

*Creating businesses that adapt and flourish  
in a changing world*

# Resilient *by* Design



JOSEPH FIKSEL  
*foreword by David Orr*

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Creating Businesses That Adapt and Flourish  
in a Changing World

Joseph Fiksel



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# Contents

*Foreword by David Orr* ix

*Preface* xi

## **Part 1: Resilience as Competitive Strategy** 1

Chapter One Embracing Change 3

Chapter Two From Risk to Resilience 19

Chapter Three Systems Thinking 35

Chapter Four The Resilient Enterprise 51

## **Part 2: Practicing Enterprise Resilience** 69

Chapter Five Generating Business Value 71

Chapter Six Resilience in Supply Chain Management 89

Chapter Seven Resilience in Environmental Management 113

Chapter Eight Organizational Resilience 129

Chapter Nine Tools for Managing Resilience 149

## **Part 3: Designing Resilient Systems** 171

Chapter Ten Design for Resilience 173

Chapter Eleven Connecting with Broader Systems 191

Chapter Twelve Looking Ahead: From Resilience to  
Sustainability 209

*Notes* 223

*Index* 233

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# Foreword

*Resilient by Design* by Joseph Fiksel is an important book on the most important subject of our time. For companies and organizations of all kinds that are navigating the rapids of accelerating technological, social, and economic change, mastery of the art and science of resilience will be the difference between thriving, surviving, and extinction. The word *resilience* implies a combination of flexibility, adaptability, and foresight; it is a close kin to the word *sustainability* for the simple reason that no organization could long survive without the capacity to anticipate and accommodate change.

As Fiksel explains, the core principles of resilience are straightforward but become more difficult to manifest as enterprises age and become victims of prior success. These principles are, I think, virtually the same for other kinds of organizations, including institutions of higher education and governments. In all cases, resilience implies a change in outlook, perspective, and thinking by which enterprises learn to thrive in turbulence, thus becoming what Nassim Nicholas Taleb calls “antifragile.” Further, in all organizations, resilience requires learning to see the enterprise and the world beyond as patterns and systems that are often unpredictable. Accordingly, resilient organizations leave wide margins of safety to accommodate surprise and the unknown. They do not bet the house on a single roll of the dice.

Fiksel is a superb guide to the art and science required to navigate the rapids ahead, but even in the commercial world of “creative destruction,” some things must not change. Legitimate enterprises of all kinds must deliver what they promise at a fair price, a concept otherwise called integrity. They must compete, certainly, but they must also learn to cooperate so as to protect the health and stability of the system of which they are a part. They must improve quality and service while lowering ecological and social costs. From these steps one can discern the outlines of a wider dialogue about resilience.

Do the products and services of more resilient enterprises and organizations contribute to the resilience of the broader economy? If they do not, should such products be made or such services rendered regardless of market demand? If they should not be made or rendered, how does the enterprise or organization grow into a better and more constructive line of work? What does resilience possibly mean on our progressively hotter and more threadbare Earth? What does resilience mean on a planet losing the biological diversity and ecological stability essential to resilience itself? What is the future of resilient enterprises on this ecologically brittle Earth?

The ultimate test of resilient enterprise is not whether it is flexible and creative enough to survive and beat the competition for a while longer as things fall apart around it. The truest test of resilience is whether the transition fosters wider circles of resilience that cascade into a world that becomes more just, decent, and durable, which is to say life-centered. That would be a world that preserves things of enduring value, including children's lives, wildness, and beauty. In other words, the transition to resilience, enterprise by enterprise and organization by organization, is not an end in itself but rather a means to preserve and enhance the enterprise of life itself.

David Orr  
Counselor to the President  
Oberlin College

# Preface

As a firm believer in environmental and social responsibility, I spent most of my management consulting career advising companies on how they could adopt sustainability strategies, technologies, and business processes. I built the sustainability practice at Battelle, a prominent technology firm, and became vice president for life cycle management. By 2000, though, I had become increasingly impatient over the slow pace of change. While industry leaders were embracing sustainability goals and reporting their accomplishments, it was evident that their fundamental business models had not changed. What's more, global economic growth, especially in developing nations, was outstripping any well-intentioned efforts to slow down our consumption of energy, water, soil, and other natural resources. Even today, despite widespread concerns about manifestations of climate change, efforts to mount a serious response are met with ambivalence and political opposition.

