

**Climate Change and Effective Catastrophe Risk Management
Mechanisms: A Law and Economics Analysis of Insurance and
Alternative Approaches**

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I. Introduction

A. Climate Change Risk and Its High-Consequences

Although there is not yet consensus, most scientists believe that global climate change¹ is occurring on a significant scale.² Global climate change and the many weather-related catastrophes that have followed in its wake have generated increasing losses.³ A Special Report of the Intergovernmental Panel on Climate Change (IPCC) in 2012 stated that “[A] changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events”.⁴ A 2006 report by the United Nations Framework Convention on Climate Change (UNFCCC) said that by 2040, damage resulting from climate change might mount as high as one trillion dollars annually.⁵ American International Group (AIG), Lloyd’s of London and other leading insurers all identify climate change as a major threat for global risk management.⁶

Due to both climate change and an increasing concentration of the world’s population in vulnerable areas, it is likely that natural disasters will become more frequent, more intense, and more costly in the coming years.⁷ Data show that the frequency of and losses from natural catastrophes have mounted. The number of natural catastrophe events has risen from 1970 to 2013 (Figure 1). There has also been a marked increase in the amount of insured losses from weather-related catastrophes worldwide from 1970 to 2013. (Figure 2)

¹ The terms “climate change” and “global warming” will be used interchangeably throughout the Paper. “Climate change” is considered the phenomenon by which human activity has altered the Earth’s atmosphere. The term is “[o]ften used interchangeably with ‘global warming,’ . . . because it helps convey that there are changes in addition to rising temperatures.” 2 HANDLING THE LAND USE CASE § 42:1 (3d ed.) Quoted from Douglas J. Debaugh, *Marching Toward a Day of Reckoning: Dissecting the Complex Intersection of Insurance Law and Climate Change Litigation Through AES Corp. v. Steadfast Ins. Co.*, 91 N.C.L. Rev. 95A (2013).

² IPCC issued a report titled *Climate Change 2014: Impacts, Adaptation, and Vulnerability*, said the effects of climate change are already occurring on all continents and across the oceans. This report is produced by a total of 309 coordinating lead authors, and review editors, drawn from 70 countries. It also enlists the help of 436 contributing authors, and a total of 1,729 expert and government reviewers. Available at <http://www.ipcc.ch/report/ar5/wg2/>.

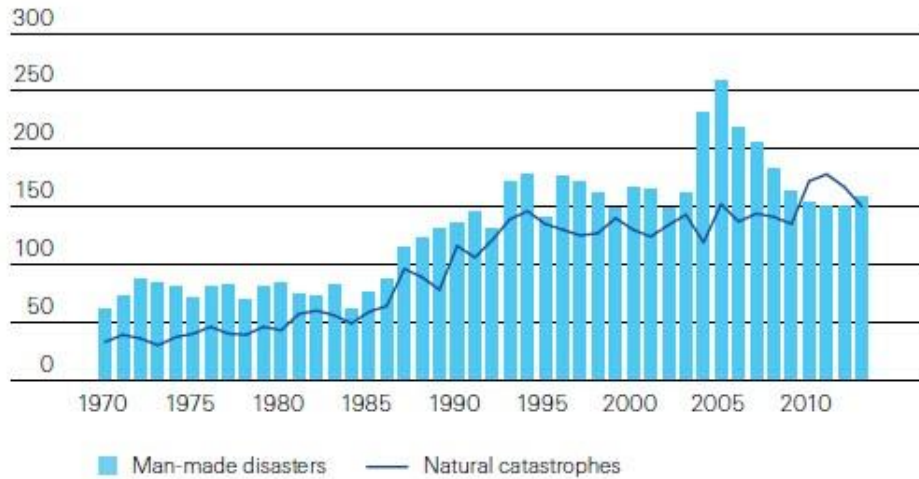
³ The Intergovernmental Panel on Climate Change (IPCC) special report on climate extremes (2012) demonstrated for the first time a clear link between climate change and many extreme weather-related catastrophes. See **IPCC**, 2012: Summary for Policymakers. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 3-21.

⁴ **IPCC**, 2012: Summary for Policymakers. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 3-21.

⁵ See United Nations Env’t. Programme Fin. Initiative Climate Change Working Group, *Adaptation and Vulnerability to Climate Change: The Role of the Finance Sector 14* (2006) (“It seems very likely that the [sic] there will be a ‘peak’ year that will record costs over 1 trillion USD before 2040.”). Quoted from Michael G. Faure, *Insurability of Damage Caused by Climate Change: A Commentary*, 155 U. Pa. L. Rev. 187 (2007).

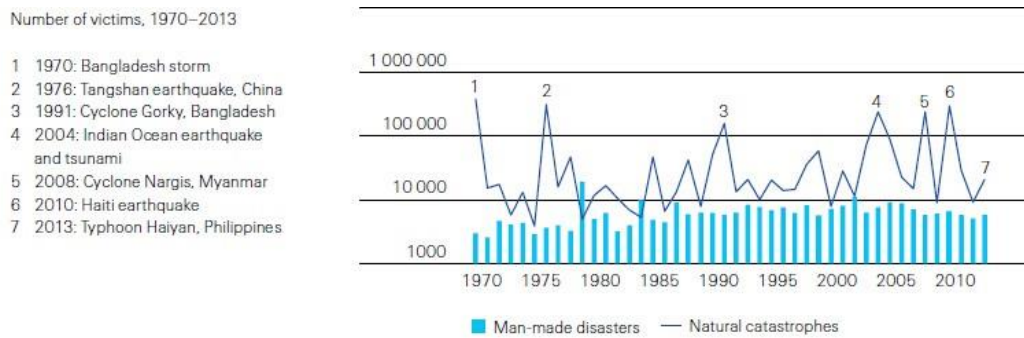
⁶ AIG, *AIG’s Policy and Programs on Environment and Climate Change*, (2009), available at http://www.naic.org/documents/committees_ex_climate_survey_sample_responses_AIG.pdf; Trevor Maynard, *Climate Change: Impacts on Insurers and How They Can Help with Adaptation and Mitigation*, 33 Geneva Papers 140 (2008).

⁷ Muthukumara Mani, Michael Keen and Paul K. Freeman, *Dealing with Increased Risk of Natural Disasters: Challenges and Options* (2003), available at <http://www.imf.org/external/pubs/ft/wp/2003/wp03197.pdf>.



Source: Swiss Re Economic Research & Consulting

Figure 1 The number of events from 1970 to 2013 (Source: Swiss Re)⁸



Number of victims, 1970–2013

- 1 1970: Bangladesh storm
- 2 1976: Tangshan earthquake, China
- 3 1991: Cyclone Gorky, Bangladesh
- 4 2004: Indian Ocean earthquake and tsunami
- 5 2008: Cyclone Nargis, Myanmar
- 6 2010: Haiti earthquake
- 7 2013: Typhoon Haiyan, Philippines

Note: Scale is logarithmic: number of victims increases tenfold per band
Source: Swiss Re Economic Research & Consulting

Figure 2 Insured catastrophe losses from 1970 to 2013 (Source: Swiss Re)⁹

Globally, the United States, China and many European countries are all vulnerable to weather-related catastrophes and the losses are increasing significantly.¹⁰ In the United States, Hurricane Katrina in 2005 killed 1,300 people and caused estimated insured losses of \$48.1 billion; Hurricane Ike in 2008 caused an estimated insured loss of \$17.6 billion.¹¹ In China, direct economic losses caused by catastrophes are around \$25 billion almost every year and the number would be considerably larger if indirect economic losses such as disaster relief were taken into

⁸ Sigma, *Natural catastrophes and man-made disasters in 2013: large losses from floods and hail; Haiyan hits the Philippines* (2014), available at

http://reliefweb.int/sites/reliefweb.int/files/resources/SwisRe_2014_Natural_Catastrophes_sigma1_2014_en.pdf

⁹ Sigma, *Natural catastrophes and man-made disasters in 2013: large losses from floods and hail; Haiyan hits the Philippines* (2014), available at

http://reliefweb.int/sites/reliefweb.int/files/resources/SwisRe_2014_Natural_Catastrophes_sigma1_2014_en.pdf

¹⁰ U.S. GOVERNMENT ACCOUNTABILITY OFFICE, *Climate Change: State Should Further Improve Its Reporting on Financial Support to Developing Countries to Meet Future Requirements and Guidelines*, (2013), GAO-13-829.

U.S. GOVERNMENT ACCOUNTABILITY OFFICE, *Catastrophe risk: U.S. and European Approaches to Insure National Catastrophe and Terrorism Risks*, (2005), GAO-05-199. Ministry of the Civil Affairs of the PRC, *Minzheng Shiye Fazhan Baogao [The Statistics Report of the Civil Affairs Development]*, (2004–2013), available at

<http://cws.mca.gov.cn/article/tjbg>.

¹¹ Howard C. Kunreuther & Erwann O. Michel-Kerjan, *Market and Government Failure in Insuring and Mitigating Natural Catastrophes: How Long-Term Contracts Can Help*, in *Public Insurance and Private Markets* 118, (Jeffrey R. Brown, ed., 2010).

consideration.¹² For example, the Pearl River Delta, a densely populated metropolitan area comprised of Hong Kong, Guangzhou and Shenzhen, is situated in one of the world's most disaster-prone regions. Floods and typhoons there put more people at risk than in any other metropolitan area in the world.¹³ Similar catastrophes and losses threaten the European Union.¹⁴

B. The Mechanism of Insurance to Cover Disasters

1. Catastrophe Risk

The concept of risk is the fundamental problem with which insurance deals.¹⁵ Different insurance theorists have different definitions of risk.¹⁶ Risk is variously defined as (1) the chance of loss, (2) the possibility of loss, (3) uncertainty, (4) the dispersion of actual from expected results, or (5) the probability of any outcome different from the one expected.¹⁷ But there are common elements: indeterminacy and loss.¹⁸ Risk and uncertainty are closely connected concepts, but they should be distinguished. Almost one hundred years ago, Frank Knight in his book *Risk, Uncertainty and Profit* carefully distinguished between risk and uncertainty. Uncertainty refers to *un-measurable* exposure. The uncertainty of an exposure cannot be quantified. This difference is relevant to insuring major catastrophes, because when there is “too much” unpredictability, there is additionally too much uncertainty to quantify an exposure to loss.¹⁹ In this Paper, the concept of risk in the context of catastrophe disasters is following to in its general meaning to indicate an uncertainty situation in which an exposure to loss exists.

Risk may be classified in many ways, such as static and dynamic risks; fundamental and particular risks; pure and speculative risks, and so on.²⁰ Among the classifications, fundamental and particular risks are particularly important for the research on catastrophe disasters. The distinction between fundamental and particular risks is based on the discussion of hazard by Kulp.²¹ Fundamental risks are those caused by conditions more or less beyond the control of the individuals and involve losses that affect a large number of populations, to which most of natural catastrophe risks belong.²² Unlike fundamental risks, particular risks are due to special or particular caused that operate in particular cases, such as the chance of fire.

Natural disasters, such as hurricanes, floods, typhoons, and snowstorms, are examples of “fundamental risks” rather than “particular risks”. As such often they cause more severe losses than particular risks. Scholar Véronique Bruggeman defines a catastrophe as a rapid onset,

¹² Ministry of the Civil Affairs of the PRC, *Minzheng Shiye Fazhan Baogao [The Statistics Report of the Civil Affairs Development]*, (2004–2013), available at <http://cws.mca.gov.cn/article/tjbg>.

¹³ Swiss Reinsurance Company, *Mind the risk: cities under threat from natural disasters* (2013), available at http://media.swissre.com/documents/Swiss_Re_Mind_the_risk.pdf.

¹⁴ U.S. GOVERNMENT ACCOUNTABILITY OFFICE, *Catastrophe risk: U.S. and European Approaches to Insure National Catastrophe and Terrorism Risks* (2005), GAO-05-199.

¹⁵ Emmett J. Vaughan & Therese M. Vaughan, *Fundamentals of Risk and Insurance* 1 (2007).

¹⁶ Emmett J. Vaughan & Therese M. Vaughan, *Fundamentals of Risk and Insurance* 2 (2007).

¹⁷ The discussion of different definition of risk can be referred in the section of “current definitions of risk” and “our definition of risk” of Vaughan’s book. See Emmett J. Vaughan & Therese M. Vaughan, *Fundamentals of Risk and Insurance* 1-3 (2007).

