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RECONSIDERING EFFICIENT TORT RULES FOR PERSONAL INJURY: THE CASE OF SINGLE ACTIVITY ACCIDENTS

JENNIFER H. ARLEN*

INTRODUCTION

Despite the expenditure of considerable effort, scholars have been unable to develop tort rules to govern serious physical injuries to strangers that satisfy the Pareto criterion¹ without resorting to theoretical devices that appear unrealistic even in the rarefied atmosphere of economic models. An analysis of single activity accidents² demonstrates that expanding the economic model of accident law to reflect the reciprocal nature of the risks that the participants in such activities impose on each other enables the design of tort rules for the resulting physical injuries that satisfy the Pareto criterion without resort to unrealistic theoretical devices. Because most tortious accidents result from bilateral risks,³ the present analysis indicates the need for a fundamental revision of the basic economic model of accident law.

Analysis of the tort system under the Pareto criterion presents two issues: the first is whether the introduction of a tort rule is an "improvement" over a system in which no tort rules exist;

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1. Throughout this Article, a tort rule satisfies the "Pareto criterion" if it is both "Pareto superior" to a system of purely voluntary transactions and "Pareto efficient," as those terms are defined below.

2. This category includes automobile accidents, the primary source of tort claims for serious permanent injury and death in this country. P. HUBER, *LIABILITY: THE LEGAL REVOLUTION AND ITS CONSEQUENCES* 9 (1988).

3. See *infra* text accompanying notes 20-21, 97-100.

the second is whether a tort rule is Pareto efficient. The interference with a system of purely private transactions associated with the introduction of a tort rule is an improvement under the Pareto criterion if the tort rule is Pareto superior to the system of purely voluntary transactions in that the rule increases the utility of at least one person and does not make anyone else worse off than he would be otherwise. A tort rule is Pareto efficient if improvement on the rule is not possible in that there is no possible change in the rule, and thus in the allocation of resources, that will make someone better off without making someone else worse off.⁴ This Article refers to tort rules that are both Pareto superior and Pareto efficient as "optimal."

Tort rules that satisfy the Pareto criterion are considered desirable for a number of reasons. First, such legal rules are considered "fair" or "just" because they produce the nonconsensual exchanges that individuals would consent to were they to bargain over what risks should be imposed.⁵ Second, Pareto efficient tort rules are favored by those who believe that legal rules should be efficient and who contend that it is not possible to aggregate the utility of different people.⁶ The Pareto criterion differs, therefore, from the efficiency criterion that the "law and economics" literature customarily employs, total social utility

4. Alternatively, a tort rule is Pareto efficient if no other rule (or allocation of entitlements) exists that is unanimously preferred (weakly) by all those affected by the rule. See Cooter, *The Best Right Laws: Value Foundations of the Economic Analysis of Law*, 64 NOTRE DAME L. REV. 817, 820-21 (1989); Kornhauser, *An Introduction to the Economic Analysis of Contract Remedies*, 57 U. COLO. L. REV. 683, 688-89 (1986); Note, *An Economic Analysis of Tort Damages for Wrongful Death*, 60 N.Y.U. L. REV. 1113, 1121 (1985) (authored by Jennifer Arlen) [hereinafter Arlen Note].

5. See Friedman, *What is 'Fair Compensation' for Death or Injury?*, 2 INT'L REV. L. & ECON. 81, 81 (1982); Graham & Peirce, *Contingent Damages for Products Liability*, 13 J. LEGAL STUD. 441, 444-45 (1984).

For a discussion of the Pareto criterion as a basis for legal rules, see, for example, Coleman, *The Economic Analysis of Law*, in LAW, ECONOMICS, AND PHILOSOPHY: A CRITICAL INTRODUCTION 102-05 (M. Kuperberg & C. Beitz eds. 1983); Cooter, *supra* note 4. For a critique of the claim justifying Pareto efficient rules on the grounds that people would consent to them, see Coleman, *Efficiency, Utility, and Wealth Maximization*, 8 HOFSTRA L. REV. 509, 547 (1980) (arguing that "[i]n the absence of a prior non-efficiency-based theory of rights and moral deserts, it would be irrational to consent to Pareto [efficiency] as a moral maxim"); Dworkin, *Why Efficiency?*, 8 HOFSTRA L. REV. 563, 574-75, 578-79 (1980) (criticizing the use of hypothetical consent as a justification for Posner's wealth maximization criterion).

6. See e.g., Cooter, *supra* note 4, at 820-21; Kornhauser, *supra* note 4, at 688-90. See generally L. ROBBINS, AN ESSAY ON THE NATURE AND SIGNIFICANCE OF ECONOMIC SCIENCE (1973); A. SEN, CHOICE, WELFARE AND MEASUREMENT ch. 9 (1982).

maximization, which depends on the ability to aggregate utility.⁷

Any discussion of optimal tort rules necessarily assumes a starting point, a benchmark by comparison with which the rule being tested either will or will not make some people better off and no one worse off.⁸ Most commentators who have considered the issue of optimal tort rules under the Pareto criterion implicitly assume that individuals in society have an *a priori* entitlement to be free from risk of physical harm resulting from the activities of others.⁹ This particular starting point is by no means arbitrary. It is consistent with the respect for individual autonomy that underlies our system of government; it coincides with broadly shared notions about the nature of the protection that the institutions of organized society afford to individuals. This plausible assumption about an initial, pre-tort-law entitlement to be free from bodily injury inflicted by others, however,⁷ carries immense consequences for those interested in tort rules that satisfy the Pareto criterion. To date, this assumption has led to the conclusion that none of the current tort rules for physical injury satisfy the Pareto criterion. Specifically, having adopted the standard assumption about the initial entitlement, scholars employing the orthodox economic model of accidents have found that none of the standard tort rules are both Pareto superior to a system of purely voluntary transactions and Pareto efficient in cases of physical injury resulting from accidents between "strangers," even in the economists' perfect world of rational and perfectly informed individuals, infallible courts, and no litigation or settlement costs.¹⁰

7. See *infra* note 40. For an insightful critique of the objectivist theory underlying the social welfare maximization criterion, see J. BUCHANAN, *COST AND CHOICE: AN INQUIRY IN ECONOMIC THEORY* (1969).

8. See, e.g., R. COOTER & T. ULEN, *LAW AND ECONOMICS* 49 (1988).

9. See, e.g., Fraser, Note: *What is 'Fair Compensation' for Death or Injury?*, 4 INT'L REV. L. & ECON. 83 (1984); Friedman, *supra* note 5; Arlen Note, *supra* note 4; see also Haddock, McChesney, & Spiegel, *An Ordinary Economic Rationale for Extraordinary Legal Sanctions*, 78 CALIF. L. REV. 1, 45-48 (1990) (implicitly assuming that the potential victim is entitled to be free from the risk of death or injury in question); Komesar, *Toward a General Theory of Personal Injury Loss*, 3 J. LEGAL STUD. 457 (1974) (same); W. LANDES & R. POSNER, *THE ECONOMIC STRUCTURE OF TORT LAW* 185-89 (1987) (same); cf. Graham & Peirce, *supra* note 5 (considering the issue of Pareto efficient rules for individuals in a market relationship under various assumptions as to the initial entitlement of potential victims). But see S. SHAVELL, *ECONOMIC ANALYSIS OF ACCIDENT LAW* 232 n.4, 247-49 (1987) (analyzing Pareto efficient tort rules for physical injury under the implicit assumption that potential victims do not initially possess the entitlement to be free from the risk of injury).

