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Correlation, Coverage, and Catastrophe: The Contours of Financial Preparedness for Disaster

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CORRELATION, COVERAGE, AND CATASTROPHE: THE CONTOURS OF FINANCIAL PREPAREDNESS FOR DISASTER

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I. AN "ACCIDENT WAITING TO HAPPEN"

There is no such thing as a natural disaster.[1] Environmental events have negative human consequences only to the extent that social conditions and practices put human beings in harm's way.[2] Conversely, proper preparation can minimize the otherwise catastrophic consequences of natural events.[3] An ounce of

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1. THERE IS NO SUCH THING AS A NATURAL DISASTER: RACE, CLASS, AND HURRICANE KATRINA (Gregory Squires & Chester Hartman eds., 2006); *see also* Jim Chen, *Law Among the Ruins*, *in* 2 LAW AND RECOVERY FROM DISASTER: HURRICANE KATRINA 1 (Robin Paul Malloy ed., 2009). *See generally* DISASTER LAW AND POLICY 203-47 (Daniel A. Farber, Jim Chen, Robert R.M. Verchick & Lisa Grow Sun eds., 2d ed. 2010).

2. *Compare* Oliver Houck, *Can We Save New Orleans?*, 19 TULANE ENVTL. L.J. 1, 28 (2006) ("Global warming and sea level rise are no more natural calamities than Katrina and Rita were. They are natural consequences of human actions, short term profits and to-hell-with-the-rest."), *with* Gilbert F. White, *Human Adjustment to Floods*, *in* 1 GEOGRAPHY, RESOURCES, AND ENVIRONMENT: SELECTED WRITINGS OF GILBERT F. WHITE 12 (Robert W. Kates & Ian Burton eds., 1986) ("Floods are 'acts of God,' but flood losses are largely acts of man.").

3. *See, e.g.*, Ken Lerner, *Governmental Negligence Liability Exposure in Disaster Management*, 23 URB. LAW. 333, 334 (1991) ("While it may seem contradictory to 'plan' for an emergency — emergencies are by definition unplanned events — ... there is considerable value in such planning."); Phil O'Keefe, Ken Westgate & Ben Wismer, *Taking the Naturalness Out of Natural Disasters*, 260 NATURE 566 (1976).

prevention is worth almost literally a pound of cure. By one estimate, each dollar spent on disaster preparedness is worth roughly $15 in mitigated future damage.[4] Society nevertheless fails to take due care to avoid or mitigate these losses. Individuals and governments alike systematically underestimate the risk and magnitude of disasters and underinvest in otherwise cost-justified precautionary measures.[5] Across the landscape of disaster, from putatively "natural" events such as hurricanes to the full range of losses such as rogue trading, fatal medical errors, and industrial accidents at Three Mile Island and Bhopal, systematic underinvestment in prevention, precaution, and preparation gives rise to "accidents waiting to happen."[6]

So strong are these forces that the entire enterprise of risk management devolves quickly from simple matters of risk avoidance and conflict resolution into economically complex and legally contested forms of risk transfer. Among the four basic tools of risk management — avoidance, reduction, retention, and transfer — the greatest amount of complexity lies in arranging the transfer of risk.[7] Intractable legal complexities confound the transfer of risk, whether

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O'Keefe, Ken Westgate & Ben Wismer, *Taking the Naturalness Out of Natural Disasters*, 260 NATURE 566 (1976).

4. *See* M. Ishaq Nadiri & Ingmar Prucha, *Estimation of Depreciation Rate of Physical and R&D Capital in the U.S. Total Manufacturing Sector*, 34 ECON. INQUIRY 43 (1996) (estimating that physical capital deployed in American manufacturing depreciates at the rate of 5.9% per year); *cf.* Andrew Healy & Neil Malhotra, *Myopic Voters and Natural Disaster Policy*, 103 AM. POL. SCI. REV. 387, 396 (2009) (estimating "the total benefit of a dollar of preparedness spending" as "all future reductions in damage," taking care to discount "those benefits … for the fact that resources invested today in other ways could have yielded their own return and that preparedness investments will depreciate, becoming less effective over time"). Combining Nadiri and Prucha's 5.9% depreciation rate with their own estimate of a 4% annual interest rate, Healy and Malhotra "estimate the NPV [net present value] of $1 of disaster preparedness to be about $15." *Id.*

5. *See* Howard Kunreuther, *Mitigating Disaster Losses Through Insurance*, 12 J. RISK & UNCERTAINTY 171 (1996).

6. *See* Jean-Pierre Benoît & Juan Dubra, *On the Problem of Prevention*, 54 INT'L ECON. REV. 787, 787 (2013).

7. *See generally, e.g.,* MARK S. DORFMAN & DAVID CATHER, INTRODUCTION TO RISK MANAGEMENT AND INSURANCE (10th ed. 2012); INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, ISO 31000: RISK MANAGEMENT — PRINCIPLES AND GUIDELINES ON IMPLEMENTATION (2009); Michael R. Powers, *Diversification, Hedging, and "Pacification,"* 11 J. RISK FIN. 441 (2010).

to government or to specialized institutions that profit by pooling risks too treacherous or ruinous for others to bear. In settings characterized by extreme loss, incurred within compressed time frames, governmental intervention is almost certain.

Laws regulating financial preparedness for catastrophes reveal the actuarial suppositions underlying disaster law and policy. This article explores three facets of risk transfer. Part II explores how risk transfer emerges as the preeminent tool for managing risk. Measures sufficient for managing more modest risks break down as the probability of loss plummets but the magnitude of potential loss increases.

The choice to transfer risk (as opposed to avoiding or managing it through mitigation, diversification, or hedging) leaves open the question of whether private insurance markets can handle catastrophic, highly correlated risks. Part III explores one alternative risk transfer mechanism by which insurance companies have sought to deepen their financial reserves in anticipation of correlated risks. Correlation among risks, the primary obstacle to functional insurance markets for catastrophic coverage, emerges in new form as the motivation for catastrophe bonds — and as these instruments' leading pitfall.

Upon part III's conclusion that catastrophe bonds have not perfected private insurers' financial preparedness for disaster (and may never occupy more than a modest niche within the market for risk transfer), part IV explores constraints on public intervention into disaster insurance. Along the dimensions of space, time, and human behavior, policies compensating individuals for disaster-related losses elude justification on any coherent economic basis. The political economy of public intervention in disaster finance virtually guarantees catastrophic legal responses to catastrophic risks.[8]

II. CORRELATION, COVERAGE, AND CATASTROPHE

Disaster law consists of "assembling the best portfolio of legal rules to deal with catastrophic risks — a portfolio that includes prevention, emergency response, compensation and insurance, and

8. *See* Richard A. Epstein, *Catastrophic Responses to Catastrophic Risks*, 12 J. RISK & UNCERTAINTY 287, 294 (1996).

rebuilding strategies."[9] Certain components of this portfolio seek the optimal balance between spreading risk *ex ante* and compensating victims of disaster *ex post*. Financial preparedness for catastrophe takes myriad forms, from case-by-case compensation through tort law to hybrid systems of private and public insurance.[10] The diverse aspects of disaster law addressing the traditional domain of insurance and finance span a complete remedial spectrum, from compensation through tort actions to alternative risk transfer and public disaster relief through *ex ante* insurance or *ex post* compensation.[11]

Law typically frames the goal of reallocating and redistributing wealth after disaster as that of compensating victims for their losses. From an economic perspective, disaster law should prepare society to avoid future losses by providing proper incentives to private parties to take due care, by bolstering the resilience of vulnerable communities, and by expanding social capacity to respond to disaster.[12] At its best, "disaster law should deploy its portfolio of tools for compensation and risk-spreading in pursuit of two related but distinct goals: risk management through avoidance of loss and reduction of hazard, plus affirmative investments in human capital and social preparedness."[13]

Disaster law presumably begins with the option of taking no action.[14] Whatever losses arise from a particular event, the law could offer no recourse, leaving individuals to absorb their losses or, at best, to allocate them according to privately contracted arrangements. Beyond this threadbare baseline, the law may compensate disaster victims through the ordinary tort system. To the extent that victims can identify individual and corporate defendants who have breached some duty of care, tort law provides a case-by-case, pay-as-you-go

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9. DISASTER LAW & POLICY, *supra* note 1, at xxi; *accord* Susan S. Kuo & Benjamin Means, *Corporate Social Responsibility After Disaster*, 89 WASH. U. L. REV. 973, 975 n.11 (2012).

10. *See* DISASTER LAW & POLICY, *supra* note 1, at 291.

11. *See generally id.* at 291-343.

12. *See generally id.* at 345-90.

13. Jim Chen, *Modern Disaster Theory: Evaluating Disaster Law as a Portfolio of Legal Rules*, 25 EMORY INT'L L. REV. 1121, 1132 (2011).

14. *See, e.g.*, 40 C.F.R. § 1508.13 (2014) (authorizing a finding of no significant impact under the National Environmental Policy Act, 42 U.S.C. §§ 4321-4327 (2012), when major federal action "will not have a significant effect on the human environment and for which an environmental impact statement therefore will not be prepared").

system of compensation. Certain statutory schemes tailor recovery according to particular types of disaster. For example, under the Oil Pollution Act of 1990, "each responsible party for a vessel or a facility from which oil is discharged, or which poses the substantial threat of a discharge of oil, into or upon the navigable waters or adjoining shorelines or the exclusive economic zone is liable for the removal costs and damages … that result from such incident."[15]

Compensation through tort suits, by whatever specific legal mechanism, leaves much to be desired economically. The tort system's inefficiency, estimated to be as high as 50 percent, undermines its effectiveness in deterring negligence, compensating victims, and spreading risk.[16] From a strictly economic view of efficiency, "catastrophic losses, almost by definition, would seem poor candidates for deterrence through" a tort-based "liability system."[17]

Local, state, and federal governments may also face lawsuits. Despite the proliferation of statutes immunizing governments against liability for negligent disaster management,[18] individuals may, under certain conditions, sue the public operators of large-scale public infrastructure that fails during times of disaster.[19] Governments may face inverse condemnation liability under state law.[20] Within limits imposed by the Federal Tort Claims Act,[21] victims may also recover damages from the United States. In litigation arising from Hurricane

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15. Oil Pollution Act of 1990, 33 U.S.C. § 2702(a) (2012); John C.P. Goldberg, *Liability for Economic Loss in Connection with the Deepwater Horizon Spill*, 30 MISS. C.L. REV. 335, 384 (2011); David W. Robertson, *The Oil Pollution Act's Provisions on Damages for Economic Loss*, 30 MISS. C.L. REV. 157, 161-62 (2011). *See generally* Symposium, *Beyond the Horizon: The Gulf Oil Spill Crisis — Analyzing the Economic, Environmental, and Legal Implications of the Oil Spill*, 30 MISS. C. L. REV. 149 (2011).

16. *See* JAMES S. KAKALIK & NICHOLAS M. PACE, COSTS AND COMPENSATION PAID IN TORT LITIGATION 70-71 (Rand Institute Civil Justice 1986).

17. George L. Priest, *The Government, the Market, and the Problem of Catastrophic Loss*, 12 J. RISK & UNCERTAINTY 219, 235 (1996) [hereinafter Priest, *The Problem of Catastrophic Loss*]; *See generally* George L. Priest, *The Current Insurance Crisis and Modern Tort Law*, 96 YALE L.J. 1521 (1987).

18. *See* Lerner, *supra* note 3, at 336-40.

19. *See* Kunz v. Utah Power & Light Co., 526 F.2d 500, 504 (9th Cir. 1975) (recognizing a common law duty arising from a utility's adoption of flood control measures).

20. *See* Paterno v. California, 113 Cal. App. 4th 998, 1003 (2003).

21. 28 U.S.C. § 2674 (2012).