¹⁸ Emmett J. Vaughan & Therese M. Vaughan, *Fundamentals of Risk and Insurance* 2 (2007).

¹⁹ Frank H. Knight, *Risk, Uncertainty and Profit* 233 (1971). This book was written in 1921.

²⁰ Emmett J. Vaughan & Therese M. Vaughan, *Fundamentals of Risk and Insurance* 5 (2007).

²¹ C.A.Kulp, *Casualty Insurance* 3 (1956).

²² C.A.Kulp, *Casualty Insurance* 3-4 (1956).

single-event disaster that causes a substantial amount of damage and/or that *involves numerous victims*.²³ Erik Banks has expanded the definition from the traditional view of a single event that causes sudden changes to include instances of a gradual accumulation of many small incidents, perhaps precipitated by the same catalyst, leading to the same scale of damages/losses; such events may not actually be recognized as catastrophes until a long period of time has passed and many losses have accumulated.²⁴ From the government perspective, for example, the Centre of Research on the Epidemiology of Disasters (CRED) treats catastrophe risk as “a situation or event, which overwhelms local capacity, necessitating a request to national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering”.²⁵ According to the Federal Emergency Management Agency (FEMA) in the United States, an event where related federal costs reach or exceed \$500 million is deemed as “catastrophe.”²⁶ In this Paper, my focus is on climate change risk, which due to “[A] changing climate... can result in unprecedented extreme weather and climate events”.²⁷ Hence, I would like to define catastrophes as the weather-related events which occur infrequently but cause very significant human and financial losses.

2. Risk Management

As with risk, risk management also has been defined in different ways. However, most definitions share two points: (1) that risk management is concerned with risk; (2) it is a process or function that involves managing those risks.²⁸ The process of risk management is based on three pillars, which are risk assessment (or risk analysis), risk control, and risk financing. Insurance is an essential part of risk financing.²⁹ The increasing catastrophe risks caused by climate change are a “long-term issue with broad-reaching implications that will significantly impact the [insurance] industry.”³⁰

Many law and economics scholars favor insurance as a private market mechanism for distributing catastrophe risk, especially when compared to government-provided compensation.³¹ For example, Jaffe and Russell,³² Kunreuther,³³ Epstein,³⁴ Priest,³⁵ and Kaplow,³⁶ argue that

²³ VÉRONIQUE BRUGGEMAN, COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH 7 (2010).

²⁴ ERIK BANKS, CATASTROPHE RISK, ANALYSIS AND MANAGEMENT 5 (2005).

²⁵ Centre for Research on the Epidemiology of Disasters (CRED), *The EM-DAT Glossary*, available at <http://www.emdat.be/glossary/9#term81>.

²⁶ U.S. GOVERNMENT ACCOUNTABILITY OFFICE, *Experience from Past Disasters Offer Insights for Effective Collaboration after Catastrophe Events* (2009), GAO-09-811.

²⁷ IPCC, 2012: Summary for Policymakers. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 3-21.

²⁸ Emmett J. Vaughan & Therese M. Vaughan, *Fundamentals of Risk and Insurance* 16 (2007).

²⁹ François Outreville, *Theory and Practice of Insurance* 45-64 (1998). Also see Rob Thoys, *Insurance Theory and Practice* 286-295 (2010).

³⁰ Trevor Maynard, *Climate Change: Impacts on Insurers and How They Can Help with Adaptation and Mitigation*, 33 Geneva Papers 140 (2008).

³¹ Michael Faure & Klaus Heine, *Insurance Against Financial Crises?* 8 *NYU Journal of Law & Business* 117 (2011).

³² Dwight Jaffe & Thomas Russell, *Catastrophe Insurance, Capital Markets, and Uninsured Risks*, 62 *Journal of Risk and Insurance* 205 (1997).

³³ Howard Kunreuther, *The Case for Comprehensive Disaster Insurance*, 11 *J.L. & Econ.* 133 (1968).

³⁴ Richard A. Epstein, *Catastrophe Responses to Catastrophe Risks*, 12 *J. RISK & UNCERTAINTY* 287 (1996).

insurance is better equipped to deal with catastrophe risks than social insurance due to its advantages of lower transaction costs, lower adverse selection, and greater efficiency.

In insurance economics, “risk aversion” is commonly used to describe individuals’ “attitude to risk”.³⁷ A person is said to be risk-averse “if she considers the utility of a certain prospect of money income higher than the expected utility of an uncertain prospect of equal expected monetary value.”³⁸ Risk aversion leads individuals to transfer risk, through substituting a small certain cost for a large uncertain financial loss. Private insurance is indeed a device to transfer risk.³⁹

The theory of risk aversion helps explain the function of insurance in covering disasters. People who are risk-averse at some level want to transfer risk above that level. Then, the question is, who is willing to take on the transferred risk? When a risk is relatively small (it depends on individuals’ attitudes and people’s attitudes to risk are different), a risk-averse individual may become risk-neutral. The relatively risk-neutral person may play the role of insurer by taking on others’ risk. This mechanism is efficient in the sense that no one is harmed but someone becomes happier by transferring risk, satisfying the conditions for “Pareto Improvement”.⁴⁰

Assume, however, that all individuals were strictly risk averse, and that no one wants to take others’ risk. Under such circumstance, a possible alternative is risk pooling. By risk pooling, each individual relies on the pool and all members of the pool become relatively risk neutral when they face a larger risk.⁴¹ If individuals’ risks are independent from each other, this risk pooling mechanism also conforms to the law of large numbers by which the future risk is more certain in larger groups. This may make the risk easier to underwrite in the aggregate than for any particular individual because it reduces uncertainty.⁴²

C. Question Raised and Road-map of the Paper

Insurance produces efficient outcomes through risk transfer and risk pooling. However, according to a survey to major insurers of U.S., it presents that most insurers ignore or are reluctant to underwrite climate change exposures.⁴³ Climate change further challenges insurers by both increasing the number and severity of weather-related extreme events and adding considerable uncertainty as to where and how those losses will develop.⁴⁴ As a matter of fact,

³⁵ George L. Priest, *The Government, the Market, and the Problem of Catastrophe Loss*, 12 J. RISK & UNCERTAINTY 219 (1996).

³⁶ Louis Kaplow, *Incentives and Government Relief for Risk*, 4 J. RISK & UNCERTAINTY 167 (1991).

³⁷ S. Hun Seog, *The Economics of Risk and Insurance* 18-33 (2010).

³⁸ Robert Cooter & Thomas Ulen, *Law & Economics* 45 (2012).

³⁹ Emmett J. Vaughan & Therese M. Vaughan, *Fundamentals of Risk and Insurance* 34-44 (2007).

⁴⁰ The result of “Pareto Improvement” is “Pareto Optimality”, also called “Pareto Efficiency”, is a state of allocation of resources in which it is impossible to make any one individual better off without making at least one individual worse off. See S. Hun Seog, *The Economics of Risk and Insurance* 35-39 (2010).

⁴¹ K.H. Borch, *Equilibrium in a reinsurance market*, *Econometrica* 30: 424-44 (1962).

⁴² The law of large numbers is the mathematical theorem, which says that for a series of independent and identically distributed random variables, the variance of the average amount of a claim payment decreases as the number of claims increases. See Howard Kunreuther & Richard J. Roth, Sr., editors, *Paying the Price: the Status and Role of Insurance against Natural Disasters in the United States* 24-26 (1998). See also Tom Baker, *Insurance Law and Policy: Cases and Materials* 3(2008); VÉRONIQUE BRUGGEMAN, *COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH* 59-60(2010).

⁴³ Joseph MacDougald and Peter Kochenburger, *Insurance and Climate Change*, *The John Marshall Law Review*_(2014, forthcoming).

⁴⁴ Joseph MacDougald and Peter Kochenburger, *Insurance and Climate Change*, *The John Marshall Law Review*_(2014, forthcoming).

insurers have done relatively little to address catastrophe risks and have even cut back coverage. It seems that there is market failure of private insurance for covering catastrophe risk. This Paper tries to explore the question that why market failure happens in private catastrophe insurance and how to solve it.

When faced with private insurance market failure, Insurance-Linked Securities (hereinafter ILS) and government intervention are two alternative mechanisms to distribute catastrophe risk and to cover catastrophe losses. However, whether these two mechanisms can distribute catastrophe risk efficiently—either singly or through a combination with private insurance—is still being debated. In this Paper, I will discuss whether ILS and government intervention can do any better than private insurance, and then explain the justification of ILS and government intervention. Finally, based on a comparison of the three mechanisms, using an equilibrium analytical framework, I will propose a potential optimal solution to cover catastrophe losses.

This Paper comes in four parts. The first part (Section II) focuses specifically on what conditions contribute to the market failure of private insurance in distributing catastrophe risk. The second part (Section III) focuses particularly on Insurance-Linked Securities (ILS), which harness the capital markets to finance insurance and discuss whether this mechanism can solve market failure of private catastrophe insurance. The third part (Section IV) III examines the justification of government intervention to manage catastrophe risk. It will discuss the merits and criticisms of government intervention and compare different types of government intervention programs. The fourth and also the concluding part (Section V) compares the above three mechanisms and propose an optimal framework for solving catastrophe risk.

II. Market Failure of Private Insurance for Covering Catastrophe Risk

Flood insurance in flood-prone areas of the United States is a typical example of market failure. Flood insurance was first offered by private insurers in the late 1890s; however, the loss was so large for insurers that they left the market in the 1960s. In 1968, Congress created the National Flood Insurance Program (NFIP) as an alternative means to offer coverage subsidized by the federal government.⁴⁵ This example raises the fundamental question of why private insurers are reluctant to underwrite catastrophe insurance policies.

As I will discuss, insurers face challenges on both the supply and the demand sides in underwriting catastrophe coverage.⁴⁶ This section applies law and economic analysis to explore the supply-demand dynamics of private catastrophe insurance.

A. Restrictions on the Supply of Catastrophe Insurance

On the supply side, traditional economic theory assumes that insurance companies are

⁴⁵ Howard Kunreuther & Richard J. Roth, Sr., editors, *Paying the Price: the Status and Role of Insurance against Natural Disasters in the United States* 40 (1998).

⁴⁶ Sean B. Hecht, *Climate Change and the Transformation of Risk: Insurance Matters*, 55 *UCLA L. Rev.* 1559 (2008).

maximizing long-run expected profits in a competitive insurance market.⁴⁷ However, in the real world, insurers' behavior often differs from the classical theory, as I will discuss.

1. Insurability Restriction of Catastrophe Risk

In theory, catastrophe risk might make good business for insurers because bearing risk is the business of insurers. In reality, insurers will decide whether or not to cover catastrophe risk based on whether that risk is insurable. Right now, however, there seems to be no agreed-upon definition of an insurable risk. Some convincing insurance literature illustrates that a risk is considered insurable if it satisfies at least two requirements: first, the insurer must have the ability to identify, quantify and estimate the chance of disasters and the resulting losses; second, the insurer must have the ability to set and collect appropriate premiums for catastrophe risks.⁴⁸

a. Predictability

Many insurable risks, such as house fires or automobile accidents, occur on a regular basis. It is possible to identify and quantify such risks and to estimate losses of such accidents by using historical data. For catastrophes, however, identifying and quantifying risks is more difficult due to the low probability of these disasters and thus limited historical data.⁴⁹ These obstacles make it almost impossible for catastrophe risks to satisfy the first requirement of insurability.

Predictability, however, may not be the decisive factor of insurability. For example, in the past the operation of commercial aircraft and commercial satellite insurance became viable even under the circumstance of imprecise predictability.⁵⁰ What's more, new developments in scientific information technology, especially Big Data, may make it easier to identify and quantify a catastrophe risk.⁵¹

b. Pricing

Price setting is the other challenge for catastrophe risks. The avoidance of correlated risks is a very important prerequisite for a large risk pool and the pricing of policy. The law of large

⁴⁷ Howard Kunreuther, Mark V. Pauly and Stacey McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 18 (2013).

⁴⁸ Howard C. Kunreuther & Erwann O. Michel-Kerjan, *Climate Change, Insurability of Large-Scale Disasters, and the Emerging Liability Challenge*, 155 U. Pa. L. Rev. 1797(2007). See also Howard Kunreuther & Richard J. Roth, Sr., editors, *Paying the Price: the Status and Role of Insurance against Natural Disasters in the United States* 27-38 (1998).

