MODERN DISASTER THEORY: EVALUATING DISASTER LAW AS A PORTFOLIO OF LEGAL RULES

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Disaster law consists of a portfolio of legal rules for dealing with catastrophic risks. This Article takes preliminary steps toward modeling that metaphor in quantitative terms made familiar through modern portfolio theory. Modern disaster theory, by analogy to the foundational model of corporate finance, treats disaster law as the best portfolio of legal rules. Optimal legal preparedness for disaster consists of identifying, adopting, and maintaining that portfolio of rules at the frontier of efficient governance.

Part I of this Article defines disaster and disaster law. In an effort to develop an analytically rigorous basis for modeling and evaluating disaster law, Part II expounds the principles of modern portfolio theory, a framework for assessing financial returns according to risk. Part III outlines the principles of modern disaster theory as the legal analog of modern portfolio theory as a branch of finance. Part IV conducts an exercise in applied modern disaster theory. It evaluates legal tools for compensating disaster victims ex post and spreading catastrophic risk ex ante according to the terms of modern disaster theory's catastrophic preparedness asset model. Part V concludes that modern disaster theory, through the use of sophisticated quantitative methods analogous to those used in financial analysis, promises to place disaster law and policy at the efficient frontier of legal preparedness.

I. DEFINING DISASTER AND DISASTER LAW

I begin by harmonizing the definitions of "disaster" and "disaster law." The International Federation of Red Cross and Red Crescent Societies ("IFRC") defines "disaster" as "a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and

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economic or environmental losses that exceed the community's or society's ability to cope using its own resources."[1]

As for "disaster law," I have joined my coauthors of *Disaster Law and Policy* in describing disaster law as a portfolio of rules:

> At first glance, disaster law seems to be nothing but a collection of legal rules of various kinds that happen to come into play when communities have suffered severe physical damage. But at a deeper level, disaster law is about assembling the best portfolio of legal rules to deal with catastrophic risks—a portfolio that includes mitigation, emergency response, compensation and insurance, and rebuilding strategies.[2]

The IFRC synthesizes these definitions of calamity and response into a coherent definition of disaster. According to the IFRC, disaster arises from a "combination of hazards, vulnerability and inability to reduce the potential negative consequences of risk."[3] In apparent homage to the poetic admonition that "Euclid alone has looked on Beauty bare,"[4] the IFRC has expressed the relationship between hazard, vulnerability, and capacity in mathematical terms:[5]

$$(1)\ \frac{Hazard+Vulnerability}{Capacity} = Disaster$$

Although this formula treats mathematics as a metaphor rather than a concrete tool for computing actual, quantifiable results, that metaphor does carry great value. The fraction on the left side of equation (1) describes disaster as an inverse relationship between natural hazard plus social vulnerability and the responsive capacity of human institutions. The numerator expresses the risk of a "sudden, calamitous event" as a function of hazard (a natural or environmental factor) and vulnerability (a social or human factor).[6] The IFRC's insistence on defining risk as a combination of natural and social factors represents a sober reminder that there is no such thing as a natural

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[1] Int'l Fed'n of Red Cross & Red Crescent Soc'ys, *What Is a Disaster?*, IFRC.ORG, http://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/what-is-a-disaster (last visited Nov. 6, 2011) [hereinafter IFRC].

[2] DISASTER LAW AND POLICY, at xxi (Daniel A. Farber, Jim Chen, Robert R.M. Verchick & Lisa Grow Sun eds., 2d ed. 2010).

[3] IFRC, *supra* note 1.

[4] EDNA ST. VINCENT MILLAY, *To One Who Might Have Borne a Message, in* EDNA ST. VINCENT MILLAY: SELECTED POEMS 47, 52 (J.D. McClatchy ed., 2003).

[5] IFRC, *supra* note 1.

[6] *Id.*

disaster.[7] As the social component of risk, vulnerability can be broken down further into two distinct subcomponents: the static, ex ante *susceptibility* of certain groups to harm at the moment disaster strikes, plus the dynamic, ex post *resilience* of those groups and their communities to recover after disaster.[8]

Of the three variables identified in the IFRC's definition of disaster, capacity offers governments and other social institutions what is by far the greatest degree of control. In the context of disaster law, meaningful capacity surely represents additional, marginal capacity over some baseline of institutional performance that society expects (and, one can only hope, delivers) in the absence of sudden, calamitous events. Law, of course, contributes to the management of all three variables: hazard, vulnerability, and capacity. Unthinking legal choices have undoubtedly contributed to anthropogenic climate change and other factors heightening the risk of environmental calamity.[9] Comparable carelessness has institutionalized social injustices at the heart of every putatively "natural" disaster.[10] As fervently as policymakers may hope to reduce these sources of environmental and social risk, disaster law may have an even greater role to play in guiding legal decisions on prevention, emergency response, mitigation, risk-spreading, compensation, and reconstruction in the face of disaster. Sharpening these tools enhances the portfolio of rules that comprise disaster law. There may be no greater way for government and private social agencies to enhance communal preparedness for sudden calamity.

The mission of the IFRC and other relief agencies is to respond to disaster and to remedy its most tragic effects.[11] By the same token, it is the mission of disaster law to increase the preparedness of all social institutions, including official and nongovernmental actors, to anticipate sudden, calamitous events, and to bring the optimal portfolio of legal rules to bear when such events

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[7] *See* 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, *supra* note 2, at 203–47.

[8] *See* B.E. Aguirre, *Dialectics of Vulnerability and Resilience*, 14 GEO. J. ON POVERTY L. & POL'Y 39, 41–45 (2007); Susan L. Cutter, Bryan J. Boruff & W. Lynn Shirley, *Social Vulnerability to Environmental Hazards*, 84 SOC. SCI. Q. 242, 242–43 (2003).

[9] *See* RED CROSS/RED CRESCENT CLIMATE CTR., RED CROSS/RED CRESCENT CLIMATE GUIDE 10 (2007), *available at* http://www.ifrc.org/Global/Publications/disasters/climate%20change/climate-guide.pdf.

[10] Chen, *supra* note 7, at 4.