10. The term "strangers" refers to individuals who are not in a consensual or a market

The orthodox model of accident law is a model of unilateral risks, in which each individual either is a potential injurer, who imposes risk on others but bears no risk himself, or a potential victim, on whom others impose risk.¹¹ In this model, tort rules function as a substitute for a market for health by enabling potential injurers to impose risk on potential victims without the victims' consent, so long as the potential injurers compensate injured victims as tort liability and damage rules require.¹² Because potential victims in this model neither impose nor wish to impose risk on others, the opportunity that tort rules grant to individuals to impose risk on others is of no benefit to potential victims; the only benefit potential victims obtain from the introduction of tort rules is the promise of damage awards if injured. Thus, given the standard assumption that each potential victim is entitled to be free from the risk in question, in the orthodox model a tort rule is Pareto superior to a system of purely voluntary exchanges only if the rule ensures that any individual injured by another is "fully compensated"¹³ by an award of damages sufficient to return him to his pre-accident level of utility, thereby ensuring that potential victims are no worse off under the rule than they were previously.¹⁴

It is this requirement of full compensation that yields the conclusion that none of the standard tort rules satisfy the Pareto

relationship with each other. Accidents between strangers are the only accidents that this Article considers. For an analysis of Pareto efficient tort rules governing physical injuries to victims who are in a market relationship with the injurer, see, for example, Danzon, *Tort Reform and the Role of Government in Private Insurance Markets*, 13 J. LEGAL STUD. 517, 520-21 (1984) (discussing this issue in the products liability context); Graham & Peirce, *supra* note 5; Schwartz, *Proposals for Products Liability Reform: A Theoretical Synthesis*, 97 YALE L.J. 353, 361-68 (1988) (same); Spence, *Consumer Misperceptions, Product Failure and Producer Liability*, 64 REV. ECON. STUD. 561 (1977) (same).

11. Most of the law and economics literature employs this unilateral risk model. *E.g.*, Brown, *Toward an Economic Theory of Liability*, 2 J. LEGAL STUD. 323 (1973); Landes & Posner, *The Positive Economic Theory of Tort Law*, 15 GA. L. REV. 851 (1981); Shavell, *Strict Liability Versus Negligence*, 9 J. LEGAL STUD. 1 (1980).

12. See, *e.g.*, S. SHAVELL, *supra* note 9, at 245-49; Friedman, *supra* note 5, at 81; Arlen Note, *supra* note 4, at 1121-27. Calabresi & Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089, 1096 (1972), discusses at length the claim that tort rules function as an involuntary market in those cases in which transaction costs preclude an actual market.

13. See *infra* text accompanying notes 51, 60-61; see, *e.g.*, Friedman, *supra* note 5, at 81; Arlen Note, *supra* note 4, at 1121-27.

14. See *infra* text accompanying notes 60-61; S. SHAVELL, *supra* note 9, at 231-35, 247-51; see also Arlen Note, *supra* note 4, at 1121-28 (discussing the impossibility of devising Pareto efficient damage awards for wrongful death resulting from accidents between strangers).

criterion. First, neither the liability rule of "pure negligence" nor "negligence with contributory negligence" satisfies the full compensation requirement of Pareto superiority because each rule permits an individual who takes "due care" to impose risks with impunity.¹⁵ Nor do strict liability rules necessarily satisfy the requirement, because for certain severe injuries, full compensation is impossible because the full compensation damage award is infinite.¹⁶ Moreover, even when one can satisfy the full compensation requirement, a liability rule of strict liability with full compensation damages is Pareto superior to a system of purely voluntary transactions but is not Pareto efficient. A tort rule is Pareto efficient if it induces individuals to take the efficient level of care and to engage efficiently in risk spreading. Unfortunately for those seeking Pareto efficient tort rules for accidents under the orthodox model, strict liability, the only Pareto superior tort rule, is not efficient because it fails to induce both efficient care-taking and efficient risk spreading in cases involving serious physical injury.¹⁷

To circumvent the obstacles to optimal tort rules arising from the full compensation requirement, scholars have imagined various mechanisms that would enable the potential victim, while healthy, to obtain some compensation for the threat of future injury, thereby lowering the amount of damages needed to fully compensate the victim—for example, "complete insurance markets" in which a potential victim sells to others insurance against the risk of future injury to the victim himself. These solutions, however, implicitly accept the conclusion that the current tort system is not efficient and, moreover, are so impractical as to offer little hope that the tort system can be made efficient.¹⁸

This Article argues that the problem of tort rules that satisfy the Pareto criterion can be solved without resort to chimerical wealth spreading devices and without abandoning the standard assumption about an initial entitlement to freedom from risk. The conclusion that in the current world of the tort system none

15. See *infra* text accompanying notes 59-63.

16. See *infra* text accompanying notes 70-75.

17. See *infra* text accompanying notes 76-80. Risk spreading refers to an individual's allocation of his wealth so as to maximize his expected utility given various contingent circumstances. See *infra* note 55. Purchasing insurance against the possibility of an accident and diversifying one's stock market portfolio are both examples of risk spreading. For a more general discussion of risk spreading and insurance, see R. COOTER & T. ULEN, *supra* note 8, at 55-70; S. SHAVELL, *supra* note 9, ch. 8.

18. See *infra* text accompanying notes 84-93.

of the current tort rules governing physical injury satisfy the Pareto criterion does not apply to accidents generally but rather applies only to the narrow class of cases described by the orthodox economic model of accidents. The orthodox economic model of accident law, as previously mentioned, views all accidents as the product of unilateral risks in which individuals are either potential injurers or potential victims.¹⁹ This model, however, ignores a salient feature of the tort system: most everyday torts between strangers, such as automobile accidents, result from activities that pose a risk of injury to both parties to an accident. Most tort accidents between strangers, in other words, result from activities in which participants both impose and bear a risk of injury, activities we refer to as "bilateral risk" activities.²⁰ Each individual thus is simultaneously a potential injurer and a potential victim—a potential seller of his own health and a potential purchaser of the health of others.²¹

Once the analysis is revised to take account of bilateral risks, the standard assumption about an initial entitlement to freedom from risk no longer precludes efficient tort rules; on the contrary, it holds the solution to the problem. In a bilateral risk model, each individual wishes to engage in an activity that imposes risk on others. If individuals are presumptively entitled to be free from risk of physical injury imposed by others, then, absent tort law, no one has the right to engage in activities that pose a risk of serious harm to others without first obtaining the consent of all those on whom the risk is imposed. Even a modest assumption about the incidence of transaction costs²² suffices to show that such negotiations will not take place. In the absence of tort law,

19. See *supra* text accompanying note 11.

20. For example, bilateral risk accidents include automobile accidents, which alone account for about 40% of all tort cases. P. HUBER, *supra* note 2, at 9.

21. See Arlen Note, *supra* note 4, at 1135-36. The concept of bilateral risks as employed in this Article is related to, but differs fundamentally from, the concept of reciprocal risks developed in George Fletcher's seminal article, *Fairness and Utility in Tort Theory*, 85 HARV. L. REV. 537, 540-42, 543-56 (1972). Fletcher defines a reciprocal risk accident as one in which the risks imposed by the defendant on the plaintiff are neither greater in degree nor different in order from those imposed by the plaintiff on the defendant. *Id.* at 540-41. In contrast, bilateral risk accidents are those in which each party imposes a risk of harm on the other; the magnitude and the nature of the risk imposed by each individual on the other may differ.

22. The term "transaction costs" refers to all pecuniary and nonpecuniary costs associated with conducting a transaction. Transaction costs include information costs, the costs of actually doing the transaction (for example, legal costs), and collective bargaining problems. These costs are discussed in considerable detail in Calabresi & Melamed, *supra* note 12, at 1094-95.

therefore, individuals would not be able to engage in risky activities.²³

Recognition of these consequences—always latent in the standard assumption about the initial entitlement—produces the possibility of Pareto superior tort rules. The same tort rules that enable others to impose risk on us also enable us to impose risk on others. Because each participant in a risky activity, such as driving a car, is a potential injurer as well as a potential victim, the principal benefit that the introduction of the tort system affords is not the promise of money damages for injuries suffered, but the ability to make a choice—presumptively rational and perfectly informed—to engage in an activity that otherwise would be prohibited. This benefit by itself may be sufficient to fully compensate the participant for the risk that others impose on him; at the very least, it suggests that full compensation damages may not be necessary in order for a tort rule to be Pareto superior.²⁴ The fact that full compensation is not required for a tort rule to satisfy the Pareto criterion presents the possibility of optimal tort rules.