⁴⁹ J.D. Cummins & C.M. Lewis, *Catastrophe Events, Parameter Uncertainty, and the Breakdown of Implicit Long Term Contracting: The Case of Terrorism Insurance*, 26 THE JOURNAL OF RISK AND INSURANCE 154 (2003).

⁵⁰ Both of these lines involved potentially huge losses and neither had any history of loss from which to assess probabilities. See Borch, K. H., *Economics of Insurance* 315 (1990).

⁵¹ There is no rigorous definition of big data. Initially the idea was that the volume of information had grown so large that the quantity being examined no longer fit into the memory that computers use for processing, so engineers needed to revamp the tools they used for analyzing it all. One way to think about the issue today is that big data refers to things one can do at a large scale that cannot be done at a smaller one, to extract new insights or create new forms of value, in ways that change markets, organizations, the relationship between citizens and governments and more. Big data is not about trying to 'teach' a computer to 'think' like humans, instead, it's about applying math to huge quantities of data in order to infer probabilities. Viktor Mayer-Schonberger & Kenneth Cukier, *Big Data: A Revolution That Will Transform How We Live, Work, and Think* (2013).

numbers as the basic principle of insurance requires independent events so the insurer can spread the risk over a large risk pool.⁵² Catastrophe risk can make the law of large numbers inapplicable because the thousands of losses from a single catastrophe are highly correlated.⁵³

2. Capacity Restrictions of the Insurance Industry

Due to the highly correlated nature and potentially high level of losses from catastrophes, the insurance market may not have the capacity to absorb those losses. The potential losses from catastrophe risks are severe and uncertain. What's more, annual losses are highly variable, and may require a large sum of money on reserve in order to cover high losses in certain years.

3. Profitability Constraints on Insurers

In some circumstances, even when the risk is insurable and the insurer has the capacity to cover the risk, underwriting some risks may not be economically profitable due to other constraints. The first such constraint is rate regulation which may prevent insurers from pricing policies to accurately reflect risk.⁵⁴ The second is the short-run profit horizon of insurers. Even if the owners/investors are risk neutral and prefer to underwrite catastrophe risk to maximize long-run expected profits, the managers may follow safety-first rule due to risk aversion and fail to underwrite that risk.⁵⁵ The third is the risk appetite of insurers.⁵⁶ Even if a catastrophe risk is insurable, if the insurers have no appetite for it, they will decline to write policies.

B. The Challenges of Catastrophe Insurance Demand

On the demand side, classic economic theory posits that individuals will make decisions under uncertainty according to the *expected utility theory of choice*.⁵⁷ Nobel Prize winner Kenneth J. Arrow points out that individuals purchase insurance because they are willing to pay a certain small premium to protect against an uncertain large loss.⁵⁸ According to this assumption, a potential rational victim residing in a hazard-prone area will voluntarily purchase catastrophe

⁵² G. L. Priest, *The Government, The Market and the Problem of Catastrophic Loss*, 12 J. RISK & INSURANCE 219, 221-22 (1996).

⁵³ For example, the Hurricane Katrina in 2005 stuck thousands of houses at New Orleans. The exposed properties are classified as a highly correlated risk which has a bad effect on the evaluation of the insurability of catastrophe risk and making premium unreliable.

⁵⁴ Sean B. Hecht, *Climate Change and the Transformation of Risk: Insurance Matters*, 55 UCLA L. Rev. 1559 (2008).

⁵⁵ Safety-first rule, also called safety-first model, is a model of insurer pricing that reflects the insurer's threshold probability that losses for a specific event will not exceed a pre-specified value. See Howard Kunreuther, Mark V. Pauly and Stacey McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 146-154 (2013).

Of course, in other situation, managers might equally be too risk-loving. They earn short term profits by taking on exposure to long term risk that will materialize, if at all, after they have moved on. This argument is inspired by Prof. Peter Siegelman through an email communication at 2014 June.

⁵⁶ Inspired by Prof. Douglas Simpson, Attorney, Consultant and Educator. And emailed interview at 2012 May.

⁵⁷ This theory assumes that individuals with accurate information about risks decide on insurance purchases by making explicit tradeoffs between the expected benefits and the costs of different policies. See Howard Kunreuther, Mark V. Pauly and Stacey McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 8 (2013).

⁵⁸ Kenneth J. Arrow, *Essays in the Theory of Risk-Bearing* 199-200 (1971).

insurance if he perceives the premium to be sufficiently low in comparison to the risks. However, many people fail to purchase insurance offered even at subsidized prices against low-probability but high-consequence disasters.⁵⁹

Prospect theory, developed by Daniel Kahneman and Amos Tversky, is helpful in explaining consumer anomalies in purchasing catastrophe insurance.⁶⁰ Under prospect theory as applied to insurance, consumers are more willing to take an uncertain risk than to suffer a certain loss in the form of a premium payment.⁶¹ This tendency to treat certain loss as more painful than the pleasure of uncertain gains is also termed as myopic loss aversion.⁶² It makes even actuarially fair insurance unattractive, let alone low-probability and high-consequence catastrophe insurance where it is difficult to gauge accurate premiums.

Another reason why some people do not buy catastrophe insurance because they believe that if they suffer catastrophic damages, the government will bail them out.⁶³ This reason for people's demand of insurance is not anomalous but arguably based on the rational behavior.

C. A Short Conclusion: Feasibility of Catastrophe Insurance

Based on the above supply-demand framework analysis, underwriting catastrophe insurance faces both supply-side and demand-side barriers. On the supply-side, problems of insurability and capacity restrict the underwriting process. Meanwhile, on the demand-side, consumers buy insufficient catastrophe insurance due to behavioral anomalies.

III. Market Infancy of Insurance-Linked Securities in Distributing Catastrophe Risk

There are two alternative risk transfer mechanisms that may solve the anomalies of private catastrophe insurance: Insurance-Linked Securities (ILS) and government intervention. ILS has also been described as the securitization of catastrophe risk.⁶⁴

⁵⁹ Howard Kunreuther, Mark V. Pauly and Stacey McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 113 (2013).

⁶⁰ Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision under Risk*, *Econometrica*, Vol. 47, No. 2, 263-292 (1979).

⁶¹ Howard Kunreuther, Mark V. Pauly and Stacey McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 115 (2013).

⁶² Shlomo Benartzi & Richard Thaler, *Myopic Loss Aversion and the Equity Premium Puzzle*, *Quarterly Journal of Economics* 110: 73-92 (1995).

⁶³ Michael Faure & Véronique Bruggeman, *Catastrophic Risks and First-Party Insurance*, 15 *Conn. Ins. L.J.* 1 (2008); Sean B. Hecht, *Climate Change and the Transformation of Risk: Insurance Matters*, 55 *UCLA L. Rev.* 1559 (2008); Howard Kunreuther, Mark V. Pauly and Stacey McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 114-115 (2013); Jack Hirshleifer, *War Damage Insurance*, 35 *THE REV. OF ECON & STAT.* 144, 146-47 (1953), reprinted in 9 *CONN. INS. L.J.* 1 (2002); James M. Buchanan, *The Samaritan's Dilemma*, in *Altruism, Morality and Economic Theory* 71-85 (E.S. Phelps eds., 1975).

⁶⁴ The terminology "insurance-linked securities (ILS)" is interchangeable with the terminology "securitization of catastrophe risk" used in this Paper.

A. ILS Market

1. ILS Market Developments

Insurance-Linked Securities are a mainstay of the alternative risk transfer (ART) market and are used to spread catastrophe risk.⁶⁵ Generally speaking, securitization is the process of removing assets, liability or cash flow from the corporate balance sheet and conveying financial interests in those assets to third parties through tradable securities.⁶⁶ Securitization of insurance risk is regarded as the process of transferring insurance risks from corporations and spreading those risks to third parties through tradable securities.

The idea of securitizing insurance risk was first suggested by Robert Goshay and Richard Sandor in the 1970s.⁶⁷ The first issuance of ILS dated back to 1995 when catastrophe options were introduced by the Chicago Board of Trade (CBOT).⁶⁸ Around the same time, Hurricane Andrew and the Northridge Earthquake led to other types of ILS, such as catastrophe bonds. The issuance of ILS and its trading activity has been growing at a fast rate since then. By 2008, the total notional value of tradable insurance risk had reached \$50 billion and by then, had been growing at a rate of 40% to 50% a year since 1997.⁶⁹ During the 2008 financial crisis, like most other markets, the ILS market was adversely affected. However, ILS proved to be more resilient than many other markets. The most important ILS products—catastrophe bonds—issued \$3 billion in 2009, rebounding from \$2.7 billion in 2008.⁷⁰ As of June 30, 2013, the annual issuance volume of catastrophe bonds reached \$6.7 billion, and total catastrophe bonds outstanding were at an all-time high of \$17.5 billion, an increase of \$2.6 billion from the previous year and surpassing the previous record of \$16.2 billion at June 30, 2008.⁷¹ (Figures 3 and 4).

⁶⁵ ART is a broad concept. Generally speaking, the ART market achieves risk management through capital market solutions, using risk management tools other than traditional insurance and reinsurance to provide protection. The key differential between ART and the traditional insurance marketplace is that insurance and reinsurance markets provide catastrophic risk coverage whereas ART provide additional financial capacity for insurance coverage. See Michel-Kerjan, E., & Morlaye, F., *Extreme Events, Global Warming, and Insurance-linked Securities: How to Trigger the "Tipping Point"*, The Geneva Papers on Risk and Insurance-Issues and Practice, 33(1), 153-176 (2008); Banks, E., *Alternative Risk Transfer: Integrated Risk Management through Insurance, Reinsurance, and the Capital Markets* 49 (2004). Kampa, Christopher. *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part I, A Broad Overview* (2010). Robert J. Rhee, *TERRORISM RISK IN A POST-9/11 ECONOMY: THE CONVERGENCE OF CAPITAL MARKETS, INSURANCE, AND GOVERNMENT ACTION*, 37 *Ariz. St. L.J.* 435 (2005); Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part I, A Broad Overview* (2010).

⁶⁶ Erik Banks, *Catastrophic Risk, Analysis and Management* 111 (2005).

⁶⁷ Robert Goshay & Richard Sandor, *An Inquiry into the Feasibility of a Reinsurance Futures Market*, 5(2) *Journal of Business Finance* (1973).

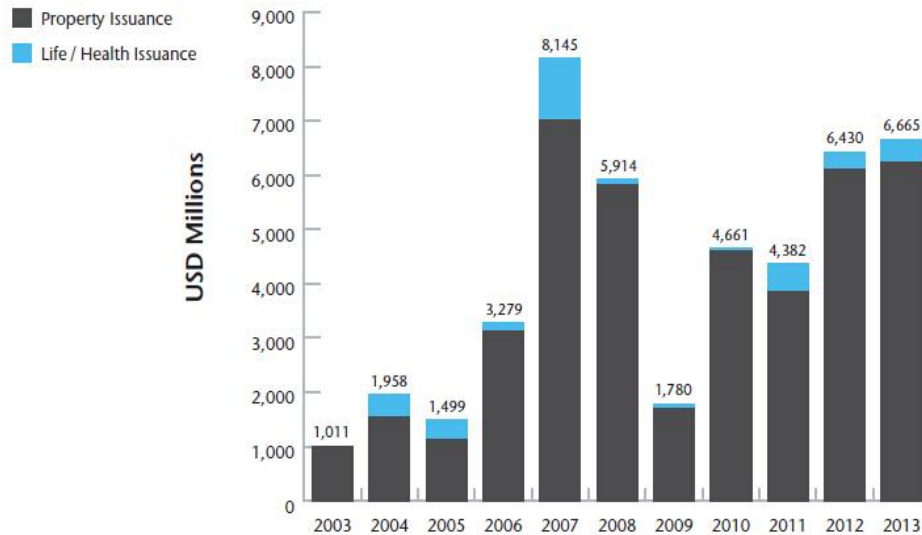
⁶⁸ U.S. Gov't Accountability Office, *Catastrophe Insurance Risk: The Role of Risk-Linked Securities and Factors Affecting Their Use* (2002) GAO-02-941.

⁶⁹ A World Economic Forum Report, *Convergence of Insurance and Capital Markets*, World Economic Forum (2008).

⁷⁰ Colleen McCarthy, *New Structures Revive Market for Cat Bonds*, *Business Insurance* (March 29, 2009) at 43.

