POLICY RESEARCH WORKING PAPER

7634

THE TRIPLE DIVIDEND OF RESILIENCE

Background Paper

Capturing the Co-Benefits of Disaster Risk Management on the Private Sector Side

Adam Rose **WORLD BANK GROUP**

Development Economics

Climate Change Cross-Cutting Solutions Area

April 2016

Abstract

In most countries, the private sector owns the vast majority of the buildings and a considerable portion of the infrastructure at risk. However, most investment in disaster risk management is made by the public sector, with the private sector lagging far behind. The situation represents missed opportunities for businesses to capture not only higher levels of the direct benefits of disaster risk management, but also a broader set of co-benefits to themselves and society as a whole. These co-benefits include ways of lowering production costs, improving the health of workers, and contributing to general economic stability. Ironically, many of these co-benefits are more tangible and immediate than

ordinary disaster risk management benefits, which may not appear until a disaster has struck many years after the investment has been made. This study analyzes several important facets of private sector investment in disaster risk management, primarily from an economic perspective. It is intended as a first step toward promoting greater investment in disaster risk management by identifying potential co-benefits, explaining why they are not always pursued, and suggesting ways to integrate them into private sector decision-making. The latter includes government incentives, justified on the grounds that many private sector investments have extensive co-benefits, many of which pay dividends to society as a whole.

This paper is a product of the Climate Change Cross-Cutting Solutions Area, and a background paper to “The Triple Dividend of Resilience” report, a joint initiative by the Global Facility for Disaster Reduction and Recovery and the Overseas Development Institute. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted adamzros@price.usc.edu.

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

Capturing the Co-Benefits of Disaster Risk Management on the Private Sector Side

Adam Rose

Price School of Public Policy and
Center for Risk and Economic Analysis of Terrorism Events,
University of Southern California

Keywords: disaster risk management, private sector, market failure, co-benefits, spillover effects

JEL: Q54, H32, D22, D60

1. Introduction

The private sector comprises most of the economy of nearly every country of the world. As such, it represents the major source of potential losses from disasters, and hence the sector with the most at stake. In most countries, however, the majority of disaster risk management (DRM) is carried out by government. This paper explains this mismatch and offers insights on how greater awareness of the broader benefits of DRM can stimulate an increase in much needed additional investment in the private as well as the public sector. This investment is not only beneficial to businesses, but also to their host economies and the people they sustain. Moreover, this has positive feedback effects as well, not only to the firm undertaking the investment, but also to the private sector in general.

The private sector is very prominent in nearly all developing and industrialized countries as part of the growth process and because of the now decades-long shift toward greater market orientation and less government ownership (see data for selected countries in Table 1). Overall, in most countries the private sector owns the vast majority of the buildings and a considerable portion of the infrastructure at risk.

Of course, the private sector does not operate in isolation; it is dependent on infrastructure services, a trained workforce, and sound institutions. In addition to providing goods and services, the private sector attracts foreign investment and foreign exchange, as well as providing tax revenues for government. Interdependencies exist within the private sector as well in relation to its supply chains. All of these interactions add to overall vulnerability to disasters, as damages to one entity are transmitted to others. It also means that DRM investments have the potential to ripple throughout the economy, not only in helping stem losses, but also through their spending stimulus and broader risk reduction.

There is no doubt that the primary motivation of businesses is to maximize profits. On the surface, only those DRM actions that are viewed as promoting this objective will be undertaken, but all of these are recognized. But there are several broader benefits of DRM to businesses themselves and to the economy as a whole that are typically neglected, and hence businesses underinvest in DRM both from their own perspective and also from the standpoint of society.

We refer to the broader benefits, or spillover effects, of DRM as *co-benefits*. When a business installs a sprinkler system to protect against fire spreading on its premises, it also helps protect adjacent buildings and an entire community. This is also the case for strengthening the foundation of a tall building, lest it collapse on its neighbors, or for instituting better water drainage practices that reduce flooding potential for the community. More broadly actions by any one business can contribute to overall community well-being in terms of improving the quality of life and promoting economic stability. These co-benefits are not captured by the firm, and this leads to underinvestment in DRM.

Overall, private sector DRM strategies have many benefits, including avoided losses and other direct or indirect benefits for the firms implementing them, as well as positive spillover effects (“externalities”) for other firms, the macroeconomy, and society as a whole. However, businesses tend not to engage in DRM sufficiently from a societal perspective, because of internal decision-making limitations and

Table 1. Private Sector Contribution to GDP for Selected Countries

Country	Ratio of Private Sector Economic Activity to Gross Domestic Product	
	1995	2010
Australia	89.65%	89.40%
Brazil	84.84%	84.94%
Canada	84.09%	86.05%
Estonia	89.33%	88.26%
Greece	87.15%	82.10%
India	94.05%	93.33%
Indonesia	96.30%	94.65%
Ireland	87.95%	87.55%
Italy	89.59%	88.31%
Japan	89.18%	86.52%
Korea, Republic	92.41%	91.17%
Mexico	92.65%	90.94%
Netherlands	86.19%	84.52%
Poland	90.88%	91.05%
Romania	95.16%	91.56%
Spain	89.20%	87.73%
Sweden	84.46%	84.94%
Taiwan, China	90.20%	91.23%
Turkey	95.21%	92.13%
United Kingdom	85.92%	82.74%
United States	83.24%	80.50%

Source: European Commission (2014).

because they cannot capture many of these spillovers. Therefore, we identify some guidelines and incentives government can implement to encourage private firms to increase investment in DRM.

Another source of co-benefits pertains to broader gains to society apart from disasters. This refers to DRM investments that benefit disadvantaged segments of the population and that contribute to sustainable development itself, such as vaccinating their employees or using more durable materials in their buildings. Many of these gains are external to the firm but feed back positively on businesses themselves by promoting economic stability, spawning a healthier and more productive workforce, etc.

Still another category of co-benefits can be captured primarily by businesses themselves, if they are able to recognize them. These include DRM investments that improve the image of the firm or that otherwise lead to an increase in long-run profits, such as actions that are viewed as being in the public interest or that protect society from catastrophic risk. Ironically, many of these co-benefits are more tangible and immediate than most ordinary DRM benefits, which may not appear until a disaster has struck many years after the investment has been made.

Inducements are often needed for businesses to invest in a manner and at a level that captures these co-benefits for themselves and/or their host economies. Examples include providing businesses with better information on how they can reap some of the rewards of broader co-benefits, developing more versatile financial instruments, or providing them with subsidies that correspond to some portion of the co-benefits that contribute to societal goals. Although the subsidies represent a cost to government, it may be less expensive, as well as more effective, to have the private sector undertake these efforts. The appropriate design of incentives, preferably based on strong theoretical foundations and empirical evidence, is critical to cost-effective implementation of DRM.

This paper analyzes many important facets of private sector investment in DRM, primarily from an economic perspective. It is intended as a first step to greater investment in DRM by identifying potential co-benefits, explaining why they are not always pursued, and suggesting ways to integrate them into private sector decision-making. Section 2 of the paper summarizes disaster reduction strategies, including both pre-event mitigation and post-event resilience, as well as adaptation. It also discusses their integration into the business culture and broader sustainable planning. Section 3 offers explanations for why private sector DRM investment fall short of private optimum levels despite the existence of several major types of private sector co-benefits. Much of the explanation falls under the general rubric of bounded rationality, or limitations in decision-making. Section 4 examines why private sector investment in DRM also falls short of social optimum levels. Major explanations are various forms of market failure and related considerations. From the standpoint of society, private sector DRM not only falls short in terms of the efficiency of resource allocation but also in terms of the equitable distribution of disaster losses and DRM gains. Section 5 addresses co-benefits of public sector DRM investment, including gains to the private sector. Section 6 discusses the resilience dividend as a sustainable development theme, which broadens the scope of DRM considerably. Section 7 focuses on policies to incentivize private sector DRM, including innovative financial instruments, regulation and, and awareness of contributions to the broader development context. We conclude with a discussion of limitations of the analysis and some of the obstacles to increasing private sector investment in DRM.

2. Disaster Reduction Strategies

2.1. Pre-Disaster Mitigation

The first line of defense against disasters is to minimize the probability that a disaster will take place, followed closely by minimizing losses should it happen. Many natural disasters, such as earthquakes, tornadoes and hurricanes, cannot be stopped, while others, such as terrorist attacks or major technological failures, can be. Other hazards such as floods can in some cases be stymied by proactive human actions in advance, ranging from adequate sewage system capacity to land-use planning.

Several studies have been undertaken to carefully evaluate the benefits of hazard mitigation. One of the best known (MMC 2005; Rose et al. 2007b) evaluated a random sample of 10 years of FEMA hazard mitigation grants and arrived at a 4:1 benefit-cost ratio, including some social benefits such as environmental protection and historical preservation. The vast majority of the grants were for structural measures, such as reinforcing buildings, buying out buildings in floodplains, and constructing levees, but some related to mitigation “processes” such as warning systems, hazard vulnerability mapping, and zoning. More than 95% of the FEMA grants went to the public sector, but there is every indication that the private sector benefit-cost ratio would be at least as large. The Mexico Case Study (ODI, 2014) found a similar 4:1 ratio for the private sector. Hochrainer-Stigler et al. (2011) in a review of 21 studies in developing countries found results similar to those of the MMC. More broadly, Mechler and Bouwer (2015) make the case that, despite the increase in risk exposure, various DRM strategies have decreased vulnerabilities (potential losses should the event happen) throughout the world.

