



Interdependent Disaster Risks The Need for Public-Private Partnerships

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Introduction

Thank you Mr. Hida. It's a real pleasure to be here today to share ideas in the areas of interdependent risks, disaster risks and the need for public/private partnerships. I know that last year's theme was public/private partnerships so in some sense there is continuity between many of the issues that were discussed then and what I will talk about today. I will focus on the issue of catastrophic risk, emergency preparedness and how we deal with disasters, not necessarily a pleasant topic, but one that is extremely important.

I feel it is very relevant to have a meeting like this between people who are concerned with the problems of managing catastrophic risks in Japan and those concerned with these same issues in the United States. This should enable us to deal with common elements between the two cultures. In fact the whole issue of globalization is an important component of many of these decisions and highlights the theme of interdependency.

Let me tell you a little bit about my interest in the management of low probability, high consequence events. As Mr. Hida indicated, Paul Kleindorfer and I are the co-directors of the Wharton Risk Management and Decision Processes Center at the Wharton School, University of Pennsylvania. Since its inception in 1987 the Wharton Risk Center has focused on low probability high consequence events. On the descriptive side we look at the institutional arrangements associated with a particular problem, understanding the decision making process and learning how people deal with information. Based on this knowledge we analyze alternative risk management strategies.

So a lot of the themes that you'll be hearing today and thinking about tomorrow relate to understanding how the real world operates and how we can do a better job of managing it.

I spent the 2001-2 academic year on sabbatical at Columbia University and arrived in New York City one week before September 11, 2001. I am a cyclist and was riding my bicycle along the Hudson River on the morning of September 11th and was listening to music on WQXR when the program was interrupted by an announcement that a small plane had hit the World Trade Center. I was close enough to the 69th Street Pier that I actually rode out to the end of the pier and saw the first World Trade Center (WTC) building in smoke and flames. Of course, at the time I had no idea what really happened and left the pier at 9:01 AM – one minute before the second plane hit the other WTC building.

September 11th changed my life and the research that I have been doing. What I am going to talk to you about today reflects the challenges in dealing with not only terrorism, but extreme events in general. More specifically I will focus on research Geoffrey Heal of Columbia University and I have been undertaking in conjunction with interested scholars and practitioners from a number of universities on issues of interdependency..

Here is an outline of my talk. First I want to characterize a framework that integrates risk assessment and vulnerability analysis with risk perception and risk management. Then I will focus on the issue of interdependency using a game theoretic model for characterizing solutions. Those of you who have read the book or seen the movie *A Beautiful Mind* can now see an application of this approach developed by John Nash to a set of real world problems where there is some chance that one firm/individual can contaminate others by not investing in protection. I will conclude my presentation with a set of questions on risk management strategies.

Interdependency is relevant in a wide variety of problems where there is a potential for a catastrophic loss. I will focus on the earthquake hazard since I know that this is a theme of this meeting. Professor Shiroyama will examine the issue in relation to the Great Hanshin Earthquake in Kobe, Japan in 1995 in the next talk.

A Conceptual Framework

As I just indicated the conceptual framework brings together risk assessment and vulnerability analyses with risk perception and risk management strategies. **Risk assessment and vulnerability analysis** requires data gathered by experts such as scientists, engineers, and practitioners. Unless you can characterize what we know and don't know about the risk, it is going to be very hard to design risk management strategies that will be implemented. One of the challenges in assessing the risk is that you can have many experts, each one with a different view of the world. That can create conflicts between the key interested parties since each stakeholder can find its own favorite expert to defend its position.

We need to have better ways of settling these differences and therefore I would argue that experts need to make their assumptions explicit so we can understand more fully how to model these risks. Statistical data building and scenarios may be very important here. That certainly is the case with terrorism where we have an extraordinarily hard time estimating future risks because we do not know what a terrorist might do next. But it also holds for natural hazards and technological hazards. Experts may want to develop a set of scenarios as to what can happen under a variety of different circumstances and then indicate the likelihood of each of these scenarios occurring.

