

**Toward A New Risk Architecture:
Welcome to Risk Management 2.0**

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Toward A New Risk Architecture: Welcome to Risk Management 2.0

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Essay in honor of Howard Kunreuther

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“Although disasters of various sorts are part of our everyday life, even if only vicariously, little empirical and theoretical work has been done by economists on the long-run recovery problems arising out of these events. This is unfortunate because the cost of unexpected catastrophes and the problems they have created have increased in recent years and threaten to get even further out of hand unless some basic policy changes are undertaken.”

Howard Kunreuther – 1968

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In the last decade, natural disasters claimed on average each year 80,000 lives and \$70 billion in damages.

It was \$9 billion in the 1960s, \$16 billion in the 1970s and \$22 billion in the 1980s.

“According to experts, disasters will become even more frequent and their impact more severe, expecting a 5-fold global cost increase over the next 50 years, mainly due to climate change and a further concentration of the world's population in vulnerable habitats.”

Sources: OECD – 2008

As recently as few years ago, few world leaders or thinkers would have pegged for the accelerating rhythm of large-scale catastrophes as one of the biggest economic challenges in the foreseeable future. But one of the hallmarks of this new century will be more and more such unthinkable events, previously unseen contexts, and pressure for individuals, private companies and government authorities to react extremely quickly, even when they cannot predict the cascading impact their actions will have.

Don't think only financial crisis, but also food and energy security, intercontinental pandemics, mega-terrorism and new war type; think worldwide global warming and large-scale natural disasters, to name a few. There will be more of these as well as brand new ones in the future. This poses a real challenge: dealing with an average of one or two such catastrophes every 20 years is one thing; dealing with 10 or 15 on many different fronts, as is currently occurring, is a whole different game.

One figure is particularly eye opening: If you consider the twenty most costly insured catastrophes in the world during the past thirty-eight years (1970-2007), all of them occurred after 1987 (in 2007 prices, corrected for inflation, so you can compare apples to apples). Further, among these twenty events, half of them have occurred since 2001, nine of them here in the United States. It's no wonder that new business opportunities around catastrophes are proliferating. The volume of insurance-linked securities, for example, has tripled over the last two years.

I predict that this trend toward more catastrophes will continue, in large part because of hyper-concentration of population/value in high risk areas, climate change and because globalization is making the world much more interconnected than ever before. It will continue also unless one starts to balance short-term rewards and long-term sustainability. The current financial disaster is just the latest –and perhaps most devastating– illustration of incredible consequences of myopic behaviors.

Managing and Financing Extreme Events: A New Era Calls for a New Model

The conference organized at the Wharton School of the University of Pennsylvania on The Irrational Economist, combines the contributions from many complementary fields pertaining to the economics of catastrophes and decision making under uncertainty. I spent the last ten years conducting research on managing and financing extreme events, with a specific focus on financial coverage of catastrophes (natural disaster and terrorism insurance, new financial instruments, and more generally how private action can reduce public vulnerability). In this short paper, I would like to step back for a moment and make a broad proposition – that in order to do a better job at preventing all sort of future disasters, there is an urgent need to better understand the new risk architecture.

In many ways, the catastrophe risk management field is actually at a crossroads today, as we are faced with disasters of a totally new nature and scale. And while much more research has been done to better understand disasters in past decade, there have been recent important events that have seriously challenged the established paradigm.

Not very long ago, disasters were considered to be low probability events because they did not occur often. In a sense, that assumption was very reassuring for the economist: the expected losses of these disasters (understand here, the potential loss associated with a disaster multiplies by the probability of that event occurring) was often relatively low. But in the first few years of the 21st century, the world has faced a string of catastrophes of a totally new dimension. In fact, there has not been a 6-month period in the past few years without a major crisis that simultaneously affected several countries or industry sectors. In the terrorist attacks of 9/11, a superpower was challenged on its own soil in an unprecedented