[11] *See* Red Cross/Red Crescent Climate Ctr., *Mission & Strategy*, CLIMATE CENTRE, http://www.climatecentre.org/site/mission (last visited Sept. 30, 2011).

occur. Though it may seem trivial, I define "preparedness" as the reciprocal of disaster:

$$(2)\ Preparedness = \frac{1}{Disaster} = \frac{Capacity}{Hazard+Vulnerability}$$

I restate the relationship in a very slightly different fashion. I characterize preparedness as the performance of legal institutions and rules in times of disaster, adjusted for risks posed by environmental hazard and social vulnerability:

$$(2a)\ Preparedness = \frac{Performance\ (of\ legal\ institutions\ and\ rules\ in\ times\ of\ disaster)}{Risk\ (as\ posed\ by\ environmental\ hazard\ and\ social\ vulnerability)}$$

This approach of defining disaster preparedness as institutional performance discounted by risk permits us to express the goals of disaster law in terms made familiar through theoretical analyses of financial markets. To infuse even a modest measure of mathematical rigor into my metaphor of disaster law as a portfolio of legal rules, I turn now to a very abbreviated survey of modern portfolio theory.

II. MODERN PORTFOLIO THEORY

Modern portfolio theory offers a mathematically informed approach to financial risk management through diversified investing.[12] By no means is it a panacea. Modern portfolio theory has drawn withering criticism, among many other reasons, for its failure to account for investor behavior,[13] its reliance on historical measures of risk without accounting for the causes of risk,[14] and its mathematically elegant but practically unrealistic construction of "beautifully Platonic models on a Gaussian base."[15] These limitations do constrain modern portfolio theory's contributions to disaster law, not least because most disasters follow lopsidedly non-Gaussian distributions.[16] Worse still, behavioral biases

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[12] *See* Harry M. Markowitz, *Portfolio Selection*, 7 J. FIN. 77, 87–91 (1952). *See generally* HARRY M. MARKOWITZ, PORTFOLIO SELECTION: EFFICIENT DIVERSIFICATION OF INVESTMENTS 6 (2d ed. 1991) [hereinafter MARKOWITZ, PORTFOLIO SELECTION]; Edwin J. Elton & Martin J. Grumer, *Modern Portfolio Theory, 1950 to Date*, 21 J. BANKING & FIN. 1744 (1997).

[13] *See* Kent D. Daniel, David Hirshleifer & Avanidhar Subrahmanyam, *Overconfidence, Arbitrage, and Equilibrium Asset Pricing*, 56 J. FIN. 921, 921–22 (2001).

[14] *See* DOUGLAS W. HUBBARD, THE FAILURE OF RISK 67 (2009) (distinguishing the simple assignment of probabilities in modern portfolio theory from more comprehensive structural analyses of risk in probabilistic risk assessment).

[15] NASSIM NICHOLAS TALEB, THE BLACK SWAN: THE IMPACT OF THE HIGHLY IMPROBABLE 277 (2007).

[16] *See* Daniel A. Farber, *Probabilities Behaving Badly: Complexity Theory and Environmental Uncertainty*, 37 U.C. DAVIS L. REV. 145, 148–55 (2003).

in the perception of risk, by policymakers and members of the public, severely distort legal responses to disasters.[17] These reservations notwithstanding, I borrow the building blocks of modern portfolio theory as a basis for evaluating disaster law and policy.

Modern portfolio theory assumes that investors are rational.[18] Given two portfolios with the same expected return, investors prefer the less risky one. Reward follows risk; though a riskier investment is not necessarily more rewarding, modern portfolio theory does predict that an investor will demand a higher expected return in exchange for accepting greater risk.[19]

Measurements of risk abound within modern portfolio theory. Harry Markowitz's original formulation used the variability of returns, as measured by their standard deviation, as a proxy for risk.[20] A more sophisticated measure, beta, compares returns on an individual asset or a portfolio of assets with returns realized from a broader benchmark, based on the entirety or at least some significant portion of the financial market.[21] The beta of an asset within a portfolio measures the covariance between the rate of return on the asset and the rate of return on the portfolio as a whole, divided by the variance of returns on the portfolio.[22] More formally:

(3) $\beta_\alpha = \frac{Cov(r_a, r_p)}{Var(r_p)}$

Zero beta indicates a lack of correlation between an asset and its benchmark. Negative beta indicates inverse correlation; positive market movement means a loss in value for the asset, and vice versa.[23] For purposes of this discussion, I focus on positive values for beta. Although there is no upper or lower bound on

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[17] *See, e.g.*, Clayton P. Gillette & James E. Krier, *Risk, Courts, and Agencies*, 138 U. PA. L. REV. 1027, 1093 (1990); Dan M. Kahan, *Two Conceptions of Emotion in Risk Regulation*, 156 U. PA. L. REV. 741, 744–45 (2008).

[18] *See* Harry Markowitz, *Foundations of Portfolio Theory*, 46 J. FIN. 469, 469–70 (1991).

[19] *See id.*

[20] *See* MARKOWITZ, PORTFOLIO SELECTION, *supra* note 12, at 17.

[21] *See* MARC LEVINSON, GUIDE TO FINANCIAL MARKETS 148 (2010).

[22] Irwin Friend & Marshall Blume, *Measure of Portfolio Performance Under Uncertainty*, 60 AM. ECON. REV. 561, 565 (1970).

[23] *See* LEVINSON, *supra* note 21, at 148. For certain assets, negative beta may represent successful performance. For example, over an appropriately limited time frame, an inverse exchange-traded fund ("ETF") that uses derivatives to profit from a decline in the Standard & Poor's ("S&P") 500 would report complete success in that endeavor if it is able to report a beta of -1 relative to the S&P 500. By holding that ETF, an investor would be able to hedge against a decline in the S&P 500 without carrying the margin account needed to engage in the short selling of securities.

the value of beta, a useful analytical baseline is represented by a beta of 1. Beta of 1 indicates an asset whose systemic volatility, or sensitivity to risk, is exactly the same as that of the broader market.[24] Positive values for beta below 1—that is, $0 < \beta < 1$—indicate an asset that moves along with the broader market, but is less volatile. Values for beta greater than 1 indicate greater volatility.[25]

Beta plays a pivotal role in one of the most important expressions of modern portfolio theory, the capital asset pricing model.[26] The capital asset pricing model expresses return on an asset as a function of risk (which in turn can be expressed as the volatility embodied in a measure such as beta) and the premium demanded by the market for shouldering that asset's volatility over a benchmark represented by the return on a risk-free investment:

$$(4)\ R_a = R_f + \beta_a(R_m - R_f)$$

where R_a, R_m, and R_f respectively represent returns on the asset, on the broader market of comparable investments, and on a risk-free investment, and where β_a represents the individual asset's beta vis-à-vis a portfolio based on the broader market.[27] This formula takes the form of a linear equation where the return on an asset (R_a) is expressed as a function of the premium over a risk-free baseline ($R_m - R_f$).[28] Within the capital asset pricing model, beta (β_a) represents the slope of the linear function, and the risk-free return (R_f) is a constant that defines the function's y-intercept.[29]

Modest algebraic rearrangement of the capital asset pricing model yields the following relationship:

$$(5)\ R_m - R_f = \frac{R_a - R_f}{\beta_a}$$

The left side of equation (5) represents the *risk premium* demanded for the entire asset class represented by a particular segment of the market.[30] A very

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[24] LEVINSON, *supra* note 21, at 148.