The second component of the conceptual framework is the **risk perception**. This is a field of research that a group of psychologists led by Paul Slovic and Baruch Fischhoff have been undertaking over the last 30 years. All of us perceive risk of certain events in a particular way based upon our own past experiences, the way we process data, the way we actually interact with other people and learn about their own experiences. Policy analysts need to take into account perceptions of the risk before developing a risk management strategy.

Only in the last five or 10 years has the scientific community recognized that they have to pay attention to the perceptions of the public. Up until that time there was general consensus by experts that the public does not understand the risk. Their attitude was that we, the scientific community, understand the meaning of risk and therefore can figure out the best strategy to pursue for dealing with it. There is now a recognition that it is not just the probability and the consequences that are utilized in a risk assessment. One also has to consider feelings like dread, anxiety and catastrophic potential as factors that enter into people's decisions. Anyone who ever thought about taking a flight soon after September 11th knows the importance of feelings such as fear and dread as important parts of the decision-making process.

When you take into account public perceptions, there will be differences between the expert and the layperson. These have to be recognized and taken into account when developing **risk management strategies**. One of the most basic strategies is to *provide information* to decision makers. Even then how you provide information can make a big difference. One can frame problems in different ways. In other words, the way you present information to the public will impact on how individuals will react to specific risks. You can give people data in a variety of different forms and it will make a difference in terms of what they are going to do. Risk communication issues thus become an important part of the policy process. I know that Professor Shiroyama has a great interest in this topic and may discuss this in his talk.

One can also utilize *economic incentives*. Incentives can be positive or negative. You give someone a subsidy and/or personally reward an individual or firm for taking certain actions. If you want to encourage mitigation measures for a natural disaster, one way to do that particularly with low income people is to help subsidize that activity because they wouldn't invest in it otherwise. A negative incentive is to tax or fine a person or a firm or an organization indicating that "thou shalt not do this or we will fine you".

You can *regulate and sets standards*. Building codes for strengthening structures to withstand natural disasters are one example. Then one has to enforce the regulation and collect fines or penalties if they are not adhered to. This could be done by the public sector in conjunction with the private firms through such mechanisms as third party inspections or audits. In other words, regulations and incentive need to be considered as a package and may require some type of public/private partnership.

One could provide *compensation* to individuals or communities who are accepting an additional risk. For example, a developer could propose to compensate a community for locating a hazardous or noxious facility in its backyard. I will relate to you a personal experience that underscores the importance of framing when designing a compensation program. I did an experiment a few years ago to find out how much people would require to accept a facility sited in their backyard. I asked the following question “How much would you need in the way of compensation?” A couple of subjects said “We will not participate in this experiment. We’re going to have nothing to do with it.”

I was stunned. I didn’t expect that kind of response. When I asked them why they were leaving they said, “Compensation is immoral. You’re trying to bribe us. This must be a dangerous facility. When you use the word ‘compensation’ then that’s what I think about.” So we changed the word in the next experiment and called it “benefit-sharing “. That sounded really good to everyone. The developer who is gaining from the facility is sharing the benefits with others. So just framing something with a different word that has the same meaning can make a big difference in terms of how people actually perceive that.

Insurance can be an important component of a risk management strategy. Insurance is the only policy tool that actually rewards someone for taking a preventive measure while giving something back should the entity suffer a loss. So if you invest in a mitigation measure, you obtain a lower premium for taking

this action while still having the right to make a claim after suffering financial damage.

Insurance is a two-edged sword that can be a very effective policy tool if it's used in an appropriate manner. You can encourage preparedness with it, while at the same time financially aiding victims in their recovery process after a disaster occurs. The *liability system* also performs this function but by penalizing individuals rather than rewarding them. If you don't take certain preventive measures you could be fined and you may be required to compensate victims after an accident occurs.