One thing to note now, and that we will expand on below, is the fact that most structural mitigation measures are relatively expensive. Additionally, they are competing with (and can thus “crowd out”) other business investments that are more evidently likely to promote the firm’s bottom line. New approaches are needed to minimize such stresses and conflicts in order to achieve at least the 4:1 ratio. These can include finding lower cost alternatives to structural mitigation measures that achieve the same goals and ways of overlapping DRM in general with other private and public sector objectives.

2.2. Post-Disaster Resilience

Losses from disasters are not confined to property damage. Moreover, property (the capital *stock*) is not just valuable in and of itself but rather in terms of the *flow* of goods and services it generates, often measured in terms of gross domestic product (GDP). Disruption of this flow, or business interruption (BI), just begins at the point of the disaster and continues until the economy has recovered (Rose 2004a). In several recent disasters, such as the September 11 World Trade Center bombings and Hurricane Katrina, BI losses have exceeded property damage.

While many have defined resilience so broadly as to include all activities that reduced disaster losses, we will confine our use of the term to those activities that dampen BI losses by using remaining resources more efficiently and recovering more quickly (Rose, 2004b; Rose 2009a). Examples of the former, or *static resilience*, include conserving scarce resources, use of larger stockpiles, finding substitutes for critical materials, relocating business activity, and rescheduling lost production. Examples of the latter

approach, or *dynamic resilience*, include having a repair/reconstruction plan in place, improved logistics for construction activity, and reduction of paperwork and other administrative obstacles to obtaining funds necessary for rebuilding. Most static resilience tactics are under the control of individual businesses, and many dynamic resilience decisions are as well, with the exception of those regarding rebuilding public infrastructure. But many tactics that promote dynamic resilience, even for the private sector, relate to government planning and provision of disaster assistance.

Note that resilience is much more than just the flip-side of vulnerability. Rose and Krausmann (2013) have pointed out that disaster vulnerability is dominated by contextual, or background, variables, such as unemployment rates, literacy rates, percent minority, and percent living in hazardous zones. On the other hand resilience is composed of actionable variables, many of which are under the control of individual businesses.

Several studies have shown post-disaster resilience to be highly effective in reducing business interruption (BI) losses and others have indicated its broader potential to yield social benefits. Rose et al. (2009) estimated that 72% of potential BI losses following the September 11 World Trade Center bombings were averted by the reasonably rapid relocation of businesses to nearby sites. Kajitani and Tatano (2009) identified extensive resilience possibilities for Japanese industry. Rose and Lim (2002) found resilience to the electricity service disruption from a combination of factors following the Northridge Earthquake to be on the order of a 90% reduction in potential BI losses. Other studies have identified sizable resilience potential for a major port following a 90-day shutdown (Rose and Wei 2013) and the economy in general in the aftermath of the Shakeout Catastrophic Southern California earthquake (Wein and Rose 2011). Moreover, Yoshida and Deyle (2005) found small business to be more interested in post-disaster business continuity than in pre-disaster hazard mitigation. Flynn (2008) has emphasized the value of resilience as promoting increased self-reliance at the individual level, thereby reducing the need for outside assistance.

Resilience is not just applicable at the micro level (individual business, household, or institution) but also at the meso (industry or market) and macro (national or regional) levels. Examples of meso-level resilience include market prices as a guide to more efficient resource reallocation. Following a disaster, price increases are often viewed as gouging, but some portion of the increase often reflects increased scarcity and thus provides a valuable signal for the need to better manage supply and demand. Electricity interruptible service contracts and clearinghouses that match customers who have lost suppliers with suppliers who have lost their customers are additional examples. At the macro level, accessing imports for goods that cannot be produced domestically, and fiscal and monetary policy are prime examples (Rose 2009a) (see Hallegatte et al., 2016, for a more extensive discussion).

In essence, most resilience tactics are much less expensive than pre-disaster mitigation measures. Conservation more than pays for itself, substitution typically involves only a small penalty, inventory costs are simply the carrying costs and not the value of the inventory itself, and production rescheduling usually only requires overtime pay. Moreover, another advantage of post-disaster resilience is that it need not be implemented until one knows that the disaster has actually taken place. Still, the build-up

of resilience capacity and its implementation is not as extensive as it could be for several reasons to be discussed below, including some that are similar for implementing mitigation.

We should, however, note that post-disaster resilience should be considered only a second line of defense. While it is capable of reducing ordinary losses, it cannot compensate for irreversibilities, such as loss of human life and the destruction of unique eco-systems.

2.3. Adaptation

Climate change has opened up another aspect of DRM. Climate change manifests itself in two general forms: 1) longer-term stress from secular changes, such as increased average temperatures, and 2) short-term shocks from climate variability, such as increased frequency and magnitude of droughts and severe storms, and, though subject to dispute, the possibility of increased frequency and magnitude of hurricanes (US GCRP 2014; IPCC, 2014). Both types of impacts can be disastrous. The former represents a relatively new area, especially in terms of its scientific basis, mitigation strategies, and time horizon (projecting into future centuries). The latter overlaps with the conventional analysis of natural disasters.

Most experts agree that the main cause of climate change is the man-made generation of greenhouse gases (GHGs). Unlike most ordinary pollutants, which quickly dissipate, GHGs remain in the atmosphere for long periods (again centuries), and are thus referred to as a “fund” pollutant. That is, they build up over time, and even the cessation of emissions does not reduce their atmospheric concentrations. Thus, some climate change, both long term and short term, is inevitable.

Adaptation is a term used in this report to describe reactions to climate change manifestations that do occur, though we acknowledge the wide divergence in definitions in the literature (cf., Fields, 2012). It is frequently applied to the longer-term impacts (stressors), and thus can be thought of as the long-run counterpart to resilience, which is typically, but not always, applied to natural disasters (which in the atmospheric realm are related to short-run climate variability, or more generally as shocks). Another aspect that sometimes causes confusion is that mitigation of climate change refers to the reduction of greenhouse gases by halting their emissions or absorbing them in plant growth or geological deposits (see, e.g., Rose 20014b). This differs from mitigation of the remaining consequences of climate change, which refers to mitigating disasters, either rapid or slow onset, or adverse longer-term phenomena such as sea level rise.

Many adaptation tactics are similar to those noted above in reference to resilience. Two major differences exist, however. First, slow-onset climate change provides advanced warning and thus a greater ability for planning responses in advance, except for investments that have long lifetimes. Second, several tactics are more profound in the case of adaptation. For example, in the case of impending flooding, an area might be evacuated either before or immediately after the event, while, in the case of sea level rise, the adaptation counterpart is permanent relocation.

This report will confine its attention to DRM in response to disasters as a manifestation of short-term climate shocks and will thus not focus separately on long-term stressors. However, several of the analytical principles and policy remedies overlap between the two. For example, Kull et al. (2013), point

to index-based insurance, which requires identification of technical features of risk and hence technology to evaluate them, thereby improving risk assessments of both disasters and long-term manifestations of climate change.

2.4. Integration into Business Culture

The infrequency and sporadic nature of disasters cause a serious perception problem with respect to DRM. Learning is possible, but limited by institutional memory. Often mitigation and resilience are viewed as areas of concern separate from day-to-day business activity.

Several analysts have suggested, however, that it is prudent for businesses to integrate DRM into their general business strategies and practices. Essentially, this is a general way of capturing some co-benefits. For example, Zoli (2011) has emphasized the importance of organizational and operational flexibility, which makes businesses more capable of coping with drastic change. Sheffi (2005) has provided numerous examples of supply-chain rigidity that led to business failure in the aftermath of a disaster, but is now countered by a broader view of the supply chain as a web that includes back-up sources.

In addition, in many countries a business-continuity industry has been spawned to meet the increasingly needed functions that more companies are realizing are beyond their own expertise or can be applied more cheaply if contracted out (e.g., information technology back-up, massive clean-up, logistical support, relocation). Large companies in industrialized countries can readily form and staff their own emergency management office, but smaller firms and firms in developing countries are less likely to be able to do so. The professionalization of DRM at the operations level in this new service industry fills a much-needed gap.

2.5. Integration into Sustainability Planning

Resilience is considered to be the response to short-run shocks, while sustainability refers to maintaining a long-run development path in which actions by the current generation do not compromise the well-being of future generations, with an emphasis on maintaining the value of natural capital and human capital, not just physical capital. If a country cannot survive short-run shocks, it clearly will not be sustainable. One other aspect of the relationship is key: transforming the ingenuity that arises from short-run resilience into longer-term practices to promote sustainability. Rose (2014) has specified the following steps that can help achieve this goal:

- Identify effective resilience tactics at the micro (business), meso (industry/market), and macro (regional/national) levels based on actual experience. For example, ingenuity in conserving and substituting for critical resources under extreme stress should be examined for their more permanent potential under normal conditions.

- Develop resilience indicators based on evidence of successful practices to monitor progress on resilience capacity. Even though disasters may be sporadic, the need to develop ways to mute their negative impacts should be a continuous process.
- Disseminate findings on best-practice resilience tactics and community response. Likewise, the continuous dissemination of information about resilience will help make it ingrained in daily life.
- Evaluate the cost-effectiveness of resilience. This helps ensure resilience will be implemented as efficiently as possible, thereby helping to remain on or return to a sustainable path.
- Analyze the strategic tradeoffs between mitigation and resilience in terms of cost-effectiveness. Resilience should not be assessed in isolation of other major strategies, and that assessment should be done in terms of their ability to cope with short-run crises and to contribute to long-run sustainability.
- Identify ways to make resilience in the face of crises enduring, so as not to repeat previous mistakes. A good institutional memory contributes to both resilience and sustainability.
- Identify ways to transform short-run resilience responses into sustainability strategies. The view of resilience should go beyond consideration of individual tactics and should be evaluated in terms of broader community strategies that capture synergies.
- Steer the economy and related systems to greater flexibility in terms of resource provision and utilization. A key attribute of resilience is flexibility, and ways need to be found to take advantage of this attribute, as in broadening the array of sustainable future paths.