[25] *Id.*

[26] *See generally* Jack L. Treynor, *Toward a Theory of Market Value of Risky Assets*, *in* ASSET PRICING AND PORTFOLIO PERFORMANCE: MODELS, STRATEGY AND PERFORMANCE METRICS 15, 15–22 (Robert A. Korajczyk ed., 1999).

[27] *See* Robert A. Korajczyk, *Introduction* to ASSET PRICING AND PORTFOLIO PERFORMANCE: MODELS, STRATEGY AND PERFORMANCE METRICS, *supra* note 26, at xiii, xv.

[28] *See id.*

[29] *See id.*

[30] *See id.*

common application of the capital asset pricing model compares an index of equities designed to track the Standard & Poor's ("S&P") 500 against the putatively risk-free baseline of short-term Treasury bills.[31] This market-wide risk premium is equivalent to the risk-adjusted premium expressed on the right side of the equation—namely, the risk premium for the asset vis-à-vis a risk-free investment, divided by the individual asset's beta.[32]

This ratio between risk-adjusted return and volatility bears closer examination. Recall that equation (5) is merely an algebraically reformulated version of the basic capital asset pricing model, as set forth in equation (4). The right side of equation (5) expresses the relationship between return and volatility:

(6) Treynor ratio: $\frac{R_a - R_b}{\beta_a}$

The Treynor ratio measures reward as return on an asset (R_a) above some benchmark return (R_b) relative to the volatility of that asset's return as expressed by its beta (β_a).[33] The benchmark return (R_b) often is, but need not be, equivalent to the risk-free baseline (R_f). The Treynor ratio belongs to a class of performance metrics that include the Sharpe ratio of reward to variability ($\frac{R_a - R_b}{\sigma}$)[34] and the Sortino ratio of reward to downside risk ($\frac{R_a - R_b}{DR}$).[35] What each of these ratios has in common is the evaluation of portfolio returns—or portfolio manager performance—based on the relationship between returns and some proxy for risk, whether variability as measured through standard deviation, volatility as measured through beta, or downside risk as measured through target semideviation.[36]

In its most aggressive manifestation, modern portfolio theory defines the efficient frontier as a single portfolio consisting of the equity market as a whole, coupled with a single decision to borrow or to lend cash, based strictly on an individual investor's willingness and ability to bear risk.[37] This complete

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[31] *See* 1 HANDBOOK OF QUANTITATIVE FINANCE AND RISK MANAGEMENT 10 (Cheng-Few Lee et al. eds., 2010).

[32] *See* Korajczyk, *supra* note 27, at xv.

[33] *See* Treynor, *supra* note 26, at 16–17.

[34] *See* William F. Sharpe, *Mutual Fund Performance*, 39 J. BUS. 119, 123 (1966).

[35] *See generally* Frank A. Sortino & Robert van der Meer, *Downside Risk*, J. PORTFOLIO MGMT., Summer 1991, at 27, 27–31.

[36] *See id.* at 27–29; Sharpe, *supra* note 34, at 121–22.

[37] *See generally* James Tobin, *Liquidity Preference as Behavior Towards Risk*, 67 REV. ECON. STUD. 65 (1958).

separation of portfolio design into two unconnected investment decisions—holding a single equity portfolio reflecting the market as a whole, versus borrowing (or lending) cash—unites modern portfolio theory with the strong form of the efficient capital markets hypothesis, which posits that prices on securities reflect all information, public and private, and the prevalence of this knowledge prevents all investors from earning excess returns.[38] In practical terms, complete intellectual commitment to modern portfolio theory demands the forswearing of any returns from active management or any other method designed to squeeze excess returns from investment.[39] Assuming unity in wealth effects, tax rates, and costs of capital, all investors confront the efficient frontier in portfolio management at a single, common point of optimal efficiency: holding a portfolio containing shares in all publicly traded companies according to their relative market capitalization.[40] Differences in cash holdings (or borrowing) would serve the lone purpose of bridging differences among individual investors' need for liquidity.[41]

Especially in its most extreme manifestations, modern portfolio theory provides limited practical guidance even to investors, let alone to those who would apply its insights in the allied field of disaster law and policy. What modern portfolio theory does do well is provide the theoretical foundations for describing any exercise in financial risk management, including disaster policy, in mathematically rigorous terms. In assessing the performance of disaster law as a portfolio of legal rules for dealing with catastrophic risks, we can draw no fewer than two mathematical models from modern portfolio theory: the capital asset pricing model and the set of performance metrics represented by the Treynor ratio. Armed with these weapons, I now turn to the central task of modern disaster theory: evaluating disaster law according to mathematically based measures of risk-adjusted performance, comparable to those developed in modern portfolio theory.

III. MODERN DISASTER THEORY

Combining the IFRC's definition of disaster and my own definition of preparedness as the reciprocal of disaster, on one hand, with modern portfolio theory yields two basic mathematical models for evaluating disaster law. I

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[38] *See* Eugene F. Fama & Kenneth R. French, *The Cross-Section of Expected Stock Returns*, 47 J. FIN. 427, 427–29 (1992).

[39] *See* William F. Sharpe, *The Arithmetic of Active Management*, 47 FIN. ANALYSTS' J. 7, 7 (1991).

[40] *See id.* at 7–8.

[41] *See id.*

begin by describing one measure of the risk-adjusted performance of disaster law portfolios. From this model, I then extrapolate a broader catastrophe preparedness asset model for disaster law. I then apply these two concepts to the task within disaster law and policy most closely related to the exploitation or regulation of financial markets: striking the optimal balance between compensating victims of disaster ex post and spreading risk ex ante.

