimating the chances of specific extreme events occurring and their potential consequences originates in the field of property insurance and the science of natural hazards. In the 1800s, residential insurers managed their risk by "mapping" the structures that they covered, pinning tacks onto a wall map to display the degree of physical concentration of exposure. Although crude, the technique served insurers well at the time and limited their risk. Widespread usage of such "mapping" ended in the 1960s when it finally became too cumbersome and time-consuming to execute. Now, Geographic Information Systems (GIS) software and other digital products achieve the same with much more extensive data and sophisticated technologies.[1]

Whatever the risk-assessment process method, four basic elements for assessing risk remain the same: hazard, inventory, vulnerability, and loss (see Figure 1.1). The first element focuses on the risk of a *hazard.* For example, an earthquake hazard is characterized by its likely epicenter location and magnitude, along with other significant parameters. A hurricane is distinguished by its projected path and wind speed. One could also describe the hazard associated with terrorism or a pandemic by characterizing the target of a violent attack or the spread rate of a potentially catastrophic disease such as swine flu or severe acute respiratory syndrome (SARS). The hazard can also be usefully characterized as a range of potential scenarios. For example, what is the likelihood that a hurricane of magnitude 3, 4, or 5 on the Saffir-Simpson scale might strike the Miami, Florida, area in 2010?

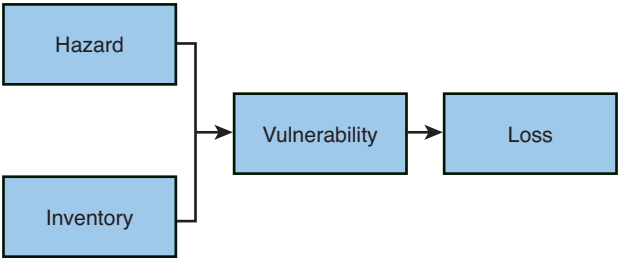


Figure 1.1 Elements of the risk-assessment process model

The risk-assessment process model's second element identifies the *inventory* of properties, humans, and the physical environment at risk. To fully inventory structures, for instance, requires evaluation of their location, physical dimensions, and construction quality. Taken together, the hazard and inventory elements enable calculation of the model's third element, the damage *vulnerability* of the structures or people at risk. And from the measure of vulnerability, the human and property *loss,* the fourth element, can be evaluated.

In working with catastrophes in this model, it is also useful to distinguish between *direct* and *indirect* losses. Direct losses include injuries, fatalities, financial losses, and the cost to repair or replace a structure, restore a service, or rescue a company. Indirect losses include future foregone income, slower growth, and other longer-term consequences of evacuation costs, disrupted schooling, and company bankruptcies.

Scientists and engineers develop reasonably accurate models for assessing risk with this model and specifying the degree of uncertainty in each of the components. In doing so, analysts take special care to minimize the role of subjective assessments and personal biases in building their estimates. But because such factors still sometimes intrude, it is not uncommon for the public to learn from one expert that there is little about which to be concerned related to a given risk, and from another expert that the alarm bells should be sounding.

Not surprisingly, the public responds in disparate ways to the added uncertainty resulting from conflicting expert forecasts. Some may simply decide to ignore the expert judgments. Others may be drawn to the expert prediction most compatible with the individual's own predispositions. Still others may seek out a host of expert opinions and then draw independent assessments of where the preponderance of informed forecasts are pointing.

Consider the uncertainties inherent in the following natural and unnatural disasters:

- What are the chances that Tokyo will experience an earthquake of magnitude 7 or greater next year, and what will be the resulting property damage, human loss, and interruption of commerce in Japan, East Asia, and beyond?

- What is the prospect of a major terrorist attack in Europe, and what would be the resulting human casualties and economic impacts?
- What is the probability of an African pandemic in the next five years, what type of disease is most likely to spread, where will it start, and how soon will it reach other continents?
- What is the probability that 5 of the 20 largest financial institutions worldwide will fail within the next 24 months and either go bankrupt, as did Lehman Brothers, or enter government receivership, as in the case of the Royal Bank of Scotland?
- What is the chance that the top ten insurance companies and commercial banks will have their credit rating dropped four tiers—say from AAA (almost no credit risk) to A1 or A+ (safe unless unforeseen events arise)—in the coming year?