In short, by recognizing the reciprocal nature of the risks that many activities impose, it may become possible to devise tort rules for physical injury that satisfy the Pareto criterion. This suggests the need to reexamine the issue of optimal tort rules for physical injury and to consider optimal tort rules for bilateral risk activities.²⁵

23. See *infra* text accompanying notes 37-49.

24. See *infra* text accompanying notes 97-106. This conclusion is consistent with Fletcher's conclusion that no tort liability should exist for reciprocal risk accidents, but, as will be seen, this Article's justification for this conclusion differs from that of Fletcher. First, Fletcher's notion of reciprocal risks differs from the concept of bilateral risks examined here. See *supra* note 21. In addition, Fletcher's argument in favor of not having liability for reciprocal risks is based on a notion of fairness as opposed to a concern for economic efficiency. Fletcher, *supra* note 21, at 537. Moreover, to the extent that he has an underlying efficiency rationale for his conclusion, it is based on the claim that negligence liability minimizes administrative costs. *Id.* at 547-48. In contrast, this Article considers which rules are efficient, as opposed to which rules are fair. Moreover, this Article shows that, even absent administrative costs, the bilateral risk accidents this Article considers can justify negligence-inclusive liability rules as being both Pareto superior and Pareto efficient.

25. The law and economics literature has virtually ignored bilateral risk activities, despite their importance. The current law and economics literature on physical injuries to strangers considers only accidents resulting from unilateral risk activities. *E.g.*, S. SHAVELL, *supra* note 9, ch. 10; Fraser, *supra* note 9; Friedman, *supra* note 5; Arlen Note, *supra* note 4. Even the literature on accidents involving purely pecuniary losses generally considers only unilateral risk activities. See, *e.g.*, S. SHAVELL, *supra* note 9, ch. 9; Brown, *supra* note 11; Landes & Posner, *supra* note 11; Shavell, *supra* note 11. The few economic

This Article examines optimal tort rules for physical injuries resulting from "single activity accidents" as a first step in a projected wider analysis of physical injuries from bilateral risks.²⁶ Single activity accidents are those accidents that occur between two individuals engaged in the same activity.²⁷ There are two reasons for this initial focus on single activity accidents. First, as will become apparent, the study of single activity accidents provides a useful starting point for a comparison of unilateral risk and bilateral risk models because it is the bilateral risk model most clearly distinguishable from the orthodox unilateral risk model. Second, single activity accidents warrant particular attention because they include automobile accidents, the primary source of tort claims for serious permanent injury and death in this country.²⁸ Such accidents deserve considerably more scholarly attention than they have received to date.²⁹

analyses of efficient tort rules for bilateral risk activities consider only purely pecuniary losses. *E.g.*, Arlen, *Re-Examining Liability Rules When Injurers as Well as Victims Suffer Losses*, 10 INT'L REV. L. & ECON. 233 (1990); Diamond, *Single Activity Accidents*, 3 J. LEGAL STUD. 107 (1974); Leong, *Liability Rules When Injurers as Well as Victims Suffer Losses*, 9 INT'L REV. L. & ECON. 105 (1989) (showing that none of the tort liability rules are efficient when both injurers and victims suffer losses but victims are immune from suit); Ordovery, *Costly Litigation in the Model of Single Activity Accidents*, 7 J. LEGAL STUD. 243 (1978) [hereinafter *Costly Litigation*]; Ordovery, *On the Consequences of Costly Litigation in the Model of Single Activity Accidents: Some New Results*, 10 J. LEGAL STUD. 269 (1981) [hereinafter *Costly Litigation: New Results*]. Moreover, these analyses consider only the issue of efficient care-taking; they do not consider efficient risk spreading. This Article is the first to analyze the issue of efficient risk spreading for losses resulting from bilateral risks.

26. Many types of bilateral risk activities exist: for example, single activity accidents, two-activity accidents resulting from simultaneous bilateral risks, and two-activity accidents resulting from subsequent bilateral risks. "Two-activity simultaneous bilateral risk" activities are those in which the two potential parties to an accident, while engaging in different activities, are so situated that both parties will be injured should an accident occur. For a discussion of simultaneous bilateral risk activities in the case of purely pecuniary losses, see Arlen, *supra* note 25.

The term "two-activity subsequent bilateral risks" refers to activities that at any given moment risk injury to only one of the two parties but in which individuals alternate over time between being potential injurers and potential victims. For example, although motorists generally impose risks on pedestrians and not vice versa, the relationship between driver and pedestrian constitutes a subsequent bilateral risk activity because today's automobile drivers are tomorrow's pedestrians and vice versa. Thus, although at any given moment an individual is either a potential injurer or a potential victim, over time he is both a potential injurer and a potential victim with respect to the risks of accident that these activities create.

27. Diamond, *supra* note 25, at 107.

28. P. HUBER, *supra* note 2, at 9 (automobile accidents account for 40% of all tort cases).

29. Although automobile accidents are the basis of a substantial portion of all tort cases, the issue of efficient tort liability and damage rules for single activity accidents

The discussion in this Article proceeds as follows. Section I reviews the problem of rules for unilateral risk accidents under the Pareto criterion. Section II discusses optimal tort rules in the context of bilateral risks generally. Section III examines the issue of optimal tort rules for physical injuries resulting from single activity accidents and describes the essential conclusions of the mathematical analysis in Appendix I.³⁰

The analysis of single activity accidents employs Peter Diamond's seminal model of single activity accidents,³¹ extended to incorporate risk-averse individuals³² who face the possibility of

has received remarkably little attention. In fact, Diamond, *supra* note 25; Ordover, *Costly Litigation*, *supra* note 25; and Ordover, *Costly Litigation: New Results*, *supra* note 25, appear to be the only articles that employ an economic model to analyze efficient tort rules for single activity accidents, and these studies consider only purely pecuniary losses.

It might appear that the prevalence of no-fault insurance laws in large part explains the relative lack of interest in efficient tort liability and damage rules for automobile and other single activity accidents. Some no-fault insurance laws do act to remove many traffic accident cases from the tort system. See generally W. PAGE KEETON, D. DOBBS, R. KEETON & D. OWEN, PROSSER & KEETON ON THE LAW OF TORTS § 84, at 606-08 (5th ed. 1984) [hereinafter PROSSER & KEETON]. The efficiency of the no-fault system thus has been the focus of those interested in efficient rules governing automobile accidents. See, e.g., Epstein, *Automobile No-Fault Plans: A Second Look at First Principles*, 13 CREIGHTON L. REV. 769 (1980); E. Landes, *Compensation for Automobile Accident Injuries: Is the Tort System Fair?*, 11 J. LEGAL STUD. 253 (1982); Rea, *Economic Analysis of Fault and No-Fault Liability Systems*, 12 CAN. BUS. L.J. 444 (1987). No-fault laws cannot explain the absence of interest in efficient tort law for automobile accidents that result in serious permanent physical injuries, however, because they do not apply to these injuries. The various no-fault laws preclude accident victims from suing in tort only if pecuniary losses and pain and suffering damages are below a specific amount. In all states, this threshold amount is less than that involved in serious permanent physical injuries. See generally PROSSER & KEETON, *supra*, § 84, at 606-08. Moreover, many no-fault statutes explicitly allow a victim to sue in tort if the injury in question results in death or serious permanent physical injury. *Id.*

30. Appendix II extends the model analyzed in Appendix I to consider the case in which individuals do not necessarily suffer the same injury should an accident occur. Appendix II also confirms the result, presented in Section III and Appendix I, that pure negligence, negligence with contributory negligence, and strict liability with contributory negligence are identically Pareto efficient in that the same damage awards induce efficiency under each of these liability rules. As in Appendix I, the model shows that full compensation damages are not necessary for efficiency. Appendix II is contained in J. ARLEN, RECONSIDERING EFFICIENT TORT RULES FOR PERSONAL INJURY: THE CASE OF SINGLE ACTIVITY ACCIDENTS (Emory University Law and Economics Working Paper No. 5, 1990).