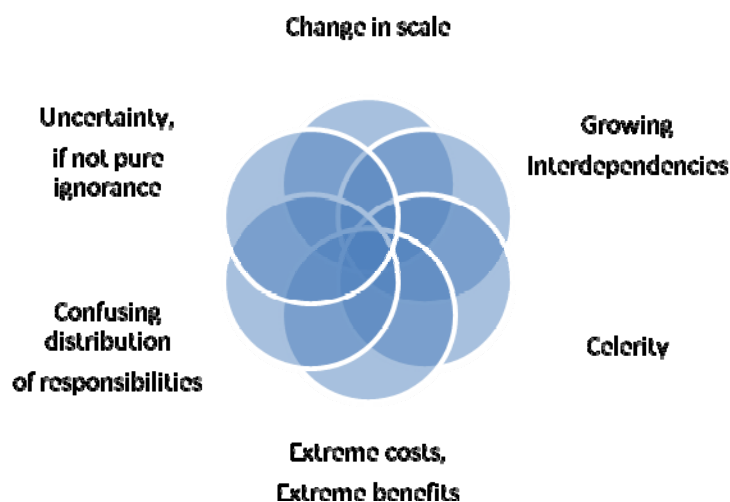
way. After 9/11, the reality of international terrorism became clear, and national security took first priority on the U.S. agenda. The event has had an enduring impact on the rest of the world as well. Hurricane Katrina, a violent but long-anticipated hurricane, overwhelmed a vulnerable coastline, met an unprepared government and inflicted lasting damage on a population. A superpower fails to meet the most basic needs of its citizens in crisis (White House, 2006). In the case of the U.S.-Canada blackout, a massive failure of the electric power-distribution system demonstrates how human error and short-term competitive pressure resulting in poor risk management can jeopardize our critical infrastructures; a 10-second event. The December 2004 tsunami was responsible for the deaths of nearly 300,000 people in just a few hours due to lack of an alert system, although in this case, the economic impact was mostly local. More recently, the major earthquake in the Sichuan province in China in Mai 2008 killed nearly 50,000, just a few weeks after a major cyclone killed over 100,000 in Myanmar.

The severity of these events demonstrates that the world is changing, and that we have entered a new era. On many critical points relating to extreme-event preparedness, the conventional thinking is wrong. Conventional thinking holds that risks are mainly local and routine; that it is possible to list all untoward events that could happen, determine their probability based on past experience, measure the costs and benefits of specific risk protection measures and implement these measures for each risk. Many organizations and governments are making decisions using risk and crisis management tools based on these outdated assumptions. As a result, these organizations do not have the agility needed to move quickly to respond to unplanned events and global risks that have occurred at an increasing rate in the recent past. Their failure to adequately prepare impacts not only them, but also a number of other interconnected organizations.

A New Risk Architecture Is Still to Be Defined

The aforementioned extreme events all seem quite different – different types of catastrophes, different countries, and different impacts on the rest of the world. But if we give a closer look it is possible to see that these events are somehow related in the sense that they define a new pattern. And this is why there a need for a new risk management architecture. Below I would like to offer a view of six defining features of this new architecture, as depicted in Figure 1: a radical change in scale of these risks from local to global risks, extreme costs and benefits to be made, growing interdependencies, celerity, a somewhat confusing redistribution of the role of the public and private sectors, and finally, as the result of all of that, a challenge in quantifying risks. Given space constraints I will discuss some more than others.

Figure 1. Six Key Features of The New Risk Architecture



Feature 1. Extreme Costs, Extreme Benefits: The new risk architecture is first and foremost characterized by a much wider variance in possible losses and gains. The recent events in the United States have translated into unprecedented economic consequences. Given the hundreds of billions of dollars of economic losses due to catastrophes that occurred in the United States since 2001, it might be difficult to imagine that when Hurricane Hugo hit the country in 1989, it was the first catastrophe to inflict more than \$1 billion of insured losses. But times have changed. Hurricane Katrina in 2005 killed 1,300 people and forced 1.5 million people to evacuate the affected area – a historic record for the nation. Economic damages are estimated in the range of \$150 billion, a third of which was covered by either private insurance (wind damage, about \$45 billion) or public insurance (flood damage, \$18 billion by the Federal National Flood Insurance Program– another historic record). Federal relief to the victims and for local reconstruction is estimated to be over \$125 billion – yet another historic record.

With increasing urbanization and concentration of social and economic activities in high risks areas, costs of catastrophes will continue to increase. The development of Florida highlights this point. According to the U.S. Bureau of the Census, the population of Florida has increased significantly over the past 50 years: 2.8 million inhabitants in 1950, 6.8 million in 1970, 13 million in 1990, and a projected 19.3 million population in 2010 (almost a 700 percent increase since 1950), increasing the likelihood of severe economic and insured losses, unless cost-effective mitigation measures are implemented. As of December 2007, no less than \$2.4 trillion of insured assets were located on the coasts of Florida alone; if one considers the coasts ranging from Texas to New York, it's more than \$8 trillion. We sit on a ticking bomb. The question is not whether other large-scale catastrophes will occur, but when and how frequently they will strike, and the extent of damage they will cause. (Kunreuther and Michel-Kerjan, 2009).