In 2002, a revelation set me down a new path. First, I realized that no company could be expected to compromise its essential mission of creating value for shareholders. As long as the current business model appeared to be working, the sustainability program would remain an appeasement tactic, simply expanding regulatory compliance to include compliance with stakeholder expectations. Initiatives that saved money, such as waste recovery, were acceptable, but there was not much appetite for transformative change. Second, I recognized that most company executives were consumed with the day-to-day burdens of managing a complex enterprise and had little patience for pondering hypothetical scenarios about the future. The primary purpose of the enterprise was to survive crises, adapt to change, and continue to flourish. Then it dawned on me that this was exactly the purpose of living systems, from the tiniest microbes to the mightiest nations. Their driving force is not the hope for sustainability, it is the necessity for resilience.

As I began to investigate this concept, I discovered that resilience had already been observed and studied in many different fields, such as anthropology, psychology, medicine, biology, evolution, ecology, engineering, and management. It appeared, however, that no one had tried to bridge these disciplines and unify knowledge about resilience, that the linkage between resilience and sustainability had never been adequately understood, and—perhaps most surprising—that no one had tried to apply the lessons of resilience in living systems to the challenges of enterprise management. It was a white space waiting to be explored. In 2003, I published a seminal paper, “Designing Resilient, Sustainable Systems,” and launched on a journey of discovery.

Working with my esteemed colleague Bhavik Bakshi, I developed financial support to establish a new research center at The Ohio State University called the Center for Resilience. Our mission was to improve the resilience of industrial systems and the environments in which they operate, with the premise that short-term risk management and long-term sustainability are two ends of the enterprise resilience continuum. Thus began the most creative, productive, and satisfying period of my life. We assembled an advisory board of prominent companies, worked on a variety of innovative grants and contracts, issued a number of influential publications, and joined a community of practice around the world that was beginning to assemble the pieces of the puzzle. About a decade later, resilience seems to be emerging as a new strategic imperative. It took some major technological failures, political upheavals, an economic recession, and several natural disasters, but world leaders are finally understanding that we need to become more resilient at both the national and local levels. Ironically, climate change is now seen as one of the greatest perils that we face. It’s not hypothetical any more.

As companies grapple with the challenges of the hyperconnected twenty-first-century economy, they are beginning to pay attention to the resilience of their critical assets: people, property, resources, and reputation. The risks of conducting business as usual are no longer acceptable, and traditional methods for managing those risks are no longer effective. Perhaps the most daunting challenge is the complexity and interdependence of environmental, social, and economic systems, making it difficult to assess the hidden consequences of innovative technologies and business practices. Companies will need to expand their planning boundaries

to consider the infrastructure, the built environment, the ecosystems, and the social fabric in which they and their business partners operate.

*Resilient by Design* is intended as a guide to executives and managers who are taking on the task of building a more resilient enterprise. The most powerful lever for enhancing resilience is design, in the broadest possible sense. The scope of design must expand from products and processes to the enterprise as a whole, exploring how changing external conditions might influence business success. Our recommended approach to “design for resilience” considers the health and viability of important external systems, including stakeholders, communities, infrastructure, supply chains, and natural resources. Thus, design will become less of a rigid specification exercise and more of a dynamic intervention in ongoing cycles of change. To understand these complexities, businesses will begin to collaborate more closely with government, academia, and non-profit groups. Best of all, this strategy may be turn out to be a practical path toward the elusive long-term goal of sustainability.

I want to acknowledge some of the outstanding individuals who have helped me over the years. David Miller of Island Press was instrumental in shaping and perfecting this book. My valued colleagues and key supporters at Ohio State have included Bud Baeslack, Bhavik Bakshi, Kate Bartter, Keely Croxton, Aparna Dial, Casey Hoy, Elena Irwin, Richard Moore, Marc Posner, Rajiv Ramnath, Phil Smith, Kathy Sullivan, Dave Williams, and Dave Woods. As an advisor to the US Environmental Protection Agency, I had the privilege of working with Derry Allen, Paul Anastas, Karen Chu, Gary Foley, Herb Fredrickson, Michael Gonzalez, Iris Goodman, Alan Hecht, Lek Kadeli, John Leazer, Montira Pongsiri, Subhas Sikdar, Cindy Sonich-Mullin, Marilyn ten Brink, Barb Walton, and other talented people too numerous to mention. I am thankful to the many others who have helped me on this journey, including Andrea Bassi, Emrah Cimeren, Bob Costanza, Peter Evans, Peter Fox-Penner, Tom Hellman, Mike Long, Andy Mangan, Oleg Mishchenko, David Orr, Tim Pettit, Jed Shilling, Kieran Sikdar, Jerry Tinianow, the late Warren Wolf, and Darrell Zavitz. Most importantly, I thank my wife, Diane, for her sage advice and constant encouragement, making me a happier and more resilient person.