Overall, the many co-benefits of DRM represent a type of “Resilience Dividend.” This concept heightens the potential of DRM to not only reduce disaster losses but also to enhance the prospects for future growth and development, and hence sustainability.

3. Shortfalls in Private Sector Investment in DRM

3.1. Private Sector Investment Decisions

The primary objective of businesses is to maximize profits, and for many firms the focus is only on the short term. Secondary objectives, such as increasing market share, are usually consistent with this primary concern as well, but are more long term. DRM will be undertaken by businesses as long as it is consistent with profit maximization. Most DRM initiatives involve investment, so the objective is often couched in terms of maximizing net present value or the internal rate of return. The latter principle is often used to compare or rank alternatives. Brugmann (2012) emphasizes the importance of factoring mitigation, adaptation and resilience into the picture, as opportunities to improve investment performance (see Section VI). He notes that this can help establish a market basis for DRM.

Investments have two interrelated features that other business activities do not have, or have to a lesser degree. First, the returns to the firm take place over the course of time. Second, because they take place in the future, the returns involve a degree of uncertainty. Interest rates are used to account for both features. Revenues in the future year are not directly comparable to each other, so the market interest rate is used to discount future returns to account for the time value of money. The interest rate

is also used to adjust for risk, such that higher than market rates reflect a *risk premium*. Investments in new or unproven technologies are relatively more uncertain than others; these are characteristic of many of the larger DRM investments, which have to be customized. Another factor that translates into greater uncertainty surrounds the benefits of DRM. These benefits are the avoidance of lost profits, adjusted by the probability of occurrence of the disaster. These probabilities are highly uncertain, so the risk premium may be increased accordingly.

A major debate revolves around whether uncertainty reduces or merely postpones business investment. Doh and Pearce (2004) suggests that a context of continuous vs. discontinuous uncertainty makes a difference, with disasters clearly being in the latter category. A great deal of literature relates to regulatory uncertainty, which is also very applicable to disaster mitigation (e.g., building codes, zoning ordinances). Findings are mixed, however, on whether uncertainty inhibits forward movement (cf. Yang et al. 2004; Aragón-Correa and Sharma 2003). Carrera et al. (2003) and others note ways of capitalizing on uncertainty, such as the advantages of being a “first-mover” (another type of co-benefit). Hoffmann et al. (2009) provide an example of three factors in a case study of German electric utilities facing climate change regulation as influencing forward progress on investment: 1) securing competitive resources, 2) leveraging complementary resources, and 3) alleviating institutional pressure.

3.2. Private Sector Investment Decisions in Relation to the Public Sector

Although businesses continuously voice their support of free markets and opposition to government interference, most firms will work in a cooperative spirit if it is in their best interest. For enlightened business managers, best interest means not just short-run maximization of profits, but also maintenance of the business’s image. Both of these factors augur well for businesses cooperating in sustainable development efforts.

Governments have led the charge to “mainstream” DRM into development planning, as exemplified by the Jamaica Case Study (ODI, 2014). That country has included a broad range of sectors and vulnerabilities into the plan, including transportation infrastructure, food security, ordinary flood protection, landslide risk reduction, and climate change. The Senegal Case Study (ODI, 2014) indicates a very broad approach in which the country’s National Platform brings together all ministries. At the same time, this case study notes shortcomings, including a lack of coherence among levels of government and an absence of the requirement of environmental impact assessments prior to the undertaking of major projects.

Public sector investment decisions are not dissimilar to the private sector at the core. Benefit-cost analysis (BCA) is typically applied with the objective of maximizing the net present value of future returns. Given the uncertain nature of disasters, the benefit side of the ledger is often weighted by the probability of occurrence. In such an expected value setting, co-benefits for extreme events can readily exceed direct benefits of DRM because the weights are so low (the events are so infrequent). It should be kept in mind, however, that with regard to other decision criteria, such as minimizing regret, the probabilities do not come into play, and the avoidance of disaster is the key factor.

Two major differences between public and private sector decision criteria should be noted, however. First, public sector evaluations are usually required to consider all benefits to society, not just narrow benefits to a private enterprise, which are often confined to market values translated into revenues. In other words, at least in theory, government investment decisions should incorporate all co-benefits. Second, the government discount rate is usually considered to be lower than the private one for several reasons, including government's much greater resources that do not necessitate borrowing in capital markets and government's relative greater ability to absorb adverse shocks from uncertainty.

3.3. Private Sector Co-Benefits

The major benefits to a firm from a DRM investment are the revenue losses avoided and any ancillary revenues it may receive. The latter would be exemplified by co-benefits in the form of salable bi-products or joint products, such as a decision to install solar panels to insulate the firm against disruptions from central power stations, where excess solar electricity can be sold back to the grid. This is still a relatively short-sighted perspective, and its limitations are discussed both from the vantage point of the firm and society as a whole in the following sub-sections.

A more enlightened view of the firm's objectives incorporates longer-run considerations relating to its good name or its survival. DRM often provides broader social benefits that might be considered by the firm, as pressures from shareholders, incentive systems, etc., tend to focus private companies on the bottom line. Examples would be voluntary reductions in pollution that improve the firm's image and implementation of flood control practices that benefit the entire flood plain.

An in-depth discussion of co-benefits is presented elsewhere, so we confine ourselves to a brief summary list here without any detailed description. There are four major categories of co-benefits for which we provide some examples:

1. Benefits to the business undertaking the investments

- improved business image (from being a "good citizen")
- improved credit rating (from increased stability)
- improved ability to deal with multiple hazards (from business continuity planning)

2. Benefits to other businesses in the supply chain or geographic vicinity

- increased supply-chain stability (from business continuity)
- reduction in contagion effects (from lower likelihood of fire spreading or falling debris)

3. Benefits to the general business climate

- reduced uncertainty (through lowering the likelihood- of disaster losses)
- increased economic stability (from business continuity)
- increased economic growth (from business continuity)
- contributions to technological progress (from embodied technological improvements)

4. Benefits to society

- improved health and education (from employee-related measures)
- improved environment (from more prudent use of resources)

3.4. Bounded Rationality

Economics has long been criticized for invoking simplifying assumptions about behavior, such as the profit maximization motive of businesses. A broader perspective has evolved that incorporates behavioral considerations. The main body of this approach is known as *bounded rationality*, and it focuses on various limitations to decision-making (see, e.g., Girgenzer and Selten 2002). A classic example is myopia, which refers to the use of unduly short time horizons. The manager may only be interested in near-term gains, as opposed to long-term ownership considerations. Kunreuther et al. (2011) found that analogous myopia was the major deterrent in undertaking DRM by households in hazard-prone areas. Even major information campaigns to raise awareness have been relatively unsuccessful (Kunreuther, 2006). A related phenomenon that also leads to market failure is that of asymmetric information. One key example is the “principal-agent” problem, best exemplified at the business level when the manager is not the owner. The manager’s incentives may be end-of-year bonuses, often based on maximizing sales, rather than maximizing profits, which is more in line with the efficient allocation of resources.

These instances are pertinent to DRM decisions. A manager may see a mitigation measure as reducing profits in the year in which they are made, without considering the longer-term view that it will reduce disaster losses in the future. Myopia and split incentives are likely to lead to even less attention to broader societal benefits of DRM, such as poverty alleviation, economic stability, and sustainable growth. Thus, just demonstrating the existence of these broader co-benefits is not necessarily enough to achieve the desired action. Some remedies that would help promote in the pursuit of co-benefits, but not necessarily in capturing them all include working with owners rather than managers, appealing to the reputation of the firm, and giving priority for disaster assistance to those firms that cooperate in DRM.

Another limitation of decision-making is lack of information and the inability to process the information available. This concept extends to expertise as well. Yoshida and Deyle (2005) found access to expertise (primarily from engineers, insurance managers and consultants) to be the major determinant of small business investment in hazard mitigation. The emergence of the business continuity industry should help in this regard, especially for smaller firms who lack in-house expertise. This is even truer for homeowners, but programs like the Institute for Business and Home Safety (IBHS, 2015) FORTIFIED Program in the U.S., which links expertise with higher standards, is a promising approach.

The concept of *moral hazard* refers to engaging in negligent actions because the entity need not bear their full cost. The very nature of large businesses lends itself to this problem, as decisions by one person in the firm are not immediately, or even eventually, penalized. Many corporations are so large that accountability loses transparency or else is dissipated. All but the top officials are insulated from the other operations. It is the mid-level management that must voice concerns about disasters, but may

be hesitant to do so, lest DRM expenditures come out of their own budgets. Moral hazard also arises for large firms when their negligent actions are forgiven by governments who lack influence over them

4. Shortfalls in Private Sector Investment from the Standpoint of Society

4.1. Externalities

The concept of *externalities* has grown in prominence as community, regions, and the entire globe have become increasingly interdependent. An externality refers to the action by one individual or business that impacts another without being transmitted to the marketplace. Externalities can be either positive or negative, with the negative externality of pollution being the most widespread example (Weimer and Vining, 2005).