These are some risk management strategies. You can add others to complement these, so you should not think of this list as being exhaustive. These policy tools suggest the importance of public/private partnerships for dealing with catastrophic risks. You need both the private sector and public sectors for managing large risks. Nothing could have been clearer after September 11th when the government had to intervene to assist individuals, firms and industries affected by the terrorist attacks. I will say a little bit more about the importance of this partnership when discussing issues of interdependency.

Evaluating Strategies I am trained as an economist. I'm often called an irrational economist because I tend to associate with psychologists and with other social scientists that study human behavior and social interactions. There is one significant difference between economics and the other social sciences. Economics has a policy orientation. It offers suggestions as to how to improve the current situation. I would say that for extreme catastrophic events you have to deal with the situation by having both the public and private sectors involved.

There are two different criteria that need to be considered when evaluating strategies. The standard one that economists use is *efficiency*. How can you most effectively allocate resources to improve social welfare? The other criterion that is often used to choose between alternative risk management programs is *equity*.

What will be the economic impact of a specific program on the different interested parties? What are the distributional impacts? How fair is the policy to specific groups such as residents in the community, specific firms and industries or the general taxpayer? We need to consider equity along with efficiency issues in developing public/private partnerships.

Illustrating the Conceptual Framework

I now want to illustrate each of the elements of this framework in a little more detail.

Vulnerability analysis, and risk assessment. By vulnerability analysis we mean the ability to characterize the impacts of a disaster on different groups. By impacts we mean not only physical damage, but social disruption, political consequences, both long and short-term economic impacts, cultural impacts and psychological harm. So all aspects of a disaster need to be taken into account. As I suggested above, scenarios become an important means of assessing vulnerability and risk. How do you construct a set of scenarios and can you then assign some probability or likelihood to these events.

If you only focus on physical damage in developing scenarios we will be missing other important components of the problem. We know that enormous amounts of money have been spent to reduce our vulnerability after September 11th by providing people with reassurance. This meant that a decision was made that one had to consider the psychological impacts of a disaster in order to reduce long-term economic consequences due to paralysis from people's fears.

Risk Perception I would like to illustrate risk perception using the example of terrorism insurance. Immediately after September 11th people said "I am worried, I am concerned." Businesses in major cities in the United States said "we want to figure out how we can be protected against future terrorist attacks. It can happen to me." These organizations were interested in purchasing terrorist insurance and

were willing to pay very high premiums for coverage. But they couldn't find any sellers. The insurance industry was very concerned with marketing this coverage because they said exactly the same thing as these businesses –“it can happen to me.” They felt there was considerable ambiguity associated with the terrorist risk and were not about to provide insurance coverage against it.

It was hard to understand why insurers wouldn't offer coverage and charge high premiums. The price that businesses were willing to pay for insurance was so high that the risk of a terrorist attack next year would have had to be enormous, in many cases greater than 1 in 10 for a building to be destroyed, to justify the insurance industry not offering coverage.

But most companies refused to provide protection. As a result, the United States Congress, in November 2002 passed the *Terrorism Risk Insurance Act (TRIA)*. Insurance firms are now forced to offer this coverage to businesses who purchase other types of protection from them, and the federal government provides protection against any major catastrophic losses. How has TRIA affected the supply and demand for terrorist coverage. To date there has been limited interest by businesses in purchasing insurance. They perceive the risk to be so low that they react as if “It won't happen to me”. Their actions could be explained by the following scenario: “Nothing has happened in the two years since September 11th so we are not going to worry about terrorism.”

So even with insurance fully available, the perceived risk is so low that most firms don't want to buy coverage. The economic consequences of an uninsured society can be enormous. If we have another terrorist attack it is not clear who will pay for the economic losses.

What are some of the factors associated with risk perception that one might want to pay attention to? One key element that has already been mentioned is *ambiguity*. People don't like ambiguity. We want to know what will happen. We don't like uncertainty. If we are uncertain about the probabilities, which is what

we mean by ambiguity, then we really feel out of control. We need a better understanding of the impact of ambiguity on the decision as to whether or not to invest in protection. This is an area for future research.