A. The Risk-Adjusted Performance of Disaster Law Portfolios

Reconsider the relationship between risk premiums and the Treynor ratio:

(5) $R_m - R_f = \frac{R_a - R_f}{\beta_a}$

Notice how the Treynor ratio quantifies a risk premium as the ratio of performance over a low-risk benchmark to risk as measured by beta. Recall also how my definition of disaster preparedness, which is the reciprocal of the IFRC's definition of disaster, relates performance to risk:

(2) $Preparedness = \frac{1}{Disaster} = \frac{Capacity}{Hazard + Vulnerability}$

(2a) $Preparedness = \frac{Institutional\ Performance}{Social\ Risk}$

The structural similarity between these formulas should be transparent. Both the Treynor ratio and my definition of disaster preparedness measure performance discounted by risk.

Disaster law begins with awareness of the social contribution to catastrophic loss. Natural events do not destroy in their own right; environmental calamities inflict loss only to the extent that human institutions place people and property in the path of destruction. A truly humane approach to disaster law extends this initial recognition to deep understanding of the contribution of social injustice to putatively natural disaster. My definition of disaster preparedness, as rendered in equations (2) and (2a), inverts the IRFC's definition of disaster. As the reciprocal of the IFRC's disaster formula, preparedness contrasts the legal, financial, and political capacity of responding institutions with the risk posed by the combination of environmental hazard with social vulnerability. This relationship between institutional performance and social risk is analogous to the relationship between the premiums commanded by particular investments and some measure (typically volatility) of those investments' risks.

Defining preparedness in this fashion gives policymakers distinct benchmarks by which they can gauge their distinct contributions to expanding legal and social capacity and to lowering environmental hazard and social vulnerability. Financial managers evaluated under either the Treynor or Sharpe ratios may improve their standing either by raising return over a benchmark (a measure known in modern portfolio theory as alpha) or by reducing the overall volatility associated with all of the assets in the fund.[42] Restating the excess return (or shortfall) from an individual portfolio relative to the market helps us see how a manager might improve portfolio performance either by raising alpha, decreasing beta, or accomplishing both of those objectives:

(7) $R_p - R_m = \beta(R_m - R_f) + \alpha$

With its deep arsenal of measurements for assessing the relationship between performance and risk, modern portfolio theory sets a rigorous analytical baseline that disaster law would do well to meet. Though the project of improving disaster law lacks the mathematical precision of financial markets, modeling disaster law according to modern portfolio theory invites practitioners of disaster law to duplicate in their own domain a feat that eludes many financial managers—that of boosting institutional capacity and performance even as they reduce hazard and vulnerability.

We may derive even more value from modern portfolio theory's expression of the risk premium as the difference between returns on a specific investment or class of investments and some sort of risk-free benchmark.[43] Contemporary society consists of a very large cluster of collective choices to incur (and perhaps sometimes to inflict) risk in order to attain levels of wealth, utility, and pleasure not otherwise attainable in a world where human beings systematically shun uncertainty and actively minimize risks within their perceived control. We have chosen, in effect, a portfolio of property, tort, tax, and regulatory rules that generate a risk profile that affects social susceptibility to catastrophic loss as well as social resilience in recovering after disaster. Our lifestyles, mediated by law, affect the natural phenomena that collide with human circumstance to produce disastrous loss. The evaluation of any disaster law portfolio's performance must take place against these benchmarks.

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[42] *See supra* notes 33–34 and accompanying text.

[43] William F. Sharpe, *Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk*, 19 J. FIN. 425, 426–27 (1964).

B. The Catastrophic Preparedness Asset Model

Part II of this Article has shown the mathematical relationship between the Treynor ratio and the capital asset pricing model:

(4) Capital asset pricing model: $R_a = R_f + \beta_a(R_m - R_f)$

Algebraic manipulation, in one direction or another, connects the Treynor ratio of reward to volatility with the more general capital asset pricing model. Indeed, the Treynor ratio restates the capital asset pricing model by demonstrating that the general risk premium of a class of investments (such as the broader market of all publicly traded equities in the United States) is equivalent to the premium for a specific investment over risk-free return discounted by the volatility of returns on that specific asset relative to returns on the benchmark class as a whole.[44]

More plainly stated, we can extrapolate the Treynor ratio from the capital asset pricing model, and the capital asset pricing model from the Treynor ratio. That insight permits us to derive a broader catastrophic preparedness asset model from the definition of disaster preparedness as the ratio of institutional performance to social risk:

(8) Catastrophic preparedness asset model: $R_a = R_f + \beta_a(R_m - R_f)$

The contribution of any individual component within a disaster law portfolio can be expressed as the risk-adjusted improvement in social value (financial or otherwise) over a risk-free baseline. $R_m - R_f$ expresses the background level of utility and wealth that society has elected to seek, in the aggregate, as an alternative to a world that minimizes risk to the utmost extent. The greater the risk—whether that risk arises from environmental hazard, social vulnerability, or both—the greater the performance premium demanded of a particular disaster law regime.

IV. AN EXERCISE IN APPLIED MODERN DISASTER THEORY: COMPENSATION, RISK-SPREADING, AND FINANCIAL PREPAREDNESS FOR CATASTROPHE

I now conduct an exercise in applying modern disaster theory. Financial preparedness for catastrophe takes myriad forms, from case-by-case compensation through the tort system to hybrid private and public insurance.[45]

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[44] *See* Treynor, *supra* note 26, at 20–21; *see also* Korajczyk, *supra* note 27, at xv.

[45] DISASTER LAW AND POLICY, *supra* note 2, at 291.

I evaluate these compensatory and risk-spreading mechanisms according to the theoretical terms I have set forth in this Article.

No set of best practices can wholly prevent disaster. When disaster does occur and victims suffer loss, disaster law must determine whether and how to compensate for those losses. The usual portfolio of rules for compensating disaster victims emphasizes some mixture of recovery through tort alongside disaster insurance, whether private or publicly subsidized.[46] The emergence of an alternative model of risk-spreading and transfer, the catastrophe bond, suggests a way of re-envisioning the entire field of disaster compensation and insurance as a unified continuum of financial preparedness against catastrophic risk.[47]

A. Tools for Managing Financial Risk from Disasters

I begin by reviewing the range of legal tools for reallocating and redistributing wealth after disaster. At a minimum, these tools should compensate victims for their losses. Ideally, these tools should put society in a better position to avoid future losses by providing proper incentives to private parties to take due care, bolstering the resilience of vulnerable communities, and expanding social capacity to respond to disaster.[48] I hope to show that these tools for compensating loss and spreading risk represent a cogent policymaking continuum within disaster law. Specifically, I intend to demonstrate that disaster law should deploy its portfolio of legal 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.