31. Diamond, *supra* note 25.

32. An individual is risk-averse if he would prefer to receive with certainty a given sum of money, such as \$X, than to make a bet with an expected value of \$X. In other words, a risk-averse individual is someone who would pay to avoid a risk. See generally S. SHAPELL, *supra* note 9, ch. 8. The assumption that individuals are risk-averse is consistent with the observation that individuals are willing to pay a premium for insurance that exceeds the expected cost of the loss, where the expected cost of the loss is the probability of the loss multiplied by the value of the loss. *Id.* This assumption thus is

suffering a serious permanent physical injury. Section III and Appendix I apply this model to determine whether any of the four standard liability rules—pure negligence, negligence with contributory negligence, pure strict liability, or strict liability with contributory negligence³³—are optimal for the single activity accidents described by the model.

As discussed above, a full analysis of a tort rule under the Pareto criterion, whatever the model employed, involves two issues. The first is whether tort rules are a justified interference with the market system in that they are Pareto superior to a system of purely voluntary transactions. Section III shows that in the case of single activity accidents, unlike the case of unilateral risks, the introduction of tort rules does not make individuals worse off, even when damages do not fully compensate victims for their losses; thus, each of the standard tort rules that this Section considers are Pareto superior to a system that permits only voluntary transactions. The second issue is whether any of the Pareto superior tort rules are Pareto efficient.³⁴ As will be explained, a tort rule is Pareto efficient in the model considered here if it maximizes the utility of each individual subject to the rule by inducing each individual to engage in efficient care-taking and efficient risk spreading.³⁵ The greater part of Section III and of the mathematical analysis set forth in Appendix I analyzes efficient care-taking and efficient risk spreading. This Section and Appendix show that, in contrast with the unilateral risk

more realistic than the assumption of many economic models that individuals are indifferent to risk; that is, that individuals are risk-neutral. *E.g.*, Brown, *supra* note 11; Diamond, *supra* note 25; Landes & Posner, *supra* note 11; Ordover, *Costly Litigation*, *supra* note 25; Shavell, *supra* note 11. This Article is the first analysis of accidents resulting from bilateral risks to incorporate the assumption that individuals are risk-averse.

33. This Article examines these four liability rules because they are the rules generally examined by economic analysis of law scholars, and they are the only liability rules examined by those who have considered efficient tort rules for physical injuries. *E.g.*, S. SHAVELL, *supra* note 9, ch. 10; Cooter, *Towards a Market in Unmatured Tort Claims*, 75 VA. L. REV. 383 (1989); Danzon, *supra* note 10; Fraser, *supra* note 9. Consistent with this prior literature on efficient tort rules for physical injury, this Article does not examine comparative and relative negligence. For a discussion of comparative negligence in the context of purely pecuniary losses, see Cooter & Ulen, *An Economic Case for Comparative Negligence*, 61 N.Y.U. L. REV. 1067 (1986); Haddock & Curran, *An Economic Theory of Comparative Negligence*, 14 J. LEGAL STUD. 49 (1985); Rea, *The Economics of Comparative Negligence*, 7 INT'L REV. L. & ECON. 149 (1987).

34. See *supra* note 4 and accompanying text.

35. Efficient care-taking and efficient risk spreading are the standard conditions for Pareto efficiency when individuals are risk-averse. This Article does not consider a further issue, the "efficient level of activity." See *infra* note 109.

model, three tort rules—pure negligence, negligence with contributory negligence, and strict liability with contributory negligence—are Pareto efficient in the single activity accident context in that they induce both efficient care-taking and efficient risk spreading. By contrast, this portion of the Article shows that the rule of pure strict liability is inefficient. Finally, Section III and Appendix I show that full compensation damages are not necessary for Pareto efficiency under any of the three efficient tort rules.

These results suggest that those interested in tort rules for physical injury that satisfy the Pareto criterion should redirect their efforts. Instead of attempting to circumvent the familiar obstacles to optimality in the unilateral risk model, scholarly attention might be engaged more profitably in further exploration of the bilateral risk model, which offers a more accurate description of most tortious accidents and presents the possibility of optimal tort rules. The results of this analysis of Pareto efficiency also should be of interest to those who favor social utility maximization notions of efficiency, because in the model considered here any tort rule that is Pareto efficient also maximizes total social utility.³⁶

I. PARETO EFFICIENCY AND UNILATERAL RISKS

A. *Tort Rules and Transaction Costs*

To understand both the nature of optimal tort rules under the Pareto criterion and the challenge to orthodox law and economics that this Article presents, one must first understand the orthodox economic view of when and why tort rules are necessary to promote efficiency.³⁷ A central tenet of economics generally, and of law and economics in particular, is that society's preferences should reflect the preferences of its members.³⁸ This belief in the primacy of individual preferences provides the foundation for the partiality of economics for voluntary transactions, such as market transactions. Absent coercion or other imperfections, voluntary transactions are unambiguously welfare improving in that a voluntary transaction clearly makes both parties better off. Through the voluntary transaction, each party reveals his preference for

36. As it happens, the tort rules that are Pareto efficient under the present analysis also are efficient under the social utility maximization criterion for efficiency. *See infra* note 136.

37. This is not to say that efficiency is the only goal of the tort system. Efficiency is, however, the only goal that this Article considers.

38. *E.g.*, Graham & Peirce, *supra* note 5, at 445.

the product of the exchange over his situation prior to the exchange. These exchanges thus generally can be relied on to improve the welfare of individuals in society, even in cases in which the government cannot determine the utility functions of the individuals engaged in such transactions.

Because individual preferences are subjective and are truly known only by an individual himself, economics generally encourages reliance on voluntary transactions to reallocate resources in a way that promotes individual (and thus social) welfare and generally does not encourage government intervention to reallocate resources.³⁹ Government intervention to reallocate resources is warranted only when voluntary exchanges will not take place as desired, and even then only when government intervention will improve the situation. The Pareto criterion provides a standard for determining when government intervention to reallocate resources "improves" a situation: if it makes at least one person better off and makes no one worse off.⁴⁰ Government intervention to reallocate resources is Pareto efficient when it cannot be improved upon, in the sense that any change in the government's approach that would improve the well-being of one person would be detrimental to someone else.⁴¹

Tort rules are one form of government intervention that reallocates resources. From an economic standpoint, the essence of all tort rules is that they allow an individual to avoid the bargaining process associated with voluntary exchanges and to appropriate another's "entitlement,"⁴² such as physical well-being, without first obtaining that person's consent, so long as the taker pays for the entitlement according to the price schedule set by the tort system. Tort rules thus substitute an involuntary exchange for a voluntary one.⁴³ As these exchanges are involuntary,

39. For an excellent discussion of the subjectivist, as opposed to the objectivist, approach to economics, see Buchanan, *supra* note 7.

40. If each individual's utility is entirely subjective (and cannot be measured by others), the requirement that no one be made worse off is necessary to ensure that a change is welfare improving. If others cannot measure individual utility, then a determination of aggregate social utility is impossible, and the only way to be sure that society as a whole is better off is to know that at least one person is better off and no one is worse off. See Cooter, *supra* note 4, at 820-21. See generally A. SEN, *supra* note 6, ch. 9.

41. See *supra* note 4 and accompanying text.

42. This Article uses the term "entitlements" broadly to refer to those commodities, monetary wealth, and nonpecuniary assets such as health that an individual possesses, such that they are properly included within the individual's utility function.