Another factor that influences risk perception is *myopia*. People say “I only want to think about what is going to happen in the next year or two years”. Businesses are very vulnerable to this way of thinking. They want to make sure their bottom line is satisfied next year rather than thinking long term. Investing in protection is a long-term proposition. You incur upfront costs and reap benefits over a long period of time. If a homeowner or firm is only concerned about the next year or two, it will not want to invest in protective measures. The challenge is to determine how one can overcome myopia so that one can appreciate the long-term value of these types of investments. A potential solution is to provide mitigation loans so that the cost of protection can be spread over a long period of time.

One other issue that has only recently become part of the risk perception landscape is the impact of *emotions* on behavior. How can we one effectively handle dread, worry and anxiety? Unless we can understand how to deal with these emotions, risk management policies may not address issues of public concern.

Risk Management Strategies As I indicated earlier public/private partnerships are essential for managing catastrophic risks. What are some ways that the two sectors can work together? The public and private sectors can jointly collect information on risks, construct scenarios and communicate information to others. How they frame the problem will be important. This is illustrated by the use of the word “benefit sharing” rather than “compensation” in the experiment I described above for siting noxious facilities.

Other strategies may involve designing incentive systems. What kinds of subsidies or fines are appropriate to encourage investment in productive measures? Developing insurance programs for encouraging investment in

protective measures has its own challenges as you already know from the TRIA example. Designing well-enforced regulations to which the public will subscribe is extremely vital. This may not be easy to accomplish as illustrated by the following example triggered by the terrorist attacks. Earlier in 2003 all health workers were requested to get a vaccination against smallpox. Most didn't do it because of a concern with the negative side effects from the vaccine. So here was a group that you really wanted to encourage to take protective measures because they were health workers. Yet they had their own problems with respect to following through with this request because of their perception of the risk. And so the vaccination program was dropped.

Interdependent Security

I want to link risk assessment and vulnerability, risk perception and risk management using the concept of interdependency. Here are two basic premises on which a model of interdependent security is based.

(1) The risk faced by one person, one business, one individual or organization depends on the actions of others. In economics we use the term *negative stochastic externalities* to characterize this interdependency. They are externalities because the actions of others impact on you and your actions impact on others. The externalities are stochastic because they are uncertain as characterized by a probability and negative because failure to take certain actions can lead to contamination problems..

(2) You can only die once. The event that occurs is catastrophic, so that two events are no worse than one.

To illustrate both of these premises suppose that I own an apartment unit and have invested in a sprinkler system to protect my dwelling from a fire. I contact my insurance company and ask for a reduction in my homeowners' insurance premium because I have reduced the risk of a fire damaging my property and

contents. My insurer responds; “We know you have done a great thing but unfortunately all your neighboring apartment units have not installed sprinkler systems. They could have a fire in their apartments that could spread to yours and damage your property and contents even though you have installed a sprinkler system. So we are sorry that we cannot reduce your insurance premiums by as much as you feel you deserve unless you get your neighbors to protect themselves as well.”

The above scenario served as a basis for a series of discussions that Geoffrey Heal and I had at Columbia University shortly after September 11th. We were trying to understand the limitations of the private insurance market in encouraging adoption of protective activities when there is the possibility of contamination. It turns out that for the class of problems where there is the possibility of an epidemic such the spreading of a fire, disease or computer virus, if no one else invests in protection you have zero incentive to do it yourself unless you can build a firewall to shield you. Vaccines are one example of providing immunity against a disease; sprinkler systems may not be able to protect you against fires that start in other apartment units.

In this type of situation where all parties have identical characteristics you have two equilibria ---either everyone invests in protection or no one does. There appear to be a whole class of problems that exhibit this type of interdependency and require public/private partnerships because the private market fails. With respect to earthquakes, the type of interdependency is characterized as follows: a home that is not protected structurally collapses after an earthquake and causes damage to another building. Another example of interdependency revolves around damage to a region’s infrastructure causing business interruption to firms in the affected area.