Katrina, the Fifth Circuit has held that the federal government could not claim immunity under the Flood Control Act against claims related to the dredging of the Mississippi River Gulf Outlet, but could assert immunity against claims stemming from levee breaches caused by the dredging of the canal.[22] It could also assert immunity against other claims under the discretionary-function exception to the Federal Tort Claims Act.[23] Furthermore, the federal government may face takings clause liability for government-induced flood control measures that effect a permanent or even temporary occupation of private property.[24] Despite their complexities, tort actions against governments treat official defendants in their proprietary rather than their regulatory capacities — that is, as owners of property as opposed to sovereigns capable of regulating private actors, collecting taxes, and redistributing wealth.[25]

Property owners, private or public, routinely self-insure against risks.[26] If expected exposure to a risk is sufficiently small and regular to be managed without resort to outside financial intermediaries, a private party may manage risk by systematically contributing to a sinking fund or maintaining a liquid reserve in excess of its own assessment of probable exposure.[27] Not surprisingly, self-insurance plays a modest, even negligible role in

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22. *See* In re Katrina Canal Breaches Litig., 696 F.3d 436, 444-52 (5th Cir. 2012).

23. *Compare* United States v. James, 478 U.S. 597 (1986) (holding that 33 U.S.C. §702c, which provides that no "liability of any kind shall attach to or rest upon the United States for any damage from or by floods or flood waters at any place," exempts the United States from liability for injuries resulting from flood control projects conducted by the United States Corps of Engineers), *with* Central Green Co. v. United States, 531 U.S. 425 (2001) (holding that immunity under § 702c depends upon "the character of the waters that cause the relevant damage rather than the relation between that damage and a [federal] flood control project").

24. *See* Arkansas Game & Fish Comm'n v. United States, 133 S. Ct. 511, 522 (2012).

25. *See* Lockheed Aircraft Corp. v. United States, 460 U.S. 190, 198 (1986).

26. *See generally, e.g.,* Eric Briys & Harris Schlesinger, *Risk Aversion and the Propensities for Self-Insurance and Self-Protection*, 57 S. ECON. J. 458, 458-59 (1990); Georges Dionnes & Louis Eeckhardt, *Self-Insurance, Self-Protection, and Increased Risk Aversion*, 17 ECON. LETTERS 39 (1985); Isaac Ehrlich & Gary S. Becker, *Market Insurance, Self-Insurance, and Self-Protection*, 80 J. POL. ECON. 623, 623-24 (1972).

27. *See* ROBERT RIEGEL & JEROME S. MILLER, INSURANCE PRINCIPLES AND PRACTICES 26 (5th ed. 1996).

disaster law.[28] Sudden, calamitous events warranting the label of "disaster" routinely exceed the financial and managerial capacity of individual property owners and even that of governments.[29]

Indeed, it is not too far-fetched to assert that disaster law begins at the precise point where risk may be expected to transcend the managerial capacity of any individual party. The probability of loss, multiplied by its magnitude, may simply exceed financial resources at hand. In addition, multiple sources of risk may correlate with each other, thus raising the amount that a party must raise or reserve in order to be financially prepared. Wealth effects of all sorts are likely to complicate social responses to risk. Despite their reputation as "great social equalizers" that "strike unpredictably and at random," natural disasters inflict far disproportionate injury upon the socially and economically vulnerable.[30] Finally, certain hazards may lurk beyond the capacity of planners to project the true probability that those hazards may come to pass, let alone the expected value of the total exposure at stake.[31]

In somewhat different language, we might say that tort law defines due care as a straightforward exercise in cost-benefit analysis. The celebrated case of *United States v. Carroll Towing*[32] defined negligence and due care "in algebraic terms: if the probability be called P; the injury, L; and the burden, B; liability depends upon

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28. *See* DISASTER LAW & POLICY, *supra* note 1, at 342.

29. *See id.* at 291, 342.

30. *See* BEN WISNER, PIERS BLAIKIE, TERRY CANNON & IAN DAVIS, AT RISK: NATURAL HAZARDS, PEOPLE'S VULNERABILITY AND DISASTERS 11 (2d ed. 2003) (defining "social vulnerability" during disaster as "the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard").

31. *See* Herman B. Leonard & Arnold M. Howitt, *Acting in Time Against Disasters: A Comprehensive Risk-Management Framework*, *in* LEARNING FROM CATASTROPHES: STRATEGIES FOR REACTION AND RESPONSE 18, 25 (Howard Kunreuther & Michael Useem eds., 2010) (observing that *ex ante* planning for disaster, in contrast with *ex post* responses, must anticipate a range of hypothetical scenarios and outcomes, and do so on the basis of incomplete information). For a treatment of "parameter uncertainty" or the impossibility of calculating actuarially sound premiums for unprecedented events in the context of terrorism insurance, see J. David Cummins & Christopher M. Lewis, *Catastrophic Events, Parameter Uncertainty, and the Breakdown of Implicit Long-Term Contracting in the Insurance Market: The Case of Terrorism Insurance*, 26 J. RISK & UNCERTAINTY. 153 (2003).

32. United States v. Carroll Towing, 159 F.2d 169 (2d Cir. 1947).

whether B is less than L multiplied by P: *i.e.*, whether B < PL."[33] Insurance is a common and convenient arrangement for gathering the financial resources needed to take due care. Disaster policy, at its best, should identify the physical, fiscal, political, and epistemological points of stress that are most likely to undermine catastrophic preparedness.

In light of the foregoing considerations, private insurance represents one of the first most important layers of financial preparedness for disaster. Losses that are at once catastrophic in magnitude and attributable to minute risks are best suited for insurers with the wealth and financial integrity to pool risks too great for most other actors to bear alone and to spread those risks across a broader financial base.[34]

But many disasters pose special trouble even for the largest, most financially secure insurers.[35] Like their customers, insurance carriers have trouble evaluating the true likelihood of actuarially remote events.[36] Leptokurtic "probability distributions," more commonly known as fat-tailed distributions, "are inherently difficult to estimate."[37] When "events are rare," the sheer lag time between iterations often makes it "impossible to estimate just how quickly the tail tapers off."[38] Because "fat tails bring with them an epistemic problem,"[39] the law has failed to develop "a commonly accepted economic framework for dealing with … thick-tailed extreme disasters."[40] In other words, the risks combining the lowest probability with the highest potential losses defy prediction under any statistical model. Their very rarity renders the most catastrophic

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33. *Id.* at 173.

34. *See* ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, ENVIRONMENT RISKS AND INSURANCE: A COMPARATIVE ANALYSIS OF THE ROLE OF INSURANCE IN THE MANAGEMENT OF ENVIRONMENT-RELATED RISKS 68-69 (2003).

35. *See generally* RAWLE O. KING, HURRICANE KATRINA: INSURANCE LOSSES AND NATIONAL CAPACITIES FOR FINANCING DISASTER RISKS (2008) (Congressional Research Service Report No. 33086).

36. *See* RIEGEL & MILLER, *supra* note 27, at 34-35.

37. Martin L. Weitzman, *A Review of The Stern Review on the Economics of Climate Change*, 45 J. ECON. LIT. 703, 723 (2007).

38. Daniel A. Farber, *Uncertainty*, 99 GEO. L.J. 901, 926 (2011).

39. *Id.*

40. *Id.*

events virtually impossible to manage with any degree of *ex ante* confidence or competence.

If a calamity is large enough, the sheer magnitude of the losses at stake will exceed the capacity of any single financial actor.[41] As a rule, "private insurers do not offer policies to cover water damage for hurricanes or actively promote earthquake coverage" because they fear both "the uncertainty of the risk and … the severe financial cost of a catastrophic disaster" for which the insurance industry had extended "widespread coverage."[42] Insurance against disasters is bedeviled by the same factors that cripple private insurance in every realm. In order to pool risks and pay claims profitably, insurers must be able to predict losses with accuracy.[43] The mere availability of insurance invites moral hazard in the sense that insured parties have an incentive at the margin, by virtue of the insurer's agreement to pay, to engage in risky behavior.[44] Moreover, adverse selection all but guarantees that an insurer must cover the worst risks within any

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41. *See id.*

42. Kunreuther, *Mitigating Disaster Losses Through Insurance, supra* note 5, at 178; *see also* Howard Kunreuther, Neil Doherty & Anne Kleffner, *Should Society Deal with the Earthquake Problem?*, REGULATION, Spring 1992, at 60, 65 ("[R]einsurers show little interest in offering more protection against … earthquakes [and other natural hazards] because they believe that the premium they feel they can justify will expose them to excessive risk.").

43. *See, e.g.*, Sanchez v. Lindsey Morden Claims Serv., Inc., 72 Cal. App. 4th 249, 254 (1999); Nancy R. Page, *Risky Business: Consumer Protection in the Insurance Industry*, 23 HARV. J. ON LEGIS. 287, 291 (1986) ("When accurate prediction is no longer possible, some liability markets become theoretically too risky for insurance.").

44. *See* MARK A. DORFMAN & DAVID CATHER, INTRODUCTION TO RISK MANAGEMENT AND INSURANCE 480 (10th ed. 2012); Tom Baker, *On the Genealogy of Moral Hazard*, 75 TEX. L. REV. 237, 239 (1996); Christopher C. French, *Construction Defects: Are They "Occurrences"?*, 47 GONZAGA L. REV. 1, 29 (2011); Christopher C. French, *Debunking the Myth That Insurance Is Not Available for Intentional Injuries or Damage*, 8 HASTINGS BUS. L.J. 65, 93 (2012); Adam Scales, *The Chicken and the Egg: Kenneth S. Abraham's The Liability Century*, 94 VA. L. REV. 1259, 1263 (2008) (reviewing KENNETH S. ABRAHAM: THE LIABILITY CENTURY: INSURANCE AND TORT LAW FROM THE PROGRESSIVE ERA TO 9/11 (2008)). The economic literature on moral hazard is legion. *See generally, e.g.*, Richard Arnott & Joseph E. Stigliz, *The Basic Analytics of Moral Hazard,* 90 SCAND. J. ECON. 383 (1988); Richard Arnott & Joseph E. Stigliz, *Moral Hazard and Optimal Commodity Taxation*, 29 J. PUB. ECON. 1 (1986); Bengt Holmström, *Moral Hazard and Observability*, 10 BELL J. ECON. 74 (1979); Steven Shavell, *On Moral Hazard and Insurance*, 93 Q.J. ECON. 541 (1979).

market.[45] The countervailing tendency of insurers to "cherry-pick" low-risk clients raises a regulatory concern in its own right, that of inadequate coverage for individuals of modest means and political power.[46]

Correlation is perhaps the most insidious factor undermining the financial integrity of private insurance for catastrophic risk. The business of insurance ordinarily relies on the "law of large numbers" to manage "statistically independent risks," since an increase in "the number of insured persons possessing independent and identically valued risks" yields a corresponding improvement to the accuracy of predicting each individual insured's risk by "the reduction in the variance of risk of expected outcomes."[47] The ability of insurance pools to segregate high and low risk individuals likewise reduces the expected cost of insurance by further reducing variance in the expected outcomes of the insured population as a whole.[48]

By contrast, private insurers are extremely loath to cover risks that are highly correlated to each other.[49] Coverage liability for

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45. *See* EMMETT J. VAUGHAN & THERESA M. VAUGHAN, FUNDAMENTALS OF RISK AND INSURANCE 21-22 (10th ed. 2007); *see also* BANKS MCDOWELL, DEREGULATION AND COMPETITION IN THE INSURANCE INDUSTRY 39 (1989); Kenneth S. Abraham & Lance Liebman, *Private Insurance, Social Insurance, and Tort Reform: Toward a New Vision of Compensation for Illness and Injury*, 93 COLUM. L. REV. 75, 102 n.82 (1993) (defining adverse selection as "the disproportionate tendency of those who are more likely to suffer losses to seek insurance against those losses"). *But see* Peter Siegelman, *Adverse Selection in Insurance Markets: An Exaggerated Threat*, 113 YALE L.J. 1223 (2004). *See generally* George A. Akerlof, *The Market for "Lemons": Quality Uncertainty and the Market Mechanism*, 84 Q.J. ECON. 488, 493-94 (1970).

46. *See* MCDOWELL, *supra* note 45, at 39.

47. *See* Priest, *The Problem of Catastrophic Loss*, *supra* note 17, at 221.

48. *See id.* at 222. *See generally* Keith J. Crocker & Arthur Snow, *The Efficiency Effects of Categorical Discrimination in the Insurance Industry*, 94 J. POL. ECON. 34 (1986). Formally speaking:

$$\sum_{k=1}^{n} \sigma_k < \sigma_t$$

where σ_t represents the variance within the insurance pool considered as a single unit and σ_k represents the variance within one of n subgroups segregated according to their risk.