Those perpetrating a negative externality are able to do so until some legal or regulatory recourse comes about, which is increasingly the case not only in the industrialized but also the developing world. There is, however, yet another approach to dealing with externalities. Nobel laureate Ronald Coase (1960) pointed out that most externalities are due to a lack of property rights (the most poignant example being the global “commons”, where lack of ownership translates into lack of custodianship and hence abuse). He suggested the establishment and delineation of property rights can lead to entities engaging in bargaining, or trading, to alleviate the externality to the extent of the satisfaction of all parties (marketable pollution emission permits, now called cap and trade, are an outgrowth of what is known as the Coase Theorem).

Many externalities lead to or make society more vulnerable to disasters. These include the generation of greenhouse gases that cause climate change, wasting of water that exacerbates drought, or tilling practices that contribute to flood. Clearly, reducing negative externalities that make society more vulnerable to disasters should be a target of DRM. For example, if decision-makers are convinced that climate change will cause drought and increased frequency and magnitude of hurricanes, they can consider mitigating the root cause (the emission of GHGs) rather than waiting and mitigating the disasters that climate change will spawn. Another reason to do so is to prevent the irreversible damages that even this subsequent mitigation cannot prevent.

Furthermore, some mitigation measures generate negative externalities, which are essentially “co-costs” or negative co-benefits. For example, the Mexico case study (ODI, 2014) found that a major flood mitigation project in that country resulted in water being diverted, such that flooding was merely “transferred”. The case of DRM can be strengthened if these unintended consequences can be minimized cost-effectively.

Contagion effects are a sub-set of externalities that focus on cascading interdependencies between entities. Examples relate to the spread of fire among adjacent buildings or the spread of disease across the population. This means that a business that installs a sprinkler system or contains the drainage from its own property will benefit its neighbors. Unfortunately, it is unable to reap the entire rewards of these actions, as will be discussed more thoroughly in the next sub-section.

Yet another set of externalities are referred to as *transboundary* effects when they cross political jurisdiction boundaries. Rose and Kustra (2013) point out that more in-depth hazard loss estimation that distinguishes various loss categories can help delineate these externalities and enhance the possibility of cooperative action in addressing them.

Overall, Brugmann (2012) and others emphasize the importance of “internalizing” various externalities, including co-benefits of DRM, into investment calculations. He notes: “The challenge of climate adaptation, and of other risk reduction strategies, is to create the institutional, planning and policy frameworks, business practices, information systems and financing instruments to establish a market basis for resilience upgrading of vulnerable urban areas and systems as private investments flow into these assets and areas over the coming decades” (pp. 217-18). considered, including regulations, taxes, and subsidies. These include, local zoning ordinances to restrict growth in flood zones, carbon taxes to stem climate change, and subsidies to entice behavior that generates broader social benefits of DRM. .

4.2. Public Goods

The concept of *public goods* is especially pertinent to DRM. A public good is one that: a) can benefit more than one entity at a time without detracting (much or at all) from the benefits of another, and b) from whose benefits exclusion is technologically infeasible, socially unacceptable, or economically unviable. It is not actually the same thing as a project having multiple benefits, but focuses on the tenor of those benefits. Thus, the construction of a hydroelectric dam generates a private good (electricity) and several public goods (e.g., flood control and recreation). Because entities cannot always be excluded from partaking in the benefits of the good, they cannot always be charged a price for it. Hence, those goods with publicness attributes will be under provided in the marketplace. It is not just the usual expense, or lumpiness as it is sometimes referred to (see, e.g., Vorhies 2012), but this combination of widespread benefits and the inability of individual businesses to capture them that leads to this type of “market failure.”

At the same time, public goods need not always be provided by government. Education has public good characteristics -- the same schoolroom being able to serve many students and it being socially unacceptable to deny students an education. However, private schools flourish at the same time, though they are not likely to lead to the socially optimal level of education by themselves (for one thing, they would exclude the masses of people who could not afford schooling). Large-scale projects, such as major hydroelectric dams are almost always provided by the public sector, but lesser DRM tactics, even those that involve some public goods characteristics, can be provided by the private sector with some government institutional or regulatory support. In addition, subsidies, such as tax rebates, can be provided to promote the level of a public good in the best interests of society, by making up the gap between the public and private optima.

A pure public good is one that can be enjoyed by an unlimited number of users without detracting from one another, though there are only a handful of examples of this extreme case (e.g., National defense, pollution control). Deterioration of the quantity/quality of public goods is typically due to congestion.

A related concept is that of the *common property resource*, which has one of the two major characteristics of the public good— the lack of excludability. However, otherwise it is a private good, in that any unit consumed by one person represents one less for everyone else (this differs from congestion in that it is an absolute one-for-one subtraction. Examples range from oil fields to fisheries to the atmosphere (often referred to as the *global commons*).

Also related to public goods are *merit goods*, which are often placed in the same category because government promotes or provides them. However, many of them have private good characteristics. Education has merit good aspects, while smoking has *merit bad* aspects, and hence is discouraged or banned. Many otherwise private goods can be provided by government on this basis, including many forms of post-disaster assistance such as meals for disaster victims or low-interest loans for small businesses to rebuild.

4.3. Economic Interdependencies

No business operates in isolation; it requires inputs from its suppliers and sells its products to other businesses, governments or households. In essence, the economy is a set of integrated supply chains. These *economic interdependencies* can cause losses to one entity to ripple throughout the economy. At the national level this is often measured in terms of a multiplier (the ratio of total impacts to direct impacts), with numerical values 2 to 4 times the initial hit. However, multiplier effects can be even larger when we consider critical material shortages or key bottlenecks in the economy that can be caused by disasters.

Thus, the lack of adequate DRM by one business can negatively affect the entire economy if substitutes for goods or services cannot be found or produced, or only so at a higher cost. One would not expect business to actually value these implications for the broader community, but they should be taken into account (see also Hallegatte et al., 2016). Hence, only government is likely to be able to incorporate this aspect into DRM decisions.

“Interdependencies” can be broadened to include many categories of indirect economic losses. Hallegatte and Przyluski (2010) stress the fact that direct losses from disasters are not sufficient to garner support for DRM. Other forms of interdependencies would include losses stemming from interdependent infrastructure systems, such as those that led to the recent Fukushima disaster, or cascading failures in general as evidenced by Hurricane Katrina.

4.4. Moral Hazard

Here we address moral hazard external to the firm. A classic example is in the area of natural hazards, when businesses and households continue to rebuild in floodplains because they are certain they will receive continued government assistance after the next flood takes place.

Moral hazard poses a classic dilemma for government. Those hit by a disaster are the neediest among all of society, and it is difficult to refuse aid immediately following the crisis. In other cases, post-disaster assistance is a means of currying favor with certain key constituencies. Several obvious

remedies exist, including: stating in advance no additional aid will be reduced, land-use planning that forbids development in the floodplain, and buying out of structures in the hazardous areas (the MMC study noted above found floodplain buyouts to have some of the highest benefit-cost ratios).

Although businesses do not present as needy an image as a family that has been displaced from its home, businesses still seek and do not refuse disaster assistance, even if they are guilty of moral hazard. This ranges from the smallest businesses in developing countries to the largest corporation in industrialized ones, as evidenced in the aftermath of the financial meltdown leading to the Great Recession recently in the U.S.

Many well-intended policies contribute to the moral hazard situation. For example, the Ministry of Finance and Public Credit in Mexico has implemented two major strategies: a) creation of a natural disaster fund and b) risk transfer through reinsurance and catastrophe bonds. The former sends a signal to potential disaster victims that they will be bailed out. The latter does not really reduce disaster risk, but simply spreads it out. This is not to say that the policies are not well-intended or beneficial, it is just that they have some features that do not reduce overall risk. At the same time, there are several ways to stem moral hazard, such as the deductibles in insurance policies or “index-based” insurance, where protection is gauged in terms of factors that cause losses rather than the level of losses.

4.5. Distributional Considerations

Often neglected in risk assessments is the distribution of costs and benefits. These are important for at least three reasons. First, numerous studies have determined that the least well-off groups are those most vulnerable to disasters; moreover, their condition is exacerbated by disasters. Thus, disasters are a great concern from an equity, or fairness, standpoint. Second, lagging social economic groups or lagging regions have been found to represent a drag on economic growth and development. Third, identifying the impacts on various stakeholders provides insight into the motivations of government decision-makers and the likelihood of support or lack of support for DRM policies. Distributional information can better inform stakeholders and thus enhance the public participation process, as well as serving as a predictive tool for the decisions the process is likely to yield. Used appropriately, distributional data can fill in many needed informational gaps and help lead to a more enlightened citizenry, and hence DRM more attuned to the needs of the public (Rose et al. 1989).

5. Co-Benefits of Public Sector Investment

5.1. Co-Benefits to Society

Not adequately considering co-benefits of DRM is a major reason for underinvestment (Vorhies 2012). Public officials in general need to be better informed of these co-benefits and need to do a better job of communicating them to their finance ministries and to the business community.

To expand on the discussion in the previous section, there are several reasons why even the knowledge of co-benefits may not be sufficient for adequate public sector action. Such reasons come under the

heading of “government failure”, the counterpart to “market failure”. One of them is the short time-horizon of elected officials, who often cannot see beyond the next election. A counterpart is the insulation of appointed officials. Further exacerbating the problem is the opportunity cost of DRM investment in relation to other goods and services that public officials may prefer to provide, as they view the public interest or their own political self-interest (Vorhies, 2012). There are several ways of overcoming this problem. For example greater public participation in the decision process injects a two-way flow of information that promotes DRM. Flores and Smith (2010) have noted that democratic societies tend to do a better job in terms of DRM.