43. This view of the tort system, in particular of liability rules, is based on the analysis presented in Calabresi & Melamed, *supra* note 12, at 1106-11.

economic analysis favors the use of tort rules only when some form of market failure precludes reliance on voluntary transactions and only if the tort rules will improve matters in the sense previously described.⁴⁴

The question thus arises: What circumstances warrant government intervention in the form of tort rules? In 1960, Ronald Coase established that under certain assumptions, including the absence of transaction costs,⁴⁵ government intervention in the form of tort rules is unnecessary to achieve efficiency, even in those situations in which individuals impose a risk of injury on others.⁴⁶ Rather, in a perfect world, individuals achieve efficiency by bargaining among themselves for an exchange of entitlements, including the entitlement to impose or to avoid the risk of physical injury.⁴⁷ As Coase recognized, the real world differs in significant respects from the perfect world that this economic model envisions. High transaction costs preclude many Pareto-improving exchanges that otherwise would occur in a perfect world of no transaction costs.⁴⁸ Although individuals wishing to impose a risk of harm on others could in theory bargain with those others and compensate them for the risk, thereby leading to an optimal allocation of entitlements, transaction costs in the real world normally preclude such exchanges. For example, the transaction costs associated with the large number of people who drive automobiles preclude the formation of markets in the risks imposed and borne as a result of automobile use. Thus, when transaction costs are high, voluntary exchanges cannot be relied on to produce the efficient outcome.

Transaction costs provide the central justification for tort rules in the standard economic analysis of the tort system: tort rules circumvent the transaction cost problem by permitting the involuntary exchange of entitlements.⁴⁹ As explained above, however, not all efforts to use tort rules to circumvent the transaction cost problem are desirable. Economic analysis dictates that tort rules should be employed to permit such involuntary exchanges only when allowing such exchanges improves the welfare of individuals in society.

44. See *supra* text accompanying notes 40-41; Graham & Peirce, *supra* note 5, at 444-45; Arlen Note, *supra* note 4, at 1121-22.

45. See *supra* note 22.

46. Coase, *The Problem of Social Cost*, 3 J. L. & ECON. 1 (1960).

47. *Id.*; see Calabresi, *Transaction Costs, Resource Allocation and Liability Rules—A Comment*, 11 J. L. & ECON. 67 (1968).

48. Coase, *supra* note 46; see Calabresi & Melamed, *supra* note 12.

49. See Calabresi & Melamed, *supra* note 12, at 1106-10.

Accepting the Pareto criterion as the standard of improvement, this view of the tort system as an alternative to a system of voluntary transactions in a world of high transaction costs produces two requirements that a tort rule must satisfy when individuals otherwise possess an enforceable entitlement to be free from the risk in question.⁵⁰ First, the tort rule must be Pareto superior to a system of purely voluntary transactions with high transaction costs in that the rule must ensure that those put at risk are no worse off than they would be in a system in which no one may impose risk on another without the other's consent and transaction costs preclude such bargains.⁵¹ In other words, potential victims must be no worse off *ex ante* than they would be in the absence of the risk. In addition, the tort rule selected should itself not be subject to improvement: it should be Pareto efficient. As explained previously, a tort rule is Pareto efficient if it maximizes the utility of the individuals affected by the rule in that any change in the tort rule, and thus in the allocation of entitlements, that would make someone better off would make someone else worse off.⁵² The standard conditions for utility maximization produce two conditions for efficient tort rules: tort rules must induce individuals to take the efficient level of care and to spread the risk of loss efficiently. Specifically, tort rules must induce expenditures on accident prevention—that is, “care”—by risk imposers such that the social marginal cost of care equals the social marginal benefit of care;⁵³ and tort rules, or tort rules combined with an insurance system, must enable risk-averse potential victims⁵⁴ to spread efficiently the risks associated with having an accident.⁵⁵

50. This Article, like most prior analyses, considers those risks from which the victim would be entitled to be free absent the tort system and assumes that the victim would be able to enforce his legal right to be free from such risks absent the tort system. See *supra* text accompanying note 9. Legally imposed remedies, such as injunctions or damages, might be used to enforce this right. Alternatively, the right might be enforced through nonlegal enforcement mechanisms such as blood feuds. The assumption that an individual can protect his initial entitlement is implicit in most prior Pareto efficiency analyses. See, e.g., Fraser, *supra* note 9; Friedman, *supra* note 5.

51. See *supra* text accompanying notes 43-44.

52. See *supra* text accompanying note 4.

53. S. SHAVELL, *supra* note 9, at 215-27.

54. See *supra* note 32.

55. A risk-averse person is someone who prefers certainty to uncertainty. See *supra* note 32. Faced with a loss of \$m should some event occur, a risk-averse individual would prefer to spread the risk of loss by paying an amount of money whether or not the loss occurs in return for a promise of reimbursement should the loss occur (such as occurs with insurance). This transfer of wealth between the situation in which the individual

B. *Efficient Tort Rules: The Orthodox Model*

To date, the economic analysis of tort law has concluded that none of the four standard tort rules—pure negligence, negligence with contributory negligence, pure strict liability, and strict liability with contributory negligence⁵⁶—governing accidents resulting in serious permanent physical injury satisfy the Pareto criterion.⁵⁷ All previous efficiency analyses of physical injury, however, have employed the orthodox economic model of the tort system, which is a model of unilateral risks. This model assumes that all individuals are divided into two types: potential injurers, who impose risk on others but have no risk imposed on them, and potential victims, who have risk imposed on them but who do not impose risk on others.⁵⁸

1. *Negligence Liability Rules in the Orthodox Model*

Given this orthodox unilateral risk model of accidents, neither pure negligence nor negligence with contributory negligence is Pareto superior to a system of purely voluntary transactions when victims initially possess an entitlement to be free from the risk in question. Although both rules induce efficient care-taking and efficient risk spreading,⁵⁹ these rules are not Pareto superior to a system of purely voluntary transactions because neither rule ensures that the introduction of tort rules leaves no one worse off than he would be otherwise. When, absent the tort system, the victim possesses an enforceable entitlement to be free from the risk in question, the requirement that tort rules not make anyone worse off translates, in the orthodox model, into a requirement that each potential victim be fully compensated for the costs of any risk imposed on him. In the orthodox model, the

suffers the loss and the situation in which he does not suffer the loss is referred to as risk spreading. Risk spreading is efficient when the individual allocates his wealth to maximize his expected utility given these various contingent circumstances. *See generally* R. COOTER & T. ULEN, *supra* note 8, at 55-70; S. SHAVELL, *supra* note 9, ch. 8. Risk spreading can be achieved in either of two ways. The tort system can impose an involuntary insurance scheme, or the tort system can allow individuals to spread risks efficiently through the purchase of insurance on private insurance markets. *See generally* S. SHAVELL, *supra* note 9, ch. 9. The concept of efficient risk spreading is discussed in greater detail at *infra* text accompanying notes 76-80 and in S. SHAVELL, *supra* note 9, chs. 8-9.

56. *See supra* note 33.

57. *See supra* note 50 and text accompanying note 9.

58. *See* Brown, *supra* note 11, at 326; Landes & Posner, *supra* note 11, at 867; Shavell, *supra* note 11, at 1.

59. *See* S. SHAVELL, *supra* note 9, at 215-27.

tort system only compensates potential victims through damage awards. Because damages are awarded *ex post*, to injured victims, and not *ex ante*, to those at risk of being injured,⁶⁰ to satisfy the full compensation requirement tort rules must entitle potential victims to damages whenever they are injured as a result of risk imposed by others and award each victim sufficient damages to leave him as well off injured as he was when healthy. In the language of economics, the damages awarded must be sufficient to return the victim to his pre-accident level of utility.⁶¹

Negligence liability rules do not satisfy this full compensation requirement. Negligence rules permit a potential tortfeasor to impose risk on a victim without liability so long as the potential tortfeasor takes due care. Under both pure negligence and negligence with contributory negligence, when due care equals the efficient level of care and individuals and courts have perfect information, potential injurers always take due care and thus are never liable for the injuries they cause.⁶² Victims accordingly receive no compensation for their injuries. As compared to a world without tort rules in which each individual can enforce an entitlement to be free from risk, potential victims are worse off. Negligence rules in this context therefore do not satisfy the Pareto criterion.⁶³

2. *Strict Liability for Physical Injuries: The Orthodox Model*

In the orthodox model, strict liability rules for physical injury often are not Pareto superior and are never Pareto efficient. Strict liability rules require an injurer to pay damages to all whom he injures. Because injurers compensate victims for all losses, strict liability rules would appear to satisfy the Pareto criterion as long as damage awards fully compensate each victim for his loss. This conclusion is correct when the injuries result in purely pecuniary losses;⁶⁴ it is incorrect, however, when the

60. See generally PROSSER & KEETON, *supra* note 29, § 30, at 165. But see *id.* (Supp. 1988), § 54, at 60 n.34 (discussing recent cases allowing recovery for "cancerphobia").