When expert analysts attempt to answer these questions, they usually ask for more precise information to define the event for their model. Take the question related to the chances of an earthquake of magnitude 7 or greater in Tokyo next year. Experts will want to know how to define Tokyo (the city proper or the entire metropolitan region), whether *next year* means the calendar or fiscal year, and what should be included among the indirect losses. Because experts often take variant responses to these kinds of questions into account, divergent forecasts for even relatively specific events can leave people and their leaders unclear whether and how to prepare and respond.

For many years, the focus of hazard-loss estimation for natural disasters had been largely confined to property damage and loss of life. And estimations were generally limited to the immediate period of the disaster, just hours or days after the earth shook or floodwaters peaked. Now, risk-assessment models are incorporating longer time periods extending to weeks and even months, and to more diverse measures, such as disrupted commercial flows or post-traumatic stress disorders. As experts have expanded the time periods and range of losses in their models, risk assessment has become much more complex and forecasts are likely to be fraught with uncertainty. That, in turn, has added to public and leadership hesitation on how best to prepare for and react to disasters.

Risk Perception and Choice

Whereas risk assessment focuses on objective losses such as financial costs, *risk perception* is concerned with the psychological and emotional factors associated with risk. Research has demonstrated that the perception of risk has an enormous impact on behavior, regardless of the objective conditions.

In a set of path-breaking studies begun in the 1970s, decision scientists and psychologists such as University of Oregon's Paul Slovic, Carnegie Mellon University's Baruch Fischhoff, and others began studying people's concerns about various types of risks. They found that people viewed hazards with which they had little personal knowledge and experience as highly risky, and they especially dreaded their possibility. In the case of unfamiliar technologies with catastrophic potential such as nuclear power, people perceived the risks as much higher than did the experts.[2]

Research also found that people often perceive the world of low-probability and high-consequence events quite differently from experts, and that this impacts on their decision-making process and choice behavior. For years, however, this disparity was simply ignored by expert analysts, who made little effort to communicate the inventory, hazards, vulnerability, and losses from risks in ways that the public could accept and act upon. Sometimes, important underlying assumptions were not made explicit; other times, complex technical issues were not explained well; and often, little effort was made to help the public appreciate why experts could disagree with one another. Rarely were public perceptions even considered.

In recent years, however, the scientific and engineering communities have devoted increased attention to the psychological factors that impact on how individuals make decisions with respect to risks from natural and technological hazards. Rather than simply urging policy makers and organizational leaders to take actions on the basis of their traditional risk-assessment models, experts are increasingly incorporating salient human emotions such as fear and anxiety into the models.

Researchers have discovered that people are generally not well prepared to interpret low probabilities when reaching decisions about unlikely events. In fact, evidence suggests that people may not

even want data on the likelihood of a disastrous event when the information is available to them. One study found, for instance, that when faced with several hypothetical managerial decisions that are risky, individuals rarely ask for data on the probabilities of the alternative outcomes. When one group was provided limited information about the choices they were facing and given an opportunity to find out more about their risks, fewer than one in four requested information on the probabilities, and none sought precise likelihood data. When another group was presented with precise probability data, fewer than one in five drew upon the concept of probability when making their choices between alternative courses of action.[3]

If people do not think probabilistically, how then do they make their choices in the face of risk? Extensive research on decision making now confirms that individuals' risk perceptions are affected by judgmental biases.[4] One of the important forms of bias in the case of extreme events such as large-scale disasters is a tendency for people to estimate the risk they face on the basis of their own experience regardless of what the experts may have communicated. If an event is particularly recent or impactful, people tend to ignore information on the likelihood of a recurrence of the event and focus their attention on the consequences should another similar disaster occur.[5] Following the terrorist attacks with hijacked aircraft on September 11, 2001, many of those living in the United States refused to fly because they believed that the chances of ending up on a hijacked aircraft were dangerously high—even though the actual likelihood was extremely low given the tightened security measures introduced in the wake of 9/11.