In that context, a question I have devoted a large part of my research is: who should pay for the economic cost of future disasters and what is the most effective way for a country to provide financial protection to possible victims of these extreme events (people and firms)? This was done on terrorism risks and natural disasters through a series of research papers and books, more than 20 of which were co-authored with Howard.

This brings me to the positive side of this new era of catastrophes: this wider variance in the level of risk also creates new business opportunities. For instance, catastrophe bonds (cat bonds), which are financial instruments transferring catastrophe exposure to investors on the financial markets, quickly developed in the aftermath of the 2005 hurricane season in the U.S. In 2006, twenty cat bonds were issued (\$4.7 billion issued and \$8.7 billion capital outstanding), compared with eleven in 2005 (\$2.1 billion issued and \$2.9 outstanding), the previous record. In 2007, the total value of cat bonds issued for natural disasters alone was \$7.1 billion; 27 transactions were completed, a new record compared with the 10 transactions closed in 2005. (Michel-Kerjan and Morlaye, 2008). Beyond financial instruments, as catastrophe unfold, business should start thinking not only how to protect their assets, but also what new products and services that could develop to create new markets in this new environment.

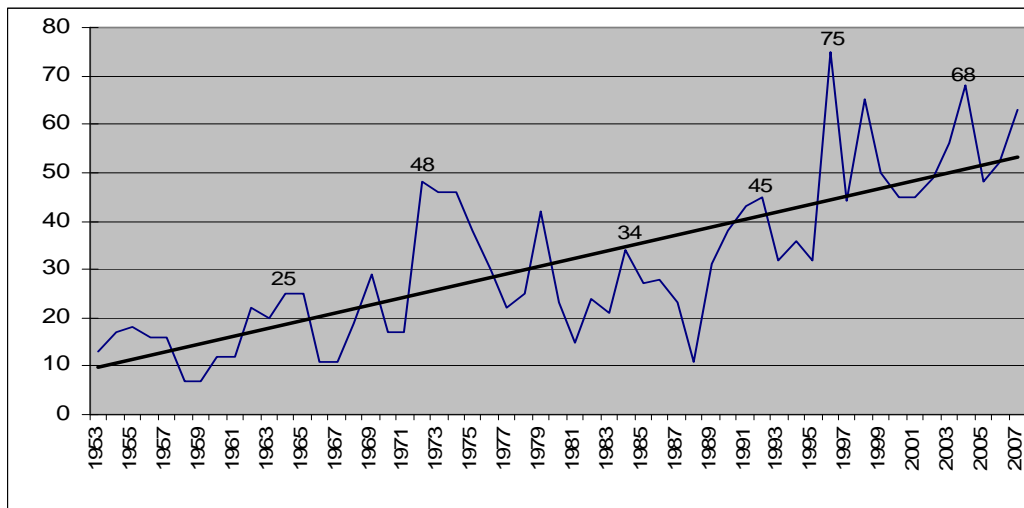
Feature 2. Confusing Distribution of the Roles and Responsibilities of the Public and Private Sectors:

In almost all catastrophes that occurred in the past 10 years, it has been almost impossible to dissociate the economics of catastrophe management from politics, which contributes to a fuzzy distribution of the roles in preparing against future disasters. If one asks people on the street, "Who do you think is in charge of preparing the country against future crises?" the most cited response will certainly be state and federal governments (whether as regulators or first responders). However, although government entities certainly play a crucial role, a large portion of critical services that allow our countries to operate is owned or operated by the private sector (85 percent in the U.S., for example). We must look at how private actions affect public vulnerability so that we are better prepared.

One measure of this confusing distribution of roles lies in the lack of pre-established and publicly known rule as to who should pay what amount to victims of disasters. Under the current U.S. system of disaster assistance, the Governor of the state(s) can request that the President declare a "major disaster" and offer special assistance if the damage is severe enough. Although the President does not determine the amount of aid (the House and Senate do), he is responsible for a crucial step in the process.