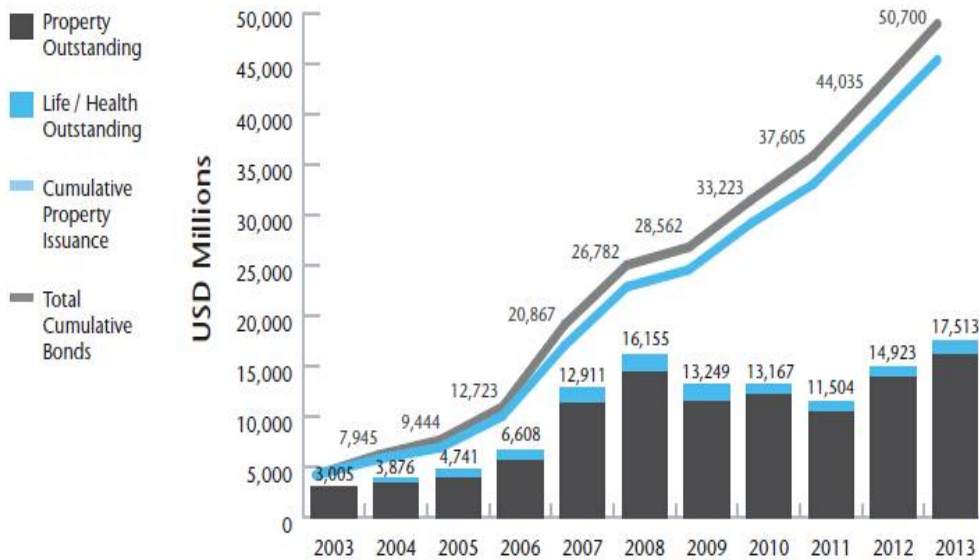
⁷¹ Aon Benfield Securities, *Insurance-Linked Securities: Capital Revolution – ILS Market Expands to New Heights* (2013), available at

http://thoughtleadership.aonbenfield.com/Documents/20130830_ab_ils_annual_report_2013.pdf.



Source: Aon Benfield Securities

Figures 3 Catastrophe Bond Issuance by Year (Years Ending June 30) ⁷²



Source: Aon Benfield Securities

Figures 4 Outstanding and Cumulative Catastrophe Bond Volume, 2003-2013 (Years Ending June 30) ⁷³

2. Main Products of ILS

The ILS market and its products are considered alternative risk transfer mechanisms because

⁷² Aon Benfield Securities, *Insurance-Linked Securities: Capital Revolution – ILS Market Expands to New Heights* (2013), available at http://thoughtleadership.aonbenfield.com/Documents/20130830_ab_ils_annual_report_2013.pdf.

⁷³ Aon Benfield Securities, *Insurance-Linked Securities: Capital Revolution – ILS Market Expands to New Heights* (2013), available at http://thoughtleadership.aonbenfield.com/Documents/20130830_ab_ils_annual_report_2013.pdf.

they blur the boundaries of conventional insurance and reinsurance.⁷⁴ In the next passage, I discuss three types of ILS—catastrophe derivatives, contingent capital and catastrophe bonds—and then analyze the structure and triggers of catastrophe bonds, which are the most prominent and popular products for managing catastrophe risk in greater depth.⁷⁵ Weather bonds is one kind of catastrophe bonds which is the direct transfer of weather risks influenced by climate change to the capital market.⁷⁶

a. Catastrophe Derivatives

Derivatives are increasingly being used in the ILS market to facilitate the transfer of catastrophe risk among capital markets investors.⁷⁷ Specifically, catastrophe derivatives are financial contracts used to spread catastrophe risk to capital market investors which derive value from the value of financial instruments, events or conditions, for example, the event can be a wind storm making landfall within a certain distance of a given location.⁷⁸

Catastrophe derivatives are classified into exchange-traded derivatives and “over the counter” (OTC) derivatives contracts.⁷⁹ The exchange-traded derivatives are standardized derivative contracts, traded through an authorized exchange with the exchange or its clearinghouse acting as intermediary on every contract. “Futures”, “Options” and “Future Options” comprise the primary types of exchange-traded derivatives.⁸⁰ OTC derivatives, on the hand, are bespoke derivative contracts that are traded directly and informally between two parties rather than via a formal exchange or other intermediary. Popular OTC derivatives include “swaps,” “forwards,” and “credit derivatives.”⁸¹

⁷⁴ Banks, E., *Alternative Risk Transfer: Integrated Risk Management through Insurance, Reinsurance, and the Capital Markets* 58 (2004).

⁷⁵ Pauline Barrieu & Luca Albertini, *The Handbook of Insurance-Linked Securities* 9(2009). Also see the U.S. Gov’t Accountability Office, *Catastrophe Insurance Risk: The Role of Risk-Linked Securities and Factors Affecting Their Use* (2002) GAO-02-941; Sylvie Bouriaux & Richard MacMinn, *Securitization of Catastrophe Risk: New Developments in Insurance-Linked Securities and Derivatives*, *Journal of Insurance Issues*, vol. 32, issue 1, 1-34 (2009).

⁷⁶ Xu, W., Odening, M., and Musshoff, O., *Optimal Design of Weather Bonds*. In Annual Meeting of the American Agricultural Economics Association (AAEA), Orlando, Florida (2008).

⁷⁷ Partner Re, *A Balanced Discussion on Insurance Linked-Securities* (2008), available at www.parterre.com.

⁷⁸ Partner Re, *A Balanced Discussion on Insurance Linked-Securities* (2008), available at www.parterre.com.

⁷⁹ VÉRONIQUE BRUGGEMAN, *COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH* 162 (2010).

⁸⁰ A “Future” is a standardized, transferable, exchange-traded contract that represents an obligation to buy or sell a specific quantity of an underlying asset, at a price agreed but not exchanged on trade date, for settlement at a future time. An “Option” is a contract that gives the purchaser the right, but not the obligation, to buy or sell the underlying reference asset at a set price, at any time until an agreed expiry date or on the expiry date. A “Future Option” is an option on a futures contract, thus giving the purchaser the right to enter into an underlying futures transaction in exchange for a premium. A futures put gives the purchaser the right to sell a futures contract at a set strike price, while a futures call gives the purchaser the right to buy a futures contract at a set strike price. See VÉRONIQUE BRUGGEMAN, *COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH* 162 (2010).

⁸¹ A “Swap” is a bilateral transaction calling for periodic exchange of payments between two parties based on a defined reference index, and can be regarded as a package of forward contracts. A “Forward” is a customized, bilateral, single period contract referencing a specific market/asset reference. A “credit derivative” is an OTC derivative designed to a transfer credit risk from one party to another. See VÉRONIQUE BRUGGEMAN, *COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH* 163 (2010).

b. Contingent Capital

A contingent capital arrangement is a type of financing that is arranged before a loss occurs. When a catastrophic event (the trigger) occurs, the financier provides the insurer with capital; when no catastrophic event occurs, the insurer has no need for additional capital and the facility remains unused.⁸² Generally, contingent capital can be divided into contingent debt and contingent equity. Contingent debt includes “contingent debt facilities” and “contingent surplus notes”; contingent equity includes “catastrophe equity put options” and “put protected equity”.⁸³

c. Catastrophe Bonds

Catastrophe bonds are risked-linked securities that transfer catastrophe risks from insurers to investors through fully-collateralized special purpose vehicles (SPV).⁸⁴ These bonds are currently the main alternative to catastrophe reinsurance. The SPV is usually created by an insurance company or a reinsurance company which issues the bonds to capital market for purchase by institutional investors such as hedge funds and pension funds. When a trigger event occurs, such as a hurricane, the principal capital should be used to pay loss. If a trigger event does not occur, the investors can earn relatively high interest from the SPV.⁸⁵

3. Structure and Triggers of Catastrophe Bonds

a. Structure

Catastrophe bonds are also called “cat bonds” or “Act of God bonds”. In catastrophe bonds issuances, a special purpose vehicle (SPV) or a single purpose reinsurer (SPR) is sponsored by an insurance company, a reinsurance company, acting as an issuance vehicle. The insurer pays a premium for the coverage to SPV. Meanwhile, investors will purchase catastrophe bonds from the SPV. In exchange for the purchase, investors will receive some form of guaranteed interest on the catastrophe bonds. Both the premium paid by the insurer and the purchase proceeds from investors are placed in a trust account owned by the SPV and invested in accordance with the trust agreement. The trust account is designed to hold the principal invested as funding for a payout in the event that the insurer’s losses pierce the layer covered by the SPV because the insurer pays a negotiated premium amount for the coverage. The trust is also designed to produce the interest

⁸² VÉRONIQUE BRUGGEMAN, COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH 160 (2010).

⁸³ “Contingent debt facilities” are available as “committed capital facilities” and “contingency loans”. A “Committed capital facilities” is funded capital that is arranged prior to a catastrophic loss and which is accessible only when two triggers events are breached. The “contingency loans” is a bank of line of credit that is arranged in advance of a loss and invoked when a trigger event occurs. “Contingent surplus notes” are notes sold to investors that are counted as policyholders’ surplus rather than a liability on an insurer’s statutory balance sheet. A “catastrophe equity put options” is a right to sell equity at a predetermined price in the event of a catastrophic loss. The “put protected equity” is a mechanism where a company buys a put on its own equity in order to generate an economic gain should the value of its stock decline in the aftermath of a loss. See VÉRONIQUE BRUGGEMAN, COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH 160-161 (2010).

⁸⁴ Partner Re, *A Balanced Discussion on Insurance Linked-Securities* (2008), available at www.parterre.com.

⁸⁵ Partner Re, *A Balanced Discussion on Insurance Linked-Securities* (2008), available at www.parterre.com.

rates contractually agreed on with the investors in the various tranches.⁸⁶

Furthermore, to insure that the necessary interest rates will be paid, the trustee will often enter into a swap agreement in which the swap counterparty will provide protection to the trust if the interest generated falls below the amount necessary to pay the required interest payments to the various tranche investors.⁸⁷ Figure 5 illustrates the expanded structure of catastrophe bonds.

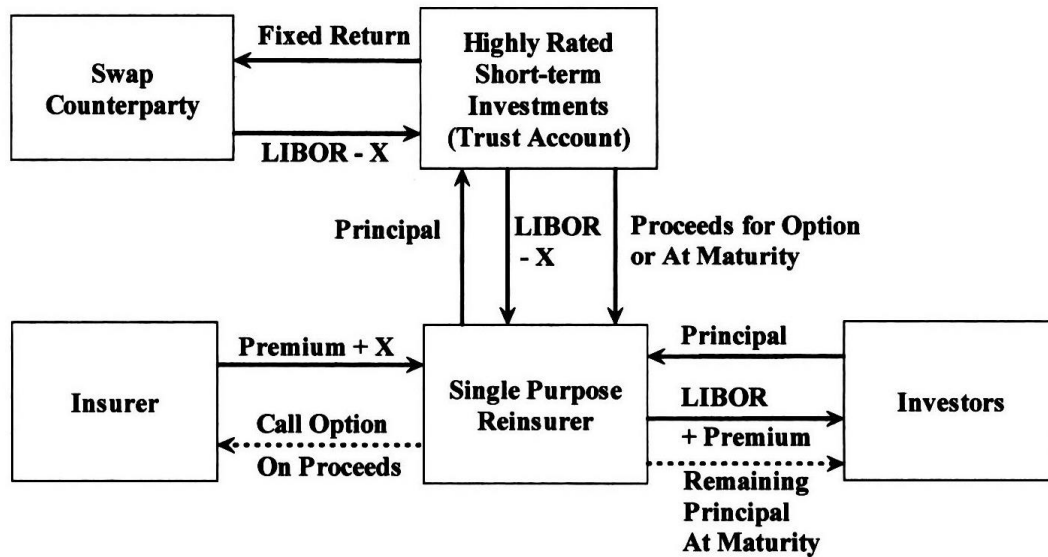


Figure 5 Illustration of the Structure of Catastrophe Bonds⁸⁸

b. Triggers

The trigger of catastrophe bonds is an important issue. A trigger may be a single event or multiple events. These events determine whether the issuer can suspend the principal or interest payments either temporarily or permanently to investors.⁸⁹ Triggers are usually structured as indemnity, index and parametric triggers. An indemnity trigger is based on an insurer's actual losses from a particular catastrophe.⁹⁰ The first hurricane bond issued by USAA was of this type, as it is based on ultimate net loss defined under USAA's portfolio parameters. An index trigger is

⁸⁶ The lower of the tranche is rated, the higher the rate of return but with no guarantee of the return of principal. Conversely, the higher of the tranche is rating, the lower the guaranteed interest rate, but the return of principal may be guaranteed. In this tranche, the trigger events would affect the interest and spreading payments and the timing of the repayment of principal. For example, a 2-year catastrophe bond subject to the payment of interest and a spread premium might convert into a 10-year zero-coupon bond that would return only the principal. This principal-protected tranche is relatively rare. See James S. Gkonos & Braden A. Borger, *At the Crossroads of Insurance and the Capital Markets: An Analysis of the Current Regulatory Environment and New Developments in Alternative Risk Transfers*, New Appleman on Insurance: Current Critical Issues in Insurance Law (2010). Cummins, J. D., *CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments*, Risk Management and Insurance Review, 11(1), 23-47 (2008).