49. *See, e.g.*, Patricia Grossi, Howard Kunreuther & Don Windeler, *An Introduction to Catastrophe Models and Insurance*, *in* CATASTROPHE MODELING: A NEW APPROACH TO MANAGING RISK 23, 37-38 (Patricia Grossi & Howard Kunreuther eds., 2005).

simultaneous, geographically concentrated risk can be ruinous to an insurer.[50] For this reason, insurers routinely exclude coverage for flood damage (or even water damage more generally),[51] even in policies that purport to cover all risks.[52] In certain areas, an insurer asks not whether flooding will occur, but when.[53]

The reluctance of private insurers to cover flood damage arises from the same financial instinct that counsels investors to diversify their portfolios by holding asset classes whose correlation, as measured by the *r*-squared statistic, is low.[54] Highly correlated catastrophic risks inflict "numerous losses ... simultaneously from a single event."[55] High correlation undermines the ability of insurance markets to rely on "risk aggregation, also known as the law of large numbers, which specifies that for a series of independent and identically distributed random variables, the variance of the average amount of the claim payment decreases as the number of claims

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50. *See, e.g.*, Donald T. Hornstein, *The Balkanization of CAT Property Insurance: Financing and Fragmentation in Storm Risks*, 11 RUTG. J.L. & PUB. POL'Y 9, 14 (2013); Adam F. Scales, *A Nation of Policyholders: Governmental and Market Failure in Flood Insurance*, 26 MISS. C.L. REV. 3, 7 (2006).

51. *See generally* Joseph Lavitt, *The Doctrine of Efficient Proximate Cause, the Katrina Disaster, Prosser's Folly, and the Third Restatement of Torts: Cracking the Conundrum*, 54 LOY. L. REV. 1 (2008); Brendan R. Vaughn, *Watered Down: Are Insurance Companies Getting Hosed in the Wind Versus Water Controversy?*, 2008 U. ILL. L. REV. 777.

52. *See, e.g.*, Leonard v. Nationwide Mut. Ins. Co., 499 F.3d 419, 430 (5th Cir. 2007) (evaluating private insurance coverage for damage during Hurricane Katrina that could be attributable to wind, water, or both phenomena); Tuepker v. State Farm Fire & Cas. Co., 507 F.3d 346, 354-55 (5th Cir. 2007); Corban v. United Servs. Auto. Ass'n, 20 So. 2d 601, 618 (Miss. 2009). *See generally* Jennifer McNair, Note, *The Winds of Change: The Mississippi Supreme Court Examines Concurrent Causation in Hurricane Katrina Claims*, 30 MISS. C.L. REV. 579 (2012).

53. *Cf.* Hornstein, *supra* note 50, at 26 (noting that insurers who fail to secure approval for rate increases can limit their exposure by refusing to underwrite policies, limiting maximum coverage, and/or raising deductibles or copayments in order to pass losses to policyholders).

54. For an explanation of *r*-squared as the square of the correlation coefficient in statistics, see ROBERT G.D. STEEL & JAMES H. TORRIE, PRINCIPLES AND PROCEDURES OF STATISTICS 187, 287 (1960). For an explanation of the use of *r*-squared in finance, see generally Richard Roll, R^2, 43 J. FIN. 541 (1988).

55. Michael J. Trebilcock & Ronald J. Daniels, *Rationales and Instruments for Government Intervention in Natural Disasters*, *in* ON RISK AND DISASTER: LESSONS FROM HURRICANE KATRINA 89, 93 (Ronald J. Daniels et al. eds., 2006).

increases."[56] Aggregating highly correlated risks would force insurers to perform the "unproductive" and unprofitable task of maintaining financial reserves that "would equal or, perhaps, exceed the reserves that individuals would have to maintain if uninsured."[57] Indeed, "[p]roviding coverage of highly correlated losses is exactly the opposite of the risk-reducing function of aggregation."[58] Underwriting policies for highly correlated losses such as flood damage thus inflicts a financial risk that most prudent insurers are unwilling to bear.[59]

High levels of correlation among risks may signal a fundamental flaw in the statistical modeling of a particular hazard. Unexplored or unexplained connections among correlated risks may be the reason that statistical models fail so regularly to predict the actual probability and magnitude of tail risks. Contrary to our assumptions, these (negative) outcomes are emphatically not independent and identically distributed. The central limit theorem does not hold, and problems of correlation and covariance will bedevil efforts to predict risks and to prescribe responses.[60]

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56. *Id.* at 92-93.

57. Priest, *The Problem of Catastrophic Loss*, *supra* note 17, at 222; *see also id.* ("Where risks are highly correlated, they *cannot* be effectively reduced by spreading them among those subject to the risk" (emphasis in original)).

58. *Id.* at 226.

59. *See* MCDOWELL, *supra* note 45, at 39; *see generally* PAYING THE PRICE: THE STATUS AND ROLE OF INSURANCE AGAINST NATURAL DISASTERS IN THE UNITED STATES (Howard Kunreuther & Richard J. Roth, Sr., eds., 1998); *cf.* Kunreuther et. al, *Should Society Deal with the Earthquake Problem?*, *supra* note 42, at 65 (observing that reinsurers, rather than offering coverage "at an exorbitantly high premium," prefer instead to "indicate that they do not have enough capacity" to cover earthquakes and other natural disasters).

60. *See* OLAV KALLENBERG, FOUNDATIONS OF MODERN PROBABILITY 66-67 (1997); C.C. Heyde, *Central Limit Theorem*, *in* 4 ENCYCLOPEDIA OF STATISTICAL SCIENCES 651 (Samuel Kotz *et al.* eds., 1983). On nonparametric methods for testing departures from the central limit theorem's assumption of independent and identically distributed random variables, see generally SIDNEY SIEGEL & N. JOHN CASTELLAN, JR., NONPARAMETRIC STATISTICS FOR THE BEHAVIORAL SCIENCES (2d ed. 1988); A.N. Kolmogoroff, *Sulla determinazione empirica di una legge di distribuzione*, 4 G. IST. ITAL. ATTUARI 83 (1933); N. Smirnov, *Table for Estimating the Goodness of Fit of Empirical Distributions*, 19 ANNALS MATH. STAT. 279 (1948); William H. Kruskal & W. Allen Wallis, *Use of Ranks in One-Criterion Variance Analysis*, 47 J. AM. STAT. ASS'N 583 (1952); Robert G. Mogull, *The One-Sample Runs Test: A Category of Exception*, 19 J. EDUC. & BEHAV. STAT. 296

Correlation within certain classes of losses, such as floods or crop loss, is so strong (as measured by *r*-squared or variants on that mathematical theme) that private insurers ordinarily refuse to underwrite those risks. The consideration of correlation by property and casualty insurers mirrors the treatment of correlation in the management of long asset portfolios, where *r*-squared and beta play vital roles in guiding investment decisions.[61] Indeed, beta, defined as the covariance between asset-specific and portfolio-wide returns, divided by the variance of returns within the portfolio,[62] is routinely treated as the simplest measure of systemic risk that cannot be managed by mere diversification.[63] This is the sense in which the *P* branch of mathematical finance, or portfolio theory, unites the worlds of investment, insurance, and disaster policy as distinct but related manifestations of risk management.[64]

III. CATASTROPHE BONDS AND THE RISE OF ALTERNATIVE RISK TRANSFER

The emergence of a relatively new method of alternative risk transfer, the catastrophe bond, unites catastrophic risk management

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(1994); N. Smirnov, *Table for Estimating the Goodness of Fit of Empirical Distributions*, 19 ANNALS MATH. STAT. 279 (1948).

61. *See, e.g.*, Robert A. Korajczyk, INTRODUCTION TO ASSET PRICING AND PORTFOLIO PERFORMANCE: MODELS, STRATEGY AND PERFORMANCE METRICS, at xv (Robert A. Korajczyk ed., 1999); William F. Sharpe, *Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk*, 19 J. FIN. 425, 427-28 (1964).

62. *See* Irwin Friend & Marshall Blume, *Measurement of Portfolio Performance Under Uncertainty*, 60 AM. ECON. REV. 561, 565 (1970).

63. *See, e.g.*, William F. Sharpe, *A Simplified Model for Portfolio Analysis*, 9 MGMT. SCI. 277, 281 (1963); Jack L. Treynor, *How to Rate Management of Investment Funds*, 43 HARV. BUS. REV. 63, 66 (1965).

64. *See generally, e.g.*, WEIMIN DONG, BUILDING A MORE PROFITABLE PORTFOLIO: MODERN PORTFOLIO THEORY WITH APPLICATION TO CATASTROPHE INSURANCE (2001); IOANNIS KARATZAS & STEVEN SHREVE, METHODS OF MATHEMATICAL FINANCE (1998); ATTILLO MEUCCI, RISK AND ASSET ALLOCATION (2005); J. David Cummins, *Convergence in Wholesale Financial Services: Reinsurance and Investment Banking*, 30 GENEVA PAPERS ON RISK & INS. 187 (2005).

with other branches of finance and portfolio management.[65] Disaster law traverses a single continuum of methods for compensation and risk-spreading.[66] At the most practical level, catastrophe bonds and similar financial tools bridge the gap between conventional risk transfer (the traditional business of insurance and reinsurance) and innovative risk finance.[67]

Hurricane Andrew in 1992 and the Northridge earthquake of 1994 inflicted cataclysmic losses on insurers that had underwritten policies in areas affected by those disasters.[68] The insurance industry responded to these financial meltdowns by seeking alternative ways to securitize its risks.[69] This quest for alternative methods for risk transfer culminated in the catastrophe bond.[70] Like all other forms of

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65. *See* Todd V. McMillan, *Securitization and the Catastrophe Bond: A Transactional Integration of Industries Through a Capacity-Enhancing Product of Risk Management*, 8 CONN. INS. L.J. 131, 133 (2001).

66. *Cf.* Matthew D. Adler, *Policy Analysis for Natural Hazards: Some Cautionary Lessons from Environmental Policy Analysis*, 56 DUKE L.J. 1, 44 (2006) (recognizing the value of "using probability distributions" to characterize and account for "uncertainties in inputs and outputs" in predictive models, as opposed to "'deterministic' assessment" based on specific "point estimates"). On methods for assessing risks to human health and/or the environment, see generally VINCENT T. COVELLO & MILEY W. MERKHOFER, RISK ASSESSMENT METHODS: APPROACHES FOR ASSESSING HEALTH AND ENVIRONMENTAL RISKS (1993); ROBYN FAIRMAN ET AL., ENVIRONMENTAL RISK ASSESSMENT — APPROACHES, EXPERIENCES AND INFORMATION (1999); HUMAN AND ECOLOGICAL RISK ASSESSMENT: THEORY AND PRACTICE (Dennis J. Paustenbach ed., 2002); Judson Jaffe & Robert N. Stavins, *On the Value of Formal Assessment of Uncertainty in Regulatory Analysis*, 1 REG. & GOVERNANCE 154 (2007); Dennis J. Paustenbach, *Retrospective on U.S. Health Risk Assessment: How Others Can Benefit*, 6 RISK: HEALTH, SAFETY & ENV'T 283 (1995).

67. *See* Véronique Bruggeman, *Capital Market Instruments for Natural Catastrophe and Terrorism Risks: A Bright Future?*, 40 ENVTL. L. REP. 10,136, 10,137 (2010).

68. *See, e.g.*, Douglas R. Richmond, *Insurance and Catastrophe in the Case of Katrina and Beyond* 26 MISS. C.L. REV. 49, 53 (2006) (reporting that Hurricane Andrew pushed ten insurance companies to the brink of bankruptcy). *See generally* J. David Cummins et al., *Can Insurers Pay for the "Big One"? Measuring the Capacity of the Insurance Market to Respond to Catastrophic Losses*, 26 J. BANKING & FIN. 557 (2002).

69. *See* Christopher M. Lewis & Peter O. Davis, *Capital Market Instruments for Financing Catastrophe Risk: New Directions?*, 17 J. INS. REG. 110, 113 (1998).