Resilience teaches us that we can't achieve a utopian steady state because it is not realistic and perhaps not even desirable. We live in

a world of perpetual change, including cycles of growth and collapse. Some companies will prosper, and others will decline. There will be catastrophes and reversals of fortunes. There will be renewal of old industries and growth of new industries based on new ideas. In this increasingly dynamic world, we need to ensure that the things we care about deeply are resilient and able to survive the inevitable turbulence.

We may seem complacent, but we can be ingenious and powerful when our comfortable existence is threatened. Now is the time for resilience.

**PART 1**

Resilience as  
Competitive Strategy

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## From Risk to Resilience

*Our world is dominated by the extreme, the unknown, and the very improbable . . . while we spend our time engaged in small talk, focusing on the known and the repeated.*

*Nassim Nicholas Taleb<sup>1</sup>*

**E**mbracing change means accepting uncertainty about the future. Of course, making business decisions is challenging when the outcomes are uncertain. An entire academic field called management science offers mathematical tools to help companies make all sorts of decisions, from setting inventory targets to making major capital investments. Central to this field is the concept of *risk*, a term that is widely used and often misunderstood.

### Upside Downside

There are two main interpretations of risk, depending on whether you take an operational perspective or a financial perspective. In the world of operations, a risk is viewed as a threat to business continuity, that is, the possibility of an adverse event resulting in loss, damage, or injury. From this perspective, risk is a *downside* to be avoided and ideally eliminated; it is a defect in an otherwise smoothly operating system.

In contrast, the financial world views risk as a fundamental measure of variability. Every business activity or investment of resources involves some downside risk, but we pursue these activities and investments with the hope of gaining an *upside* reward. Typically, the larger the risk, the larger the potential reward. Savvy managers and investors have learned to

discern the important business characteristics that increase the likelihood of success.

Both types of risk can be represented mathematically by a “risk profile,” a curve that gives the likelihood of positive or negative outcomes. These outcomes can be measured in monetary terms (e.g., dollars gained or lost) or in a variety of other ways (e.g., market share gained or lost). Generally, the procedure of describing risks in this way is called risk analysis or risk assessment, and it can entail a lot of effort to gather the necessary information. Without good historical information, it is especially difficult to estimate the probabilities of various outcomes.

Figure 2.1 illustrates a typical risk profile for a hypothetical situation, such as a capital investment.<sup>2</sup> Although there is a high likelihood of a positive return (upside), there is also a considerable chance of a loss. The best case and worst case are at the extreme ends of the curve, but in reality it is difficult to pinpoint a maximum gain or maximum loss. In fact, as shown in figure 2.1, we often underestimate the possibility of rare events that could result in catastrophic losses, as indicated by the “fat tail” of the curve. Statisticians have found that complex, interconnected systems often follow a *power law* pattern; for example, an event of magnitude  $x$  might occur with a likelihood of  $1/x^2$ . In other words,

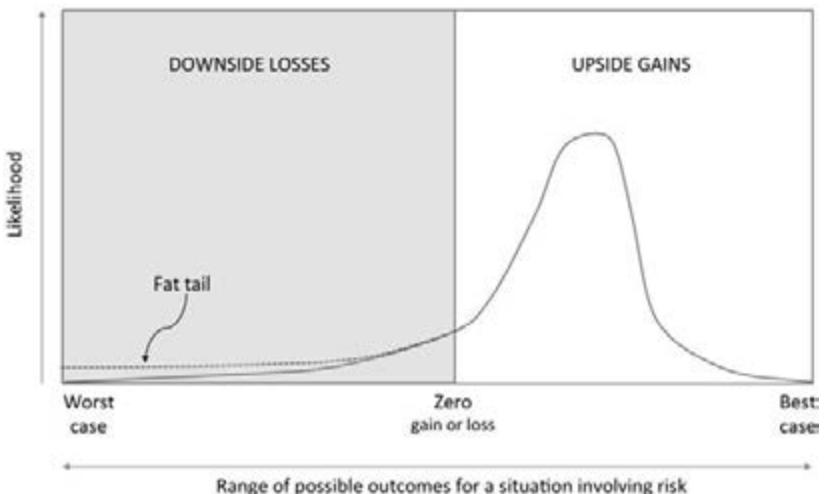


Figure 2.1. Example of a risk profile

extreme events are much more likely to happen than is predicted by the commonly used *normal*, bell-shaped distribution, which assumes independence among system components.<sup>3</sup> The power law explains the apparent frequency of extreme disruptions, such as hurricanes, stock market swings, and traffic jams.