⁸⁷ James S. Gkonos & Braden A. Borger, *At the Crossroads of Insurance and the Capital Markets: An Analysis of the Current Regulatory Environment and New Developments in Alternative Risk Transfers*, New Appleman on Insurance: Current Critical Issues in Insurance Law (2010).

⁸⁸ LIBOR is the abbreviation of "London interbank offered rate". See Cummins, J. D., *CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments*, Risk Management and Insurance Review, 11(1), 23-47 (2008).

⁸⁹ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

⁹⁰ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

based on existing industry loss indices.⁹¹ Industry losses are derived from granular property databases which normally include number of risks, value by type, occupancy, coverage and business. A parametric trigger is based on parameters associated with a peril such as event location and intensity.⁹² For an earthquake, the parametric trigger can be the magnitude of the earthquake. For a hurricane, the parametric trigger can be the location of landfall or the average sustained wind speed. Munich’s reissuance of Prime Capital is a good example of a multiple peril parametric structure. While most of the earliest bonds in the market featured indemnity triggers, a gradual shift towards parametric and index triggers occurred since 2000, partly as a result of the lack of transparency surrounding portfolios of risk, which investors find difficult to analyze. Figure 6 shows the strengths and weaknesses of the three triggers, which can partly explain the shift.⁹³

	Indemnity	Index	Parametric
Trigger	Based on insurer’s actual losses	Based on industry loss estimates	Based on defined parameters of catastrophic event
Advantages	Eliminate basis risk	More transparent; eliminates moral hazard risk	More transparent; quicker settlement period leading to increased liquidity
Disadvantages	Long recovery period to calculate loss claims, leading to less liquidity for investors; potential for moral hazard risk	Exposes risk transferor to basis risk	Exposes risk transferor to basis risk

Figure 6 Cross-comparison of Catastrophe Bonds Triggers⁹⁴

B. Supply and Demand Dynamics of ILS

Whether ILS provides a sustainable solution for distributing catastrophe risk depends in large part on the supply-demand dynamics in which the insurers create the supply of ILS and capital market investors generate the demand. Because most trading to date has taken place through catastrophe bonds, I will focus on those instruments.

1. Benefits and Drawbacks of ILS Supply

Insurers are significant participants in the ILS market. Because most of ILS SPVs are controlled or owned by insurers, these firms virtually design ILS products. Insurers manage their own risk exposures through ART-related mechanisms and supply ILS products to increase their

⁹¹ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

⁹² Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

⁹³ In the table, “basis risk” is the risk that the index calculation will not be the same as the client’s actual loss. It is further discussed in below 6.1.2.

⁹⁴ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

capacity to underwrite catastrophes.⁹⁵ Investment banks remain the primary arrangers of ILS given their experience in other types of securitizations and their ability to place bonds through large distribution networks.⁹⁶

The benefits and drawbacks of supplying ILS contrast with those of reinsurance. Traditionally, insurers have protected themselves through private reinsurance contracts whereby portions of their losses from a catastrophic disaster are covered by some type of treaty or excess-loss arrangement.⁹⁷ Reinsurance provides insurers with risk financing while ILS provide insurers with risk transfer.⁹⁸ ILS is regarded as a useful tool to transfer catastrophe risk to the capital markets and serves as a complement to traditional reinsurance.

a. Benefits of Supplying ILS

The first benefit of ILS is that these securities may lower the cost to insurers when reinsurance is experiencing a hard market. A “hard market” typically refers to the time period soon after the occurrence of a catastrophe event, when reinsurers generally limit their coverage and charge higher premiums for these risks. During such periods, catastrophe bonds can reduce the costs associated with most severe types of catastrophic risks.⁹⁹ In that regard, the presence of catastrophe bonds as an alternative way of transferring catastrophe risk can help prevent reinsurance prices from increasing faster than expected.¹⁰⁰

The second benefit of ILS is that they have the potential to solve capacity problems in insurance markets. Because of the enormity of capital markets, and the potential for pure risk transfer, ILS can solve capacity gaps.¹⁰¹ Representatives from one insurance company state that their company is not able to claim the amount of reinsurance needed in this risk category from traditional reinsurers. As a result, the company pays premiums to Special Purpose Vehicles (SPVs) to get the coverage via catastrophe bonds and to replace some of its reinsurance coverage in this risk category.¹⁰² The potential capacity of capital markets creates greater coverage capacity than traditional risk pooling could provide.¹⁰³

The third benefit of ILS is that these bonds provide multi-year protection, while reinsurance

⁹⁵ Banks, E., *Alternative Risk Transfer: Integrated Risk Management through Insurance, Reinsurance, and the Capital Markets* 53 (2004).

⁹⁶ Banks, E., *Alternative Risk Transfer: Integrated Risk Management through Insurance, Reinsurance, and the Capital Markets* 118 (2004).

⁹⁷ Froot, K. A. (Ed.), *The Financing of Catastrophe Risk* 151-152 (1999).

⁹⁸ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part I, A Broad Overview* (2010).

⁹⁹ U.S. Gov’t Accountability Office, *Catastrophe Insurance Risk: The Role of Risk-Linked Securities and Factors Affecting Their Use* (2002), GAO-02-941.

¹⁰⁰ U.S. Gov’t Accountability Office, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk* (2003), GAO-03-1033.

¹⁰¹ Sylvie Bouriaux & William L. Scott, *Capital Market Solutions to Terrorism Risk Coverage: A Feasibility Study*, 5 J. RISK FIN. 34 (2004). (Noting that risk transfer to the capital markets can increase coverage capacity by taking pressure off insurers to maintain tremendous capital surpluses). See also Andrew Gerrish, *TERROR CATS: TRIA’S FAILURE TO ENCOURAGE A PRIVATE MARKET FOR TERRORISM INSURANCE AND HOW FEDERAL SECURITIZATION OF TERRORISM RISK MAY BE A VIABLE ALTERNATIVE*, 68 Wash. & Lee L. Rev. 1825 (2011).

¹⁰² U.S. Gov’t Accountability Office, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk* (2003), GAO-03-1033.

¹⁰³ Sylvie Bouriaux & William L. Scott, *Capital Market Solutions to Terrorism Risk Coverage: A Feasibility Study*, 5 J. RISK FIN. 34 (2004).

is often limited to a twelve-month timeframe.¹⁰⁴ Multi-year protection insulates insurers against cyclical price changes inherent in catastrophe risk and reduces transaction costs.¹⁰⁵ Due to these benefits, insurers prefer catastrophe bonds with three- or five-year maturity dates, so insurers can respond to new information, protect against reinsurance price changes, and keep costs down.¹⁰⁶

The fourth benefit of ILS is that they reduce the exposure to the credit risk of an individual reinsurer. As with any financial transaction, there is a potential credit risk associated with reinsurance due to the risk of insolvency or slow payment by the reinsurer.¹⁰⁷ Catastrophe bonds provide full collateralization of losses by entering into a swap agreement with the swap counterparty, which eliminates credit risk for clients.¹⁰⁸

b. Drawbacks of Supplying ILS

ILS, however, are not without their drawbacks vis-à-vis traditional reinsurance, and these drawbacks prevent ILS from becoming more prominent.

The first drawback of ILS is that the total costs of issuing catastrophe bonds are high in comparison to reinsurance, at least when reinsurance is experiencing a soft market offering coverage to insurers on reasonable terms. These costs include but are not limited to legal fees, broker fees, rating agency fees, bank fees, actuarial/modeling fees, administrative costs and relatively high rates of return paid to investors. On the contrary, reinsurance only has brokerage fees.¹⁰⁹ Some insurance company officials estimated that the total costs associated with catastrophe bonds could be double more than traditional reinsurance which significantly exceeded the costs associated with purchasing reinsurance coverage.¹¹⁰

The second drawback of ILS is that they expose the insurer to basis risk while reinsurance does not. Basis risk is the risk that the index calculation will not be the same as the client's actual loss.¹¹¹ Basis risk generally reflects the possibility that ILS may not be partially or fully triggered (for covered perils) even when the sponsor of the ILS has suffered a loss.¹¹² Since most ILS structures are index-based, basis risk can be significant and may result in the bond not paying enough to cover the client's losses.¹¹³

2. Benefits and Drawbacks of ILS Demand

Investors provide the capital, or risk capacity, that produces the demand for ILS. These

¹⁰⁴ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part I, A Broad Overview* (2010).

¹⁰⁵ Cummins, J. D., *CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments*. *Risk Management and Insurance Review*, 11(1), 23-47 (2008).

¹⁰⁶ Cummins, J. D., *CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments*. *Risk Management and Insurance Review*, 11(1), 23-47 (2008).

¹⁰⁷ Partner Re, *A Balanced Discussion on Insurance Linked-Securities* (2008), available at www.parterre.com.

¹⁰⁸ See the above Figure 3: Illustration of the structure of catastrophe bonds. There can still be counterparty risk, however, as the Lehman Brothers bankruptcy demonstrated.

¹⁰⁹ Partner Re, *A Balanced Discussion on Insurance Linked-Securities* (2008), available at www.parterre.com.

¹¹⁰ U.S. Gov't Accountability Office, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk* (2003), GAO-03-1033.

¹¹¹ Partner Re, *A Balanced Discussion on Insurance Linked-Securities* (2008), available at www.parterre.com.

¹¹² A.M. Best Methodology (2012), *Gauging the Basis Risk Of Catastrophe Bonds*, available at <http://www3.ambest.com/ambv/ratingmethodology/OpenPDF.aspx?rc=197690>.

¹¹³ Partner Re, *A Balanced Discussion on Insurance Linked-Securities* (2008), available at www.parterre.com.

investors are vital to the ART market, as they allow risks to be assumed, transferred, hedged or otherwise transformed. In fact, without this capital, the ILS market would simply cease to function. Investors are generally large institutions that seek adequate returns on their investment portfolios in return for the provision of capital.¹¹⁴

a. Benefits of ILS for Investors

The first benefit of ILS for investors is the non-correlation with the credit risks of other parts of the portfolio. ILS has little correlation with the risks that traditional securities face. Most natural catastrophes are uncorrelated with economic conditions, and investments in catastrophic risk could therefore help market investors diversify their portfolios.¹¹⁵ Unless hit by a financial crisis like the 2008 international financial crisis in which the bankrupted Lehman Brother was the major swap counterpart for ILS, investors are insulated from credit risk because their risk-linked securities are fully collateralized by the safe and short-term securities such as government bonds, held in the SPV's investment account.¹¹⁶

The second benefit of ILS for investors is that ILS offer relatively high rates of return compared to other types of traditional securities assuming that the ILS are not triggered. Investors are paid a risk premium to compensate them for the risk of losing principal.¹¹⁷

b. Drawbacks of ILS for Investors

ILS, however, are not without their drawbacks vis-à-vis traditional securities, and these drawbacks limit the number of catastrophe bonds purchased.

The first drawback of ILS arises from the fact that the risks of catastrophe bonds are difficult to assess. The data of natural perils and geographical areas are very important for the actuarial calculations of loss; however, there are still no standardized and united data.¹¹⁸ A mutual fund industry official said that mutual fund companies had not purchased catastrophe bonds in funds potentially available to individual investors because the companies were not capable of evaluating the risks.¹¹⁹

The second drawback of ILS lies in the cost-consuming and time-consuming nature of due diligence by investors given ILS' complicated structures. It is not cost-effective for investors to improve their technical capability to analyze the risks of catastrophe bonds because those bonds are quite different from the securities they currently invest.