61. See Friedman, *supra* note 5; Arlen Note, *supra* note 4, at 1121-22.

62. E.g., Brown, *supra* note 11; Landes & Posner, *supra* note 11; Shavell, *supra* note 11; see Diamond, *supra* note 25 (obtaining the same result for single activity accidents).

63. But see S. SHAVELL, *supra* note 9, at 232 n.4, 247-49. Shavell shows that Pareto efficiency is possible under a negligence rule, but his analysis depends on the implicit assumption that victims are *not* initially entitled to be free from the risk in question. *Id.* For a more detailed discussion, see *infra* note 94.

64. Throughout this Article, the term "pecuniary losses" refers to injuries to commod-

injuries result in nonpecuniary losses,⁶⁵ such as those occasioned by serious, permanent physical injuries.

In the case of injuries that result in purely pecuniary losses, strict liability rules satisfy the Pareto criterion when damage awards equal the victim's pecuniary loss. A rule of strict liability with full compensation damage awards clearly satisfies the requirement that victims be left no worse off under a tort rule than they would be in its absence. In addition, in cases of purely pecuniary losses, strict liability with full compensation damages is Pareto efficient. Strict liability with full compensation damages leads to efficient care-taking because it forces each injurer to pay all the costs that he imposes on others. Strict liability thereby induces him, through appeal to his own self-interest, to expend resources on accident avoidance up to the point at which the marginal cost of care equals the marginal benefit of care to society, namely the resulting reduction in expected accident costs.⁶⁶

In addition, in the purely pecuniary loss context, strict liability with full compensation damages induces efficient risk spreading by victims.⁶⁷ Given a risk of injury, a risk-averse individual maximizes his utility when his wealth should he remain uninjured and his wealth should he be injured are such that he derives the same utility from the last dollar of wealth in each of the two states. In other words, risk spreading is efficient when the potential victim's marginal utility of wealth is equal whether he is injured or uninjured.⁶⁸ An accident that results in purely pecuniary losses, by definition, affects only the victim's wealth. The victim thus feels equivalently about his last dollar of wealth, whether uninjured or injured, when his wealth is the same in either condition. Strict liability with full compensation damages for pecuniary losses ensures that the victim's wealth is the same

ities that Philip Cook and Daniel Graham refer to as "replaceable commodities." Cook & Graham, *The Demand for Insurance and Protection: The Case of Irreplaceable Commodities*, 91 Q. J. ECON. 143, 144-46 (1977). The term "nonpecuniary losses" refers to injuries to commodities Cook and Graham call "irreplaceable commodities." *Id.* As defined by Cook and Graham, the concepts of replaceable and irreplaceable are purely subjective. A commodity is replaceable if the owner of the commodity perceives that equivalent commodities are available on the market; market prices therefore determine the value to the owner of a replaceable commodity, and that value does not depend on the owner's wealth. *Id.* at 145. An irreplaceable commodity is one for which no equivalent commodities are available on the market. The value of an irreplaceable commodity to its owner may vary with the owner's wealth. *Id.* at 146.

65. *Id.*

66. S. SHAVELL, *supra* note 9, at 215-26; see Arlen Note, *supra* note 4, at 1116.

67. See *supra* note 55 and accompanying text.

68. S. SHAVELL, *supra* note 9, at 203.

regardless of whether he is injured; it therefore results in efficient risk spreading by the victim.⁶⁹

Although in the case of purely pecuniary losses strict liability with full compensation damages is both Pareto superior and Pareto efficient, in the case of accidents resulting in serious physical injury, strict liability is not necessarily Pareto superior and is never Pareto efficient. A rule of strict liability with full compensation damages is not invariably Pareto superior to a system of purely voluntary transactions because full compensation for losses is not possible for victims of certain physical injuries.⁷⁰ But if victims are not fully compensated, then strict liability makes them worse off than they would be otherwise. The problem for full compensation arises, first, because in the orthodox model the only compensation available to victims is monetary compensation and, second, because the current tort system awards damages *ex post* for physical injuries suffered and not *ex ante* for the mere risk of injury.⁷¹ Thus, to achieve full compensation, money damages paid to the injured victim must be sufficient to return him to his pre-accident level of utility.⁷² Victims of certain severe injuries, however, derive little or no benefit from money they receive above the bare amount necessary to keep them alive.⁷³ When money has little value to the injured victim, the amount necessary to return him to his pre-accident level of utility may exceed any injurer's ability to pay, in which case the victim will not be fully compensated. Moreover, and more importantly, in cases in which the victim receives no benefit whatsoever from wealth paid to him over and above the

69. See *id.* at 210-11. This discussion focuses on efficient risk spreading by victims and assumes implicitly that injurers are risk-neutral. When injurers are risk-averse, risk spreading by injurers is efficient if the injurers can purchase liability insurance. When insurance companies are perfectly informed and can monitor care-taking by injurers, insured injurers will take the efficient level of care. For a more thorough discussion of liability and insurance, see *id.*, chs. 8-9.

70. Arlen Note, *supra* note 4, discusses this issue in greater depth.

71. The current tort system grants a cause of action only when an individual has suffered an actual injury; an individual cannot sue for the mere additional risk of injury that another imposes on him. PROSSER & KEETON, *supra* note 29, § 30, at 165. But see *id.* (Supp. 1988), § 54, at 60 n.34 (discussing recent cases allowing recovery for "cancerphobia").

72. See Friedman, *supra* note 5; Arlen Note, *supra* note 4, at 1119-20. But see Haddock, McChesney, & Spiegel, *supra* note 9, at 13-17 (damages for wrongful death need only remove the gains to the defendant of taking action, and need not make the victim whole, in those cases in which the purpose of the rules is to completely dissuade the defendant from imposing the risk in question on the victim). For a more complete discussion of the Haddock, McChesney, & Spiegel analysis, see *infra* note 201.

73. If we assume that some accident victims derive no benefit from the prolongation of life, the conclusion advanced in the text holds with even greater force.

amount necessary to keep him alive,⁷⁴ monetary damages can never return the victim to his pre-accident level of utility; in this circumstance, full compensation damages are "infinite."⁷⁵

Further, even in those cases in which full compensation is possible, a rule of strict liability with full compensation damages is Pareto superior but not Pareto efficient because full compensation damages for physical injuries induce efficient care-taking by potential injurers but preclude efficient risk spreading by victims.⁷⁶ In contrast to purely pecuniary losses, physical injuries affect more than just the victim's wealth; they also result in nonpecuniary losses.⁷⁷ The amount of wealth necessary to fully compensate the victim for both his pecuniary and nonpecuniary losses exceeds the efficient level of insurance coverage; in other words, full compensation damages exceed the level of wealth at which the individual's marginal utility of wealth is equal whether he is injured or uninjured.⁷⁸ Thus, the damage award that fully compensates the potential accident victim who suffers a physical injury and induces efficient care-taking by injurers does not maximize the victim's expected utility because this newly re-

74. For example, a permanently comatose individual with neither spouse nor children probably receives no benefit from any wealth in excess of the amount necessary to keep him alive. See *supra* note 73.

75. Arlen Note, *supra* note 4, at 1124, 1127-28; see R. POSNER, *ECONOMIC ANALYSIS OF LAW* § 6.12, at 182 (3d ed. 1986); Mishan, *Evaluation of Life and Limb: A Theoretical Approach*, 79 J. POL. ECON. 687, 693 (1971).

76. E.g., S. SHAVELL, *supra* note 9, at 231-33, 247-51; see Cook & Graham, *supra* note 64, at 159.

77. See *infra* text accompanying notes 111-19.

78. E.g., S. SHAVELL, *supra* note 9, at 247-51; see Cook & Graham, *supra* note 64, at 159 (showing that full insurance coverage for nonpecuniary losses exceeds efficient insurance coverage).