The Wharton Risk Center and Columbia Univ. Business School are working closely with Lockheed Martin on problems of *airline security*, another type of interdependency. . Here the question might be: “ What incentive does any airline

have to invest in baggage security on its own if they know that they can be contaminated by bags from other airlines that are not inspected?

The crash of Pan Am 103 illustrates this point. It was caused by a bag loaded in Malta on Malta Airlines where there was no security system, transferred at Frankfurt Airport to a Pan Am feeder and then loaded onto Pan Am 103 at London's Heathrow Airport. The bomb was designed to explode only when the aircraft flew higher than 28,000 feet, which would normally not occur until the plane started crossing the Atlantic. There wasn't a thing that Pan Am could do to prevent the bomb from exploding unless they checked all transferred bags, as El Al does today. The terrorists who placed the bomb knew exactly where to check the bag. They put it on Malta Airlines, which had minimum security measures and Pan Am was helpless. More generally, any airline's incentive for incurring the costs of tighter security measures is reduced if it knows that bags from other airlines could contaminate its planes.

What about securing *computer systems*? Viruses spread from one computer to another and your incentive to invest in protective measures for catching your own viruses decreases if you cannot prevent outside viruses from entering your own system and contaminating it. We all know about the virus that occurred last August. How do you protect yourself against such a virus? Is it possible to build a firewall to prevent these bugs from contaminating your system?

Consider vaccinations programs against *infectious diseases*. Columbia University and the University of Pennsylvania is considering undertaking a study on AIDS and tuberculosis to try and understand the diffusion pattern on diseases and how one can prevent their spread through vaccinating key individuals.

How do we protect against *power plant failures*? Geoffrey Heal had a Letter to the Editor published in the *Financial Times* after the power failure of August 14th saying; "What incentive did any utility have to invest in protective measures given the fact that all the other utilities were not doing it." The answer is there is

a tremendous amount of interdependency here and you cannot really encourage one utility to take protective measures unless you get them all to play the game together.

One of the areas that several of us are working on at Wharton is *supply chain management and product contamination*. What incentive does any supplier have to invest in high quality parts if they know that when the product fails there is no easy way to determine which part caused the failure? So firms have no economic incentive to invest in higher quality parts unless the manufacturer utilizes some type of inspection system or initiates some incentive program for coordinating actions by suppliers of their parts.

All of these problems involve interdependencies; however, the nature of the interactions and how to prevent their spread differs from one problem to another. In the case of vaccinations, you are likely to want to protect yourself if no one else is vaccinated because you basically are worried about getting the disease. If everyone else is protected, then you can free-ride and not get vaccinated. Airline security, computer security, power grids and supply chains are exactly the opposite. If all other competitors invest in security you will also want to invest.. If no one invests in security you are much less likely to want to do this.

Turning to *bankruptcy problems* and interdependencies within an organization, each division may resist investing in risk-reducing measures. What incentive did any division in Arthur Andersen have to invest in reducing their risk if they knew that every other division in Arthur Andersen wasn't doing this any single division could bring the whole firm down? What incentive did any division in Barings Bank have to invest in any protective measures if they knew all the other divisions were not doing so? These examples illustrate the challenges of establish an organizational culture where risk reduction becomes the established norm. It also raises questions as to how you establish effective controls. In general, when organizations are decentralized, it becomes more difficult to manage interdependent risks.

Public-Private Partnerships for Managing Interdependent Risks

I will now address the following two questions associated with managing risk and establishing public-private partnerships in a more systematic way by focusing on the earthquake problem:

- (1) What incentives do property owners have for investing in protection when their neighbors have not invested in mitigation measures?

- (2) What public/private partnerships can encourage the adoption of cost effective risk-reducing measures?

Consider a property owner who is asked whether he wants to invest in a structural mitigation measure to reduce his losses from a future earthquake. When making that decision he has to balance the cost of the mitigation measure with the reduction in risk from an earthquake damaging his home. His home can be damaged directly by the earthquake or from a neighboring house that suffers earthquake damage and collapses on his.