The evolution of the number of U.S. presidential disaster declarations over the past 53 years, which shows clearly an upward trend (as depicted in Figure 2), is illustrative. Overall, the number of declarations has dramatically increased over the past 50 years: there had been 162 over the period 1955-1965, 282 over 1966-1975, increasing to 319 over the period 1986-1995 and 545 for 1996-2005 (Michel-Kerjan, 2008). On average, one can say that the average annual number of declarations has increased by 10 every decade since the 1950s. This obviously raises the question of what are the key drivers of such a presidential decision and whether some states are more likely to benefit from such situation than others, and if so, when does this occur?

FIGURE 2. DISASTER PRESIDENTIAL DECLARATIONS PER YEAR
(PEAK-VALUES ON THE GRAPH CORRESPOND TO SOME PRESIDENTIAL ELECTION YEARS)



Sources: Author's calculation with data for the U.S. Department of Homeland Security

Figure 2 also shows that many (although not all) of the peak years correspond to presidential election years. This is consistent with recent research that has shown that election years are a very active time for disaster assistance (all other things being equal). Four salient examples are the Alaska earthquake in 1964 (a Presidential election year), Tropical Storm Agnes in June 1972, Hurricane Andrew in September 1992 and the four hurricanes in 2004. More recently, it has also been shown that a battleground state with 20 electoral votes has received more than twice as many Presidential disaster declarations as a state with only three electoral votes (Reeves, 2004, 2005). Research also shows that a driving force with respect to the actual provision of government relief is the occurrence of disasters where the losses are large (Moss, 2002). The recent massive bailout of Wall Street will have at least one very predictable enduring effect: the Samaritan's dilemma is here to stay... (Buchanan, 1975; Rasky and Schwindt, 2008)¹.

¹ A graphic example comes from the Alaska earthquake of 1964, when the federal government provided low-interest loans to aid the recovery and retired debts from existing mortgages for those who were uninsured. It was not uncommon to hear the few homeowners who did purchase earthquake insurance bemoan their decision because they discovered they would have been better off financially had they not purchased this coverage. (Dacy and Kunreuther, 1969).

Feature 3. Growing Interdependencies – Globalization: This third feature is critical to understand as it comes as a result of a growing globalization of social and economic activities: we are becoming more dependent on each other. While this is not totally new, we have reached a degree of interdependence that no other society has experienced before us: What happens on one continent today can affect those on another continent tomorrow. At the Annual meeting of the World Economic Forum in Davos in 2007 former British Prime Minister Tony Blair stated that “*Interdependency is the defining element of the 21st century.*” (World Economic Forum, 2007). I could not agree more.

For economists, this means that we see the emergence of “*security externalities.*”² This is a topic Howard Kunreuther has researched quite extensively since I have known him. In 2001 when he was on sabbatical at Columbia University and along with Geoff Heal, they have developed since a series of research papers on the concept of interdependent security. This concept implies that failures of a weak link in a connected system could have devastating impacts on all parts of it, and that as a result there may be suboptimal investment in the individual components (Kunreuther and Heal, 2003; Heal and Kunreuther, 2006). Certainly their most illustrating example is the PanAm 103 catastrophe, where an uninspected bag containing a bomb was placed on Malta Airlines at a small unsecured airport in Malta, transferred in Frankfurt to a Pan Am feeder line, and then loaded onto Pan Am 103 in London's Heathrow Airport. The bomb was designed to explode above 28,000 feet, a height normally first attained on this route over the Atlantic Ocean. The plane exploded over Lockerbie, Scotland, killing all 243 passengers and 16 crew members and 11 people on the ground. There was nothing PanAm could have done to prevent the crash, unless it inspected all transferred bags, a costly practice only followed by El Al airlines at that time.

Another example is the August 2003 power failures in the northeastern U.S. and Canada that were caused by a Ohio utility, a weak link in a highly interconnected system. With respect to the 2008 financial crisis, the potential collapse of the American International Group (A.I.G.), the world's largest insurer, was the result of a 377-person London unit known as A.I.G. Financial Products that was run with almost complete autonomy from the parent company. The fall of the consulting company Arthur Andersen, due in part to its Houston branch's activities with Enron, is another corporate example.

Another example was developed in the context of work Howard and I recently did for the World Bank. Consider the problem facing two villages located next to each other, near a river, which exchange goods for their respective production activities. Both villages might want to increase their population and economic base by using land closest to the river, which requires destroying trees and other natural vegetation. In undertaking such development they might increase the risk of flooding for both villages, since replacing soil and vegetation with concrete increases the runoff from rain and storms. In addition, there is no natural barrier anymore to restrain excess water. To reduce the likelihood of future flooding, each village could construct a flood control measure to control this additional flow of water from their new economic developments. Coping with the management challenges of such floods is, however, a very difficult matter, as the interdependencies involved require cooperative activity and monitoring across these two villages in ways that are not captured in the traditional risk assessment and risk management approach where each village is assumed to make its own decision and there are no negative externalities associated with their actions³.