70. *See generally* ERIC BANKS, ALTERNATIVE RISK TRANSFER: INTEGRATED RISK MANAGEMENT THROUGH INSURANCE, REINSURANCE, AND THE CAPITAL MARKETS (2004); ERIC BANKS, CATASTROPHIC RISK: ANALYSIS AND

alternative risk transfer, catastrophe bonds enable insurers to acquire risk-spreading capabilities beyond the traditional financial tools available to the insurance industry. The ultimate goal is to enable insurers to derive revenue from sources besides premiums and returns from investments on reserves built by those premiums. After all, "[i]nsurers do not simply hang onto premiums … ; they invest them for the time period between payment of premiums and payment of losses."[71] Income derived from these investments "allows the industry to remain profitable as a whole even with significant negative underwriting losses."[72] In the aftermath of financially devastating events such as Andrew or the Northridge earthquake, the insurance industry may not recover more than half of the surplus it had accumulated from premiums collected before these disasters.[73]

Catastrophe bonds transfer risks from the sponsoring insurer or reinsurer to investors willing to finance a contingent reserve in exchange for high returns on principal in the event the catastrophe never materializes. In turn, securitization through catastrophe bonds extends the financial resources of the insurance and reinsurance industries.[74] By harnessing the resources of the capital markets to provide capacity for selected property/casualty and life/health risks, catastrophe bonds "go beyond traditional forms of reinsurance."[75]

Like reinsurance or any other market mechanism available to the insurance industry, catastrophe bonds work best where highly

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MANAGEMENT (2005); THE HANDBOOK OF INSURANCE-LINKED SECURITIES (Pauline Barrieu & Luca Albertini eds., 2009); Sylvie Bouriaux & Richard MacMinn, *Securitization of Catastrophe Risk: New Developments in Insurance-Linked Securities and Derivatives*, 32 J. INS. ISSUES 1 (2009); Ernst N. Csiszar, *An Update on the Use of Modern Financial Instruments in the Insurance Sector*, 32 GENEVA PAPERS 319 (2007). The notion of insurance-linked securities is thought to have originated with Robert C. Goshay & Richard L. Sandor, *An Inquiry into the Feasibility of a Reinsurance Futures Market*, 5 J. BUS. FIN. 56 (1973).

71. Eliot Martin Blake, *Rumors of Crisis: Considering the Insurance Crisis and Tort Reform in an Information Vacuum*, 37 EMORY L.J. 401, 422 (1988).

72. *Id.* at 423.

73. *See* Kunreuther, *Mitigating Disaster Losses Through Insurance, supra* note 5, at 180. *See generally* NEIL DOHERTY, LISA POSEY & ANNE KLEFFNER, INSURANCE SURPLUS: ITS FUNCTION, ITS ACCUMULATION AND ITS DEPLETION (1992).

74. *See* Tamar Frankel & Joseph W. LaPlume, *Securitizing Insurance Risks*, 19 ANN. REV. BANKING L. 203, 205-06 (2000).

75. Heidi E. Hutter, *Convergence and Innovation: Developments in the Reinsurance Marketplace*, 44 RISK MGMT. 57, 58 (Sept. 1997).

correlated, "locally dependent risks" are nevertheless "globally independent" and therefore capable of diversification within a pool of deeper financial resources.[76] Interest in catastrophe bonds as a way of extending the capacity of the private insurance market to pay claims arising from disasters has reached New York in the immediate aftermath of Superstorm Sandy, the event that inspired this symposium.[77] Historically, the domain of developed economies and the insurers who serve those markets, catastrophe bonds have drawn the attention of Latin American governments[78] and the World Bank.[79]

To issue a catastrophe bond, an insurance company forms a special purpose reinsurance vehicle, typically underwritten by an investment bank chartered in an offshore jurisdiction (such as the Cayman Islands) known for relaxed financial regulation.[80] Catastrophe bonds are typically structured as floating rate bonds whose principal is lost if specified trigger conditions are met.[81] If no catastrophe occurs, the bonds pay a generous coupon to investors.[82] If a catastrophe does occur, the bondholders would forgive the principal.[83] Those funds

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76. J. David Cummins, *Should the Government Provide Insurance for Catastrophes?*, 88 FED. RES. BANK ST. LOUIS REV. 337, 343 (2006).

77. *See* Georgia Levenson Keohane, Op-Ed, *Preparing for Disaster by Betting Against It*, N.Y. TIMES, Feb. 12, 2014, http://opinionator.blogs.nytimes.com/2014/02/12/preparing-for-disaster-by-betting-against-it/#more-151853 (reporting how New York's Metropolitan Transit Authority, "[i]n the wake of Sandy," had worked with "the First Mutual Transportation Assurance Company," the MTA's own "'captive' (or in-house) insurer to obtain reinsurance … by issuing the world's first 'catastrophe' bond designed specifically to protect against storm surge").

78. *See* Searchlight Process, *Catastrophe Bonds: Financial Innovations Insuring Against Severe Climate Events (Or High-Loss Level Events)*, FUTURECHALLENGES.ORG (Jan 4, 2013), http://futurechallenges.org/local/searchlight/catastrophe-bonds-financial-innovations-insuring-against-severe-climate-events-or-high-loss-level-events.

79. *See MultiCat Program*, TREASURY.WORLDBANK.ORG (April 26, 2011), *available at* http://treasury.worldbank.org/bdm/pdf/MultiCat_ProductNote.pdf (describing the World Bank's MultiCat program, "a catastrophe bond issuance platform that allows governments to use a standard framework to buy insurance on affordable terms through the capital markets" as part of the Bank's "broad spectrum of disaster risk financing instruments offered … to assist member countries in planning efficient responses to catastrophic events").

80. *See* McMillan, *supra* note 65, at 140.

81. *See id.* at 140, 140 n.17.

82. *See id.* at 140.

83. *See id.* at 141.

would then enable the insurer to honor claims arising from the disaster.[84]

In an ideal circumstance, one in which a catastrophe bond's principal exceeds the issuer's liability for payments on a disaster, the forgiveness of the obligation to repay principal on a catastrophe bond allows the insurer to write down that liability and thereby realize an immediate increase in its net worth.[85] This benefit to insurers reinforces investors' interest in catastrophe bonds' ability to deliver generous returns that do not correlate with conventional stocks and bonds.[86] On the other hand, if the scale of a disaster exceeds the principal on a related catastrophe bond, the insurer and any reinsurers would face an all-too-familiar situation: falling short of the funds needed to satisfy claims arising from the disaster.

Whether catastrophe bonds will significantly enhance the ability of private insurers and reinsurers to manage catastrophic risk without governmental intervention depends on the ability of catastrophe bonds to outperform competing financial tools at the disposal of insurance and reinsurance carriers.[87] Studies by the Government Accountability Office suggest that transaction costs may consume as much as two percent of the insurance coverage provided by a catastrophe bond.[88] If these transaction costs are analogized to the expense ratio on financial instruments, they would align the managerial expense of catastrophe bonds with that of very expensive

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84. *See id.* at 140.

85. *See id.* at 170; *see also* INSURANCE SERVICES OFFICE, FINANCING CATASTROPHE RISK: CAPITAL MARKET SOLUTIONS 1 n.1 (Jan. 1999), *available at* http://www.iso.com/Research-and-Analyses/Studies-and-Whitepapers/Financing-Catastrophe-Risk-Capital-Market-Solutions.html.

86. *See generally* MILKEN INSTITUTE, FINANCIAL INNOVATIONS FOR CATASTROPHE RISK: CAT BONDS AND BEYOND (2008); J. David Cummins & Philippe Trainar, *Securitization, Insurance, and Reinsurance*, 76 J. RISK & INS. 463 (2009); Robert H. Litzenberger et al., *Assessing Catastrophe Reinsurance-Linked Securities as a New Asset Class*, J. PORTFOLIO MGMT., 76 (Winter 1996); McMillan, *supra* note 65, at 170-71.

87. *See* Bruggeman, *supra* note 67, at 10,141-42.

88. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-02-941, CATASTROPHE INSURANCE RISKS: THE ROLE OF RISK-LINKED SECURITIES AND FACTORS AFFECTING THEIR USE (2002); U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-03-1033, CATASTROPHE REINSURANCE RISKS: STATUS OF EFFORTS TO SECURITIZE NATURAL CATASTROPHE AND TERRORISM RISK (2003); Bruggeman, *supra* note 67, at 10,142.

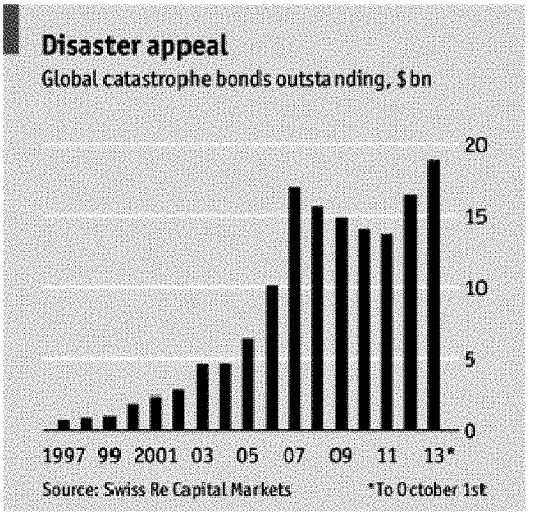
mutual funds[89] or of hedge funds.[90] Whatever its future contribution to catastrophic risk management in disaster law, the catastrophe bond concept has already proved elastic enough to provide an alternative method for managing the risk of catastrophic audit failure in securities regulation.[91]

89. One study of mutual funds, admittedly conducted before the rise of exchange-traded funds and their downward pressure on mutual fund fees, found that mutual funds reported an average expense ratio of 1.14 percent. *See* Mark M. Carhart, *On Persistence in Mutual Fund Performance*, 52 J. FIN. 57, 59 (1997). In addition, 64.5 percent of the funds in that study charged load fees, which in turn averaged 7.33 percent. *See id.*

90. Hedge funds appear to charge annual management fees with a mean and median of 1 percent, plus performance fees whose mean is 14 percent and whose median is 20 percent. *See* Carl Ackermann et al., *The Performance of Hedge Funds: Risk, Return, and Incentives*, 54 J. FIN. 833, 834, 842 (1999); *cf.* Paul Gompers & Josh Lerner, *An Analysis of Compensation in the U.S. Venture Capital Partnership*, 51 J. FIN. ECON. 3, 14 (1999) (revealing that 81 percent of venture capital funds have incentive fees of 20 to 21 percent despite a wider range of incentive fees from less than 1 percent to 45 percent). These findings confirm the popular perception that the typical hedge fund charges a 2 percent management fee, plus a 20 percent performance fee. *See* Gregory Zuckerman, Juliet Chung & Michael Corkery, *Hedge Funds Cut Back on Fees: Pressure From Disappointed Investors Changes "2 and 20" Model*, WALL ST. J., Sept. 9, 2013, *available at* http://online.wsj.com/articles/SB10001424127887323893004579054952807556352; *See generally Two and Twenty*, Investopedia, http://www.investopedia.com/terms/t/two_and_twenty.asp (last visited Oct. 26, 2014).

91. *See* Lawrence A. Cunningham, *Securitizing Audit Failure Risk: An Alternative to Caps on Damages*, 49 WM. & MARY L. REV. 711, 763-64 (2007).

Catastrophe bonds, however, have not yet fully transformed property and casualty insurance markets. One skeptical view of catastrophe bonds warns that "[t]he rise of cat bonds and other 'insurance-linked securities'" may negatively "affect the price of insurance."[92] Worse still, catastrophe bonds may attract so many unsophisticated, poorly informed investors as to give rise to a "frothy 'shadow insurance' sector with systemic implications."[93]



Closer examination undermines the premises on which this dire warning rests. As the above graphic shows, $19 billion catastrophe bonds was outstanding as of 2013. As large as this number may seem in absolute terms, it represents a relatively modest share of the overall property and casualty insurance market. The $19 billion catastrophe bond market "is a small fraction of the $300 billion in catastrophe-related payouts" for which insurers bear potential liability.[94] Catastrophe bonds comprise an even smaller share of net written premiums, estimated to run about $425 billion a year as of 2010.[95] These instruments have at most modest impact on a "global property and casualty insurance market [that] had total gross written premiums of $1,383.4 billion in 2011, representing a compound annual growth rate … of 3.1% between 2007 and 2011."[96]

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92. *Perilous Paper: Bonds That Pay Out When Catastrophe Strikes Are Rising in Popularity*, THE ECONOMIST, Oct. 15, 2013. This article is the source of the graphic embedded in the text.