Disaster law presumably begins with the option of taking no action.[49] Beyond this threadbare baseline, the law may elect to perform the task of compensating 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, generally (though not invariably) according to the

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[46] *See generally id.* at 291–343.

[47] *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).

[48] *See generally* DISASTER LAW AND POLICY, *supra* note 2, at 345–90.

[49] *Cf.* 40 C.F.R. § 1508.13 (2011) (authorizing a finding of no significant impact under the National Environmental Policy Act, 42 U.S.C. §§ 4321–4327 (2006), 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").

negligence standard, tort law provides a case-by-case, pay-as-you-go system of compensation.[50] The tort system's inefficiency, estimated to be as high as fifty percent, undermines its effectiveness in deterring negligence, compensating victims, and spreading risk.[51] When local, state, and federal governments operate large-scale public infrastructure that fails during times of disaster, suits against these public entities may provide compensatory relief. For losses attributable to failed public infrastructure, governments may face inverse condemnation liability under state constitutional law.[52] Within limits imposed by the Federal Tort Claims Act,[53] victims may also recover damages from the United States.[54] Despite their legal 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.[55]

Owners of property, private or public, routinely self-insure against risks. If expected exposure to a risk is sufficiently small and regular to be managed without resort to outside financial intermediaries, a party may manage risk by systematically contributing to a sinking fund or maintaining a liquid reserve in excess of its own assessment of value at risk.[56] Not surprisingly, self-insurance plays a modest, even negligible role in disaster law.[57] The sudden, calamitous events that warrant the label of "disaster" routinely exceed the ability of individual property owners and even governments to manage without the intervention of outside insurers.[58]

Private insurance therefore represents the first and arguably most important layer of financial preparedness for disaster. Losses that are at once catastrophic

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[50] *See generally* JAMES S. KAKALIK & NICHOLAS M. PACE, COSTS AND COMPENSATION PAID IN TORT LITIGATION (Rand Inst. for Civil Justice ed., 1986).

[51] *See id.* at 70, 71.

[52] *See, e.g.*, Paterno v. California, 6 Cal. Rptr. 3d 854 (Cal. Ct. App. 2003).

[53] 28 U.S.C. § 2674 (2006).

[54] *Compare* United States v. James, 478 U.S. 597, 612 (1986) (holding that 33 U.S.C. § 702c (1982), which provides that "no liability of any kind shall attach to or rest upon the United States for any damage from or by flood or flood waters at any place," exempts the United States from liability for injuries resulting from flood control projects conducted by the U.S. Army Corps of Engineers), *with* Cent. Green Co. v. United States, 531 U.S. 425, 437 (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").

[55] Lockheed Aircraft Corp. v. United States, 460 U.S. 190, 198 (1986).

[56] ROBERT RIEGEL & JEROME S. MILLER, INSURANCE PRINCIPLES AND PRACTICES 26 (5th ed. 1966).

[57] *See* DISASTER LAW AND POLICY, *supra* note 2, at 342.

[58] *See id.* at 291, 342.

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.[59] But many disasters pose special trouble, even for the largest, most financially secure insurers.[60] Like their customers, insurance carriers have trouble evaluating the true likelihood of actuarially remote events.[61] If a calamity is large enough, the sheer magnitude of the losses at stake will exceed the capacity of any single financial actor.[62] Insurance against disasters is bedeviled by the same factors that cripple private insurance in every realm. 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.[63] Moreover, adverse selection all but guarantees that an insurer must cover the worst risks within any market.[64] 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.[65]

Modern portfolio theory sheds clarifying light on what is perhaps the most insidious factor undermining the financial integrity of private insurance for catastrophic risk: private insurers are extremely loath to cover risks that are highly correlated to each other.[66] Incurring coverage liability for simultaneous, geographically concentrated risk can be ruinous to an insurer. For this reason, insurers routinely exclude coverage for flood damage (or even water damage more generally), even in policies that purport to cover all risks.[67] The

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[59] *See* ORGANISATION FOR ECON. CO-OPERATION & DEV., ENVIRONMENT RISKS AND INSURANCE: A COMPARATIVE ANALYSIS OF THE ROLE OF INSURANCE IN THE MANAGEMENT OF ENVIRONMENT-RELATED RISKS 68–69 (2003).

[60] *See generally, e.g.*, RAWLE O. KING, CONG. RESEARCH SERV., RL 33086, HURRICANE KATRINA: INSURANCE LOSSES AND NATIONAL CAPACITIES FOR FINANCING DISASTER RISKS (2005).

[61] RIEGEL & MILLER, *supra* note 56, at 34, 35.

[62] *Id.*

[63] *See* Tom Baker, *On the Genealogy of Moral Hazard*, 75 TEX. L. REV. 237, 239 (1996).

[64] BANKS MCDOWELL, DEREGULATION AND COMPETITION IN THE INSURANCE INDUSTRY 39 (1989).

[65] *Id.*

[66] *See generally* WEIMIN DONG, BUILDING A MORE PROFITABLE PORTFOLIO: MODERN PORTFOLIO THEORY WITH APPLICATION (2002).

[67] *See, e.g.*, Leonard v. Nationwide Mut. Ins. Co., 499 F.3d 419 (5th Cir. 2007) (determining private insurance coverage for damage during Hurricane Katrina that could be attributable to wind, water, or both phenomena). Insurers often attempt to avoid liability by using obscure and ambiguously worded policy terms and exclusions. These efforts undermine risk management through insurance by shifting the financial burden of losses back to the insureds. *See* Christopher C. French, *Debunking the Myth that Insurance Coverage Is Not Available or Allowed for Intentional Torts or Damages*, 8 HASTINGS BUS. L.J. 65 (2012); Christopher C. French, *Construction Defects: Are They "Occurrences"?*, 47 GONZ. L. REV. 1 (2011); Christopher C. French,

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.[68] Underwriting policies for highly correlated risks such as flood damage inflict a financial risk that most prudent insurers are unwilling to bear.[69]