What can be done? In some cases a change of strategy by one agent or a small set of agents can shift the equilibrium radically. This change can be referred as tipping in the sense of Schelling (1978), Katz and Shapiro (1994), and more recently Gladwell (2000). For example, there may be a Nash

² The concept of security externalities has been first introduced in Auerswald et al. (2006)

³ There is an additional challenge related to global risks: interdependencies exist not only across regions and industries but also across *time*. People tend to look for local causes to explain events. There is generally little discussion of the numerous actions taken years before that have little apparent connection to a disaster but can increase risk levels or damages significantly. (Kousky and Zeckhauser, 2006).

equilibrium at which no village (no airline or no department within an organization) invests in protection. Yet if one village changes strategy and invests, then other villages may follow suit.

Heal and Kunreuther (2007) indicate that tipping of equilibria are natural consequences of mutual reinforcement. If there are several equilibria, one of which Pareto dominates, then they show that the inefficient equilibria can be tipped to the efficient one, a result of interest in the context of coordination problems. Tipping requires an initial mover or group of movers who begin the process. Sometimes it may be in their interest to do so. In other cases agents may need an incentive from outside to change strategy and tip the equilibrium. Regulators can use the existence of a tipping set as a way of coordinating on a socially preferable equilibrium. They only have to persuade the members of the tipping set to change, rather than persuading everyone. Tipping can be facilitated by trade associations as well. This was done in the aftermath of the Anthrax crisis with the creation of a global information sharing platform. It was launched so executives could exchange information about the solutions each country is implementing and work out a concerted strategy to deal with future global threats (Lagadec, Michel-Kerjan and Ellis, 2006).

What are the policy and strategy implications in the context of large-scale global risks? Clearly one is that an equilibrium with no investment in self-protection may be converted to one with full investment by persuading a subset of the agents to change their policies. Leadership, either through trade associations and/or through influential firms may convince others of the need to adopt adequate risk management measures. In our above example, if a few villages voluntarily take actions, they could convince others to follow suit and induce tipping in the spirit of Schelling (1978).

Feature 4. Change in Scale – from Local to Global Risks: One of the consequences of these increasing interdependencies is that disasters and crises are likely to affect a higher number of people. Dealing with large-scale disasters is much more challenging than dealing with a series of local small accidents. Many do not appreciate the radical difference. Resources and collaborative effort needed simultaneously are not simply cumulative, but exponential. Furthermore, global response and global reaction capacity are needed. Multinational coordination becomes critical. Another important element is how information is shared on a larger scale and among many more stakeholders whose actions are ultimately likely to affect the level of loss.

Feature 5. Celerity – Toward a Just-in-Time Society: The development of rapid transportation and cheap communication has created a "just-in-time" society. People and products are moving faster and faster from one part of the globe to the other. While this provides a wide range of positive return, there is also a flip side: risks are more likely to spread across very rapidly. Thanks to jet travel, for instance, viruses now fly business class, too, so a pandemic starting in Asia today might very well spread extremely rapidly. The just-in-time society also put pressure on us to make decisions faster than before, without necessarily taking the time to adequately measure the possible effects these actions will have on others and in the long run.

Feature 6. Uncertainty, if not Ignorance: A lot of research has been devoted in the past decades to decision under uncertainty, and many of the pioneers in this field, including Howard, are contributors to the Irrational Economist conference and book writing. I will not discuss this here in more detail given limited space but it is likely that this question will become even more central in the near future.

Indeed, the six features above create an unprecedented environment in which assessing risks becomes more difficult. We were trained to solve problems with clear questions and clear scientific knowledge. Knowing the risk profile, we made investment decisions. But historic data does not shape the future anymore, given how rapidly the world is changing. We move from risk in the sense of Knight to uncertainty, if not dynamic uncertainty or even pure ignorance. This is of course a major challenge.

The Economics of Catastrophes: A Lot Remains to Be Found

While this is a simplified framework, these six complementary features fit a large number of recent crises we all have witnessed in different parts of the world and across industries. It should also help clarify avenues for future research. There is a lot here for economists to contribute.