93. *Id.*

94. *Id.*

95. *See* Felix Salmon, *The Tiny Cat-Bond Market,* REUTERS (April 25, 2011), http://blogs.reuters.com/felix-salmon/2011/04/25/the-tiny-cat-bond-market.

96. MARKETLINE, GLOBAL PROPERTY & CASUALTY INSURANCE (May 23, 2012) (summarized at http://www.marketresearch.com/MarketLine-v3883/Global-Property-Casualty-Insurance-7016947).

According to Felix Salmon, "catastrophe bonds are the capital-markets security of the future, and they always will be."[97] Salmon argues that two fundamentally different types of risk divide insurers from the investors they hope to invite into financial markets for indemnifying catastrophic risk. In as much as insurers and the insured want payouts defined according to losses, insurance markets operate on *indemnity* risk.[98] By contrast, would-be bondholders want payouts triggered by the "magnitude of earthquakes as measured by the modified Mercalli scale; hurricanes as measured by wind speed," and other indicia of *parametric* risk.[99]

These are issues that can be addressed, at least at the margin, through improvements in the design of catastrophe bonds as financial instruments. Indemnity risk and parametric risk represent opposite ends of the spectrum of traditional triggers for catastrophe bond payouts, a range that also contemplates forgiveness of cat bond principal based on notional portfolio (modeled loss) or industry loss triggers. Parametric triggers are certainly most attractive to investors because of their lack of correlation to insurers' financial needs and resources. As Salmon argues, this very lack of correlation with actual indemnity payments is what repels insurance companies from the catastrophe bond market.[100]

This conflict arises, however, only to the extent that catastrophe bonds must perilously lurch between the extremes of indemnity risk and parametric risk. In practice, catastrophe bond triggers offer a fuller range of options.[101] An indemnity trigger bases recovery "on the [bond] sponsor's actual losses, just as in most reinsurance contracts." A notional portfolio or modeled loss trigger calculates forgiveness of cat bond principal according to "actual events' parameters, such as magnitude and epicenter location for earthquakes," which a modeling agent in turn recreates within a

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97. Salmon, *supra* note 95.

98. *Id.*

99. *Id. See generally* Lauren Brooks, *The Caribbean Catastrophic Risk Facility: Parametric Insurance Payouts Without Proper Parameters*, 2 ARIZ. J. ENVTL. L. & POL'Y 135 (2012).

100. *See* Salmon, *supra* note 95.

101. *See* DAVID A. LALONDE ET AL., SO YOU WANT TO ISSUE A CAT BOND (Air Currents, Feb. 2008), *available at* http://www.air-worldwide.com/_public/NewsData/001410/AIRCurrents_CatBond.pdf).

proprietary catastrophe model in order to "estimat[e] their financial impact on the notional portfolio originally used to estimate the bond's risk."[102] An industry loss trigger is "based on actual losses to the insurance industry as a whole," usually based on the modeling agent's "own database of insured industry exposure to estimate the bond's probability of being triggered." Bond purchasers may also conduct their own "risk analysis of the sponsor's portfolio … in order to estimate correlations between the sponsor and the industry's risk profile, and [to] select an industry loss trigger that will minimize basis risk." Finally, a parametric trigger relies "on objective measurements, such as a hurricane's maximum wind speed and landfall location, or the ground motion measured by multiple seismometers after an earthquake."[103]

Given the availability of other benchmarks, such as losses within a notional portfolio of insurance policies or losses across the entire property and casualty insurance industry, catastrophe bond triggers need not force a binary choice between perfectly correlated indemnity risk (which favors insurers) and optimally uncorrelated environmental parameters (which attract catastrophe bond investors). For instance, parametric index triggers seek to combine environmental parameters with industry loss metrics by using models that calculate approximate loss as a function of environmental parameters (such as wind speed at differing locations) and use those models to calculate the bond's payout function.[104]

IV. PUBLIC INTERVENTION IN DISASTER INSURANCE MARKETS

A. The Samaritan's Dilemma: Avoiding Catastrophic Responses to Catastrophic Risks

The immaturity and modest size of emerging markets for catastrophe bonds and other forms of alternative risk transfer, coupled with enduring constraints on the capacity of private insurance markets, leave significant room for governmental

102. *Id.* at 4.

103. *Id.*

104. *See* A.M. BEST'S METHODOLOGY, GAUGING THE BASIS RISK OF CATASTROPHE BONDS (2012), *available at* http://www3.ambest.com/ambv/ratingmethodology/OpenPDF.aspx?rc=197690.

intervention in mitigating and compensating catastrophic losses.[105] This is to say nothing of "*cataclysmic*, or *globally undiversifiable*" events — "events that are so severe that they may not be diversifiable even through securities markets."[106] Within the United States, the federal government has subsidized disaster insurance, directly underwritten policies that private insurers are unwilling to issue, or served as reinsurer of last resort. In many markets, government has pursued some combination of these strategies. Proper calibration of disaster law and policy demands an understanding of the pitfalls that await each of the flawed strategies available to governments.

Investments in disaster preparedness, or "important potential precautionary strategies that are designed to minimize the expected cost of or consequences associated with a natural disaster," exhibit "many of the characteristics of public goods."[107] Many of the precautionary measures that can be expected to blunt disaster's blow may "enjoy significant economies of scale, require the exercise of powers of eminent domain … , and/or exhibit natural monopoly characteristics."[108] These economic traits describe "many … forms of public infrastructure" and — increasingly so in a society guided by data-driven analytics — "the generation and provision of information relating to the underlying risks and expected costs of locating in vulnerable areas, weather forecasts of impending storms … and so forth."[109]

Governments may be ideally situated to coordinate physical infrastructure, such as levees or dikes, with informational platforms, such as monitoring and early warning systems for storms or

105. *See, e.g.*, Priest, *The Problem of Catastrophic Loss*, *supra* note 17, at 225 ("In the most common view, the government is regarded as the most effective insurance instrument of the society, with increasing effectiveness as potential disasters increase in scale. … [T]he state can spread risks most broadly because it is the largest social entity in existence."). For paradigmatic expressions of this perspective, see generally GUIDO CALABRESI, THE COSTS OF ACCIDENTS (1970); *see* Kunreuther, *Mitigating Disaster Losses Through Insurance, supra* note 5.

106. Cummins, *supra* note 76, at 344 (emphases in original). *See generally* Dwight M. Jaffee & Thomas Russell, *Catastrophe Insurance, Capital Markets, and Uninsurable Risk*, 64 J. RISK & INS. 205 (1997).

107. Trebilcock & Daniels, *supra* note 55, at 92.

108. *Id.*

109. *Id.*

earthquakes.[110] In harmony with these principles, Congress in 2012 directed the Federal Emergency Management Authority (FEMA) to develop a protocol and database for allocating losses between water and wind in "named" storms.[111] In addition to directing FEMA to use the "most accurate data" in formulating flood maps in 100-year floodplains, 500-year floodplains, and "residual risk areas," Congress — in what may be its most significant move to improve the informational basis by which the federal government prepares for floods — has appropriated $400 million each year to fund FEMA's nationwide flood-mapping activities.[112] In so doing, Congress has finally fulfilled the tantalizing promise of the unenacted Natural Disaster Protection Act of 1993,[113] which would have required FEMA to identify, on a peril-by-peril basis, which states were most at risk from hurricanes, floods, windstorms, earthquakes, and volcanic eruptions.[114]

The case for public intervention in disaster finance is comparably strong. Like other forms of preparedness for disaster, insurance is "likely to be under-demanded and under-supplied" if catastrophic risk transfer is "left purely to private markets."[115] Indeed, the case for comprehensive disaster insurance, including public subsidies for types of coverage that private carriers find most unpalatable, was made half a century ago and remains mostly unrebutted on purely utilitarian grounds.[116] Global data comparing the relative resilience

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110. *See* Richard Zeckhauser, *The Economics of Catastrophes*, 12 J. RISK & UNCERTAINTY 113, 134 (1996).

111. *See* Consumer Option for an Alternative System to Allocate Losses Act of 2012, Pub. L. No. 112-141, §100251, 126 Stat. 916, 969; Hornstein, *supra* note 50, at 31.

112. *See* Consumer Option for an Alternative System to Allocate Losses Act of 2012, Pub. L. No. 112-141, § 100216(b), (f), 126 Stat. 916, 927; Hornstein, *supra* note 50, at 33.

113. S. 1350, 103d Cong; *see also* Natural Disaster Protection Partnership Act of 1994, H.R. 2873, 103d Cong.

114. *See generally* Epstein, *supra* note 8, at 296-97.

115. Trebilcock & Daniels, *supra* note 55, at 92.

116. *See* Howard Kunreuther, *The Case for Comprehensive Disaster Insurance*, 11 J.L. & ECON. 133 (1968); *cf.* Kenneth J. Arrow, *The Theory of Risk-Bearing: Small and Great Risks*, 12 J. RISK & UNCERTAINTY 103 (1996); Howard Kunreuther, *Has the Time Come for Comprehensive Natural Disaster Insurance?*, *in* ON RISK AND DISASTER, LESSONS FROM HURRICANE KATRINA, *supra* note 55, at 175. *But see* Priest, *The Problem of Catastrophic Loss*, *supra* note 17, at 219-20 (disputing "[v]irtually all [other] approaches to the problem of catastrophic loss,

of larger, developed countries vis-à-vis their smaller, less developed counterparts suggests that the best indicators of macroeconomic robustness and recovery after disaster are those that correlate most strongly with financial capacity to withstand a shock, to prevent spillovers into the broader economy, and to marshal resources for reconstruction.[117]

Yet financial preparedness for disaster, no less than physical and informational precautions, remains an "accident waiting to happen."[118] Like private financial actors, government is vulnerable to the effects of risk and uncertainty when it makes its own decisions to invest, whether in precaution or in infrastructure subject to catastrophic loss.[119] Whereas problems such as adverse selection, moral hazard, and — above all else — mismatches in statistical correlation cripple private insurance markets, the political economy of public disaster assistance destroys any coherent governmental approach to risk transfer.[120] Despite growing corporate awareness that private insurance coverage remains severely limited, the federal government — with the salient exception of the National Flood

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[which] conclude that the magnitude and character of such losses compel[] some form of governmental solution, whether in the form of ex post disaster assistance or ex ante regulation to reduce exposure").

117. *See* Ilan Noy, *The Macroeconomic Consequences of Disasters*, 88 J. DEV. ECON. 221, 221 (2009); *cf.* DENNIS S. MILETI, DISASTERS BY DESIGN: A REASSESSMENT OF NATURAL HAZARDS IN THE UNITED STATES 123 (1999) (observing that "developing nations are less able to afford disaster detection technology and resilient construction practices," much as "stratification" along lines of "socioeconomic status, gender, and race or ethnicity" in the United States and other developed countries "results in an uneven distribution of exposure and vulnerability to hazards, disaster losses," and diminished "access to aid, recovery, and reconstruction").

118. *See* Benoît & Dubra, *supra note* 6, at 787. *See generally* VÉRONIQUE BRUGGEMAN, COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH (2010).

119. Kenneth J. Arrow & Robert C. Lind, *Uncertainty and the Evaluation of Public Investment Decisions*, 60 AM. ECON. REV. 364, 364 (1970); *accord* Louis A. Kaplow, *Incentives and Government Relief for Risk*, 4 J. RISK & UNCERTAINTY 167, 174 n.17 (1991).

120. *See* William F. Shughart II, *The Politics and Economics of Disaster Relief*, 127 PUB. CHOICE 31, 31 (2006) ("no one should … expect[] government to be any more effective when confronted with natural disaster than it is in more mundane circumstances").

Insurance Act of 1968[121] and the concomitant establishment of the National Flood Insurance Program (NFIP) — "has not intervened in insurance markets to enhance coverage available for victims of natural disaster."[122] As in so many other facets of disaster policy, the lack of financial preparedness for catastrophe arises from political failures to address market failures.