If the future resembles the past, we can often construct risk profiles with a fair degree of confidence based on historical data. For example, in the property and casualty insurance industry, actuarial tables provide a reliable basis for setting premiums, but problems can arise if shifting conditions make the historical observations irrelevant. Moreover, the low-probability ranges, both upside and downside, represent rare outcomes that may never be observed in practice. For these reasons, development of risk profiles usually requires a large amount of estimation and subjective judgment, including the use of modeling and simulation. In many cases, risk assessment becomes a subjective exercise based on the beliefs of experts or decision makers, so pessimistic and optimistic assumptions may differ widely.

Clearly, risk management is a gloomy business if we focus only on downside risks. In this case, it is natural to strive for risk minimization and cling to stability. A more positive approach is to recognize that risk is inherent in competition and growth and thus view every setback as an occasion for learning and adaptation. Interestingly, the Chinese word for “crisis” consists of two characters that signify danger and opportunity (see [figure 2.2](#)). Global companies recognize that they must take calculated risks to grow and prosper in a business environment fraught with uncertainty.



**Figure 2.2.** The Chinese characters for “crisis”

## Enterprise Risk Management

During the 1990s, the upside and downside views of risk were consolidated under a practice known as enterprise risk management (ERM), which has become the prevailing approach in large corporations.<sup>4</sup> ERM provides an integrated strategic process for identifying the portfolio of risks that are faced by various businesses, determining the corporation's "risk appetite" for each line of business, and using risk control strategies, including insurance, to achieve the appropriate level of risk. Most companies appoint a chief risk officer to oversee the ongoing implementation of ERM. Likewise, for the US Environmental Protection Agency (EPA) and other agencies, risk management has become the cornerstone of regulatory decision making.<sup>5</sup>

Corporate attention to risk management was heightened by several highly visible events, such as the mass deaths in Bhopal, India, caused by an inadvertent release of poisonous gas from a Union Carbide plant in 1984. Further motivation was provided by public entities, including the introduction of International Organization for Standardization (ISO) standards, Security and Exchange Commission requirements for management disclosure of "material" risks, and regulations such as Germany's Control and Transparency in Entities Law.<sup>6</sup> Concerns about catastrophic risks have given rise to a practice called "business continuity planning," which incorporates elements from disaster recovery planning and crisis management, including coordination of response to disruptions and maintenance of backup capacity for operational systems.<sup>7</sup>

Figure 2.3 shows the cyclical steps in the enterprise risk management process as well as the limitations of this process. The major steps are as follows:

- **Objective setting:** Management establishes the organization's risk appetite and risk tolerance and sets expectations for growth, profitability, and shareholder returns.
- **Event identification:** The potential threats or vulnerabilities as well as upside opportunities are identified for each line of business, and interdependencies are considered.
- **Risk assessment:** The likelihood and impact magnitude of each identified risk is estimated based on historical data and subjective assumptions, and management determines whether these risks are acceptable.



*Figure 2.3. Limitations of enterprise risk management*

- **Risk response:** Management considers the portfolio of risks in the context of its objectives. For risks that are deemed unacceptably high, measures are taken to reduce or mitigate the risks. Conversely, when the company posture is overly cautious, management may respond by taking on additional risk.
- **Control activities and monitoring:** Management implements controls to ensure that the identified risks are appropriately managed and monitored over time.

These ERM practices can help reduce both the likelihood and the severity of major incidents that can damage a company's reputation or profitability. Of course, these practices require constant vigilance and repeated updating to keep pace with changing conditions. Human error or omission is a frequent problem. After BP's Deepwater Horizon rig failed in 2010, spilling oil into the Gulf of Mexico, federal investigators stated that they "found no evidence that BP performed a formal risk assessment of critical operational decisions made in the days leading up to the blowout."<sup>8</sup> In contrast, companies that emphasize situational awareness and foresight have been able to anticipate and overcome major challenges, as illustrated in later chapters.

### Limitations of Risk Management

The sequential process of ERM appears quite logical and thorough, but it is rooted in a simplistic, "reductionist" worldview. Each risk is identified and addressed independently, and hidden interactions are seldom

recognized. The focus is on discrete events rather than gradual buildup of stresses. This procedural approach can lull the organization into a false sense of complacency that is shattered when an unexpected event occurs, as was arguably the case with the oil spill in the Gulf of Mexico. The complex, dynamic nature of global supply chains requires constant vigilance to sense potential vulnerabilities as well as exceptional agility and flexibility to respond to unexpected shocks.