More generally, researchers have found that people tend to assess low-probability, high-consequence events by focusing on one end of the likelihood spectrum or the other: For some people, such events will surely happen, for others they will surely not happen, and few fall in between. For very unlikely events, however, people crowd toward the "will not happen" end of the spectrum. It is for this reason that there is a general lack of public interest in voluntarily purchasing insurance against natural disasters and in investing in loss-protection measures. People underestimate both the probability of a disaster and the accompanying losses, and they are often myopic when it comes to proper planning for disasters. If a disaster does occur,

people then tend to overinvest in seeking to prevent a recurrence. Protective measures are thus undertaken when it is too late. A study of homeowners in California, for example, showed that most purchased earthquake insurance only after personally experiencing an earthquake. When asked about the likelihood of another quake occurring in their area, they correctly responded that it was lower than prior to the disaster because the stress on the fault had been reduced. And yet that is when they finally decided to acquire the insurance.[6]

Risk-Management Strategies

In developing effective risk-management strategies for reducing losses from natural and unnatural disasters, leaders of public agencies and private and nonprofit organizations will want to appreciate the findings of risk-assessment studies and the factors that influence risk perception and choice. Drawing on that research, we propose six areas for improving risk management:

1. ***Risk forecasting.*** The broadening of disaster losses to include longer-term impacts and indirect costs has made forecasting more complex. Improvement in the precision of these forecasts is critical for both averting disasters and minimizing their impacts. For example, more detailed weather forecasts of the path and severity of a tropical storm can be key to wise evacuation decisions and avoiding unnecessary flight. So, too, would be better data on the systemic risks that little regulated but highly leveraged financial products can invisibly create.
2. ***Communicating risk information.*** Because people generally dismiss low-probability events by assuming that they will not personally experience such events, expanding the time frame over which the likelihood of an extreme event is presented can garner more attention. If a company is considering flood-protection insurance for the 25-year life of a production facility, for example, managers are more likely to take the risk seriously if a 1-in-100-year flood is presented as having a greater than 1-in-5 chance of occurring during a 25-year period rather than a 1-in-100 chance during the coming year.[7]
3. ***Economic incentives.*** Both positive and negative economic incentives encourage individuals to take protective measures.

But here again, the way people process information on the costs and benefits of reducing the risk can play an important role in their decision on whether to adopt the measures.

What would be the effectiveness, of say, a policy of reducing homeowners' insurance premiums for homeowners who undertake loss-reduction measures along the Mississippi River, or a policy of incentivizing villagers in Bangladesh to avoid migrating into flood-prone areas? Given that people think only about the potential benefits of such measures over the next year or two, not the next decade or two, they may not view these measures as financially attractive if there is a significant up-front cost. Had they considered a longer time period when evaluating the protective measure, the costs may well have been viewed as worthwhile.

Fines coupled with specific regulations or building standards can also be used to encourage protective measures, but they, too, must be coupled with measures that ensure a high likelihood that negligent individuals will be penalized. If people perceive the probability of detection to be low or the cost of noncompliance as modest, they may conclude that it does not pay to take protective action.

4. ***Private-public partnerships.*** Because the public, private, and nonprofit sectors share in the costs and benefits of preparing for disasters, furthering collaboration among them ahead of time can be vital for building effective leadership and strategies for facing disasters. Public-private partnerships should thus be created before they are needed.

   Insurance premium reductions should be given to those who invest in risk-reducing measures to reflect the lower losses from a future disaster. Building codes may be desirable when property owners would otherwise not adopt cost-effective mitigation measures because they either misperceive the benefits from them or underestimate the probability of a disaster occurring. This might have been a factor in the widespread loss of life in the Pakistan earthquake, magnitude 7.6, in October 2005, which killed more than 70,000 inhabitants, many buried under poorly constructed schools and homes. So, too, with

investment codes: Had there been stronger regulation on derivative products, such as insurance on subprime mortgage securities, investment bankers would have been less likely to contribute to the systemic risks that rocked the world's economy in 2008.