The inability of private insurance to provide adequate coverage for all catastrophic loss has historically motivated governments to intervene. Most typically, governments supply public subsidies for types of insurance that would otherwise be unpalatable to private carriers.[70] In the United States, the most celebrated instance of publicly subsidized disaster insurance may be the National Flood Insurance Program ("NFIP").[71] By design and in practice, the NFIP is not actuarially sound.[72] In administering the NFIP, the Federal Emergency Management Agency ("FEMA") consciously sets flood insurance rates on a nationwide basis and thereby defeats any hope that premiums might reflect regional, local, and individualized "topographic factors that are relevant to flood risk."[73] Worse still, FEMA has not only allowed "grandfathered properties" to keep lower premiums known to fall short of reflecting the actual risk of flooding and covering expected losses; the agency has elected not to collect data on the full financial impact of grandfathering.[74] More generally, FEMA struggles to keep flood insurance premiums low enough to keep property owners and insurers in the NFIP, without lowering premiums to the point of even more aggressively subsidizing high-risk behavior.[75] Despite these shortcomings, the NFIP retains value as the one policy tool that has shown

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The "Non-Cumulation Clause": An "Other Insurance Clause" by Another Name, 60 KAN. L. REV. 375 (2012).

[68] 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 (1960). For an explanation of the use of *r*-squared in finance, see generally Richard Roll, R^2, 43 J. FIN. 541 (1988).

[69] *See* MCDOWELL, *supra* note 64, at 39.

[70] *See* 42 U.S.C. § 4001(d) (2006).

[71] *See* 42 U.S.C. §§ 4001–4129 (2006). *See generally* Charles T. Griffith, Note, *The National Flood Insurance Program: Unattained Purposes, Liability in Contract and Takings*, 35 WM. & MARY L. REV. 727 (1994).

[72] *See generally Management and Oversight of the National Flood Insurance Program: Hearing Before the Subcomm. on Hous. and Cmty. Opportunity of the Comm. on Fin. Servs.*, 109th Cong. (2005) (statement of William O. Jenkins, Jr., Director of Homeland Security and Justice, U.S. Government Accounting Office).

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

[74] *Id.* at 20–21.

[75] *See Legislative Proposals To Reform the National Flood Insurance Program: Hearing Before the Subcomm. on Hous. and Cmty. Opportunity of the Comm. on Fin. Servs.*, 111th Cong. (2010).

even modest historical success in "guid[ing] development away from floodplains."[76]

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. Public subsidies for otherwise unprofitable lines of insurance represent merely one possibility within disaster law's full portfolio of tools for compensation and risk management. In the aftermath of Hurricane Katrina, the 110th Congress entertained a wide variety of proposals to subsidize or reform private disaster insurance.[77] As with flood insurance, Congress may elect to continue awarding federal subsidies.[78] 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[79] 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.[80] Private insurers might receive preferential tax treatment of contributions to financial reserves for catastrophic events.[81] Even more ambitiously, the federal government might interject itself as the ultimate reinsurer for catastrophic casualties and property loss.[82] In so doing, government as reinsurer would use its financial might to provide the underpinnings of an entire branch of the financial services industry, much as federal deposit insurance restored confidence in banking during the Great Depression.[83] The Terrorism Risk Insurance Act established a program of this sort for insurance against terrorism.[84]

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[76] Oliver A. Houck, *Rising Water: The National Flood Insurance Program and Louisiana*, 60 TUL. L. REV. 61, 160 (1985).

[77] *See* DISASTER LAW AND POLICY, *supra* note 2, at 343.

[78] *Id.*

[79] *See generally* STANLEY S. SURREY, PATHWAYS TO TAX REFORM: THE CONCEPT OF TAX EXPENDITURES (1974).

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

[81] *See* DISASTERS AND THE LAW 199–200 (Daniel A. Farber & Jim Chen eds., 2006).

[82] 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).

[83] DAVID M. KOTZ ET AL., SOCIAL STRUCTURES OF ACCUMULATION 135 (1994).

[84] *See* Terrorism Risk Insurance Act of 2002, Pub. L. No. 107-297, § 1(a), 116 Stat. 2322 (2002) (amending 12 U.S.C. § 248 (2000) and 28 U.S.C. §§ 1604, 1610 (2000)), *amended by* Terrorism Risk Insurance Extension Act of 2005, Pub. L. No. 109-144, § 1, 119 Stat. 2660 (2005), *and* Terrorism Risk

As distasteful as public subsidization may seem, some alternatives manage to combine greater political controversy with more staggering potential for fiscal damage. In the absence of effective incentives to buy subsidized federal crop insurance,[85] farmers and members of Congress representing the country's most agrarian districts routinely demand and receive ad hoc crop disaster relief.[86] By all accounts, the resulting pattern of payments has been excessive and contrary to the bedrock insurance interest in avoiding moral hazard.[87] By the admittedly abysmal standard of crop disaster assistance, government may find greater value in establishing comprehensive compensation schemes in advance. The September 11 Victim Compensation Fund[88] and the National Vaccine Injury Compensation Program[89] provide vivid, albeit 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.[90]

B. Catastrophe Bonds and the Rise of Alternative Risk Transfer

The emergence of a relatively new method of catastrophic risk management, the catastrophe bond, dramatically enhances modern disaster theory's treatment of tools for compensation and risk-spreading as a legally informed branch of finance and portfolio management.[91] At the most practical

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Insurance Program Reauthorization Act of 2007, Pub. L. No. 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 OF CATASTROPHES: A COMPARATIVE LEGAL APPROACH (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 (2005); Jeffrey Thomas, *Insurance Implications of September 11 and Possible Responses*, 34 URB. LAW. 727 (2002).

[85] *See* Federal Crop Insurance Act, 7 U.S.C. §§ 1501–1524 (2006). *See generally* Steffen N. Johnson, *Defining a Justified Federal Role in Crop Insurance*, 72 N.D. L. REV. 505 (1996).

[86] *See generally* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-548, USDA CROP DISASTER PROGRAMS: LESSONS LEARNED CAN IMPROVE IMPLEMENTATION OF NEW CROP ASSISTANCE PROGRAM (2010).

[87] *Id.*

[88] *See* 49 U.S.C. § 40101 (2006). *See generally* Robert L. Rabin, *The Quest for Fairness in Compensating Victims of September 11*, 49 CLEV. ST. L. REV. 573 (2001).

[89] *See* 26 U.S.C. § 9510 (2006); Bruesewitz v. Wyeth, Inc., 131 S. Ct. 1068 (2011).