Figure 2.3 shows several key limitations to the classic risk management paradigm:

- **Risks cannot always be anticipated.** A critical step in any risk management process is risk or hazard identification. Many of the risks that a company faces, however, are unpredictable or unknowable before the fact. Risks may not correspond to discrete events, but may result from cumulative changes that reach a tipping point. In a complex system, “emergent” risks are often triggered by improbable events whose causes are not understood, and their potential consequences are difficult to predict a priori. It would be impractical for companies to identify and investigate all the potential risks and vulnerabilities that may be hidden in their global supply chains.
- **Risks may be hard to quantify.** Even if risks can be identified, the lack of an adequate data set can make it difficult to assess the most significant threats. To assess the probability and magnitude of an identified risk, managers need reliable statistical information. Risk assessments are limited by the quality and credibility of the assumptions upon which they are based, and faulty assumptions or data may lead to misallocation of resources. That is especially a challenge in the case of low-probability, high-consequence events for which there is little empirical knowledge; in fact, managers may underestimate the probabilities or magnitudes of risks that they have never experienced.<sup>9</sup> One of the most difficult elements in risk assessment is the human factor. Human error or deliberate human malfeasance is a frequent cause of disruptions, but these triggering events are not easily modeled. Furthermore, as discussed in below, the presence of nonlinearities, cascading consequences, and interdependence among multiple threats requires a systemic rather than a reductionist approach.

- **Adaptation may be needed to remain competitive.** Risk mitigation and recovery practices, such as business continuity management, are typically aimed at returning to “normal” conditions. Instead, companies should strive to learn from disruptions and adapt their assets and business models to overcome potential weaknesses. Every disruption represents a learning opportunity and should be viewed as a stimulus to drive process improvement based on root-cause analysis and systems thinking. In today’s fast-changing world, a philosophy of “business as usual” may be untenable. Companies that are quick to adapt may identify upside opportunities and seize competitive advantage.

The limitations of risk management have also been recognized in the regulatory environment. According to the National Academy of Sciences, risk-based methods are not adequate to address complex problems such as climate change and loss of biodiversity, and more sophisticated tools are available that go beyond risk management.<sup>10</sup> The concept of a stable equilibrium, with steady growth punctuated by occasional isolated deviations, is no longer realistic.

The established approaches of risk management can be very useful for protecting companies against predictable risks that are familiar and quantifiable, such as fires or power failures. However, they are not adequate for dealing effectively with the turbulence and complexity that characterize today’s global risk landscape. The most damaging disruptions—as well as unexpected opportunities—tend to result from extreme events that are difficult or impossible to anticipate, let alone quantify.

### **Beyond Risk Management**

Since 2000, the world has experienced a continuing stream of catastrophic events; examples range from the shocking September 11, 2001, terrorist attacks to the devastating earthquake in Haiti that took 160,000 lives in 2010. Catastrophes are often “black swan” events that have never been observed and seem implausible until they actually occur. It seems that we are often taken by surprise, although in hindsight we realize that we could have been better prepared.

Another wild card is technological innovation, which introduces disruptive changes that can completely overturn the risk and cost structure of entire industries. For example, the revolution in information and



breakdowns in individual parts and components.”<sup>12</sup> Systemic breakdowns can result from tipping points that trigger a chain of cascading effects, such as floods, power blackouts, property destruction, and economic crises.

The evolution of thought in the *Global Risks* report series reflects the increasing humility of managers confronted by a fluctuating risk landscape. In the face of complexity and turbulence, when disruptions are often unknowable and unforeseen, risk assessment becomes intractable, and traditional risk management practices are no longer adequate.

Risk management nevertheless remains an important methodology for dealing with recognized phenomena such as fires, accidents, diseases, and currency fluctuations. To address less tractable uncertainties, risk management needs to be supplemented with resilience management, which involves a different set of tools and metrics, based on systems thinking. In a constantly evolving global business environment, the notion of “optimization” is unrealistic; instead, companies need to adjust their risk posture dynamically in response to changing conditions.

In short, although ERM is a valuable practice that should not be abandoned, organizations need new strategies and more innovative approaches to deal with supply chain complexity and unexpected disruptions. Resilience thinking represents a fresh approach that can help overcome most of the above limitations and enable companies to cope more effectively with the daunting challenges of the modern risk landscape. Even insurance companies are recognizing the value of resilience; for example, Zurich Insurance adjusts its commercial insurance maximum loss estimates by a resilience factor that accounts for business continuity planning and ease of recovery.