Government agencies are likely to improve access to funds through better communication. Templates for information-sharing, such as those developed by the U.S. Federal Emergency Management Agency (FEMA, 2012), are one valuable model. Still, just a listing of the relevant co-benefits is only an easy first step. The next and much more difficult step is actually measuring them. Kousky (2012) and Vorhies (2012) provide examples relating to the evaluation of mitigation measures for housing in the form of retrofits, but note difficulties in implementation such as whether to value buildings according to market prices or replacement costs.

Some of the co-benefits are especially difficult to measure, as in assessing potential improvements to the business environment or to more general economic stability. It has not even been demonstrated yet that foreign direct investment (FDI) is driven in any major way by DRM. Many of the indirect standard effects of DRM, such as multipliers stemming from economic interdependence, can be measured by conventional models, such as input-output (I-O) and computable general equilibrium (CGE) models (see, e.g., Hallegate 2008; Rose 2015). Externalities, or spillover effects, can be measured as well. For example, Rose et al. (2014) measured the side-effects of anti-terrorism measures such as traffic stops, bag and parcel checks, and closed-circuit television monitors. While the latter generated some loss of privacy, it also increased the feeling of security, which translates into increased commercial activity and more broadly an improved business climate to attract investment.

Another difficulty is in catering to various stakeholders. Not all of them are equally impacted, so distributional information (discussed above) is especially important. In addition, one must overcome the apparent bias of DRM with respect to higher income groups. Since they have much more at stake, they are likely to reap the greater share of absolute gains, though the relative position of lower income classes is relevant here, and DRM has the ability to prevent further deterioration of their material status.

5.2. Co-Benefits to the Private Sector

Despite exponentially increasing financial losses from disasters, business spending on DRM has not kept pace. The issue is how to engage the private sector in DRM from a finance and implementation standpoint. Also important is how this engagement would influence government development planning.

One more direct and apparent benefit to the private sector relates to risk-taking. Analysts have long noted its important role in entrepreneurship, and it should not be stifled but rather enhanced. Investors work in the context of background risk not under their control, but disasters exacerbate this and can

lead to greater risk aversion, which has a dampening effect on the entrepreneurial spirit. Reducing this background risk and providing better information on residual risk can help promote DRM. It leads to a context of “risk-conscious decision-making” (Hallegatte, Ch. 2).

There is an important role for insurance in DRM. Insurance is provided by the private sector throughout most of the industrialized world, and its expansion into the developing world would be valuable for this purpose. However, these initiatives are likely to require backing through re-insurance, government subsidies, or government regulation (e.g., ceilings on liability/payouts). One of the especially beneficial aspects of insurance, when structured properly, is the inducement for mitigation. This harkens back to fire loss coverage, where the insured were given reductions in premiums if they undertook sounder fire prevention practices. Lower insurance rates represent an additional co-benefit of DRM, in that it makes insurance more affordable to a larger number of people.

One of the key issues is being able to communicate effectively to businesses, taxpayers, and political supporters of these co-benefits. The main challenges are interrelated:

- Absence of controlled experiments that are the standard in the science fields but not possible in the disaster field, hence rendering analyses relatively more tenuous.
- Measuring and tracking investment effects is difficult, because first a baseline must be established and then the effects of investing ascertained (again difficult where controlled experiments are not possible, or impossible if the disaster does not strike)
- Having to do the measurement and communication in the context of uncertainty makes them relatively more difficult to come across as convincing and more difficult to understand by non-scientists.

6. Resilience Dividend as a Sustainable Development Theme

Awareness of the co-benefits of DRM must be raised. Because so many of them are not part of individual business enterprise calculations, they are likely to be ignored. Also, because many of them are especially difficult to measure, their full contributions might not be fully appreciated. Knowledge transfer can be especially valuable in making the business case for DRM. Best-practice methods of evaluation, instruments for finance, and techniques for implementation can be very valuable in this regard. This should also be extended to what is referred to as “Next Practices,” which are more forward looking and help developing countries overcome some of the mistakes and limitations of the past by learning from industrialized country experiences.

This study is only a first step in the process of improving the perceptions of the broad range of benefits of DRM. Below, we discuss some of the broader contributions of DRM in terms of a resilience “dividend.”

6.1. No-Regrets Strategy

One of the major features of the co-benefits approach to evaluating DRM investments is that many are not dependent on actually experiencing the disasters that they seek to prevent. Sometimes, such investments would be viewed as wasteful, but this is an unfair characterization, since from a probabilistic standpoint they are prudent. Thus, while the expected value of benefits (losses averted) are positive, the actual direct benefits may be viewed as zero. However, the co-benefits often take place irrespective of the occurrence of any disasters. It has been popular to refer to such instances as a “no-regrets” strategy, in that it reaps benefits irrespective of future outcomes. This terminology has come into widespread use in the climate change area, where tactics such as energy efficiency (reductions in energy use that more than pay for themselves) are considered meritorious on their own even if predictions about climate change are not accurate (IPCC 2014).

Clearly, pure no-regrets strategies are just a subset of DRM investments where co-benefits themselves outpace the costs. As such, they relieve the pressure on some highly visible projects that do not otherwise appear to have been needed. We should, however, not let the perfect be the enemy of the good, in that investments with partial offsets of costs through co-benefits are worth seeking on a probabilistic basis.

6.2. Shared Growth and Social Benefits

Prudent DRM investments will increase not only the profit margins of firms but also benefit the entire economy directly and indirectly. Direct benefits stem from the increased capital stock and production (contributions to a higher GDP) of the firm itself. Indirect effects, or co-benefits, stem from the many categories discussed in this paper, including multiplier effects, employment opportunities and tax revenues in all cases, and environmental and broader social benefits in some cases. Moreover, the reduction of uncertainty can have a stimulating effect on both the firm and the overall economy through many conduits including attracting more foreign direct investment.

Most of the population can share the gains of economic growth. Increased employment helps reduce poverty and provides improved health care for those employed (again directly and indirectly). Increased tax revenues can be used to help others, not only in terms of health care, but also education and other social services. Reduced uncertainty provides broader social benefits as well in terms of locational choices, personal investment planning, and human resilience.

There is some controversy about which socioeconomic groups benefit most from DRM. The well-to-do benefit because they have the most assets. On the other hand, the poor often live in areas with greater hazard exposure and vulnerability. Moreover, because they live on the edge of subsistence, even relatively smaller losses can be relatively more injurious to them. Economic and social equity implications of DRM need to be examined and refinements made where they violate a society’s principles of fairness. This is not an easy matter, in part because of the diverse set of relevant equity principles are espoused and sometimes conflict, as for example, comparing the benefits principle with ability to pay at the local level and the many alternative burden-sharing principles for mitigating GHGs (see, e.g., Rose 2009b).

6.3. Environmental Benefits

Climate change has placed a much stronger focus on the role of the environment in disasters than ever before. Previously only a very small portion of DRM had been oriented toward the environment. For example, a major study of the benefits of 10 years of U.S. FEMA hazard mitigation grants (MMC 2005; Rose et al. 2007b) indicated that, while significant portion of the grants yielded environmental benefits, especially those associated with flood mitigation, less than 1% of the total dollar benefits were environmental. The small fraction resulted despite the broad range of benefits, which included improved water quality (for recreational and commercial fishing, drinking water), reduction of hazardous wastes, and enhancement of wetlands, aesthetic, and health and safety benefits. In hardly any of the cases were environmental benefits cited as a major concern, but they were factored into the FEMA grant applications as co-benefits. At the same time, it should be mentioned that environmental benefits in this study and others could very well be significantly under-estimated because of measurement difficulties in this realm.

In case of climate change, the environment is not only the medium through which the disaster is transmitted, but aspects of it are also among the major receptors of damage. Threatened on a much broader scale than ever before are delicate eco-systems, biodiversity, and soils, among others. Projected economic losses from climate change are in the hundreds of billions of dollars per year, with the sizable portion being environmental (IPCC 2014). Abatement of greenhouse gas emissions is being justified on the basis of all of these losses, and adaptation to climate change the manifestations can further reduce losses. Most of the improved environmental areas are public goods or common property resources, but even still many of them are utilized by the private sector (e.g., river water for cooling, pristine areas for recreation). Many environmental goods and services have private goods characteristics as well and are of course directly related to private sector interests. These include timber, soils, and biodiversity, which are threatened more than ever by surface temperature warming, drought, and increased wind and flood damage. In these cases, environmental services are direct benefits rather than co-benefits.

7. Incentivizing Policies

7.1. Financial Instruments

Paying for DRM is a critical consideration. Many businesses, especially those in developing countries, do not have the necessary internal resources at their disposal. Several means of private financing for DRM have been developed and have been shown to be effective, though they are not without their limitations. Still, “disaster financing” often refers to risk spreading and government or philanthropic transfer payments rather than outright risk reduction, though the risk reduction can be incorporated into the former with innovative policy design.

Innovative financing instruments include: land leases, land exchanges, ‘bonusing’ incentives, and value capture. These are in addition to standard private sources such as grants, insurance/re-insurance, securitization, performance contracts, custom debt instruments, equity, guarantees, and loans (Brugmann 2012; pp. 224-5).