The conclusion that full compensation damages preclude efficient risk spreading is consistent with the conclusion that full insurance coverage of physical injuries is not efficient and that the efficient level of coverage is less than full coverage. See *id.* The conclusion that full coverage for physical injuries is inefficient is intuitive because it comports with casual observations about individuals' insurance decisions. Few people would consider themselves as well off when permanently comatose as they are when perfectly healthy, even if they were to receive \$5 million in insurance payments. Yet few persons purchase even as much as \$5 million in insurance against such losses. See Rubin, *The Pitfalls of Hedonic Value Use*, 11 Nat'l L.J., Jan. 16, 1989, at 16, col. 3 (observing that individuals generally do not insure their lives for \$2 million). The reason individuals who could afford to do so do not purchase such substantial insurance coverage against such losses is simple: purchasing a \$5 million policy requires a person to spend wealth that he otherwise could use to enjoy life while uninjured in order to receive, when comatose, an amount of money that far exceeds the amount he will be able to enjoy in his comatose state. See *infra* note 149 (discussing the availability of insurance against nonpecuniary losses).

ceived wealth would have afforded him more utility had he enjoyed some part of it prior to the accident. Because the victim would thus be better off if he could receive less wealth when injured in return for an increase in wealth when uninjured, his risk spreading is inefficient.⁷⁹ Because insurance markets are not complete in that the victim cannot shift the excess wealth from his injured state to his uninjured state, the victim is unable to correct this inefficiency, and it will persist.⁸⁰

The conclusion that full compensation damages are infinite in some cases and preclude efficient risk spreading in all cases has disturbed scholars. The possibility that efficient damages for particular injuries may be infinite is particularly troubling because it implies that the efficient rate of such injuries, and thus of the associated risk producing activities, is zero.⁸¹ Although for some risks this conclusion is correct,⁸² many activities that impose risks of severe injuries produce such substantial benefits that it is unlikely that the efficient level of such activities is zero. For example, although automobile driving subjects others to a risk of death or permanent coma, modern society's dependence on the automobile suggests that some (possibly reduced) level of automobile use is nevertheless efficient.

A belief in the importance of optimal legal rules, combined with an intuitive sense that it is not efficient to forbid all activities that impose a risk of injuries such as death or coma, led some scholars to develop creative solutions to the problem of optimal tort rules for physical injury. Those who labored at this task focused their attention on the problem of damage rules that only award compensation *ex post*. As previously observed, one problem with *ex post* compensation is that certain serious injuries eliminate the victim's ability to use additional wealth to provide utility; a second problem is that the amount necessary to compensate the victim fully is so large that it precludes

79. S. SHAVELL, *supra* note 9, at 247-51.

80. *E.g.*, *id.*; Danzon, *supra* note 10, at 520-22 (discussing this issue in the context of products liability); Schwartz, *supra* note 10 (same); Spence, *supra* note 10 (same); see Friedman, *supra* note 5 (analyzing efficient tort rules when insurance markets are complete).

81. See R. POSNER, *supra* note 75, § 6.12, at 182; Arlen Note, *supra* note 4, at 1128. The statement in the text assumes that care-taking cannot completely eliminate the risks created by risky activities; thus, the only way to eliminate such risks entirely is to not engage in the activity.

82. For an analysis of the appropriate damage remedy for such risks, see Haddock, McChesney, & Spiegel, *supra* note 9, at 13. See also *infra* note 201 (discussing the above-cited analysis).

efficient risk spreading.⁸³ Responding to these difficulties, scholars have attempted to solve the full compensation problem by inventing mechanisms that enable potential victims to receive some or all of the monetary compensation for a risked future injury while they are healthy and can better enjoy their wealth.⁸⁴ These devices include "complete insurance markets," in which potential victims can "sell insurance on themselves";⁸⁵ markets in "unmatured tort claims," in which uninjured victims can sell to others their possible future damage claims;⁸⁶ and *ex ante* damages, which compensate individuals while healthy for the risk imposed on them, regardless of whether they are eventually injured.⁸⁷ Scholars have shown that when any of these mechanisms are used to enable the victim to enjoy his compensation while healthy, strict liability rules do satisfy the Pareto criterion. Under these mechanisms, finite damages invariably suffice to leave the victim as well off after imposition of the risk as he was before because under each of these devices the victim can receive and enjoy the compensation when he is healthy; moreover, these mechanisms solve the conflict between efficient care-taking and efficient risk spreading.⁸⁸

Such efforts, although ingenious, do not solve the problem of optimal tort rules for the current tort system or any feasible tort system. They are thus of limited interest to those who argue that the current tort system is efficient or who claim that the system should be—and can be made—efficient. Existing insurance markets are not "complete,"⁸⁹ and there is little prospect that insurance markets in which individuals sell insurance on themselves will be developed.⁹⁰ Similarly, individuals currently

83. See *supra* text accompanying notes 66-80.

84. E.g., Cooter, *supra* note 33; Friedman, *supra* note 5; Shukaitis, *A Market in Personal Injury Tort Claims*, 16 J. LEGAL STUD. 329 (1987); see Graham & Peirce, *supra* note 5 (discussing *ex ante* damages for products liability).

85. Friedman, *supra* note 5, at 89-91.

86. E.g., Cooter, *supra* note 33, at 383.

87. Friedman, *supra* note 5, at 88-89; see Graham & Peirce, *supra* note 5, at 455-56 (discussing *ex ante* damages for products liability).

88. Cooter, *supra* note 33; Fraser, *supra* note 9; Friedman, *supra* note 5.

89. Friedman, *supra* note 5, at 91 (observing that existing insurance markets are not complete).

90. As explained previously, in a complete insurance market, an individual may agree to pay to another, the purchaser, a certain sum in the event that the individual is seriously injured in the future, in return for an up-front payment to the individual by the purchaser. In a world of imperfect information, complete insurance markets raise at least two problems. The first is a "reverse moral hazard" problem: the purchaser of the insurance—who might be the individual's employer or some other person in an ongoing

may not sell their possible future tort claims, and it is unlikely that a market in tort claims can be created.⁹¹ As for *ex ante* damages, damages in the current tort system are paid *ex post*, after the occurrence of the injury, not *ex ante*, based on the risk of future harm.⁹² The development of a tort system that awards damages *ex ante* to compensate for risk to all those subjected to risk is unlikely because the obvious administrative costs of such a system render it impracticable.⁹³ Moreover, these solutions apply only to strict liability rules; they do not offer the possibility of optimal negligence rules.

Scholars have constructed negligence liability rules for physical injury that satisfy the Pareto criterion only by assuming, contrary to the standard hypothesis, that potential victims are not initially entitled to be free from the risk in question. This starting point permits Pareto superior negligence liability rules because victims who are not otherwise entitled to be free from risk of injury in the first place are not made worse off when injurers impose risk on them without compensating them for their injuries.⁹⁴ The

relationship with the individual—now has an incentive to increase the probability that the individual will be injured. The second problem is that the purchaser of this insurance may have difficulty ensuring that the individual retains sufficient wealth to satisfy the terms of the insurance contract should the individual be injured.

91. The notion of a market in potential tort claims is similar to the concept of complete insurance markets, but the idea of a tort claims market has received more scholarly attention. A *Virginia Law Review* Symposium on the Law and Economics of Bargaining considers this issue in detail. See Cooter, *supra* note 33; Goetz, *Commentary on "Towards a Market in Unmatured Tort Claims": Collateral Implications*, 75 VA. L. REV. 413 (1989); Schwartz, *Commentary on "Towards a Market in Unmatured Tort Claims": A Long Way Yet to Go*, 75 VA. L. REV. 423 (1989).

92. See PROSSER & KEETON, *supra* note 29, § 30, at 165. But see *id.* (Supp. 1988), § 54, at 60 n.34 (discussing recent cases allowing recovery for "cancerphobia").