The third drawback of ILS lies in their limited liquidity. Some large mutual fund representatives share the concern that catastrophe bonds are relatively illiquid compared to

¹¹⁴ Banks, E., *Alternative Risk Transfer: Integrated Risk Management through Insurance, Reinsurance, and the Capital Markets* 57 (2004).

¹¹⁵ Froot, K. A. (Ed.), *The Financing of Catastrophe Risk* 257 (1999).

¹¹⁶ Cummins, J. D., *CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments*, *Risk Management and Insurance Review*, 11(1), 23-47 (2008).

¹¹⁷ Cummins, J. D., *CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments*, *Risk Management and Insurance Review*, 11(1), 23-47 (2008).

¹¹⁸ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

¹¹⁹ U.S. Gov't Accountability Office, *Catastrophe Insurance Risk: The Role of Risk-Linked Securities and Factors Affecting Their Use* (2002), GAO-02-941.

traditional bonds and equities.¹²⁰ Even investors who have already purchased catastrophe bonds say that they have limited their investments in the bonds to no more than 3% of their total portfolios.¹²¹

The fourth drawback of ILS lies in the adverse impact of the financial crisis on the creditworthiness of those securities. As Figure 3 above illustrates, to insure that the necessary interest rates would be obtained, the trustee would enter into a swap agreement in which the swap counterparty would provide protection to the trust if the interest obtained fell below the amount necessary to pay the required interest payments to the various tranche investors.¹²² Prior to the credit crisis, catastrophe bonds were structured with a total return swap (“TRS”) counterparty, which was usually an investment bank, to guarantee the collateral pool backing the bonds.¹²³ Investment banks, such as, Lehman Brothers often acted as the swap counter party in these transactions.¹²⁴ In 2008, the collapse of Lehman Brothers triggered substantial credit-related losses due to the underlying swap arrangements that had been designed to protect investors against counterparty risk. In the wake of the financial crisis, investors lost faith in the creditworthiness of the underlying guarantees, which temporarily impaired the market for catastrophe bonds.¹²⁵

3. A Short Conclusion—the ILS Is and May Continue to Be In Its Infancy

During the aftermath of the financial crisis, the ILS market recovered steadily and rebounded.¹²⁶ Investor demand for catastrophe bonds is now expected to grow. At the same time, more insurers—the suppliers—are participating in the catastrophe bond market as well.¹²⁷ From the perspective of investors, catastrophe bonds have yielded above-average returns in the past, while facilitating the diversification of portfolio.¹²⁸ From the viewpoint of the suppliers, not only traditional insurance and reinsurance companies, but also other noninsurance companies, such as Tokyo Disney and Universal Studio, have issued catastrophe bonds to the capital market.¹²⁹ This suggests that further growth of the catastrophe bond market is possible.

However, there are more challenges for the ILS markets. Besides the drawbacks discussed above, there are limitations on the number of qualified investors. Thus, only the most

¹²⁰ U.S. Gov’t Accountability Office, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk* (2003), GAO-03-1033.

¹²¹ U.S. Gov’t Accountability Office, *Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk* (2003), GAO-03-1033.

¹²² For example, according to USAA’s issue of cat bonds, the trustee deal with defeasance securities counterparty. See Banks, E., *Alternative Risk Transfer: Integrated Risk Management through Insurance, Reinsurance, and the Capital Markets* 125-126 (2004).

¹²³ James S. Gkonos & Braden A. Borger, *At the Crossroads of Insurance and the Capital Markets: An Analysis of the Current Regulatory Environment and New Developments in Alternative Risk Transfers*, New Appleman on Insurance: Current Critical Issues in Insurance Law (2010).

¹²⁴ James S. Gkonos & Braden A. Borger, *At the Crossroads of Insurance and the Capital Markets: An Analysis of the Current Regulatory Environment and New Developments in Alternative Risk Transfers*, New Appleman on Insurance: Current Critical Issues in Insurance Law (2010).

¹²⁵ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

¹²⁶ Aon Benfield Securities, *Insurance-Linked Securities –Consistency and Confidence* (2011), available at http://thoughtleadership.aonbenfield.com/Documents/201108_ab_securitys_ils_annual_2011.pdf.

¹²⁷ Aon Benfield Securities, *Insurance-Linked Securities –Consistency and Confidence* (2011), available at http://thoughtleadership.aonbenfield.com/Documents/201108_ab_securitys_ils_annual_2011.pdf.

¹²⁸ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

¹²⁹ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

sophisticated investors, normally the institutional investors, have the ability to value and purchase catastrophe bonds due to the lack of standardized transactions and the lack of transparency of the underlying risk and the valuation methodologies.¹³⁰

Although there are indeed both benefits and drawbacks on the issuance and purchase of ILS, the drawbacks associated with catastrophe bonds, especially the demand-side of ILS, as discussed above, are greater than potential benefits. These may be the reasons why ILS does not develop as quickly as was predicted and still in their infancy.

IV. Justifications of Government Intervention in Managing Catastrophe Risk

In this section, I will discuss the justifications of government intervention—the other potential risk transfer mechanism—in distributing catastrophe risk and examine whether it may solve the anomalies of private catastrophe insurance.

A. Justifications and Criticisms of Government Intervention in Catastrophe Insurance Market

1. Justifications of Government Interventions Due to Market Failure

Most often, government intervention is justified based on market failures.¹³¹ In the area of private catastrophe insurance, as discussed in Part I, there are several types of market failure, both in supply and demand.

To recap, in the context of catastrophe risks, it is difficult to fulfill the insurability requirements of quantifying risks and setting premiums. In addition, due to the high potential losses from catastrophe exposures, insurers' capacity and appetite to cover such losses is not sufficient. Early in 1992, Hurricane Andrew revealed that Florida faced a "capacity gap," which is the difference between the amount of available insurance industry capital and the demand for catastrophe coverage.¹³² For these reasons, the supply of catastrophe insurance is limited and volatile.

The demand function is also distorted for catastrophe coverage. Consumers do not always behave rationally and maximize their expected utility to protect themselves from catastrophe losses by purchasing insurance. For example, prior to a disaster, consumers tend to believe that natural disasters will not happen to them. In addition, many consumers regard the premium as a certain loss, which is more painful than the possible future gains. For both reasons, consumers demand too little catastrophe insurance in normal periods.

¹³⁰ Kampa, Christopher, *Alternative Risk Transfer: The Convergence of the Insurance and Capital Markets, Part II, Non-life Utilization of Insurance-Linked Securities* (2010).

¹³¹ Jeffrey R. Brown (eds.), *Public Insurance and Private Markets* 1(2010).

¹³² King, R. O., *Hurricanes and Disaster Risk Financing Through Insurance: Challenges and Policy Options*, Congressional Information Service, Library of Congress (2005).

The economic justification for government intervention due to market failure was set forth most forcefully and elegantly many years ago by Kenneth Arrow.¹³³ According to Arrow, government should undertake insurance in those cases where the private market, for whatever reason, has failed to emerge.¹³⁴ He justified government intervention with a very simple economic model. Assume, first, that each individual maximizes expected utility; second, that individuals are normally risk-averse; third, that the government can provide coverage for losses and spread the losses over the entire population of taxpayers. Based on the above assumptions which are hardly controversial, Arrow concludes that government should provide insurance in all contexts against all risks, where there is no provision of insurance by private market.¹³⁵ Catastrophe insurance is just a typical example.

In addition to Arrow's argument, Priest believes that government has the power to solve the problem of adverse selection due to compulsory insurance and also has the ability to diversify risk across generations through fiscal policy.¹³⁶

Furthermore, government intervention can also enhance social welfare. In contrast to a laissez-faire approach, government intervention targeted at addressing market failures (such as moral hazard, externalities, adverse selection, etc.) can improve social welfare and market equilibrium, since the existence of such market failures can lead to a suboptimal allocation of scarce resources in the economy.¹³⁷ Social welfare is broadly defined to include social concern for the distribution of income, adequate protection against low income in the retirement and unemployment, and adequate use of medical care.¹³⁸ The analog in the catastrophe context is the adequate protection against losses from natural disasters so as to improve the allocation of resources. For catastrophe risks, in the case of private insurance capacity, the social welfare enhancement approach calls for the government to step in and provides compensation directly to the victims or compulsory and tax-financed disaster insurance.¹³⁹

2. Justifications of Government Interventions Due to Individual's Bounded Rationality

Although some scholars suggested that systematic irrationality should be conceived as a form of market failure,¹⁴⁰ individual's bounded rationality does not constitute market failure in the strict sense of form, it has nonetheless frequently been cited as important justifications for government intervention in private markets for risk.¹⁴¹

According to rational choice theory, people are self-interested individuals who act to

¹³³ Kenneth Arrow, *Uncertainty and the Welfare Economics of Medical Care*, the American Economic Review, Volume 53, Issue 5, 941-973 (1963).

¹³⁴ Kenneth Arrow, *Uncertainty and the Welfare Economics of Medical Care*, the American Economic Review, Volume 53, Issue 5, 941-973 (1963).

¹³⁵ Kenneth Arrow, *Uncertainty and the Welfare Economics of Medical Care*, the American Economic Review, Volume 53, Issue 5, 941-973 (1963).

¹³⁶ Priest, G. L., *Government Insurance versus Market Insurance*, Geneva Papers on Risk and Insurance Issues and Practice, 71-80 (2003).

¹³⁷ Richard Abel Musgrave & Peggy B. Musgrave, *Public Finance in Theory and Practice* 664 (1976).

¹³⁸ Howard Kunreuther, Mark V. Pauly and Stacey McMorow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 265 (2013).

¹³⁹ VÉRONIQUE BRUGGEMAN, *COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH* 194 (2010).

¹⁴⁰ Jon D. Hanson & Douglas A. Kysar, *TAKING BEHAVIORALISM SERIOUSLY: THE PROBLEM OF MARKET MANIPULATION*, 74 N.Y.U. L. Rev. 630 (1999).

¹⁴¹ David A. Moss, *When All Else Fails: Government as the Ultimate Risk Manager* 306 (2002).

maximize their expected utility, which is the typical Homoeconomicus (Econs) assumption.¹⁴² Private markets are based on the assumption that almost all people, almost all of the time, make choices that maximize their own economic welfare or at the very least are better than the choices that would be made by someone else. However, this assumption is not always right in practice due to the availability heuristic, representativeness heuristic, overconfidence, loss aversion and other cognitive bias of human beings.¹⁴³

Behavioral decision theory is regarded as the alternative and competing theory with conventional rational choice theory. Behavioral decision theory is the analysis of human judgment and decision making, and proceeds from the assumption that humans display “bounded rationality” when making decisions.¹⁴⁴ Nobel Laureate Daniel Kahneman and cognitive scientist Amos Tversky empirically determined that people have problems when assessing the probability associated with uncertain events.¹⁴⁵ When making decisions, we, humans, experience “cognitive overload” and resort to shortcuts and rules of thumb, known as heuristics.¹⁴⁶ Heuristics can lead to systematic, predictable errors called cognitive biases.¹⁴⁷ According to behavioral decision theory, government can significantly alter the behavior of humans when facing and assessing catastrophe risks, by libertarian paternalistic measures.

The libertarian aspect of government intervention lies in the straightforward insistence that, in general, people should be free to do what they like, and to opt out of undesirable arrangements if they want to do so.¹⁴⁸ For example, take a person who lives in the tenth floor of an apartment located in a floodplain. Under the libertarian view, he should have the freedom to opt out of government-supplied flood insurance if he wants to. The paternalistic view of government intervention lies in the claim that it is legitimate for government to try to influence people’s behavior in order to make their life better. Generally speaking, libertarian paternalism is an approach that preserves freedom of choice but that encourages both private and public institutions to steer people in directions that will promote their own welfare.¹⁴⁹

In the case of catastrophe risks, individuals tend to make pretty bad decisions. A potential rational victim residing in a hazard-prone area will voluntarily purchase catastrophe insurance if he perceives the premium to be sufficiently low in comparison to the risks contrary to their expected utility. However, many people fail to purchase insurance offered even at subsidized prices against low-probability but high-consequence disasters.¹⁵⁰ In these situations, government intervention to steer people’s choice in direction will improve their lives.

¹⁴² Michael P. Vandenbergh, Amanda R. Carrico, and Lisa Schultz Bressman, *Regulation in the Behavioral Era*, 95 MINN. L. REV. 715, 730 (2011).