[90] *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. ENVT'L. L. & POL'Y 151 (2009).

[91] *See* Véronique Bruggeman, *Capital Market Instruments for Natural Catastrophe and Terrorism Risks: A Bright Future?*, 40 ENVT'L. L. REP. 10137 (2010).

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.[92] But more is at stake than the already substantial feat of facilitating insurance for risks that have traditionally lain beyond the reach of the insurance and reinsurance industries. Understanding the place of the catastrophe bond in catastrophic risk management illuminates the larger project of maintaining the ideal portfolio of legal tools in anticipation of disaster.

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.[93] The insurance industry responded by exploring catastrophe bonds and other ways for securitizing its risks.[94] Like all other forms of alternative risk transfer,[95] catastrophe bonds enable insurers to acquire risk-spreading capabilities beyond the traditional financial tools available to the insurance industry, namely, premiums and returns from investments on reserves built by those premiums.[96] 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.[97] In turn, the securitization of insurance through catastrophe bonds extends the financial resources of the insurance and reinsurance industries.[98] By "harness[ing] 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."[99]

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

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[92] *See id.*

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

[94] *See id*. at 113.

[95] *See generally* ERIK BANKS, ALTERNATIVE RISK TRANSFER: INTEGRATED RISK MANAGEMENT THROUGH INSURANCE, REINSURANCE, AND THE CAPITAL MARKETS (2004) [hereinafter BANKS, ALTERNATIVE RISK TRANSFER]; ERIK BANKS, CATASTROPHIC RISK: ANALYSIS AND MANAGEMENT (2005).

[96] *See generally* BANKS, ALTERNATIVE RISK TRANSFER, *supra* note 95.

[97] *See generally id.*

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

[99] McMillan, *supra* note 47, at 140 (quoting Heidi E. Hutter, *Convergence and Innovation: Developments in the Reinsurance Marketplace*, RISK MGMT., Sept, 1, 1997, at 2).

financial regulation.[100] Catastrophe bonds are typically structured as floating rate bonds whose principal is lost if specified trigger conditions are met. If no catastrophe occurs, the bonds pay a generous coupon to investors.[101] On the other hand, if a catastrophe does occur, holders of catastrophe bonds would forgive the principal.[102] Those funds would then enable the insurer to honor claims arising from the disaster.[103] 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.[104] This benefit to insurers reinforces investors' interest in catastrophe bonds' ability to deliver generous returns that do not correlate with conventional stocks and bonds.[105]

The prominence of catastrophe bonds in disaster law's portfolio for catastrophic risk management depends on these instruments' ability to outperform competing tools known to insurance and reinsurance carriers.[106] Studies by the Government Accountability Office suggest that transaction costs may consume as much as two percent of the total insurance coverage provided by a catastrophe bond.[107] Whatever its future contribution to catastrophic risk management in disaster law, the catastrophe bond concept has already proven elastic enough to provide an alternative method for managing the risk of catastrophic audit failure in securities regulation.[108]

C. Risk Management as the Unifying Theme of Disaster Law and Policy

The catastrophe bond joins a host of other instruments that reveal the continuity of risk and reward that transcends the traditional legal boundary between insurance and investment.[109] Modern portfolio theory and other branches of finance treat insurance as part of a financial continuum that also

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100 *See id.* at 140 & n.17.

101 *See id.* at 140–41

102 *Id.* at 141.

103 *See id.* at 140.

104 *Id.* at 170 (quoting INS. SERVS. OFFICE, FINANCING CATASTROPHE RISK: CAPITAL MARKET SOLUTIONS 1 n.1 (1999)).

105 *Id.* at 170–71.

106 *See* Bruggeman, *supra* note 91, at 10141–42.

107 *See* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-03-1033, CATASTROPHE REINSURANCE RISKS: STATUS OF EFFORTS TO SECURITIZE NATURAL CATASTROPHE AND TERRORISM RISK (2003); U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-02-941, CATASTROPHE INSURANCE RISKS: THE ROLE OF RISK-LINKED SECURITIES AND FACTORS AFFECTING THEIR USE (2002); Bruggeman, *supra* note 91, at 10142.

108 *See* Lawrence A. Cunningham, *Securitizing Audit Failure Risk: An Alternative to Caps on Damages*, 49 WM. & MARY L. REV. 711, 763–64 (2008).

109 *See* Steven J. Williams, *Distinguishing "Insurance" from Investment Products Under the McCarran–Ferguson Act: Crafting a Rule of Decision*, 98 COLUM. L. REV. 1996, 2017–19, 2022 (1998).

spans investments in debt and in equity.[110] It takes very little imagination to extend that conceptual spectrum just a little further, so that it also embraces different modes of governmental intervention in the economy—taxation, regulation, direct subsidization, indirect subsidization through forgone taxation or other forms of preferential tax treatment, and the entire host of proprietary functions that government performs as a participant in the broader marketplace. At its most ambitious, disaster law as a branch of risk management represents nothing less than a thorough re-envisioning of Ronald Coase and *The Nature of the Firm*.[111] At the level of the firm or of an entire society at large, economic management consists of the pursuit of profit, adjusted not only for transaction costs, but also for risk.[112]

From conventional tort litigation to catastrophe bonds, this survey demonstrates the conceptual unity of disaster law tools for compensating victims and spreading risk, whether through insurance or securitization. Because human vulnerability and social injustice always figure in catastrophic loss, there is no such thing as a strictly natural disaster. Likewise, there is no such thing as 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—taxation, subsidization, regulation, and public investment are tools of first resort in disaster law.[113] These legal tools, intrusive and interventionist by design, are the leading components of the portfolio of rules at the efficient frontier of disaster law and policy.[114]

What the catastrophe bond does specifically show is that the 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.[115] Whatever their delivery

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110 *See generally* BANKS, ALTERNATIVE RISK TRANSFER, *supra* note 95.

111 *See* Ronald H. Coase, *The Nature of the Firm*, 4 ECONOMICA 386 (1937).

112 *Id.*

113 Dwight Jaffee & Thomas Russell, *Financing Catastrophe Insurance: A New Proposal*, *in* RISKING HOUSE AND HOME: DISASTERS, CITIES, PUBLIC POLICY 37, 37–39 (John M. Quigley & Larry A. Rosenthal eds., 2008).

114 *Id.* at 37.