Credit (business loans) is one alternative, but it is not unusual to only find it available from private sources at higher than market interest rates, given the desperation of borrowers in post-disaster situations. Moreover, unless appropriately devised, this instrument can lead to moral hazard, thereby exacerbating losses. Clearly, there is a role for government provision or regulation of credit in these situations. For example, where micro credit falls short, some Latin American countries have developed public-private partnerships for what is called an Emergency Liquidity Facility.

Securitization is an approach where a stable and predictable revenue stream exists. It essentially represents a claim on these future earnings and can be sold to obtain capital at the beginning of the earnings stream. This is a popular private sector instrument, and the revenue stream could be diverted for DRM, or the instrument used more explicitly to fund DRM investments

Another major approach is insurance. In the business sphere this is a valuable contributor because the outright absorption of catastrophic losses would lead to the demise of all but the largest and strongest enterprises. The disaster insurance business itself is in an especially precarious position given the magnitude and geographic concentration of claims, and typically requires a safety net of its own in the form of re-insurance or government backing. Covered losses are still only a fraction of total property and casualty losses from disasters—nearly fifty percent on average in a country like the U.S., but a very low percentage in developing countries. One attribute of insurance that can be of immense help is the actuarial information that it provides in assessing risk. In this sense, insurance agents can serve as effective risk messengers.

Another type of insurance can also play an important role, though its prevalence today has been confined primarily to industrialized countries. This is ordinary business interruption insurance, which covers lost profits when a business cannot operate due to damage to its own facility, or contingent business interruption insurance, where the business is unable to operate because one of its suppliers (including utility lifelines) or employee access are disrupted. This form of insurance provides working capital needed to purchase inventory for re-sale or inputs for production, over and above the standard property and casualty insurance policies, which cover repair and reconstruction.

A related instrument, sometimes referred to as “quasi-insurance”, is the catastrophe (CAT) bond. This is used to spread extreme risks, whereby investors receive a premium in exchange for the bonds, but forfeit the principle if a disaster strikes. Bond revenues represent a source of private capital that can be used for mitigation or building resilience capacity instead of after-the-fact recovery and reconstruction. Obviously, the upfront use of funds has a great deal of merit but has been underutilized. CAT bonds are increasingly being used by local government authorities, but could also be adopted by the private sector (Michel-Kerjan et al. 2011).

Various other refinements of insurance products, as well as successful real world examples, are discussed in Swiss Re (2011). Also, insurance, through rate-reduction incentives, represents one of the most successful ways of promoting mitigation. Still, there is a long history of under-adoption of insurance (Kunreuther et al. 1978), although lessons learned and research innovations are helping to improve design (Kunreuther et al. 2013). For example, Kunreuther and Michel-Kerjan (2010) have

proposed combining multi-year property insurance with loans to promote mitigation that can reduce premiums.

The investment industry is likely to find various co-benefits of DRM appealing if they can be quantified. This includes bond-rating companies who seek to reflect asset risk in relation to the ability of bond issuers to make payments. It also includes investment companies, and mutual, hedge and pension funds and others that have a long-term fiduciary responsibility to protect investments (MMC, 2015).

Businesses require more sophisticated approaches than the familial or community safety nets upon which households rely. In addition to the alternatives mentioned above, some businesses have recourse in the case of multi-plant enterprises and multi-nationals to broader company funds. Here reinvestment in repair and reconstruction can be based on pure profitability considerations without constraint, and, of course, consideration of co-benefits makes this all the more likely. Still, there is possibility of gaming the system and holding back with the hope that government or donors will provide the necessary funds.

7.2. Regulation and Government Incentives

Regulation is likely necessary in risk financing for several reasons, mainly guarding against exploitation of the vulnerable. This applies to capping loan rates, setting insurance rates and promoting good faith adjudication of claims. Government can also promote the adoption of these instruments through improved risk communication, including consideration of co-benefits. Swiss Re (2011), for example, views government (and NGOs) as valuable partners to the insurance industry. Among roles it can perform are: setting rules, sponsors for insurance markets, re-insurance suppliers/backers, and reinsurance purchasers. Also, an insurance mandate is one of the most powerful ways to generate the co-benefits of avoiding adverse selection and to cross-subsidizing insurance.

As noted above, various types of subsidies might be warranted to induce the private sector to take on DRM that benefits the broader community, with the subsidy being set at the level needed to bring about the socially optimal (additional) level of DRM. Tax breaks have been very effective at doing so in the area of energy conservation in many countries, and this approach holds promise for DRM. In fact there is the possibility to tie some energy-related aspects of DRM to these existing tax reduction incentives.

Penalties can also be used to discourage behavior that increase risk, such as locating in hazard-prone areas, placing undue burdens on infrastructure and releasing toxic materials. One approach to funding DRM stems from charging for negative externalities. This has become more prevalent with greater identification and measurement of their damages. Examples include utility price “adders”, pollution taxes and the auctioning of tradable emission permits. In the latter two cases, the revenues can be used by the government to promote worthy goals, including the mitigation of the negative externalities in the first place, and promoting economic equity, as in providing tax relief or in-kind or cash transfers for those most adversely affected, especially lower-income groups (see, e.g., Rose, 2009b).

A final consideration is private sector preemption of regulation. In the face of pressure, businesses often choose to “self-regulate.” A prime example of this is the electric utility industry in the U.S. and Canada establishing the North American Electricity Reliability Council (NAERC) in the aftermath of the

1967 New York Blackout and the impending federal actions over concern about the reliability of electricity service provision. Other examples are self-reporting of pollution emissions and green labeling so as to ward off government imposed requirements that would be more stringent. In our case, it pertains to businesses taking into account positive and negative co-benefits of DRM.

7.3. Broader Approaches

Long-run considerations have been increasingly incorporated into decision-making relating to business environmental management decisions now for decades, and more recently have been integrated into sustainable planning. In the US, in more than 300 Standard and Poor's 500 Stock Exchange Index businesses report their greenhouse gas emissions. The Brazilian firm Natura chooses suppliers on the basis of economic, social and environmental performance. Alcoa bases 20% of its executive compensation to progress on sustainability (Perera et al., 2013). Moreover, NGOs, such as the World Resources Institute, have worked with the private sector to evaluate and improve environmental performance. These initiatives in the environmental area could be extended to DRM, especially in light of recent findings in general and risk management. A survey by EIU (2007) found that protecting and enhancing the firm's reputation was ranked even higher than preventing financial loss. Still, terrorism and natural weather events ranked 8th and 9th as the most important external drivers of improvements and risk management in the EIU survey of firms. The study found that the major hindrance to action in DRM was the difficulty in measuring its benefits, a finding that makes improving measurement all the more important in promoting DRM.

Liability considerations in the environmental area already have overlaps with DRM. In 1990, the Chairman and CEO of Bank of America formed an environmental task force in response to increased shareholder interest in such issues. The move was also in response to the fact that, since the 1980s, courts in the U.S. were holding lending institutions liable for contaminated properties. At the same time, the move was viewed as an opportunity to enhance the company's competitive advantage (Lawrence, 2001).

Another broader perspective is to make disaster resilience, including co-benefits, an integral part of asset management in business and community operations (MMC, 2015). Of course it takes time to institutionalize such advances but increasing the awareness of DRM co-benefits can help.

A new "layered" analytical approach to risk framing distinguishes major categories to improve the targeting of DRM. Linerooth-Bayer and Hochrainer-Stigler (2015) describe three layers:

1. Frequent but low consequence events. Here risk reduction is often cost-effective.
2. Rare but high consequence events. Here risk finance is usually most appropriate.
3. "Beyond adaptation." This refers to the realization that some risks, especially those associated with the specter of climate change, are so great as to defy risk management from either a technical or economic liability standpoint. Hence, government or donor aid is warranted. There is also the implication that some future disasters may be even beyond these capacities.

Brugmann (2011, 2012) promotes a holistic approach that integrates climate change adaptation and other DRM-related objectives into broader sustainability planning, taking account of the many interdependencies in urban areas. The specter of severe damage from climate change and the shift in focus to adaptation has resulted in a reframing of the financing for DRM. Brugmann (2012) characterizes this as a shift away from disaster risk reduction as the end goal to a sustainable development focus on financing the performance of urban assets, areas and systems. He refers to resilience as “an urban design and investment metric that measures the ability of urban areas and their individual assets to perform for users and their investors under a wide range of conditions” (pp. 215). He goes on to relate performance to predictable cash flows. This provides “business logic” to attract private investment.

It is well known that the riskiest urban places manage to attract investment. However, most analysts believe public investment is not up to the task of mitigating the increasing risks on the horizon. Brugmann proposes the solution as leveraging funds for capacity building and internalizing the downsides of future development so that vulnerabilities become *investment opportunities*.

Brugmann (2012) also notes that his “resilience upgrading” concept alters investment strategy from an international project finance approach to a more diversified and leveraged approach in a market context by incorporating a “value proposition” at the outset, which is thus a better able to capture private investment. He refers to this as “mainstreaming” DRM and sustainability investments into development planning, which he claims have relatively lower risk than special-purpose investments. (Green buildings are offered as a major example of an investment category that has been mainstreamed through performance contracts that have resulted in demonstrations of more stable and higher returns on investment.)

Brugmann suggests that the broader development context is best addressed by identifying the best mix of financing from among private sector, local governments and international sources. The best procurement strategy for investment is suggested to be managed but competitive sourcing. This comprehensive approach is best coordinated by the agent that can promote the orderly flow of financial traffic for those portions that yield private returns and that can serve as the custodian for the public goods and common property resource aspects.