¹⁴³ Thaler, Richard H., & Cass R. Sunstein, *Nudge: Improving Decisions about Health, Wealth, and Happiness* 17-40 (2008).

¹⁴⁴ Gilovich, T., & Griffin, D., *Introduction-Heuristics and Biases: Then and Now*, in *Heuristics and Biases: The Psychology of Intuitive Judgment* 1-18(Thomas Gilovich etc. eds., 2002); KEITH E. STANOVICH, *DECISION MAKING AND RATIONALITY IN THE MODERN WORLD* 52 (2009).

¹⁴⁵ Tversky, A., & Kahneman, D., *Judgment under Uncertainty: Heuristics and Biases*. *Science*, 185(4157), 1124-1131(1974).

¹⁴⁶ Harvey, N., *Use of Heuristics: Insights from Forecasting Research*, *Thinking & Reasoning*, 13(1), 5-24(2007).

¹⁴⁷ Harvey, N., *Use of Heuristics: Insights from Forecasting Research*, *Thinking & Reasoning*, 13(1), 5-24(2007).

¹⁴⁸ Thaler, Richard H., & Cass R. Sunstein, *Nudge: Improving Decisions about Health, Wealth, and Happiness* 5 (2008).

¹⁴⁹ Cass R. Sunstein & Richard H. Thaler, *Libertarian Paternalism Is Not an Oxymoron*, 70 U. Chi. L. Rev. 1159 (2003).

¹⁵⁰ Howard Kunreuther, Mark V. Pauly and Stacey McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 113 (2013).

3. Criticisms of Government Intervention

Government intervention, however, is not without criticisms vis-à-vis the private insurance market.

The most basic criticism of government intervention does not address the intervention of the government as such, but is based on the assumption that the government does not charge premiums that fully reflect the risk being insured.¹⁵¹ This causes price distortion and sends the wrong market signals.¹⁵² Ammerlaan and van Boom also criticize government-provided insurance for incorrect premiums.¹⁵³ It is a criticism shared by Levmore and Logue.¹⁵⁴

The second criticism of government intervention lies in its often mandatory nature compared with private insurance. Such intervention may lead to paternalism, over breadth, and anti-competition.¹⁵⁵ Paternalism happens when the legislature forces potential victims to purchase insurance policies even if there would be no demand.¹⁵⁶ Over breadth occurs when a generalized duty to purchase flood coverage, for example, results in the duty being imposed on those who constitute no risk at all, such as the owner of an apartment on the tenth floor.¹⁵⁷ Anti-competition problems happen when a so-called tie-in agreement forces a consumer to buy a specific service or product together with another product, which may restrict competition.¹⁵⁸

The third criticism of government intervention consists of moral hazard induced by government action. Often government intervention is motivated by an admirable humanitarian impulse which spurs redistributing wealth to those who have suffered loss from those who have escaped.¹⁵⁹ However, this humanitarian action ignores the fact that in some cases, the effect of the redistribution will be to encourage future loss-causing activities that would not otherwise be undertaken. Preferences for redistribution cannot be morally defended where the redistributive mechanism that has been selected increases moral hazard and thus the frequency and magnitude of loss to the society.¹⁶⁰

This problem has been referred to as the “Samaritan’s Dilemma”. If individuals and organizations assume that the government will provide significant assistance after hardship—for example, that the government will be insurer of last resort—there will be fewer economic incentives for those in hazard-prone areas to reduce their risks before the next disaster and to purchase adequate insurance coverage.¹⁶¹ For instance, U.S. government flood insurance has

¹⁵¹ V éronique Bruggeman, Michael G Faurea, and Karine Fiore, *The Government as Reinsurer of Catastrophe Risks?* The Geneva Papers 35, 369–390 (2010); Gron, A. & Sykes, A.O, *A Role for Government?* Regulation 25(4): 44–51 (2002); Gron, A. & Sykes, A.O. *Terrorism and Insurance Markets: A Role for the Government as Insurer?* 36 Ind. L. Rev. 447 (2003).

¹⁵² Gron, A. & Sykes, A.O, *A Role for Government?* Regulation 25(4): 44–51 (2002); Gron, A. & Sykes, A.O. *Terrorism and Insurance Markets: A Role for the Government as Insurer?* 36 Ind. L. Rev. 447 (2003).

¹⁵³ V éronique Bruggeman, Michael G Faurea, and Karine Fiore, *The Government as Reinsurer of Catastrophe Risks?* The Geneva Papers 35, 369–390 (2010).

¹⁵⁴ Levmore, S. & Logue, K.D., *Insuring against Terrorism—And Crime*, 102 Mich. L. Rev. 268 (2003).

¹⁵⁵ Michael G. Faure, *Insurability of Damage Caused by Climate Change: A Commentary*, 155 U. Pa. L. Rev. 1875 (2007).

¹⁵⁶ Id.

¹⁵⁷ Id.

¹⁵⁸ Id.

¹⁵⁹ Priest, G. L., *Government Insurance versus Market Insurance*. Geneva Papers on Risk and Insurance, vol. 28, No.1 71-80 (2003).

¹⁶⁰ Priest, G. L., *Government Insurance versus Market Insurance*. Geneva Papers on Risk and Insurance, vol. 28, No.1 71-80 (2003).

¹⁶¹ Ronald J. Daniels, Donald F. Kettle, and Howard Kunreuther (eds), *On Risk and Disaster: Lessons from Hurricane Katrina*, 10 (2011).

been criticized for subsidizing private landowners' decision to rebuild ruined properties in areas subject to chronic floods on the gamble that the government will bail them out again if their land is flooded in the future.

B. Types of Government Intervention in Covering Catastrophe Risk in Practice

Having reviewed the market failure and individuals' bounded rationality of private markets; we are now ready to ask whether government can possibly do any better. The answer may be a resounding "yes" in theory.¹⁶² In practice, however, the answer is not that easy to be confirmed.

1. Providing Direct Compensation to Victims

There are numerous examples of *ad hoc* solutions that provide immediate relief for specific cases. For example, in Germany after the "flood of the century" of the river Elbe in 2002, *ad hoc* compensation was provided through the so-called Flutopferhilfesolidaritätsgesetz, which provided a total amount of compensation of 8.1 billion euros.¹⁶³ China is another country where government has paid *ad hoc* direct compensation to victims. For example, after the Great Sichuan Earthquake of 2008, the central and local governments played a key role in combining and allocating the resources of society to victims directly in disaster relief.¹⁶⁴ Meanwhile, the so-called "Counterpart Aid" between local governments in China was another widely-used method to provide *ad hoc* direct compensation.¹⁶⁵

However, this type of government relief is heavily criticized both from a legal and an economic perspective. It can suffer from economic inefficiency due to internal rent-seeking activities. For example, Gerrett and Sobel argue that nearly half of all disaster relief by FEMA is motivated politically rather than by need.¹⁶⁶ Depoorter believes that ex post disaster relief involves negative externalities when action by one agency makes other agencies or representatives look worse.¹⁶⁷ For example, Texas sent troops and medical personnel to the Gulf Coast region after Katrina made landfall, and this affected the costs and benefits of participating in the relief effort for other states like Florida. When Texas sent troops and supplies, this probably put pressure

¹⁶² David A. Moss, *When All Else Fails: Government as the Ultimate Risk Manager* 49 (2002).

¹⁶³ Michael Faure & Klaus Heine, *Can European State Aid Control Learn from the Management of Disastrous Crises?* Available at http://www.wiwi.uni-muenster.de/06/vs/Tagungen/2010/Heine-Faure_Referat.pdf.

¹⁶⁴ Zhang Qin & Chen Liuqin, *Zhongguo Juzai Fengxian Guanli Moshi Yanjiu [Mode of Managing Catastrophic Risk in China]*, Wuhan Keji Daxue Xuebao [J. of Wuhan Uni. of Sci. & Tech. (Social Science Edition)] Vol 11. 33-41(2009).

¹⁶⁵ Counterpart Aid is a support model full of Chinese characteristics. Following central government's requirement, some local governments who have strong economic power, assist and support the reconstruction of disaster-affected areas. For example, after the Great Sichuan Earthquake, the Shandong province is responsible and helps the reconstruction of BeiChuan County which is an earthquake-stuck area. See Lan, Y, *Duikou Zhiyuan: Zhongguo Tese De Difang Zhengfu Jian Hezuo Moshi Yanjiu, [A Study on the Counterpart Aid: A Cooperation Pattern between Local Governments with Chinese Characteristics]*, XiBei Shifan Daxue Shuoshi Xuewei Lunwen [Thesis of the College of Political and Law of Northwest Normal University] (2011). Zhao, L. & Jiang, Y.J., *Difang Zhengfu Duikou Zhiyuan Moshi Fenxi [Analysis of Local Government Coordinated Assistance Modes]*, ChengDu Daxue Xuebao (Sheke Ban) [Journal of ChengDu University (Social Science Edition)], no.2, 4-7, 25(2009).

¹⁶⁶ Thomas A. Garrett & Russell S. Sobel, *The Political Economy of FEMA Disaster Payments*, 41 *Econ. Inquiry* 496, 496 (2003).

¹⁶⁷ Depoorter, B., *Horizontal Political Externalities: The Supply and Demand of Disaster Management*, 56 *Duke L.J.* 101. (2006).

on Florida to do the same to avoid appearing disinterested to voters.¹⁶⁸ If state governments take precautionary investments, however, that would have reduced losses at a small percentage of the costs. Epstein criticizes ex post government compensation as “catastrophe responses to catastrophe risks”.¹⁶⁹ The sentiment that catastrophe losses are “special” carries with it the implication that forms of government intervention are appropriate because markets cannot respond to the problem at hand.¹⁷⁰ Epstein believes this proposition is not true because government intervention generally makes it harder for markets to function.¹⁷¹

2. Bundling Compensation for Catastrophes with Other Social Insurance

Social insurance is a common type of government intervention in welfare states. It is originated in the late 19th century when German Chancellor Otto Von Bismarck introduced a number of policies, including health insurance (1883), workers’ compensation (1884), and compulsory old-age insurance (1889) to safeguard his people from financial ruin.¹⁷² As a concept, social insurance is defined by the Committee on Social Insurance Terminology of the American Risk and Insurance Association as a device for the pooling of risks by their transfer to the government that is required by law to provide cash or service benefits to or on behalf of covered persons upon the occurrence of certain specified losses.¹⁷³

Social insurance and private insurance are substantially different in characteristics and goals.¹⁷⁴ Social insurance arises in large part as a form of altruism that uses taxes from the entire population to subsidize insurance protection. Historically, social insurance in the United States has been targeted at special groups, such as older people, the unemployed, young children and their mothers, and the disabled.¹⁷⁵ Those programs are including Social Security (OASDI), Medicare, Unemployment Compensation, and Workers’ Compensation. In contrast, the National Flood Insurance Program (NFIP) is not social insurance, because this program is not compulsory. Instead, NFIP is an example of the fourth type of government intervention—government provided (re)insurance program.

In the context of catastrophe risks, the “Swiss Example” is one kind of social insurance.¹⁷⁶ In nineteen of the twenty-six cantons of Switzerland, home insurance is offered by a regional monopoly and is compulsory. Under that program, homeowners in those cantons are obliged to

¹⁶⁸ Depoorter, B., *Horizontal Political Externalities: The Supply and Demand of Disaster Management*, 56 Duke L.J. 101. (2006).

¹⁶⁹ Richard A. Epstein, *Catastrophic Responses to Catastrophic Risks*, 12 J. Risk & Uncertainty 287(1996).

¹⁷⁰ Richard A. Epstein, *Catastrophic Responses to Catastrophic Risks*, 12 J. Risk & Uncertainty 287(1996).

¹⁷¹ Richard A. Epstein, *Catastrophic Responses to Catastrophic Risks*, 12 J. Risk & Uncertainty 287(1996).

¹⁷² Leah Rogne ... [et al.], eds, *Social Insurance and Social Justice: Social Security, Medicare and the Campaign Against Entitlements* xxvi (2009).

¹⁷³ Rejda, G. E. *Social Insurance and Economic Security* 16 (2012).

¹⁷⁴ The major differences are as follows: social insurance is compulsory, while private insurance is generally voluntary; minimum floor of income protection while larger mounts depending on individual desires and ability to pay; emphasis on social adequacy while emphasis on individual equity; benefits prescribed by law while benefits based on contract; government monopoly or limited completion while competition; costs more difficult to predict while costs more readily predictable; full funding not needed while full funding emphasized; and etc. See Rejda, G. E. *Social Insurance and Economic Security* 33-36 (2012).