Government systematically underinvests in disaster preparedness *ex ante* and overinvests in disaster relief *ex post*.[123] Even though precautionary investments *ex ante* may "reduce the risk and magnitude of damage from disasters" on a cost-effective basis, "the results are relatively more uncertain and less tangible" than dramatic, even heroic *ex post* measures such as "[s]ending in troops, personnel, and food and medical supplies."[124] Worse still, politicians reap immediate rewards from *ex post* relief, but may wait in vain for dividends from *ex ante* preparation.[125] Politicians "prefer" (and pursue) "policies that yield tangible benefits for constituents in the near term."[126] And with good reason: voters reward incumbent politicians for making relief expenditures after disaster, but not for investing in preparedness before disaster.[127] This dynamic has transmogrified *ad hoc* relief under the Robert T. Stafford Disaster

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121. 42 U.S.C. §§ 4001-4129 (2012).

122. Robert H. Jerry II & Steven E. Roberts, *Regulating the Business of Insurance: Federalism in an Age of Difficult Risk*, 41 WAKE FOREST L. REV. 835, 875 (2006).

123. *See* Ben Depoorter, *Horizontal Political Externalities: The Supply and Demand of Disaster Management*, 56 DUKE L.J. 101, 103 (2006).

124. *Id.* at 111; *see also id.* ("[A] local municipality's stringent enforcement of building codes will receive less attention than the ex post rescue efforts after a building collapse, even though preventing code violations may save more lives.").

125. *Id.*

126. RICHARD A. POSNER, CATASTROPHE 137 (2004); *accord* Depoorter, *supra* note 123, at 111.

127. *See* Healy & Malhotra, *supra* note 4, at 397; *see also id.* at 388 ("[V]oters offer scant incentive to presidents to pursue cost-effective preparedness spending, but do encourage them to send in the cavalry after damage has been done and lives have been lost."); *cf.* Justin Pidot, *Deconstructing Disaster*, 2013 BYU L. REV. 213, 233 n.102 ("Describing those assisting with disaster response as the cavalry, even if they have no relationship to the military, is not uncommon."). For legal analysis of actual military involvement in disaster response, see William Banks, *Who's in Charge: The Role of the Military in Disaster Response*, 26 MISS. C.L. REV. 75 (2006).

Relief and Emergency Assistance Act,[128] originally conceived as a limited stopgap for disasters exceeding local and state resources, into a quasi-entitlement of first rather than last resort.[129]

Along every dimension — spatial, temporal, and behavioral — the political economy of disaster assistance dictates perverse outcomes.[130] In the logic and language of collective action, disaster relief presents a problem of concentrated benefits and diffuse costs.[131] Though local governments are all too eager to "allow development to occur where it should not" and to relax protective land use regulation, all in the name of enhanced property tax revenues, local governments willingly export "the costs of disaster… to the federal government."[132] For its part, the federal government allocates more disaster expenditures in states whose representatives sit on congressional committees charged with overseeing FEMA.[133]

Political cycles, alas, are shorter than the time horizons on which economically optimal disaster planning should take place.[134] Disasters that occur during election years draw more *ex post*, *ad hoc*

128. 42 U.S.C. §§ 5121-5208 (2012).

129. *See* Daniel D. Barnhizer, *Givings Recapture: Funding Public Acquisition of Private Property Interests on the Coasts*, 27 HARV. ENVTL. L. REV. 295, 328-31 (2003).

130. *See* Charles Cohen & Eric Werker, *The Political Economy of "Natural" Disasters*, 52 J. CONFLICT RESOLUTION 795 (2008).

131. *See generally* MANCUR OLSON, JR., THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS (1965); Gary Becker, *A Theory of Competition Among Pressure Groups for Political Influence*, 98 Q.J. ECON. 371 (1983).

132. Pidot, *supra* note 127, at 246.

133. *See* Thomas A. Garrett & Russell S. Sobel, *The Political Economy of FEMA Disaster Payments*, 41 ECON. INQUIRY 496 (2003); *cf.* Thomas A. Garrett, et al., *Political Allocation of US Agriculture Disaster Payments in the 1990s*, 26 INT'L REV. L. & ECON. 143, 157 (2006) ("[T]otal [agricultural] disaster payments are about $44 million higher in those states having representation on the House Appropriations subcommittee.").

134. *See* Depoorter, *supra* note 123. at 112 ("[T]he political benefits of ex ante preparation policies and may accrue beyond the time horizons of many politicians."); *cf.* Howard Kunreuther, *Long-Term Contracts for Reducing Losses from Future Catastrophes*, *in* LEARNING FROM CATASTROPHES: STRATEGIES FOR REACTION AND RESPONSE, *supra* note 31, at 235, 236-39 (describing the disinclination of homeowners and businesses to evaluate investments in disaster preparedness on a time horizon exceeding two or three years).

funding.[135] Roughly a quarter of federal disaster relief for farmers appears to be politically motivated.[136] As much as half of all federal disaster relief may be traceable to political rather than environmental or economic considerations.[137] Disaster relief epitomizes the practice of "fiat givings," whereby "the government declares — either expressly or by implication — that it will not permit... property to move, erode, or disappear."[138] In the politics of extreme natural events, it is a short path indeed from compassion to entitlement.[139]

The politicization of disaster relief punishes not only the public fisc, but also the politicians themselves. Put simply, "disaster relief breeds public corruption."[140] The political economy of disaster relief often delivers sudden "windfalls" into stricken areas, and the political imperative to be perceived as proactive creates conditions "ripe for corruption and waste."[141] *Ceteris paribus*, politicians from disaster-prone states are likelier to be indicted and convicted of corruption.[142]

Behavioral constraints on human and institutional decisionmaking further pervert disaster policy. The endowment effect, a bedrock element of humans' innate heuristics for evaluating risk,[143] leads

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135. *See* Leonard & Howitt, *supra* note 31; Erwann Michel-Kerjan, *Haven't You Switched to Risk Management 2.0 Yet?*, *in* THE IRRATIONAL ECONOMIST: MAKING DECISIONS IN A DANGEROUS WORLD 41 (Erwann Michel-Kerjan & Paul Slovic eds., 2006).

136. *See* Garrett et al., *supra* note 133, *Political Allocation of US Agriculture Disaster Payments in the 1990s,* at 159 ("[A]lmost 12-30% of all direct agricultural disaster relief is due to political influence rather than actual crop and feed losses.").

137. *See* Garrett & Sobel, *supra* note 133, at 509.

138. Barnhizer, *supra* note 129, at 320-21.

139. *See* RUTHERFORD H. PLATT, DISASTERS AND DEMOCRACY: THE POLITICS OF EXTREME NATURAL EVENTS 11 (1999); *see also id.* at 57-58 (characterizing "disaster gerrymandering" as a species of off-budget pork barrel politics).

140. William F. Shughart II, *Disaster Relief as Bad Public Policy*, 15 INDEP. REV. 519, 521 (2011).

141. *Id.*; *see also* Peter Boettke et al., *The Political, Economic, and Social Aspects of Katrina*, 74 S. ECON. J. 363, 367-68 (2005); Peter T. Leeson & Russell S. Sobel, *Weathering Corruption*, 51 J.L. & ECON. 667, 667-69 (2008).

142. Shughart, *supra* note 140, at 521; *cf.* Nejat Anbarci, et al., *Earthquake Fatalities: The Interaction of Nature and Political Economy*, 89 J. PUB. ECON. 1907 (2005) (documenting the impact of political corruption on fatalities associated with earthquakes).

143. *See, e.g.*, Ziv Carmon & Dan Ariely, *Focusing on the Forgone: How Value Can Appear So Different to Buyers and Sellers*, 27 J. CONSUMER RESEARCH 360, 361-63 (2000); Nathan Novemsky & Daniel Kahneman, *The Boundaries of Loss Aversion*, 42 J. MARKETING RESEARCH 119, 119 (2005).

governments to overvalue pre-disaster wealth and to take economically unwarranted account of sunk costs.[144] It is politically impossible to refuse aid "once there are identified victims ... featured on the evening news."[145] Indeed, disaster relief hinges on the timing of a disaster within the news cycle: the relative abundance or scarcity of other newsworthy events affects the magnitude of the aid that government grants to any particular disaster.[146] Neither economic wisdom nor constitutional restraint can withstand the political "imperative to respond to blameless suffering."[147]

Salience, not sanity, dives the political economy of disaster law as a branch of prospect theory.[148] Too often disaster policy falls under

144. *See* W. Kip Viscusi, *The Hold-Up Problem: Why It Is Urgent to Rethink the Economics of Disaster Insurance Protection*, *in* THE IRRATIONAL ECONOMIST, *supra* note 135, at 142, 145. On sunk costs, see, for example, Alenco Communications, Inc. v. FCC, 201 F.3d 608, 615 (5th Cir. 2000) (recognizing that "historical investments" in legacy infrastructure are "sunk costs" and have no relevance to contemporary business decisions in competitive markets whose prices respond solely "to current costs"); Fresno Mobile Radio, Inc. v. FCC, 165 F.3d 965, 969-70 (D.C. Cir. 1999); ARMEN A. ALCHIAN & WILLIAM R. ALLEN, EXCHANGE AND PRODUCTION 222 (3rd ed. 1983) (observing that the cost of an item, "once ... acquired," is "irrelevant to any future decision"); JAMES D. GWARTNEY & RICHARD L. STROUP, ECONOMICS 417-19 (4th ed. 1982) ("If they are to minimize costs, business decision-makers must recognize the irrelevance of sunk costs."); N. GREGORY MANKIW, PRINCIPLES OF ECONOMICS 291 (1997) ("The irrelevance of sunk costs explains how real businesses make decisions."); ROBERT S. PINDYCK & DANIEL L. RUBENFELD, MICROECNOOMICS § 7.1, at 199 (2d ed. 1992) (arguing that sunk costs, though "usually visible," nevertheless "should always be ignored when making economic decisions"); RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW § 1.1, at 7 (3d ed. 1986) ("[C]ost to an economist is a forward-looking concept"; costs already incurred "do not affect decisions on price and quantity."); PAUL A. SAMUELSON & WILLIAM D. NORDHAUS, ECONOMICS 227 (19th ed. 2010) ("One of the most important lessons of economics is that you should look at the marginal costs and marginal benefits of decisions and ignore past or sunk costs.").

145. Viscusi, *supra* note 144, at 146. *See generally* David Moss, *The Peculiar Politics of American Disaster Policy: How Television Has Changed Federal Relief*, *in* THE IRRATIONAL ECONOMIST, *supra* note 135, at 151, 155-59.

146. *See* Thomas Eisensee & David Strömberg, *News Droughts, News Floods, and U.S. Disaster Relief*, 122 Q.J. ECON. 693 (2007).

147. MICHELE LANDIS DAUBER, THE SYMPATHETIC STATE: DISASTER RELIEF AND THE ORIGINS OF THE AMERICAN WELFARE STATE 6 (2013).

148. *See generally, e.g.*, DANIEL KAHNEMAN, THINKING, FAST AND SLOW (2012); Hein Fennema & Peter Wakker, *Original and Cumulative Prospect Theory: A Discussion of Empirical Differences*, 10 J. BEHAV. DECISION MAKING 53

the sway of the gambler's fallacy[149] and "overinvest[s] in reconstruction in the wake of disaster based on a mistaken assumption that a period of repose and relative safety will follow."[150] In a manifestation of the availability heuristic, which hinges on the salience of data taken into account during decision-making,[151] the public may fall into a dangerous complacency after "a long period of calm," "as though… natural hazards no longer exist."[152] Finally, under the influence of the affect heuristic,[153] disaster policy may evaluate the magnitude of risk and expected loss according to raw likes and dislikes.[154] One of the more obvious and expensive examples of this trap in action is the law's treatment of beachfront property.[155]

The iron cross of public choice and behavioral economics subjects disaster law to a form of moral hazard unique to the formulation of governmental policies for compensation, recovery, and reconstruction after catastrophe.[156] "[G]overnment relief distorts insurance decisions and [individual] behavior" because individuals ignore the fact that "their incentives to reduce risk affect the expected cost of government relief."[157] So treacherous is the terrain that this special case of moral hazard deserves a name of its own: charity

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(1997); Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision Under Risk*, 47 ECONOMETRICA 263 (1979); Amos Tversky & Daniel Kahneman, *Advances in Prospect Theory: Cumulative Representation of Uncertainty*, 5 J. RISK & UNCERTAINTY 297 (1992).