7.4 Imperatives

Climate change poses serious challenges because of the difficulty of evaluating the risk of new and distant threats. Surminski (2010) has summarized efforts by insurers, mainly in industrialized countries, to finance mitigation strategies in this context. Linerooth-Bayer and Hochrainer-Stigler (2014) note that most of these attempts have been ad hoc and mainly in the form of improved risk communication at the micro level. They encourage new approaches, including loss modeling to improve economic assessments.

Additions to the current level of DRM, especially in developing countries, are imperative. At present, losses are often absorbed by governments or donor institutions, whose coffers will be even more strained as disaster losses increase (under business as usual projections). Stronger efforts are needed to

promote DRM in the form of mitigation, preparedness, post-disaster resilience, and long-term adaptation. Other approaches are needed as well, such as the increased transfer of risk to capital markets. Risk finance and risk reduction are not necessarily mutually inclusive, and it is important to capitalize on the complementarities between these two strategies.

Unfortunately, DRM will have to be undertaken in the context of a new reality in many countries of Europe, the US, and Japan, where aging populations are slowing growth of their economies and government tax revenues (Pisano and Callahan, 2012). This has inspired a trend among local public officials to link fiscal and environmental decisions, which has essentially made officials in several instances more crisis and sustainability conscious, thereby promoting the consideration of longer planning horizons (Callahan and Pisano, 2014). It has also resulted in formulating environmental sustainability planning in a manner that demonstrates its worthiness in terms of performance, including considerations of return on investment. Callahan and Pisano (2014) emphasized the need to develop a constituency for fiscal sustainability as has been done for its environmental counterpart. Means to this end are improved communication with beneficiaries, including identification of what we have referred to as co-benefits. It would also extend to training to increase capacity to value DRM benefits and to identify and evaluate actions to promote it.

The presence of co-benefits helps to justify various types of expenditures on DRM at several levels. Those co-benefits internal to the firm can be counted as part of broader set of returns on investment. Those external to the firm can be addressed in several ways. One is collective action by parties that are benefited. Governments can play a role here in coordinating efforts and subsidizing some part of the DRM for the common good. Even areas of risk finance, specifically with respect to governments or private donors providing assistance, can be rationalized by the existence of co-benefits. What is often considered bailing out individual businesses is justified in part because of the broader contributions to such objectives as economic stability, growth, and sustainability.

8. Conclusion

Co-benefits refer to DRM investment outcomes other than those intended to directly lower risk from disaster. Most businesses maximize short-term profits and will only invest in the amounts and manner of DRM that promotes this goal. More enlightened firms have broader goals, such as maximizing long-run profits, and this may make them more likely to spend more on DRM. However, businesses often do not even invest sufficiently in DRM to maximize either short-or long-run profits due to endemic problems, such as the “principal-agent” situation of large firms, in which the motives of managers differ from those of owners.

There are several categories of co-benefits:

- *Benefits to the business undertaking the investments:*
- *Benefits to other businesses interacting with the firms undertaking the investment*
- *Benefits to the general business climate*

- *Benefits to society.*

Co-benefits of DRM offer several attractive rewards to businesses. Some of these co-benefits are more certain, tangible and immediate than the intended direct benefits of mitigation, which may never materialize if the disaster does not take place. Some of the co-benefits are consistent with a no-regrets strategy in that they yield cost-savings irrespective of whether a disaster strikes. Some DRM investments provide protection against several hazards in addition to those that are the main focus. Others contribute to shared growth of the economy and to broader social benefits. Some represent the payment for unpriced services, such as the environment; these payments enhance the reputation of businesses and can thus serve to increase long-run profits.

This paper has presented the case for private sector consideration of the co-benefits of disaster risk management. We have elucidated the co-benefits of private DRM and explained conditions under which they are and are not considered. We also examined the relationship between private sector and public sector aspects of the issue. We explained how broadening the picture of resilience as an important contributor to sustainable development would help identify additional co-benefits and would provide a decision-making framework in which they would be more fully appreciated. We also established the basis for formulating incentives and other means of pursuing DRM goals within the private sector beyond its pursuit of more narrow goals.

Co-benefits of DRM would seem to be subservient to direct benefits, especially in the private sector decision-making process. However, neither the direct benefits nor the co-benefits of DRM typically result in revenue flows, and thus are both relegated to lesser importance than investments impacting increases in sales revenue (or decreases in production costs). Thus, it would help to estimate co-benefits in monetary terms, so they can be viewed in the light that most businesses understand.

Of course, some DRM actions result in adverse co-benefits, which need to be acknowledged, and which should be reduced, especially where it is cost-effective to do so. Private firms will undertake such calculations to the boundaries of their self-interest in the face of competitive pressures, while government entities must often be required to do so. Fortunately, most economic/environmental impact assessments require consideration of co-benefits, both positive and negative, for both private and public sector entities.

Interestingly, many co-benefits, because they are widely dispersed, could help bring about a broader swath of popular support. One problem that needs to be kept in mind, however, is negative co-benefits (typically negative externalities), which may also be widely distributed, and where efforts to reduce the negative impacts among various groups may be decided on the basis of political influence rather than economic merit.

In general, compliance with policy objectives, including DRM, is likely to be greater where there is more flexibility and freedom of choice. Thus most policy analysts and most business leaders emphasize incentives in contrast to regulations. When regulations are necessary, they favor performance-based requirements, which focus on the end goal, rather than procedural requirements, which focus on specific action.

The post-disaster phase, for which we have reserved the term resilience, is especially critical for businesses in relation to their survival. This is a strong inducement for them to operate efficiently and recover quickly (recall our static and dynamic economic definitions of resilience). However, this does pose some problems for broader perspectives on DRM. Businesses are likely to be especially inward-looking and short-sighted during recovery out of what they perceive as necessity. Longer-term considerations and broader societal benefits may be pushed aside. Co-benefits are less likely to fit into their decision-making process at this stage. Moreover, even longer-term opportunities to reduce their vulnerability through enhanced mitigation and the building of resilience capacity ahead of the next disaster will likely be considered of secondary importance. This may signal an even stronger need for government involvement in DRM at this stage to identify and help induce investments in the best long-term interests of society as a whole.

Incentivization of DRM for the private sector faces some serious obstacles. Disaster risk is a relatively minor consideration in many areas, such as construction loans, though it is a larger consideration for property appraisal. Insurance policies are property-specific and do not consider the condition of the community in its entirety, which reaps the greater share of co-benefits. Also, insurance premiums are such a small percentage of business costs that it is easy to overlook an even smaller incentive rate reduction. At the same time, globalization has led to even greater competitive pressures to consider all benefits, as well as costs, and has led to greater capital mobility, which has increased pressure to reduce investment risk.

Unfortunately, examples of private sector consideration of a comprehensive set of the co-benefits of disaster risk management are limited. It is hoped this paper will help identify opportunities, as well as obstacles and ways to overcome them, to take co-benefits into account in private sector investment decisions on DRM. In addition, it is intended to provide insight into ways policy makers can facilitate private sector actions by removing obstacles and providing incentives.

Acknowledgements

The author is Research Professor in the Price School of Public Policy at the University of Southern California and Faculty Affiliate of USC's Center for Risk and Economic Analysis of Terrorism Events (CREATE). He wishes to acknowledge the helpful suggestions of Swenja Surminski, Philip Schneider, Adrien Vogt-Schilb, and Marianne Fay on earlier drafts of this paper.

References

Aragón-Correa, J. Alberto and Sharma, Sanjay. 2003. "A Contingent Resource-Based View of Proactive Corporate Environmental Strategy." *Academy of Management Review* 28(1): 71–88.

Brugmann, Jeb. 2011. *Financing the Resilient City: A Demand-driven Approach to Development, Disaster Reduction and Climate Adaptation – An ICLEI White Paper*, ICLEI Global Report, Bonn, Germany.

Brugmann, Jeb. 2012. "Financing the Resilient City," *Environment and Urbanization* 24(1): 215–32.

Callahan, Richard F. and Pisano, Mark. 2014. "Aligning Fiscal and Environmental Sustainability." In *Elgar Companion to Sustainable Cities: Strategies, Methods and Outlook*, edited by Daniel A. Mazmanian and Hilda Blanco, 154–165. Cheltenham, UK: Edward Elgar.

Carrera, Alejandro, Mesquita, Luiz, Perkins, Guillermo, and Vassolo, Roberto. 2003. "Business Groups and their Corporate Strategies on the Argentine Roller Coaster Competitive and Anti-Competitive Shocks." *Academy of Management Executive* 17(3): 32–44.

Coase, Ronald. H. 1960. "The Problem of Social Cost," *Journal of Law and Economics* 3: 1–44.

Doh, Jonathan P. and Pearce, John A. 2004. "Corporate Entrepreneurship and Real Options in Transitional Policy Environments: Theory Development." *Journal of Management Studies* 41(4): 645–64.

Economist Intelligence Unit. 2007. *Best Practice in Risk Management: A Function Comes of Age*. London: The Economist.

European Commission, Research Directorate General. 2014. *World Input-Output Database: National Input-Output Tables*. <http://www.wiod.org>.

Field, C. B. 2012. *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Summary for Policymakers: a Report of Working Groups I and II of the IPCC*. Published for the Intergovernmental Panel on Climate Change.

Flores, Alejandro Quiroz and Smith, Alastair. 2010. *Surviving Disasters*. Wilf Family Department of Politics, New York University.