As defined in [chapter 1](#), enterprise resilience is the capacity to survive, adapt, and flourish in the face of turbulent change and uncertainty. A resilient company understands that managing uncertainty can lead to superior performance. Risk management tends to dwell on downside risks, but resilience thinking is equally relevant to upside rewards. Resilient companies are innovative and nimble in recognizing and capturing new business opportunities. As we shall see, the concept of resilience applies not only to enterprises, but to any self-organizing system. By learning from natural systems that have evolved for millions of years, enterprises can develop resilience strategies that provide competitive advantage.

## Antifragile?

We live in a culture that values order and predictability. As a result, most of our artifacts and institutions are fragile and are easily damaged by random forces. What if an object were antifragile; that is, what if it actually thrived on chaos?

That is the fascinating premise of *Antifragile: Things That Gain from Disorder*, a book by Nassim Nicholas Taleb.<sup>13</sup> In his previous book, *The Black Swan*, he pointed out the futility of trying to predict major disruptive events (e.g., recessions, revolutions, disasters) with cascading consequences that could change the course of our lives. In this sequel, he argues that we should accept uncertainty as not only inevitable, but even beneficial; after all, biological organisms can adapt and regenerate in response to random shocks or fluctuations. Stress is an essential aspect of life, and it makes you stronger.

Taleb, a former businessman turned philosopher, proposes a fundamental fragile-robust-antifragile triad, a sort of spectrum along which everything can be positioned. The systems that we design to be robust are actually vulnerable to unexpected events or forces. Antifragility goes beyond robustness in that it benefits from disorder.

Taleb is merciless in skewering the “fragilista,” those who cling to the illusion of order and predictability, including government bureaucrats, bankers, physicians, and even fitness trainers. He calls risk a “sissy” concept and is openly scornful of academics who pursue reductionism and elimination of uncertainty. Instead, he advocates “decision making under opacity.”<sup>14</sup> Although his views are extreme, he presents a provocative challenge to the conventional wisdom of risk management.

Unfortunately, *Antifragile* conflates resilience and robustness, treating them as synonymous. In practice, the meaning of resilience is actually very close to the notion of antifragility. Rather than resisting change, resilient systems are able to survive, adapt, and flourish in a volatile environment.

## Resilience in Action

### *Climate Adaptation by Entergy and Swiss Re<sup>15</sup>*

Although debates over climate change may linger, some companies are taking positive action to understand potential climate risks and position themselves accordingly. One example is Entergy, an electric utility company operating in the United States, including along the Gulf Coast. In 2010, Entergy partnered with America's Energy Coast and America's Wetlands Foundation to quantify climate risks in this region and identify economically sensible approaches for building a resilient Gulf Coast.<sup>16</sup> The global reinsurance company, Swiss Re, was a lead contributor to this study and applied a methodology called "economics of climate adaptation" to build a portfolio of economically suitable adaptation measures.

This study represents the first comprehensive analysis of climate risks and adaptation economics along the US Gulf Coast. The study team's projections were sobering. They estimated that over a twenty-year time frame, from 2010 to 2030, annual economic losses due to extreme storms would increase by 50 to 65 percent, resulting in more than \$350 billion of cumulative expected losses. This figure includes about 7 percent of total capital investment for the Gulf Coast area and 3 percent of annual gross domestic product (GDP) that would go toward reconstruction activities. Severe hurricanes such as Katrina could also have a significant dampening effect on growth and reinvestment in the region.

Ideally, the Gulf Coast needs to identify a portfolio of adaptation solutions that involve "no regrets"; in other words, the solutions should have low investment needs, high potential for loss reduction, and additional significant benefits (e.g., wetlands restoration). Such investments will avoid mortgaging the future in the sense of imposing a heavy financial burden with an uncertain payback.

The study methodology involved the following steps.

1. **Hazard assessment:** Three key hazards were considered: hurricanes, subsidence of land, and sea-level rise. Future scenarios were developed in consultation with expert scientists in the

field. There is broad agreement that warmer sea-surface temperatures in the future may lead to more severe hurricanes. To address uncertainty in climate change, three scenarios were developed in the 2030 and 2050 time frames, representing low, average, and extreme climate change. Natural hazard modeling, using probabilistic simulation of tropical cyclones and hurricanes, was done in collaboration with Swiss Re.