5. ***Reinsurance and other financial instruments.*** The shortage of reinsurance—insurance for insurance companies that allows them to offer greater protection to policyholders than the assets of the insurers would ordinarily permit—following Hurricane Andrew's damage to Florida in 1992 and the Northridge, California, earthquake in 1994, led U.S. financial institutions to market new instruments for providing protection against mega disasters. Known as catastrophe bonds, these were offered at high interest rates to overcome investors' qualms about the likelihood of losing their principal should a major disaster occur. The market for such bonds grew rapidly in the 2000s, with $2.7 billion in new and renewed catastrophe bond issues in 2008.[8]

   In anticipating exceptionally massive disasters, it may be necessary for the government to provide insurance protection to pay for losses that the private sector is not willing to cover. Florida established the Florida Hurricane Catastrophe Fund following Hurricane Andrew in 1992, for instance, when a number of insurers reported that they could no longer include windstorm damage as part of their standard homeowner coverage. After the Northridge earthquake in 1994, insurers backed off from earthquake coverage, and the state formed the California Earthquake Authority to provide homeowners with earthquake coverage.

   In providing coverage against large-scale catastrophes, it is important that premiums closely reflect risk. Equity and affordability considerations may justify some type of subsidy for those deserving special treatment, such as low-income residents. This subsidy should *not* be in the form of artificially low premiums, but should preferably take the form of a grant from the public sector. For example, if a risk-based flood insurance premium of $2,000 is considered to be unaffordable to a household in a high hazard area, the family could be provided an insurance voucher to buy a policy in much the way that food

stamps are provided to those in need of household staples. If the family reduces its risks by investing in a mitigation measure such as elevating its house, it receives a premium discount.

6. ***Resiliency and sustainability.*** The resilience of a community after a disaster and its sustainability over the long run have important ramifications for estimating the extent of hazard damage and developing risk management policies. Resilience refers to the ability of a business, household, or community to cushion potential losses through inherent or explicit adaptive behavior in the aftermath of a disaster and through a learning process in anticipation of a future one. Businesses may have alternative power generators in place, households may ration their water supply, and communities may open shelters for those forced to evacuate their homes.[9]

   Resilience also includes the ability to use price signals, such as premium discounts for investing in mitigation measures, to encourage appropriate actions before and after a disaster. And it entails the ability of community, company, and other leaders to remain focused on recovery even as they may be at risk or personally suffering in the immediate aftermath of a disaster. In the wake of Hurricane Katrina, for example, the president and senior administrators of Tulane University in New Orleans were marooned on campus for four days without food, water, power, or regular contact with the outside world. Despite their severe personal circumstances, they plunged into the arduous work of staff rescue and university restoration. After "being stranded for four days," recalled the president, Scott S. Cowen, "I realized that I could either focus on the darkness, or I could try to see beyond it and focus on the light. I chose the latter." In reflecting on the experience and its personal hardships, he said, it "has taught us as an institution to stay focused on our mission and goals even in the face of financial and physical crisis. It has taught us the responsibility that comes with our role as the largest employer in our home city—a responsibility to help rebuild our city and heal its people."[10]

   Advanced economies are becoming increasingly interlinked and dependent on sophisticated, vulnerable systems—especially

infrastructural services such as highways, electric supply, and the Internet—for which substitution is difficult and thus resilience more critical. When the west coast of Japan was hit by a minor earthquake in July 2007, a supplier of auto piston rings was forced to close, and because Japanese auto making was built on a just-in-time inventory system, the supplier's closing forced Toyota and Honda to suspend production.[11] Researchers have a role to play here in identifying ways to improve resilience in a more interdependent and interconnected world, such as the establishment of information clearinghouses for suppliers without customers and for customers without suppliers.