To take just one example in empirical microeconomics that parallels Howard's seminal work that helped better understand *individual* (lack of) purchase of insurance, one could ask: what do we know about *corporate* demand for insurance? Surprisingly enough, while hundreds of theoretical papers have been written on the subject in the past twenty years, I have not been able to find a single empirical analysis for the U.S. market. So no one really knows what are the drivers for U.S. corporations to buy insurance or not, the price they pay for such product, let alone the price elasticity of demand for insurance.

In order to shed some light to this question, we recently obtained access to the entire portfolio of the largest insurance broker in the world, Marsh, which whom I had already worked to do other terrorism studies. My original plan was to better evaluate the market penetration of terrorism insurance in the United States seven years after the September 11, 2001 terrorist attacks. Based on a sample of over 1,850 large corporations headquartered in the U.S. and across industries, we found several interesting results, not only on terrorism but also on property insurance decisions (Michel-Kerjan, Rasky and Kunreuther, 2008). For instance, on average these firms pay \$4.80 per \$1,000 of property coverage (if you disregard the administrative expenses and cost of capital, this means an implicit probability of 1-in-210) versus \$0.60 per \$1,000 for terrorism insurance (likewise, an implicit probability of 1-in-1700). Furthermore, only 60 percent of these companies bought terrorism insurance; not clear what will happen to the other 40 percent the day after the next large-scale terrorist attacks; losses might be transferred to their shareholders or perhaps they count on federal intervention post crisis; at the light of the recent disasters, this might not be an irrational behavior.

Demand price elasticity was also calculated at a national level and for a sub-sample of firms in the New York metropolitan area. Using different econometric techniques we found that price elasticity for property insurance in New York area was 0.17 versus 0.07 for terrorism insurance in that area; in other words, a 10 percent increase in insurance price will decrease the quantity of property insurance by 1.7 percent and the quantity of terrorism insurance purchased by only 0.7 percent there. This is a very low price elasticity of demand. While there is a New York effect (perception of a higher risk), we still find that demand for terrorism insurance is less price elastic than noncatastrophe demand when we looked at data nationwide⁴. In the coming months we plan to expand our analysis to corporate demand of insurance against other types of catastrophes (e.g. earthquake, flood, hurricanes, etc) so we can better compare it with what we know about residential insurance markets and individual behavior.

Conclusion

The general surprise that came with the series of catastrophes and crises that have unfolded one after another over the past few years – the revolutionary moment in the financial system being the most recent one – reminded me of excerpts of *The Plague*, the famous novel written some 60 years ago by French author, journalist and Nobel laureate Albert Camus: “*There have been as many plagues as wars in history, yet always plagues and wars take people equally by surprise.*”

⁴ These preliminary results are different than Grace, Klein and Kleinförfer (2003), who find evidence that catastrophe demand (mainly hurricane coverage) is *more* price elastic than noncatastrophe demand for *residents* in New York.

In his seminal 1968 paper (actually his first published paper on the economics of disasters), Howard predicted that catastrophes threatened to get even further out of hand unless some basic policy changes are undertaken. Forty years have passed, and it is fair to say that these issues have recently become much more salient than ever.

Still, the number of economists who contribute significantly to the study of catastrophes is extremely limited (Froot, 1999; Moss, 2002, Grace et al., 2003, Auerswald et al., 2006). Maybe this is because this is not an easy field on which to focus an academic career: usual models often do not apply, data are (we hope) limited, etc. But we might very well be at a crossroads today and I will not be surprised to see more economists in the next 10 or 20 years use their skills and imagination to solve catastrophe-related puzzles.

Moreover, business and political history has shown that new world leaders emerge from crisis time as they have ideas that can (and will) reshape the future and make enough people believe in them. A world full of catastrophes and crises simply requires different types of leaders, with a different agenda and also different markets. This defines a new risk architecture I have attempted to characterize in this paper. It might also require a different type of economists.

As the world is becoming more of a small interdependent village, crises that you decide to ignore because they are occurring 5,000 miles away from where you're now reading this paper will certainly have second-order effects on you, very soon. Given this, we might reflect on an irony: that being selfish today means taking care of others.

Or, if you prefer, in Albert Camus' own words: *"until now I always felt a stranger in this town, and that I'd no concern with you people. But now that I've seen what I have seen, I know that I belong here whether I want it or not. This business is everybody's business."*

Welcome to Risk Management 2.0.

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