Using game theory one can show that there are two stable equilibria for the above problem. Either both homeowners invest in mitigation or neither of them incur these costs and take their chances. More specifically, if the cost of mitigation is high relative to the expected direct damage from an earthquake (i.e. probability of an earthquake damaging your house multiplied by the magnitude of the loss), then neither homeowner will invest in protection. Similarly if the cost of mitigation is sufficiently low then both homeowners will invest in mitigation. When the cost is between these two values then the solution is indeterminate: either both homeowners invest in protection or neither does.

Suppose that the problem is expanded from two identical homeowners to many property owners with different risk and cost characteristics . Then there is a much greater range where the optimal investment strategy is indeterminate because there are many stable equilibria. This leads to a key concept when one is talking about interdependency---tipping and cascading. Can you encourage enough homeowners to invest in protection, so that you can convince others to also take these steps? What is the nature of the tipping point and what are the levers to push in order to reach it?

Private insurance won't solve the problem for the reasons discussed when one was considering the sprinkler system case. On the other hand, a government insurer can require all relevant parties to protect themselves against a particular hazard and provide premium reductions to all of them. In this sense the public sector is more efficient in dealing with risks than the private sector because it can reduce the externalities through regulations and requirements.

The liability system only works if the contaminating agent is held liable for the damage to others because it did not invest in protection. For events where causality is difficult to establish, the system breaks down. But I do not want to encourage the use of the liability system. I know how few lawyers there are in Japan and have argued many times that we could do a lot better in our own society by following the Japanese system and not encouraging the use of the legal system to solve these problems.

Regulations are critically important. Well-enforced building codes and standards are even more important than we realized when introducing the interdependency problem. You could also levy a tax on any home that does not invest in mitigation to encourage it to adopt cost effective measures.

One area that would be interesting to explore is the role that formal or informal coordinating mechanisms such as trade or industry associations can play in

reducing the interdependency risk faced by individual firms who do not cooperate with each other.

Managing the Earthquake Risk in Japan

The above framework and concepts can be applied to the earthquake problem in Tokyo. Here are a few open questions to consider in this regard:

- What is the likelihood that an earthquake can cause major damage and loss of lives in Tokyo in the next 20 years?
- Have building codes in Tokyo been well enforced?
- How much insurance has been sold in Tokyo?

Do insurance premiums encourage individuals to adopt cost-effective mitigation measures?

- Does the Japanese government provide sufficient reinsurance for catastrophic losses from earthquakes and other natural disasters? .

To address these and related questions future research needs to be undertaken on risk assessment, risk perception and risk management. Here are some suggestions on how one might undertake this effort:

- Collect better information on the risks and the costs by getting good data on the probabilities, consequences and mitigation costs
- Construct scenarios characterizing the nature of the risk under different risk management programs
- Design better incentive systems to encourage investment.
- Develop insurance programs coupled with well-enforced building codes to address the interdependency problem
- Determine what role the public sector should play in covering losses from catastrophic events and assisting victims in their recovery process given both the short and long-term economic consequences?

Proposed risk management strategies depend on the following factors:

- What kind of a disaster are we looking at? Terrorism is different from a natural disaster, which is different from a chemical accident and different from a disease.
- What data are available on the risk?
- What are the institutional arrangements in the country? Japan will deal with the problem differently than the United States.
- What are the decision processes and behavioral considerations that have to be taken into account?

What criteria should we be using for evaluating different programs? As I mentioned earlier, both efficiency and equity considerations should be considered in designing a risk management strategy.

In conclusion, interdependent disaster risks raises questions as to what types of strategies should be pursued for reducing contamination problems. Given the negative externalities associated with these risks, there is a need for creative public-private partnerships to manage them. We need insights from scientists, engineers, social scientists, the policy community, the private sector and the public sector. And that makes for an exciting challenge.