¹⁷⁵ Howard Kunreuther, Mark V. Pauly and Stacey McMorro, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 245 (2013).

¹⁷⁶ Veronique Bruggeman, Michael Faure and Tobias Heldt, *Insurance against Catastrophe: Government Stimulation of Insurance Markets for Catastrophic Events*, 23 Duke Envtl. L. & Pol’y F. 185 (2012).

buy housing insurance against fire and natural disasters.¹⁷⁷

Due to the nature of social insurance, however, the public discourse has become increasingly negative in recent years.¹⁷⁸ The dominant ideology of individualism that extols free market values rejects social insurance as outmoded and unsustainable.¹⁷⁹ In the catastrophe context, the “Swiss Example” is regarded as an exception rather than the rule.¹⁸⁰

3. Requiring a Mandatory Cover on Voluntary Insurance Policies

In this type of government intervention, the government requires a mandatory cover on top of voluntary insurance policies to cover disaster risk. In the private market, catastrophe insurance is generally voluntary. Under a mandatory cover, however, when voluntary (for example, homeowner) insurance is purchased, cover for the damage caused by natural hazards is automatically included.¹⁸¹

France provides one of the best-known examples of this type. Through the Act of July 13, 1982, France created a duty in its “code des assurances” to provide coverage for the consequences of natural disasters.¹⁸² This French example has recently been followed in Belgium through the Acts of May 21, 2003 and September 17, 2005.¹⁸³

This type stimulates the demand for catastrophe insurance, but does not solve the supply-side problem. What’s more, it may force individuals, who run no risk at all — for example, an owner of a tenth-floor apartment who has hardly any risk of suffering flood damage—to take out coverage.

4. Supplying Government-supported (re) Insurance

This type of government intervention consists of the well-known “public-private partnerships” in which government intervenes to facilitate private insurance solutions. In one model, the government may act as primary insurer, such as in the National Flood Insurance Program (NFIP), administered by FEMA. The NFIP, created under the Housing and Urban Development Act of 1968, is a joint private industry and federal government cooperative program enabling homeowners and businesses in participating communities to purchase subsidized insurance protection against losses from flooding.¹⁸⁴ In another model, the government may act as reinsurer of last resort, with the partnership taking the form of a multi-layered insurance program that is

¹⁷⁷ Thomas von Ungern-Sternberg, *The Limits of Competition: Housing Insurance in Switzerland*, 40 Eur. Econ. Rev. 1111, 1113-14 (1996).

¹⁷⁸ Leah Rogne ... [et al.], eds, *Social Insurance and Social Justice: Social Security, Medicare and the Campaign Against Entitlements* xxix (2009).

¹⁷⁹ Leah Rogne ... [et al.], eds, *Social Insurance and Social Justice: Social Security, Medicare and the Campaign Against Entitlements* xxix (2009).

¹⁸⁰ Veronique Bruggeman, Michael Faure and Tobias Heldt, *Insurance against Catastrophe: Government Stimulation of Insurance Markets for Catastrophic Events*, 23 Duke Envtl. L. & Pol’y F. 185 (2012).

¹⁸¹ Willem H. van Boom & Michael Faure (eds.), *Shifts in Compensation between Private and Public Systems* 24 (2007).

¹⁸² Act No. 82-600 of 13 July 1982 on the Indemnification of Victims of Natural Catastrophes, JORF 2242 (1982).

¹⁸³ VÉRONIQUE BRUGGEMAN, *COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH* 247-260 (2010).

¹⁸⁴ King, R., *The National Flood Insurance Program: Status and Remaining Issues for Congress*. Congressional Research Service, 7-5700 (2013). See also GAO, *National Flood Insurance Program: Continued Actions Needed to Address Financial and Operational Issues* (2010) GAO-10-631T.

normally administered by private insurance companies that sell the insurance, collect premiums, and pay claims.¹⁸⁵ American terrorism insurance (TRIA) after 9/11 attack has this feature.¹⁸⁶ This public-private partnership is a necessary part of helping the private marketplace address the economic risks associated with terrorism.¹⁸⁷ Other examples in other jurisdictions include the following: the California Earthquake Authority (CEA),¹⁸⁸ the Dutch Agriver,¹⁸⁹ the Turkish catastrophe insurance pool (TCIP),¹⁹⁰ and the China Shenzhen Catastrophe Insurance Framework.¹⁹¹

In next Part, Part IV, I will make concluding remarks by comparing the discussed three mechanisms of distributing catastrophe risks, and explore which one is the optimal to cover catastrophe losses.

V. Proposal and Concluding Remarks: The Optimal Mechanism for Efficient Catastrophe Risk Management

Global climate change and the many weather-related catastrophes that have followed in the wake have generated increasing losses. Private insurance, Insurance-Linked Securities and government intervention are different mechanisms to distribute catastrophe risk and cover catastrophe losses. The benefits and drawbacks of each mechanism have been discussed in the above three Parts. In this Part, I compare the three mechanisms and explore a framework for determining what will be optimal to cover catastrophe losses.

Since there has been market failure of private insurance, I will assume that the baseline is private insurance. In market economies, it is assumed that private markets deliver services most efficiently absent market failure, so private insurance is the appropriate basis of comparison. The goal that I seek to optimize is more coverage of catastrophe risk with fair premiums. This is based on the conclusion that greater individual coverage of catastrophe risk is better for both those individuals and for social welfare.

¹⁸⁵ Levmore, S., & Logue, K. D., *Insuring Against Terrorism - and Crime*, 102 Mich. L. Rev. 268 (2003).

¹⁸⁶ Based on the “the American terrorism risk insurance act of 2002”. See Levmore, S., & Logue, K. D., *Insuring Against Terrorism - and Crime*, 102 Mich. L. Rev. 268 (2003).

¹⁸⁷ Advocate, *Ensuring Economic Security in the Face of Terrorism: A Public-Private Partnership* (2005), available at <http://www.aiadc.org/AIAdotNET/docHandler.aspx?DocID=276542>.

¹⁸⁸ CEA still relies on private insurers, but they merely administer the risk; risk-bearing was taken over by the government. See Willem H. van Boom & Michael Faure (eds.), *Shifts in Compensation between Private and Public Systems* 199-217 (2007).

¹⁸⁹ The Netherland government plays a role as reinsurer of last resort for agricultural damages against heavy rains. See V éronique Bruggeman, Michael G Faurea, and Karine Fiore, *The Government as Reinsurer of Catastrophe Risks?* *The Geneva Papers* 35, 369–390 (2010).

¹⁹⁰ TCIP was established as a public-sector insurance entity providing innovative catastrophe risk insurance for Turkish homeowners through the existing market mechanisms. See Charles Scawthorn & Kiyoshi Kobayashi (eds.), *Asian catastrophe insurance* 264-266 (2008).

¹⁹¹ Shenzhen Catastrophe Insurance Framework is consisted by three parts, first is government catastrophe relief insurance, second is government-supported catastrophe fund; third is private catastrophe insurance. See China Insurance Regulatory Commission (CIRC), available at <http://www.circ.gov.cn/web/site0/tab5168/info3900215.htm>.

A. Comparison between Private Insurance and ILS

In this section, I use private insurance as the baseline for comparison. For many types of insurance products, private insurance generally produces optimal outcomes in which consumers maximize utility and insurers maximize profits. However, for low-probability but high-consequence catastrophe risks, the supply and demand of private insurance are plagued by market failures.

On the supply side, the nature of catastrophe risks makes it difficult to fulfill all insurability requirements. Identifying and quantifying catastrophe risk is difficult due to the low probability of these disasters and thus limited historical data. What's more, the uncertainty of catastrophes increases the difficulty of estimating the frequency and damages of disasters.¹⁹² Setting premiums is also difficult for catastrophe risks due to factors such as the ambiguity of risk, the degree of correlated risk, and asymmetric information about the risk. Due to high potential losses from catastrophe exposures, insurers' capacity and appetite to cover such losses are not sufficient. In sum, the supply of catastrophe insurance is limited and volatile.

On the demand side, consumer behavior in purchasing catastrophe insurance deviates from classic economic theory in which they are willing to pay a certain small premium to protect against an uncertain large loss.¹⁹³ Consumers thus fail to purchase catastrophe insurance offered even at subsidized prices.¹⁹⁴

In sum, private catastrophe insurance experiences market failures in both the supply side and demand side. These inefficiencies indicate that private insurance may not be the optimal mechanism to cover catastrophe risk.

Given the inherent market failures in private catastrophe insurance, ILS provide a possible alternative solution. In this mechanism, insurers, working through Special Purpose Vehicle (SPV), issue ILS—such as catastrophe bonds—to investors in order to attract capital and thereby increase their capacity to underwrite catastrophe policies. As of June 30, 2013, annual issuance volume of catastrophe bonds reached \$6.7 billion.¹⁹⁵ Since ILS could attract capital and thus increase the capability for insurers to underwrite catastrophe insurance, it may increase insurers' supply of private insurance. In the situation of competitive private markets, increasing supply will lower the price of product and thus could attract more demand. The new equilibrium of premium and quantity is supposed to occur at the interaction of the new supply curve and demand curve. However, due to the same problems of demand anomalies in catastrophe insurance market discussed before, demand might also increase little or not at all. As a result, a new equilibrium might not become reality. Even with greater supply of catastrophe insurance, the goal of increasing catastrophe coverage may not be accomplished under the mechanism of ILS.

¹⁹² J.D. Cummins & C.M. Lewis, *Catastrophe Events, Parameter Uncertainty, and the Breakdown of Implicit Long Term Contracting: The Case of Terrorism Insurance*, 26 THE JOURNAL OF RISK AND INSURANCE, 154 (2003)

¹⁹³ Kenneth J. Arrow, *Essays in the Theory of Risk-Bearing* 199-200 (1971).

¹⁹⁴ Howard Kunreuther, Mark V. Pauly and Stacey McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry* 113 (2013).

¹⁹⁵ Aon Benfield Securities, *Insurance-Linked Securities: Capital Revolution – ILS Market Expands to New Heights* (2013), available at http://thoughtleadership.aonbenfield.com/Documents/20130830_ab_ils_annual_report_2013.pdf.

B. Comparison between Private Insurance and Government Intervention

Besides ILS, government intervention is the other mechanism that might solve the inefficient supply and demand of private insurance. Market failure and behavioral decision theory are all rationales for government intervention.¹⁹⁶ In practice, there are four main types of government intervention potentially available to solve the supply and demand anomalies in private insurance: providing direct compensation to victims; bundling compensation for catastrophes with other social insurance; requiring a mandatory cover on voluntary insurance policies; and supplying government-supported (re)insurance. On the supply side, government has the ability to be the “last resort” for private insurers due to its tax power and its power to diversify risk across generations through fiscal policy.¹⁹⁷ More important, government has the power to require consumers to buy catastrophe coverage. Therefore, government intervention has the potential ability to increase both supply and demand of catastrophe insurance.

C. A Proposal and Conclusion

Compared with the pure private insurance and ILS, government intervention both will increase supply and demand and thus move the equilibrium to a new position where coverage is expanded. It implies that private insurance with government intervention is—or at least has the potential to be—the optimal mechanism to sustainably distribute catastrophe risk, rather than the pure private insurance and ILS.

Of course, there are also many criticisms of government intervention that could render government catastrophe coverage suboptimal, including politicization of insurance premiums, corruption, lack of profit-making incentives, crowding out of the private market, and insufficient attention to moral hazard. These problems raise questions, among other things, about whether a governmentally set premium would be actuarially fair. These issues in evaluating whether government intervention is the optimal approach to distributing catastrophe risk needs for further research.

Nonetheless, the point of the comparison and discussion has been made clear that government does enjoy certain advantages over private insurance and capital market. How government intervention will be more efficient in covering catastrophe risk, given the various theories and types in practice, is the subject for further research.

¹⁹⁶ Refer to the discussion In Part IV: Government Intervention in Managing Catastrophe Risk.

¹⁹⁷ Bruggeman, V., Faure, M., and Heldt, T. *Insurance Against Catastrophe: Government Stimulation of Insurance Markets for Catastrophic Events*, 23 Duke Envtl. L. & Pol'y F. 185 (2012).