Sustainability refers to the long-run viability and self-sufficiency of the community in the face of hazard threats. The more general definition of the term emanates from economic development and stipulates that decisions taken today should not diminish productive capacity—broadly defined to include natural resources and the environment of a community—in the future. In the case of natural hazards, sustainability implies that land-use decisions made today—such as forest management or strip mining—should not place the community in greater jeopardy in the future or make it more dependent on external assistance to survive. Sustainability emphasizes the importance of integrating mitigation measures into overall economic development policy and eliminating practices that increase a community's exposure to hazards.[12]

Many developing countries are especially vulnerable to disasters because of low-quality structures, poor land use, inadequate emergency response, environmental degradation, and limited funds. Climate change may especially increase the likelihood of disasters in these areas, such as flooding in low-lying Bangladesh. Developing countries often lack the infrastructure and institutions that developed countries take for granted in formulating risk management strategies. And in areas where poverty is extreme, the indirect effects of disaster may include a surge in endemic disease, widespread starvation, and human-rights violations. In the wake of the Mozambique flooding in

2000, for instance, families irretrievably lost birth certificates, marriage documents, and land titles because few personal records had been backed up or computerized.

Guiding Principles

In characterizing and developing strategies and leadership for perceiving, assessing, and managing risks associated with extreme events, it is useful to focus on a set of guiding principles. These principles apply not only to leadership in averting and responding to natural catastrophes but also to leadership facing other extreme events, whether terrorist attacks, financial crises, or governance failures. We briefly highlight these principles here:

Principle 1: Appreciate the importance of estimating risks and characterizing uncertainties surrounding such estimates. For developing the strategies and leadership for reducing and managing a specific risk, it is essential to have reliable estimates of the likelihood of the event and its consequences.

Consider a business facing a decision on whether to invest $100,000 to make its property more fire resistant. An informed decision on whether to incur this cost depends on having accurate estimates of fire frequencies and likely losses. Its executives will be more likely to make this investment if they learn that the chances of a fire next year are 1-in-100 rather than 1-in-1,000, and if the likely property damage and business interruption would total $5 million rather than $500,000. The less uncertainty surrounding these estimates, the more confident the executives will be regarding their decision as to whether to undertake these measures.

Principle 2: Recognize the interdependencies associated with risks and the dynamic uncertainties associated with the interdependencies. Many factors contribute to extreme risk, and they are connected through ever-changing linkages. For disaster strategies and leadership, understanding the evolving interconnectedness can be very challenging because the linkages are often hidden or indistinct.

On December 21, 1988, Pan American flight 103 exploded near Lockerbie, Scotland. In Malta, terrorists had checked a bag containing a bomb onto Malta Airlines, which maintained minimal security procedures. Airport personnel transferred the bag at Frankfurt's airport to a Pan Am feeder line, and personnel at London's Heathrow airport in turn loaded the bag onto Pan Am 103. The bomb was designed to explode above 28,000 feet, a flight altitude normally attained over the Atlantic Ocean, though not over Europe. Terrorists had deliberately exploited widely varying security procedures in place across the airports and airlines. Measures to prevent an aircraft disaster were only as strong as the weakest link in the system.[13]

Relationships among these interdependencies evolve over time, and measures to thwart their catastrophic impact on others may become inadequate later on. Airport authorities around the world improved security for bag transfers in the wake of the loss of Pan Am 103, but terrorists did find other ways of working around airline security measures, as the world learned on September 11, 2001. And even though government regulators in a host of countries tightened their rules in the wake of the financial crisis of 2008, new forms of systemic risk may nonetheless insidiously reappear beyond the reach of the new regulatory provisions. Evolving uncertainties point to the need for continuous vigilance and updating of risk-projection measures.

Principle 3: Understand people's behavioral biases when developing risk management strategies. Among the well-documented biases are misperceptions of the likelihood of catastrophic events, a focus on short-term concerns and returns, and a falsely optimistic confidence that a calamity will simply not happen on my watch—the NIMTOF (not in my term of office) phenomenon. Appreciating such biases is an important step for creating remedies and building cultures that can reduce or eliminate them.