Flynn, Stephen E. 2008. "America the Resilient: Defying Terrorism and Mitigating Natural Disasters." *Foreign Affairs* 87(2): 2–8.

Girgenzer, Gerd and Selten, Reinhard, eds. 2002. *Bounded Rationality: The Adaptive Toolbox*. Cambridge: MIT Press.

Hallegatte, Stéphane. 2008. "An Adaptive Regional Input-Output Model and its Application to the Assessment of the Economic Cost of Katrina." *Risk Analysis* 28(3): 779–97.

Hallegatte, Stéphane and Przyluski, Valentin. 2010. "The Economics of Natural Disasters: Concepts and Methods." Policy Research Working Paper 5507. Washington, DC: World Bank.

Hallegatte, S., Bangalore, M., and Jouanjean, M-A. 2016. "Higher Losses and Slower Development in the Absence of Disaster Risk Management Investments"

Hoffmann, Volker H., Trautmann, Thomas, and Hamprecht, Jens. 2009. "Regulatory Uncertainty: A Reason to Postpone Investments? Not Necessarily." *Journal of Management Studies* 46(7): 645–64.

Institute for Business and Home Safety (IBHS). 2015. FORTIFIED Program. <http://www.smarthomeamerica.org>.

- IPCC. 2014. *Fifth Assessment Report (AR5)*. Geneva, Switzerland.
- Kajitani, Yoshio and Tatano, Hirokazu. 2009. "Estimation of Lifeline Resilience Factors Based on Surveys of Japanese Industries." *Earthquake Spectra* 25(4): 755–776.
- Kousky, Carolyn. 2012. "Informing Climate Adaptation: A Review of the Economic Costs of Natural Disasters, Their Determinants, and Risk Reduction Options." Washington, DC: Resources for the Future.
- Kull, Daniel, Mechler, Reinhard, and Hochrainer-Stigler, Stefan. 2013. "Probabilistic Cost-Benefit Analysis Of Disaster Risk Management In A Development Context." *Disasters* 37(3): 374–400.
- Kunreuther, Howard. 2006. "Disaster Mitigation and Insurance: Learning from Katrina," *Annals of the American Academy of Political and Social Science* 604: 208–27.
- Kunreuther, Howard and Michel-Kerjan, Erwann. 2010. "From Market to Government Failure in Insuring U.S. Natural Catastrophes: How Can Long-Term Contracts Help." In *Private Markets and Public Insurance Programs*, edited by Jeffrey R. Brown. Washington, DC: American Enterprise Institute Press.
- Kunreuther, Howard, Michel-Kerjan, Erwann, and Pauly, Mark. 2013. "Making America More Resilient Toward Natural Disasters: A Call for Action." *Environment* 55(4): 15-23.
- Kunreuther, Howard, Meyer, Robert, and Michel-Kerjan, Erwann. 2014. "Strategies For Better Protection Against Catastrophic Risks," In *Behavioral Foundations of Policy*, edited by Eldar Shafir. Princeton, NJ: Princeton University Press.
- Kunreuther, Howard, Ginsberg, Ralph, Miller, Lawrence, Sagi, Phillip, Slovic, Paul, Borkan, B., and Katz, Nancy. 1978. *Disaster Insurance Protection: Public Policy Lessons*. New York: Wiley Interscience.
- Lawrence, Anne T. 2001. "The Emergence of Conservation Banking in Southern California." In *Ahead of the Curve: Cases of Innovation in Environmental Management*, edited by Ken Green, Peter Groenewegen, and Peter S. Hofman, 93–105. Dordrecht: Kluwer.
- Linnerooth-Bayer, Joanne and Hochrainer-Stigler, Stefan. 2015. "Financial Instruments For Disaster Risk Management And Climate Change Adaptation." *Climatic Change*, forthcoming.
- Mechler, Reinhard. 2005. *Cost-Benefit Analysis of Natural Disaster Risk Management in Developing Countries*. Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ).
- Mechler, Reinhard and Bouwer, Laurens M. 2015. "Understanding Trends And Projections Of Disaster Losses And Climate Change: Is Vulnerability The Missing Link?" *Climatic Change*, forthcoming.
- Multihazard Mitigation Council (MMC). 2005. *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*. Report to U.S. Congress on behalf of the National Institute of Building Sciences, Washington, DC.
- Multihazard Mitigation Council (MMC). 2015. "Multihazard Mitigation Council Approach to Resilience Incentives." Washington, DC.

(ODI) Overseas Development Institute. 2014. "Case Studies to Support *Realising the Resilience Dividend*, Climate and Environment Programme, ODI, London, UK.

Perera, Alex, De Pino, Samantha Putt, and Oliveira, Barbara. 2013. "Aligning Profit and Environmental Sustainability: Stories from Industry." World Resources Institute Working Paper. Washington, DC.

Pisano, Mark and Callahan, Richard F. 2012. "Case Study I: Fiscal Sustainability in Los Angeles County." *National Civic Review* 101(1): 11–17.

Rose, Adam. 2004a. "Economic Principles, Issues, and Research Priorities in Natural Hazard Loss Estimation." In *Modeling the Spatial Economic Impacts of Natural Hazards*, Yasuhide Okuyama and Stephanie Chang, 13–36. Heidelberg: Springer.

Rose, Adam. 2004b. "Defining and Measuring Economic Resilience to Disasters." *Disaster Prevention and Management*, 13(4): 307–14.

Rose, Adam. 2009a. *Economic Resilience to Disasters*. CARRI Research Report #8. ORNL.

Rose, Adam. 2009b. *The Economics of Climate Change Mitigation Policy: International, National and Regional Perspectives*. Cheltenham, UK: Edward Elgar.

Rose, Adam. 2014. "Economic Resilience and the Sustainability of Cities in the Face of Climate Change: An Ecological Economics Framework," In *Handbook of Sustainable Cities*, edited by Daniel A. Mazmanian and Hilda Blanco. Cheltenham, UK: Edward Elgar.

Rose, Adam. 2015. "Macroeconomic Consequences of Terrorist Attacks: Estimation for the Analysis of Policies and Rules." In *Benefit Transfer for the Analysis of DHS Policies and Rules*, edited by Carol Mansfield and V. Kerry. Cheltenham, UK: Edward Elgar.

Rose, Adam and Krausmann, Elisabeth. 2013. "An Economic Framework for the Development of a Resilience Index for Business Recovery." *International Journal of Disaster Risk Reduction* 5(September): 73–83.

Rose, Adam and Kustra, Tyler. 2013. "Economic Considerations in Designing Emergency Management Institutions and Policies for Transboundary Disasters." *Public Management Review* (15)3: 446–64.

Rose, Adam and Lim, Dongsoon. 2002 "Business Interruption Losses from Natural Hazards: Conceptual and Methodological Issues in the Case of the Northridge Earthquake." *Environmental Hazards: Human and Policy Dimensions* 4(1): 1–14.

Rose, Adam and Wei, Dan. 2013. "Estimating the Economic Consequences of a Port Shutdown: The Special Role of Resilience." *Economic Systems Research* 25(2): 212–32.

Rose, Adam, Avetisyan, Misak, and Chatterjee, Samrat. 2014. "A Framework for Analyzing the Economic Tradeoffs between Urban Commerce and Security." *Risk Analysis* 14(8): 1554–79.

Rose, Adam, Oladosu, Gbadebo, and Liao, Shu-Yi. 2007a. "Business Interruption Impacts of a Terrorist Attack on the Electric Power System of Los Angeles: Customer Resilience to a Total Blackout." *Risk Analysis* 27(3): 13–31.

Rose, Adam, Stevens, Brandt, and Davis, Gregg. 1989. "Who Gains and Who Loses from Natural Resource Policy: Distributional Information and the Public Participation Process." *Resources Policy* 15(4): 282–291.

Rose, Adam, Oladosu, Gbadebo, Lee, Bumsoo, and Beeler Asay, Garrett. 2009. "The Economic Impacts of the 2001 Terrorist Attacks on the World Trade Center: A Computable General Equilibrium Analysis." *Peace Economics, Peace Science, and Public Policy* 15(2): Article 6.

Rose, Adam, Porter, Keith, Tierney, Kathleen, et al. 2007b. "Benefit-Cost Analysis of FEMA Hazard Mitigation Grant." *Natural Hazards Review* 8(4): 97–111.

Sheffi, Yossi. 2005. *The Resilient Enterprise*. Cambridge, MA: MIT Press.

Surminski, Swenja. 2010. "Adapting to the extreme weather impacts of climate change—how can the insurance industry help?" *Climate Wise*.

Swiss Re. 2011. *Closing the Financial Gap: New Partnerships between the Public and Private Sectors to Finance Disaster Risks*. Zürich, Switzerland.

Swiss Re. 2012. *Microinsurance—Risk Protection for 4 Billion People*. Zürich, Switzerland.

U.S. Global Change Research Program (USGCRP). 2014. *National Climate Assessment*. Washington, DC. <http://nca2014.globalchange.gov/report>.

Vorhies, Francis. 2012. "The Economics of Investing in Disaster Risk Reduction." Working paper based on a review of the current literature commissioned by the Secretariat to the UN International Strategy for Disaster Reduction (UNISDR), Geneva.

Weimer, David L. and Vining, Aidan. 2005. *Policy Analysis: Concepts and Practice* (4th ed.). Upper Saddle River, NJ: Pearson.

Wein, Anne, and Rose, Adam. 2011. "Economic Resilience." *Earthquake Spectra: Special Issue on the ShakeOut Earthquake Scenario* 27(2): 559-73.