149. *See* Tristam McPherson, *Moorean Arguments and Moral Revisionism*, 3 J. ETHICS & SOC. PHIL. 2, 20 (209); Stephen P. Stitch & Richard E. Nisbett, *Justification and the Psychology of Human Reasoning*, 47 PHIL. SCI. 188, 192-93 (1988).

150. Pidot, *supra* note 127, at 138.

151. *See* Christine Jolls, Cass R. Sunstein & Richard H. Thaler, *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471, 1477-78 (1998).

152. Pidot, *supra* note 127, at 213.

153. *See generally* Melissa L. Finucane et al., *The Affect Heuristic in Judgments of Risks and Benefits*, 13 J. BEHAV. DECISION MAKING 2 (2000).

154. *See* Pidot, *supra* note 127, at 242.

155. *See id.*; *cf.* Houck, *supra* note 2, at 43 ("The property rights movement is nowhere stronger than on the American coastline … , and it loves insurance payouts and second home mortgage deductions and it hates planning.").

156. *See generally* PLATT, *supra* note 139, at 37-41; Mark Pauly, *Overinsurance and Public Provision of Insurance: The Roles of Moral Hazard and Adverse Selection*, 88 Q.J. ECON. 44 (1974).

157. Kaplow, *supra* note 119, at 168.

hazard.[158] Because people "typically are unaware of the hazards they face," they "rely heavily on emergency relief when the need arises."[159] Indeed, it is no exaggeration to declare that disaster victims rely on the provision of ex post relief.[160] Charity hazard poses a true Samaritan's dilemma: at the individual as well as the society level, *post hoc* disaster relief strongly breeds reliance on wealth transfers whose greatest inefficiency lies in their erosion of incentives to pursue optimal *ex ante* preparedness for disaster.[161]

B. REFORM AND (INCIPIENT) RETRENCHMENT IN THE NATIONAL FLOOD INSURANCE PROGRAM

Even a cursory look at the National Flood Insurance Program,[162] the United States' most celebrated and comprehensive system of publicly subsidized disaster insurance, confirms these economic weaknesses in disaster law and policy. The NFIP was not originally designed to be actuarially sound.[163] NFIP premiums, whether calculated according to FEMA's modeling of flood risk or consciously discounted, were supposed to be sufficient to cover claims in an "average historical loss year," or the mean annual loss over the life of the program.[164]

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158. *See* Paul A. Raschky & Hannelore Weck-Hanneman, *Charity Hazard — A Real Hazard to Natural Disasters?*, 7 ENVTL. HAZARDS 321, 321 (2007); *cf.* Tatyana Deryugina & Barrett Kirwan, *Charity Hazard in Crop Insurance* (April 14, 2014) (working paper available at http://deryugina.com/2014-04-14CharityHazard.pdf).

159. MILETI, *supra* note 117, at 136-37.

160. *See* Zeckhauser, *supra* note 110, at 130.

161. *See* Stephen Coate, *Altruism, the Samaritan's Dilemma, and Government Transfer Policy*, 85 AM. ECON. REV. 46, 46-47 (1995).

162. *See* 42 U.S.C. §§ 4001-4131 (2012). *See generally* Charles T. Griffith, *The National Flood Insurance Program: Unattained Purposes, Liability in Contract and Takings*, 35 WM. & MARY L. REV. 727 (1994).

163. *See generally* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-06-183T, FEDERAL EMERGENCY MANAGEMENT AGENCY: OVERSIGHT AND MANAGEMENT OF THE NATIONAL FLOOD INSURANCE PROGRAM, (2005) (testimony of William O. Jennings, Jr., Director of Homeland Security, before the U.S. House of Representatives, Committee on Financial Services, Subcommittee on Housing and Community Opportunity).

164. *See* Carolyn Kousky & Howard Kunreuther, *Addressing Affordability in the National Flood Insurance,* 1 J. EXTREME EVENTS 1450, 1451 (2014).

The NFIP departed in two respects from the process by which a private insurer would set an actuarially fair premium. First, a private insurer would consider catastrophic as well as average loss years. Second, a private insurer would account for the cost of capital, including the cost of holding capital reserves required by insurance regulators.[165] Even worse, the NFIP appears to have engaged in no rigorous analysis at all in choosing the hundred-year "base flood"[166] as its actuarial baseline.[167]

Historically, the federal approach to flood insurance rested on the goal of keeping premiums low enough to keep property owners and insurers within the NFIP, without lowering premiums to the point of even more aggressively subsidizing high-risk behavior.[168] In prescribing guidelines for NFIP premium rates, Congress was willing to accept rates that were *either* "adequate, on the basis of accepted actuarial principles, to provide reserves for anticipated losses" *or* — in the case of rates "less than such" an actuarially sound "amount" — "consistent with the objective of making flood insurance available where necessary at reasonable rates so as to encourage prospective insureds to purchase such insurance."[169] The NFIP's discounts were neither means-tested nor otherwise targeted at lower-income

165. *See id.*

166. *See* 44 C.F.R. § 9.4 (2014) ("Base Flood means the flood which has a one percent chance of being equalled or exceeded in any given year [also known as a 100-year flood]. This term is used in the National Flood Insurance Program [NFIP] to indicate the minimum level of flooding to be used by a community in its floodplain management regulations,"); *id.* § 59.1 (defining a "100-year flood" as a "flood having a one percent chance of being equaled or exceeded in any given year"). For technical details on the computation of an exceedance probability such as the NFIP's 100-year "base flood" concept, see generally Grossi et al., *supra* note 49, at 29-32.

167. *See* NATIONAL RESEARCH COUNCIL, RISK ANALYSIS AND UNCERTAINTY IN FLOOD DAMAGE REDUCTION STUDIES 142-43 (2000). Matthew Adler treats this "intuitive" but unsystematic policy choice as evidence that environmental law in general and disaster policy in particular should eschew "arbitrary non-zero numerical cutoffs." *See* Adler, *supra* note 66, at 31-35.

168. *See Legislative Proposals to Reform the National Flood Insurance Program: Hearing Before the Subcomm. on House and Community Opportunity of the Comm. on Fin. Servs.,* 111th Cong. 8 (2010).

169. 42 U.S.C. § 4015(b)(2) (2012).

homeowners.[170] Even at subsidized rates, homeowners failed to buy "below-cost NFIP flood insurance to complement their all peril ... coverage."[171]

The actual administration of the NFIP compounded the inefficiencies of the program's pricing policies. FEMA has consciously set flood insurance rates on a nationwide basis. This practice defeats any hope that premiums might reflect regional, local, and individualized "topographic factors that are relevant to flood risk."[172] FEMA historically allowed "grandfathered properties" to keep lower premiums known to fall short of reflecting the actual risk of flooding and covering expected losses; worse still, the agency elected not to collect data on the full financial impact of grandfathering.[173] NFIP rates have never been set according to "market forces — which would tend to eliminate actuarially unsound rates — but by political forces and special interests."[174]

These flaws in the design of the NFIP compounded the unintended effect of risk management for flood-prone regions: although measures such as the construction of levees may reduce the probability of flooding, those steps invite further settlement in floodplains and thereby increase the magnitude of losses incurred during floods.[175] The NFIP nevertheless flashed promise as the one policy tool that has delivered even modest historical success in "guid[ing] development away from floodplains."[176]

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170. *See* Kunreuther, *The Case for Comprehensive Disaster Insurance*, *supra* note 116, at 161-62; Edward T. Pasterick, *The National Flood Insurance Program, in* PAYING THE PRICE, *supra* note 59, at 125.

171. Hornstein, *supra* note 50, at 15.

172. U.S. GOV'T GOVERNMENT ACCOUNTABILITY OFFICE, GAO-09-12, FEMA'S RATE-SETTING PROCESS WARRANTS ATTENTION 4 (2008).

173. *See id.* at 20-21.

174. Barnhizer, *supra* note 129, at 336.

175. *See* MILETI, *supra* note 117, at 25-26.

176. Oliver A. Houck, *Rising Water: The National Flood Insurance Program and Louisiana*, 60 TULANE L. REV. 61, 160 (1985); *see also* Charlene Luke & Aviva Abramovsky, *Managing the Next Deluge: A Tax System Approach to Flood Insurance*, 18 CONN. INS. L.J. 1, 8 (2011-12) (observing that individuals may "participate in the NFIP" only if "their communities agree to abide by [federal] regulations intended to mitigate flood loss"); Scales, *supra* note 50, at 12 ("NFIP-backed insurance was conceived as a way of inducing communities to adopt flood mitigation policies that the federal government ... could not compel.").

In what was almost certainly "the largest revamping of the flood insurance program since its origin in 1968,"[177] the Biggert-Waters Flood Insurance Relief Act of 2012[178] made considerable progress toward the elusive goal of placing the NFIP on actuarially sound footing. Put simply, Biggert-Waters "mark[s] the beginning of the end for NFIP's historically below-market insurance rates for flood insurance."[179] Prospectively, all new policies issued within the NFIP must insure homes according to "actuarial rates."[180] Biggert-Waters adopts an aggressive schedule for phasing out subsidized rates on flood insurance for second homes, business properties, and properties that have suffered multiple severe flood losses. Flood insurance premiums on these properties are to rise 25 percent per year until they reach "full actuarial cost."[181] The vast majority of homes currently insured under the NFIP are subject to an only modestly slower schedule (20 percent per year) that is designed to phase in actuarially accurate rates within five years.[182] If successful, the Biggert-Waters reform would address three of the NFIP's historical shortcomings: the failure to encourage widespread uptake of flood insurance, the failure to spur more prudent floodplain management, and the utter lack of long-run actuarial soundness.[183]

The economic wisdom of the Biggert-Waters reform lies beyond serious dispute. A commitment to zero governmental relief provides a "unique optimum" solution for natural disasters, even where private expenditures to reduce risk are "not observable by insurance companies" and moral hazard reaches its apex.[184] The prevalence of exclusions, deductions, and coinsurance requirements, even in settings where private insurers have full control of underwriting, suggests that the reduction of moral hazard promises the ability to

177. Eli Lehrer, *Strange Bedfellows: SmarterSafer.org and the Biggert-Waters Act of 2012*, 23 DUKE ENVTL. L. & POL'Y F. 351, 352 (2013).

178. Pub. L. No. 112-141, 126 Stat. 916 (amending 42 U.S.C. §§ 4001-4129).

179. Hornstein, *supra* note 50, at 32.

180. Pub. L. No. 112-141, § 100205, 126 Stat. 916, 917 (2012).

181. *Id.* § 100205(a), 126 Stat. at 917.

182. *Id.* § 100207, 126 Stat. at 919.

183. *See* Thomas L. Hayes & D. Andrew Neal, *Actuarial Rate Review: In Support of the Recommended October 1, 2011 Rate and Rule Changes* (FEMA 2011), *available at* http://www.fema.gov/media-library-data/20130726-1809-25045-2347/actuarial_rate_review2011.txt); Kousky & Kunreuther, *supra* note 164, at 3.

184. Kaplow, *supra* note 119, at 172.

offer insurance to a broader swath of the population, at reduced cost for all participants.[185] Even where governmental intervention is warranted on grounds of efficiency, as in instances where "some individuals may incorrectly perceive the probability of loss," "[c]ompulsory government insurance" based on "actuarially fair premiums" would be superior to the dispensing of disaster relief on an *ad hoc* basis.[186] Financially sound disaster policy should strive to enable an actuarially sound system of "insurance [to] mimic any level of government relief" and thereby to reduce the degree to which "[g]overnment relief for risk distorts incentives because individuals no longer bear the full cost of their actions."[187]

Not surprisingly, politics has again undermined optimal disaster policy. As if to prove the political impossibility of achieving these economic goals, the immediate effect of the Biggert-Waters Act's provisions migrating NFIP premiums toward actuarially fair levels was to spur congressional retreat. In late 2013 and early 2014, both houses of Congress considered bills to retard the Biggert-Waters reform's timetable for achieving actuarial soundness, with an apparent eye toward eventual, outright repeal.[188] As of July 2014, the Senate has passed its version of a would-be Homeowner Flood Insurance Affordability Act. Once again, popular expectations that government will compensate victims for disaster-related losses drive the "self-fulfilling prophecy" that "citizens ... will prefer not to insure [catastrophic] risk."[189] "[S]olidarity" between empowered

185. *See* Priest, *The Problem of Catastrophic Loss*, *supra* note 17, at 224, 228. *See generally* George L. Priest, *A Theory of the Consumer Product Warranty*, 90 YALE L.J. 1297 (1981) (describing the function of exclusions and other limitations on coverage as that of reducing excessive *ex ante* incentives to consume insurance services).