Many individuals, for instance, will not invest in protective measures for a property unless they believe they can recoup their investment in two or three years, even though the measures will be of benefit as long as the property stands. People often purchase insurance following a disaster, not before, and

then tend to cancel their policies after a few years if they have not collected on their policy. Rarely do people concur with the principle that "the best return on an insurance policy is no return at all" (that is, no loss whatsoever).

Principle 4: Recognize the long-term impact of disasters on a region's or nation's politics, culture, and society. Catastrophes often create enduring change in areas far from the epicenter in ways that public and private leaders need to appreciate in taking preventive measures prior to a disaster and use to their advantage in developing strategies following a catastrophic event. The massive earthquake of 2008 in southeast China, for example, stimulated private charitable giving, attracted international support, and revised how Chinese officials view substandard schools, homes, and office buildings.

Principle 5: Recognize transboundary risks by developing strategies that are global in nature. Most disasters do not recognize political borders. The terrible Southeast Asia tsunami of 2004 killed residents of 11 countries. The Pakistan earthquake of 2008 left more than a thousand dead in neighboring areas of India. The failure of Lehman Brothers and the near collapse of other American banks in 2008 had catastrophic consequences for banks in dozens of other countries, from Britain and Iceland to China and Mongolia.

One strategy to address and minimize risks is to have countries sign a treaty to reduce certain environmental risks, such as global warming or atmospheric pollution. There are potential benefits to all societies if enough countries take action, but there is also a net cost to any single country for adopting the treaty, as the United States argued at one point in refusing to sign the Kyoto treaty. What incentive is there for any one nation to adopt a treaty if it knows that a number of other countries will not join? How can policy makers and national leaders convince countries with leverage to sign the treaty to induce others to follow suit?

Principle 6: Overcome inequalities with respect to the distribution and effects of catastrophes. Whether natural or human caused, disasters often bring disproportionate hardships to those already at risk from low income or poor health.

Public policies and private actions can help prepare a readiness plan on the part of those with more financial resources to support those in distress with fewer resources.

Consider the flow of domestic and international assistance to China's southeast Sichuan Province in the aftermath of its great earthquake in 2008, with more than 69,000 dead (including 19,000 school-children), 274,000 injured, and 4.8 million homeless. The Chinese government invested more than $100 billion in the region's restoration, dispatched more than 50,000 soldiers and police to the area, and accepted humanitarian support from abroad, including South Korea, Japan, Russia, the United States, and even Taiwan. The Red Cross Society of China and many private organizations and individuals provided rescue and restoration equipment and funds (Yao Ming, of the Houston Rockets, donated more than $300,000.) Together, they helped thousands of families of modest means recover from the disaster. The experience points to the value of having government agencies and organizations such as the Red Cross prepared to provide assistance when it is most needed.

Principle 7: Build leadership for averting and responding to disasters before it is needed. The best time to create a readiness to face and overcome a low-probability, high-consequence disaster is before the event occurs. Leadership development is a time-consuming and labor-intensive process, and investing in it now can be seen as a preemptive and cost-effective measure to ensure that the six principles above are turned into active practice.

Had American financial institutions and regulators taken greater care to understand the growth of systemic risk in the U.S. housing and derivatives market, and had they created a greater readiness among their leaders to anticipate sharp downturns in those markets, the deep recession that the systemic risk caused in 2008 might not have reached such a depth. The failures of a host of banks, insurers, and manufacturers might have been averted, and the jobs of millions in the United States and abroad might have been saved.

The risk-management strategies and guiding principles we have identified here are intended to furnish a foundation for public and private policies and practices for preventing and reducing losses from low-probability, high-consequence events. The chapters that follow expand and draw upon these strategies and principles for catastrophic risks ranging from natural disasters to financial crises, and they provide guidance to leaders in all institutions for designing and developing measures to reduce losses and create a sustainable recovery in the wake of a catastrophe.

INDEX

B

C

D

E

F

G

H

I

J–K

L

M

N

O–P

Q–R

S

T

U–V

W–Z