2. **Economic value assessment:** This step required estimating the size and location of current and future assets along the Gulf Coast, accounting for both the replacement value of physical assets and the economic value of business interruption. The Gulf Coast currently has more than \$2 trillion dollars in asset value and is expected to grow to more than \$3 trillion in the 2030 time frame. The analysis included a detailed and granular assessment of oil and gas assets and electric utility assets, covering more than 50,000 pipelines, offshore structures, and wells; more than 500,000 miles of electric transmission and distribution assets; and about 300 generation facilities.<sup>17</sup>
3. **Vulnerability assessment:** Vulnerability curves were developed relating the value at risk to events of different severities. A vulnerability curve shows the correlation between hurricane severity (i.e., height of storm surge, wind speed) and asset loss (i.e., percentage lost of total asset value). Different categories of assets typically have different vulnerability curves; for example, residential property may be quite different from utility assets in terms of vulnerability to extreme winds. Similarly, within a single asset category, vulnerability curves are highly sensitive to parameters such as construction codes or materials used.

The analysis concluded that the Gulf Coast faces significant losses today, averaging on the order of \$14 billion per year. These losses are expected to increase going forward, amounting to about \$18 billion per year (with no climate change) or \$23 billion per year (with extreme climate change) by 2030. Losses may increase further by 2050, ranging from about \$26 billion to \$40 billion per year. Current loss rates represent about 2 to 3 percent of the region's

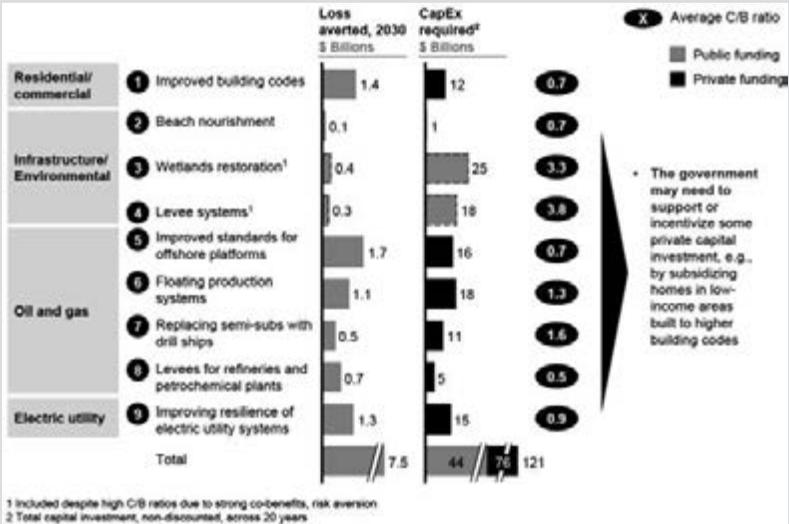
GDP and about 7 percent of the region's annual capital investment. The implication is that the Gulf Coast region spends about 7 percent of its invested capital each year on rebuilding infrastructure rather than on capital investments that could be driving future economic growth.

A key finding of the study is that *regardless of climate change*, the Gulf Coast faces an increase in risks from natural hazards going forward. Approximately half the increase is driven entirely by baseline economic growth and subsidence unrelated to climate change. Among economic sectors, the oil and gas industry and commercial/residential interests were found to be particularly vulnerable, accounting for about 88 percent of loss in the 2030 time frame.

To prevent or mitigate these anticipated losses, a broad range of potential measures were identified, ranging from infrastructure upgrades to systemic behavior change to risk transfer via insurance. The primary focus was on measures that can be implemented today, so that future innovations in technology (e.g., hurricane-resilient building materials and methods) were not assessed. Therefore, the analyses should be repeated periodically to account for technological innovations.

The study then considered both the costs and benefits of the adaptation measures to help prioritize actions. The cost analysis considered the present value of life cycle costs over time, including capital expenditures, operating expenditures, and operating expenditure savings. Similarly, the benefits analysis considered the present value of averted losses over time. It was found that, in the near-term, potentially attractive measures can address almost all the increase in loss and thus maintain a constant risk profile for the region.

The study team concluded that investing in measures totaling about \$50 billion over the 2010–2030 time frame would lead to approximately \$135 billion in averted losses over the lifetime of those measures. On a broader scale, pursuing all potentially attractive actions would involve an investment of approximately \$120 billion over that time frame and may lead to \$200 billion in averted losses. The portfolio of measures would include a focus on



*Figure 2.5. Recommended climate adaptation measures and estimated benefits*

adaptation to address near-term risks combined with mitigation to address longer-term risks. The study did not, however, try to monetize the additional co-benefits that will result from these measures; for example, wetlands protection and restoration will help ensure the resilience of critical ecosystem services (see [chapter 7](#)).

[Figure 2.5](#) depicts a grouping of the recommended measures into nine broad categories across all sectors: residential/commercial, infrastructure/environmental, oil and gas, and electric utility. The study recommended that approximately \$44 billion of public funding be invested from 2010 to 2030 to fund key infrastructure projects (including wetlands and levees). In addition, some \$76 billion in private funding would be required. Policy makers, however, may need to support and provide incentives for some private capital investment, such as by subsidizing homes in low-income areas built to higher building codes.