115 *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).

vehicle, subsidies add public dollars to private insurance markets.[116] Official involvement in catastrophic risk management draws government inexorably into 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.[117] An obvious next step for modern disaster theory is the creation of "capacity bonds," or opportunities for private investors to join government in mitigating disasters, lowering environmental hazards, building social resilience, and enhancing overall catastrophic preparedness.[118]

We can now see the catastrophic preparedness asset model in sharper detail. Recall how the basic IFRC definition of disaster, as set forth in equation (1), described disaster as the function of hazard and vulnerability, offset by capacity. Equation (2) transformed the reciprocal of this definition into a definition of preparedness as capacity in anticipation of hazard and vulnerability. If we break down vulnerability into its constituent components of susceptibility and resilience, we can see that these four variables align rather neatly along a single dimension:

(9) $Hazard \Leftrightarrow Susceptibility \Leftrightarrow Resilience \Leftrightarrow Capacity$

These four functions correspond roughly with the purposes of insurance products and investment holdings in any financial portfolio. Pure insurance products hold no cash value.[119] A term life insurance policy, for instance, pays upon the untimely death of its holder,[120] but can occasionally be surrendered for cash or converted for immediate consumption through a viatical contract.[121] At the other extreme, a purely speculative investment cushions against no risk other than those inherent in any financial marketplace.[122] Notwithstanding all

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116 *Id.* at 351.

117 *See* Bruggeman, *supra* note 91, at 10140–41.

118 *See* Monti, *supra* note 90, at 162–63.

119 Robert F. Weber, *Combating the Teleological Drift of Life Insurance Solvency Regulation*, 8 BERKELEY BUS. L.J. 35, 70 (2011).

120 *See generally id.* at 69–73 (describing the mechanics of term life insurance and other insurance products).

121 *See* Anna D. Halechko, *Viatical Settlements and the Elderly: Potential Advantages and Hidden Dangers*, 6 N.Y. CITY L. REV. 135, 136–37 (2003).

122 Thomas C. Singher, *Regulating Derivatives: Does Transnational Regulatory Cooperation Offer a Viable Alternative to Congressional Action?*, 18 FORDHAM INT'L L.J. 1397, 1410–11 (1995).

other contrary claims, including some outlandish ones that merely confirm the yellow metal's psychological grip as a "barbarous relic" of economic history,[123] a position in gold hedges against no risk except the possibility that the price of gold may change. The complex world of finance spans a far more diverse set of instruments that fall between these extremes. Financial instruments routinely combine insurance functions with investment functions.[124] Insurance and portfolio maintenance, from this perspective, are merely different exercises in the common enterprise of risk management.

So too with risk management in disaster law. Some tools within disaster law's overall portfolio exhibit traits that are primarily associated with risk reduction and avoidance of loss.[125] These are tools best suited to lowering environmental hazard and the social susceptibility that routinely arises when poor people engage the natural world. Other disaster law tools are better suited to the related tasks of improving resilience within human communities and investing in overall social preparedness.[126] Private individuals and communities have a natural, endogenous ability to resist loss and recover when disaster does strike.[127] Investments in human capital reduce the need to intervene and raise the financial base upon which governments can draw when cataclysmic events overwhelm the best-laid plans. To be sure, disaster law's existing portfolio for managing risk seems better suited—to the extent it is well adapted in any meaningful sense—to reducing risk than to building resilience and capacity. The relatively recent emergence of risk securitization through catastrophe bonds, however, suggests that disaster law has the capacity to adapt and innovate.[128] The next stop along the efficient frontier of disaster law and policy, rather plainly, consists of devising methods for enticing individual and institutional investors to join government in affirmatively enhancing social and regulatory assets for dealing with disaster.

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123 JOHN MAYNARD KEYNES, MONETARY REFORM 187 (1924).

124 Richard Lewis, *The Foreign Irrevocable Life Estate Trust as Asset Protection*, 9 CONN. INS. L.J. 613, 622 (2003) (noting use of foreign irrevocable life estate trusts as both an insurance and investment tool).

125 *See, e.g.*, Monti, *supra* note 90, at 168.

126 *See* DISASTER LAW AND POLICY, *supra* note 2, at 345–90.

127 *See id.*

128 *See id.*

CONCLUSION: MODERN DISASTER THEORY AND THE EFFICIENT FRONTIER OF LEGAL PREPAREDNESS

If disaster law consists of a portfolio of legal rules, then that portfolio can and should be evaluated according to criteria to measure the performance of financial portfolios and their managers. Applying modern portfolio theory to disaster law yields basic tools for modeling this field of law as a mathematically informed discipline called modern disaster theory. The first steps toward that project consist of giving concrete meaning to the two theoretical concepts I have identified in this Article: evaluating disaster law portfolios on a risk-adjusted basis and examining those portfolios under a more comprehensive catastrophic preparedness asset model. The practical exercise of evaluating tools for compensating disaster victims and spreading risk does more than apply modern disaster theory to existing legal tools and doctrines. My survey of risk management techniques in disaster law—from private insurance to public subsidies, the involvement of government as ultimate reinsurer, and the promise of enhancing catastrophic preparedness through private capital markets—shows how disaster law represents a single, theoretically coherent exercise in societal risk management.

Throughout this Article, I have emphasized the limitations of modern disaster theory. In particular, I have made no serious effort to reconcile this highly rational and formal analogy to modern portfolio theory with the asymmetrical, horribly inelegant distribution of risk. Nor have I attempted to account for the behavioral quirks that afflict makers and implementers of disaster law, every bit as much as they bedevil investors and portfolio managers. Human behavior routinely undermines the quest for optimal returns at the efficient frontier of personal and corporate finance.[129] Those same limitations confound the effort to perfect the portfolio of rules that comprise disaster law. I nevertheless believe that the relationship between institutional performance and systemic risk, which after all inspired modern portfolio theory and placed it at the forefront of contemporary learning about finance, will likewise form the foundation of modern disaster theory. A diversified disaster law portfolio—namely, the optimal mixture of policy instruments for reducing environmental hazard and human susceptibility and for enhancing social resilience and capacity—represents the efficient frontier of legal preparedness in times of disaster.

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[129] *See, e.g.*, DANIEL C. GOLDIE & GORDON S. MURRAY, THE INVESTMENT ANSWER 13–15 (2011); CARL RICHARDS, THE BEHAVIOR GAP: SIMPLE WAYS TO STOP DOING DUMB THINGS WITH MONEY (2012).