186. Kaplow, *supra* note 119, at 173. This observation applies not only to disaster relief, but also to "a wide range of government programs [such as] ... Medicare" and bank bailouts. *Id.*

187. *Id.* at 172.

188. *See* Homeowner Flood Insurance Affordability Act of 2014, H.R. 3370, 113th Cong. (2013); Homeowner Flood Insurance Affordability Act of 2013, S. 1846, 113th Cong. (2013).

189. Christian Gollier, *Some Aspects of the Economics of Catastrophe Risk Insurance*, *in* CATASTROPHIC RISKS AND INSURANCE 13, 25 (2005) (Organisation for Economic Co-operation and Development, Policy Issues in Insurance, No. 8).

disaster victims and their political representatives "kills market insurance."[190]

C. Beyond Flood Insurance

Flood insurance and FEMA's administration of the NFIP illustrate merely one facet of the grander problem. National governments are often the only entities with sufficient size and power to serve as reinsurers at large for the global insurance industry. From a global perspective, only a few national governments have sufficient size and stability to serve that function. For a shifting variety of economic and political reasons, not all of those governments can or will provide a financial backstop for the global insurance and reinsurance industries.

Public subsidies for otherwise unprofitable lines of insurance represent just one possibility within disaster law's portfolio of tools for compensation and risk management. In the immediate aftermath of Hurricane Katrina, Congress entertained diverse proposals to subsidize or reform private disaster insurance.[191] As with flood insurance, Congress may elect to continue awarding federal subsidies. Properly managed, these subsidies may motivate private insurers and local governments to manage risks, particularly by directing insured parties to avoid or even to leave high-risk areas. Tax expenditures through exemptions, deductions, and credits[192] may enable taxpayers to recover tax credits against insurance premiums or to establish catastrophe savings accounts analogous to health savings accounts, "529" college savings accounts, and individual retirement accounts.[193] Private insurers might receive preferential tax treatment of contributions to financial reserves for catastrophic events.[194] Even

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190. *Id.*

191. *See* DISASTER LAW & POLICY, *supra* note 1, at 343.

192. *See generally* STANLEY S. SURREY, PATHWAYS TO TAX REFORM: THE CONCEPT OF TAX EXPENDITURES (1974). On the regressive effect of tax expenditures within a progressive tax structure, *see* Stanley S. Surrey, *Tax Incentives as a Device for Implementing Government Policy: A Comparison with Direct Government Expenditures*, 83 HARV. L. REV. 705, 721-23 (1970); Jim Chen, *Progressive Taxation: An Aesthetic and Moral Defense*, 50 U. LOUISVILLE L. REV. 659, 662 (2012).

193. *See* H.R. 2100, 112th Cong. (1st Sess. 2011).

194. *See* DISASTERS AND THE LAW: KATRINA AND BEYOND 199-200 (Daniel A. Farber & Jim Chen eds., 2006).

more ambitiously, the federal government might interject itself as the ultimate reinsurer for catastrophic casualties and property loss.[195] In so doing, government as reinsurer would use its financial might to buttress an entire branch of the financial services industry, much as federal deposit insurance restored confidence in banking during the Great Depression.[196] The Terrorism Risk Insurance Act established a program of this sort for insurance against terrorism.[197]

As distasteful as public subsidization may seem, some alternatives manage to combine greater political controversy with more staggering potential for fiscal or even environmental damage. In the absence of effective incentives to buy subsidized federal crop insurance,[198] farmers and members of Congress representing the country's most agrarian districts routinely demand and receive ad hoc crop disaster relief. The Federal Crop Insurance Act of 1980[199] aimed to encourage farmers to participate in a program covering the entire United States by subsidizing 30 percent of the premium needed to indemnify 65 percent of the average farm's yield.[200] Despite concerted efforts at reform, payments under the federal crop

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195. *See* Dwight Jaffee & Thomas Russell, *Financing Catastrophe Insurance: A New Proposal*, *in* RISKING HOUSE AND HOME: DISASTERS, CITIES, PUBLIC POLICY 37, 40 (John M. Quigley & Larry A. Rosenthal eds., 2008).

196. *See* Martin H. Wolfson, *The Financial System and the Social Structure of Accumulation*, *in* SOCIAL STRUCTURES OF ACCUMULATION 133, 135 (David M. Kotz, Terrence McDonough & Michael Reich eds.,1994).

197. *See* Terrorism Risk Insurance Act of 2002, Pub. L. 107–297, § 1(a), 116 Stat. 2322 (2002) (amending scattered sections of 12 and 28 U.S.C.), as amended by Terrorism Risk Insurance Extension Act of 2005, Pub. L. 109–144, § 1, 119 Stat. 2660 (2005) and Terrorism Risk Insurance Program Reauthorization Act of 2007, Pub. L. 110–160, § 1(a), 121 Stat. 1839 (2007). *See generally* Robert L. Rabin & Suzanne A. Bratis, *Financial Compensation for Catastrophic Loss in the United States*, *in* FINANCIAL COMPENSATION FOR VICTIMS AFTER CATASTROPHE 303 (Michael Faure & Ton Hartlief eds., 2005); 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 (2007); Jeffrey Thomas, *Insurance Implications of September 11 and Possible Responses*, 34 URBAN LAW. 727 (2002).

198. *See generally* Steffen N. Johnson, *Defining a Justified Federal Role in Crop Insurance*, 72 N.D. L. REV. 505 (1996).

199. *See* Federal Crop Insurance Act of 1980, 7 U.S.C. §§ 1501-1524 (2012).

200. *See* BARRY K. GOODWIN & VINCENT H. SMITH, THE ECONOMICS OF CROP INSURANCE AND DISASTER AID 46-47 (1995); Scott E. Fancher, *How Safe Is the Safety Net?: The Implications of* Wiley v. Glickman, 7 DRAKE J. AGRIC. L. 527, 531 (2002).

insurance program have been excessive and contrary to the bedrock insurance interest in avoiding moral hazard.[201] Worse still, because agriculture makes a significant contribution to climate change, the failure to reform crop insurance and other policies will promote monoculture and aggravate farming's negative ecological footprint.[202] One alternative to ad hoc agricultural assistance or publicly subsidized crop insurance lies in index-based, parametrically triggered futures contracts that might stabilize agricultural finance in a way comparable to the impact of catastrophe bonds on financial preparedness for natural disasters.[203]

By the admittedly abysmal standard of crop insurance and agricultural disaster assistance, government may find greater value in establishing comprehensive compensation schemes in advance. The September 11 Victim Compensation Fund[204] and the National Vaccine Injury Compensation Program[205] provide vivid if controversial illustrations of this strategy. In these circumstances, federal intervention accomplishes in legal terms what widespread insurance typically seeks to do as a matter of financial practice: neutralizing the ruinous and financially destabilizing prospect of tort liability. The heightened risks posed by climate change put a premium on efforts to reinforce private insurance through subsidies and other forms of federal intervention.[206]

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201. *See generally* GOVERNMENT ACCOUNTABILITY OFFICE, GAO-10-548, USDA CROP DISASTER PROGRAMS: LESSONS LEARNED CAN IMPROVE IMPLEMENTATION OF NEW CROP ASSISTANCE PROGRAM (2010).

202. *See, e.g.*, Mark Hertsgaard, *Harvesting a Climate Disaster*, N.Y. TIMES, Sept. 13, 2012, at A31. *See generally* Trevor Maynard, *Climate Change: Impacts on Insurers and How They Can Help with Adaptation and Mitigation*, 33 GENEVA PAPERS ON RISK & INS. 140 (2008).

203. *See* Jerry R. Skees, *A Role for Capital Markets in Natural Disasters: A Piece of the Food Security Puzzle*, 25 FOOD POL'Y 376 (2000).

204. *See* 49 U.S.C. § 40101 (2012). *See generally* Robert L. Rabin, *The Quest for Fairness in Compensating Victims of September 11*, 49 CLEV. ST. L. REV. 573 (2001).

205. *See* 26 U.S.C. § 9510 (2012); Bruesewitz v. Wyeth, Inc., 131 S. Ct. 1068 (2011).

206. *See* Sean Hecht, *Climate Change and the Transformation of Risk: Insurance Matters*, 55 UCLA L. REV. 1559 (2008); Alberto Monti, *Climate Change and Weather-Related Disasters: What Role for Insurance, Reinsurance and Financial Sectors?*, 15 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 151 (2009).

V. THE EFFICIENT FRONTIER OF DISASTER FINANCE

From conventional tort litigation to catastrophe bonds, this survey demonstrates the conceptual unity of legal tools for compensating victims and spreading risk, whether through insurance, securitization, or public disaster assistance. Just as there is no such thing as a strictly natural disaster, there is no such thing as strictly private disaster law. The very existence of calamities beyond the capacity of ordinary citizens, companies, and institutions demands public intervention at every level. Far from being deviations from the presumed tasks of private law — the enforcement of primary rights and duties binding private citizens to each other[207] — taxation, subsidization, regulation, and public investment are tools of first resort in disaster law.[208] These tools, intrusive and interventionist by design, are the leading components of the portfolio of rules at the efficient frontier of disaster law and policy.[209]

The catastrophe bond specifically shows that disaster law's interplay of private actors and public governance operates in both directions. Conventional portrayals of risk management techniques in disaster law begin and end with public contributions to systems of compensation and insurance that the private sector cannot adequately manage on its own.[210] Whatever their delivery vehicle, subsidies add public dollars to private insurance markets.[211] Official involvement in catastrophic risk management inexorably thrusts government into

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207. *See* HENRY M. HART, JR. & ALBERT M. SACKS, THE LEGAL PROCESS 130 (William N. Eskridge, Jr. & Philip P. Frickey eds., 1994) (defining a primary duty as "an authoritatively recognized obligation … not to do something, or to do it, or to do it if at all only in a prescribed way"); *cf.* Ann Woolhander & Michael G. Collis, *Federal Question Jurisdiction and Justice Holmes*, 84 NOTRE DAME L. REV. 2151, 2154-55 (2009) (distinguishing between "primary dut[ies]" running between individuals — for instance "not to cause injury to the property" of each other — and "remedial dut[ies] … to provide a remedy to the person whose primary rights were violated") (citing Hart & Sacks, *supra*, at 137).

208. *See* Jaffee & Russell, *supra* note 195, at 37-39.

209. *See id.* at 37; *cf.* Jim Chen & Daniel J. Gifford, *Law as Industrial Policy: Economic Analysis of Law in a New Key*, 25 U. MEMPHIS L. REV. 1315, 1359-60 (1995) (describing a wide range of laws as variations on the theme of public finance).

210. *See, e.g.*, Louis Cruz, *Examining Current Proposals for Increasing the Federal Role in Dealing with Coastal Hurricane Risk*, 16 CONN. INS. L.J. 323, 329-31 (2009).

211. *See id.* at 351.

the role of the ultimate reinsurer for all risks to property, life, and health. Catastrophe bonds illustrate the opposite effect. In all of its manifestations, alternative risk transfer promises the tantalizing possibility that private capital markets can infuse money from voluntary, profit-seeking participants into the project of managing catastrophic risk.[212]

The practical exercise of evaluating tools for compensating disaster victims and spreading risk does more than apply disaster theory to existing legal tools and doctrines. This survey of risk management techniques in disaster law — from private insurance to public subsidies, with a tantalizing promise that private capital markets may yet enhance catastrophic preparedness — depicts disaster law as a comprehensive, theoretically coherent exercise in societal risk management. The elusive pursuit of a fully diversified and theoretically coherent portfolio of financial tools for managing catastrophic risk shows how far disaster policy must still travel in order to reach the efficient frontier of legal preparedness for calamity.

212. *See* Bruggeman, *supra* note 67, at 10,140-41.