The most cost-effective way to offset the remaining \$14 billion in annual expected losses associated with extreme events is through insurance or risk transfer. Four key risk transfer actions can help address residual loss: increasing penetration of existing insurance

through more affordable premiums linked to physical measures, decreasing the prevalence of underinsurance through incentives that encourage updating of insured value of property, encouraging additional self-insurance, and transferring top-layer risk (e.g., through catastrophe bonds).

The recommended climate adaptation measures will require cooperation among a broad set of stakeholders with conflicting interests and varying levels of effectiveness. For example, measures related to improved construction codes may require new policies to be put in place by local regulators, investments to be made by individual home owners, and appropriate enforcement. The aim of the study was to develop practical solutions that will take Gulf Coast resilience to the next level. Although significant and broad stakeholder engagement will be required, these actions are essential to place the region on a resilient path going forward. The alternative will be to enter a long-term spiral of increasing losses with corresponding adverse economic and social impacts.

In a 2014 interview, David Bresch, head of sustainability and political risk management at Swiss Re, commented on the Entergy climate adaptation study:

At Swiss Re we have realized that the real opportunity for Entergy and other firms goes beyond avoiding damage; it is about being better organized to rapidly detect problems and to best serve their customers. This way, they'll gain market share after an event, as it will take competitors longer to be back in business. It is not necessarily about protecting an electric substation, it is more about how you engage with customers to be prepared for an emergency. Serving a customer by bringing in a generator may succeed just as well as flood-proofing a substation, and may be a more economical use of resources. The question is: what helps to best serve the joint interests of both the company and its customers? This study provided good insights into how companies can organize to weather these types of challenges and improve their resilience.

## Takeaway Points

- In the world of operations, risk is an undesirable threat to be avoided; in the world of finance, risk is a fundamental uncertainty that can be managed; that is, without risk, there is no reward.
- These different views of risk are reconciled under enterprise risk management, which enables corporations to gauge the appropriate level of risk in an uncertain business environment.
- Conventional risk management is helpful for familiar threats but has severe limitations in a world of turbulent change and unforeseen black swan events.
- Resilience thinking augments risk management by helping companies cope with turbulence, respond effectively to unforeseen disruptions, and adapt to change.
- **Resilience in Action:** Entergy worked with Swiss Re and others to analyze the potential long-term losses associated with climate change in the Gulf Coast region and recommended several cost-effective adaptation strategies to improve overall resilience.

# **RESILIENT BY DESIGN**

## ***Creating Businesses that Adapt and Flourish in a Changing World***

Joseph Fiksel

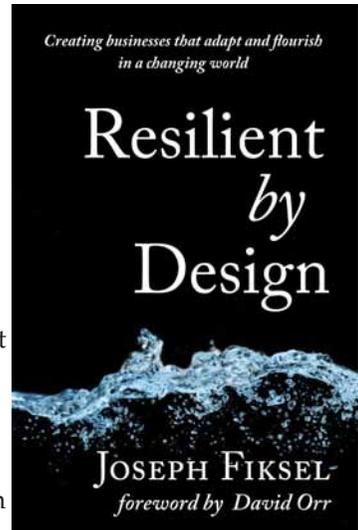
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As managers grapple with the challenges of climate change and volatility in a hyper-connected, global economy, they are paying increasing attention to their organization's resilience—its capacity to survive, adapt, and flourish in the face of turbulent change. Sudden natural disasters and unforeseen supply chain disruptions are increasingly common in the new normal. Pursuing business as usual is no longer viable, and many companies are unaware of how fragile they really are. To cope with these challenges, management needs a new paradigm that takes an integrated view of the built environment, the ecosystems, and the social fabric in which their businesses operate.

*Resilient by Design* provides business executives with a comprehensive approach to achieving consistent success in a changing world. Rich with examples and case studies of organizations that are designing resilience into their business processes, it explains how to connect with important external systems—stakeholders, communities, infrastructure, supply chains, and natural resources—and create innovative, dynamic organizations that survive and prosper under any circumstances.

Resilient enterprises continue to grow and evolve in order to meet the needs and expectations of their shareholders and stakeholders. They adapt successfully to turbulence by anticipating disruptive changes, recognizing new business opportunities, building strong relationships, and designing resilient assets, products, and processes. Written by one of the leading experts in enterprise resilience and sustainability, *Resilient by Design* offers a confident path forward in a world that is increasingly less certain.

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