93. See Arlen Note, *supra* note 4, at 1120 n.37 (discussing the impracticability of *ex ante* damage rules).

94. S. SHAVELL, *supra* note 9, at 232 n.4, 247-49. Shavell shows that efficiency is possible under a negligence liability rule, but his analysis depends on the implicit assumption that victims are *not* entitled to be free from the risk in question. *Id.* He concludes that negligence rules are Pareto efficient because his model does not entitle victims to be free from any risk of harm and, therefore, they are not made worse off if injurers impose reasonable risks of harm on them without compensation; that is, they are not made worse off if injurers impose the risks associated with taking due care. Thus, Shavell shows that, setting due care equal to the efficient level of care, Pareto efficiency is possible under a negligence rule if damages are sufficiently high to induce injurers to take due care. Injurers will then take due care and will not be liable for damages; victims are no worse off because they are not entitled to be free from this risk. Moreover, as victims do not receive damages, damage awards do not interfere with the victim's ability to engage in efficient risk spreading through the purchase of accident insurance. Shavell's results do not apply to those cases in which each potential victim is initially entitled to be free from the risk of injury in question. Moreover, it appears that Shavell's results do not

success of such an analysis, however, depends completely on the assumption that potential victims are not otherwise entitled to be free from risk. Such an assumption is probably unattractive as applied to most everyday torts, such as those resulting from automobile accidents, because the assumption is inconsistent with the belief in the personal integrity of each individual that lies at the foundation of the common law tort system.

II. PHYSICAL INJURY FROM BILATERAL RISKS

Although in the orthodox model such mechanisms as complete insurance markets, markets in unmatured tort claims, and *ex ante* damages are prerequisites for optimal tort rules for physical injury in those cases in which the victim is initially entitled to be free from the risk,⁹⁵ such mechanisms are not necessarily prerequisites to optimal tort rules in the actual world of the tort system. The orthodox model of the tort system describes an extremely narrow class of cases: those in which potential victims are never potential injurers and vice versa.⁹⁶ In reality, few risky activities involving strangers⁹⁷ are best described as situations in which one person is an injurer who imposes but does not bear the risk of injury, and another bears risk but does not impose any. Rather, most everyday torts between strangers result from situations in which each person is engaged in an activity that imposes a risk of harm on the person himself, as well as on others.⁹⁸ In other words, most everyday torts result from bilateral risk activities in which each individual is both a potential injurer and a potential victim.⁹⁹ Accidents between motorists are an example of everyday accidents resulting from bilateral risk activities.¹⁰⁰

The move from unilateral to bilateral risks is more than one of those minor changes in assumptions for which economists are famous. The switch from a unilateral to a bilateral risk model implies a fundamental change in the economic paradigm of the

apply to those cases in which injurers are initially entitled to impose as much risk as they choose because negligence rules force injurers to pay for imposing unreasonable risks.

95. See *supra* notes 83-93 and accompanying text.

96. See *supra* text accompanying note 11.

97. See *supra* note 10 and accompanying text.

98. See *supra* note 20 and accompanying text.

99. As discussed in notes 21 and 24, *supra*, this notion of bilateral risks echoes the concept of reciprocal risks that George Fletcher developed in his seminal article, *Fairness and Utility in Tort Theory*. Fletcher, *supra* note 21.

100. See *supra* note 20.

tort system and suggests a possible revision of the orthodox claim that optimal tort rules are those that induce the exchanges of entitlements between an injurer and his victim that would take place in the marketplace in the absence of transaction costs.

As explained above, the unilateral risk model treats the tort system as creating a market in certain entitlements—those that the presence of high transaction costs otherwise would preclude—by allowing involuntary exchanges of those entitlements.¹⁰¹ Under this view, injurers are purchasers of entitlements (here, the physical well-being of others), accident victims are sellers, and damage awards are the price at which participants exchange the entitlements. In the bilateral risk context, by contrast, all individuals impose risk on others by engaging in a particular activity. Unlike the unilateral risk model—in which, absent a tort system, potential victims do not impose risk on others and can go about their business—in cases of bilateral risk activity, each individual engaged in the activity imposes risk on others and, absent the tort system, no one would be permitted to engage in the activity without obtaining the consent of others. When high transaction costs preclude these voluntary exchanges, each individual stands to benefit from the introduction of tort rules that enable him to engage in a risk-producing activity from which he would otherwise be barred.

In the bilateral risk context, therefore, the tort system operates not as a market in health, in which injurers appropriate the physical well-being of victims in return for compensating them monetarily, but as a reciprocal exchange of the right to engage in risky activities, in which monetary damages are not the central mechanism of compensation.¹⁰² Because the primary benefit of the introduction of the tort system comes in the form of the capacity to impose risk on others, as opposed to the right to collect monetary damages if injured, optimal tort rules may be possible without full compensation damages. Because the requirement of full compensation damages is the reason optimal tort rules are not possible in the unilateral risk context, removing this requirement opens the possibility that optimal tort rules may nevertheless be possible in the case of everyday torts resulting from bilateral risks.

The question thus arises: Which, if any, of the standard tort rules¹⁰³ are optimal when applied to bilateral risk activities, and

101. See *supra* text accompanying notes 42-55.

102. See Arlen Note, *supra* note 4, at 1135-36.

103. See *supra* text accompanying note 33.

what is the optimal level of damages? To address this question, one must develop an economic model of accidental physical injuries resulting from bilateral risk activities. A full examination of the question would require a separate analysis of accidents resulting from each category of bilateral risk activities; that is, single activity accidents, two-activity accidents resulting from simultaneous bilateral risks,¹⁰⁴ and two-activity accidents resulting from subsequent bilateral risks.¹⁰⁵ As previously explained, this Article begins that study with an examination of tort rules for serious physical injuries resulting from single activity accidents, which are the primary source of tort claims for serious permanent injury and death in this country.¹⁰⁶

III. EFFICIENT TORT RULES FOR PHYSICAL INJURIES RESULTING FROM SINGLE ACTIVITY ACCIDENTS

An economic analysis of single activity accidents is by its nature mathematical. Appendix I sets forth the mathematical analysis of the full single activity accident model developed for this Article. Readers interested in this analysis are encouraged to turn to that Appendix for an account of the proofs underlying the contentions that follow. For those who prefer a textual discussion to mathematics, this Section provides a brief description of the model used and presents the central results of the mathematical analysis of the model. Of necessity, these results are merely stated and are not proved; all proofs are confined to Appendix I.¹⁰⁷

A. *The Model*

The model employed is based on Diamond's model of single activity accidents,¹⁰⁸ extended here to risk-averse individuals who face the possibility of suffering a serious permanent physical injury. Following Diamond, it is assumed that the relevant world

104. See *supra* note 26.

105. *Id.*; see Arlen, *supra* note 25 (discussing simultaneous bilateral risk activities for cases involving purely pecuniary losses). This Article is the first to examine physical injuries resulting from bilateral risk activities. It is also the first to consider efficient risk spreading in the bilateral risk context.

106. See *supra* text accompanying notes 26-29.

107. Readers interested in a further extension of this mathematical model will find it developed in Appendix II. See *supra* note 30.

108. Diamond, *supra* note 25.

is composed of a fixed¹⁰⁹ and large number of identical, risk-averse individuals. Each person is engaged in an activity, for example driving, that benefits him monetarily and presents a risk of accident both to him and to others engaged in the activity.

Should an accident occur, each party to the accident suffers the same serious, permanent physical injury.¹¹⁰ This physical injury has two distinct consequences for a victim. First, the injury results in pecuniary losses,¹¹¹ which include increased medical expenses and lost expected future earnings. In addition, the injury has a nonpecuniary consequence: it directly alters the victim's utility function.¹¹² It is assumed that the injury itself, apart from any impact on the victim's wealth, makes the victim worse off; that is, it lowers the utility the individual gets out of

109. Consistent with the other articles on efficient tort rules for physical injury, this Article considers only the issues of efficient care-taking and risk spreading. This Article does not consider the efficient level of the activity, measured here by the number of drivers. The Article therefore assumes that the number of drivers is fixed. Prior scholarship suggests that when the activity level varies, tort law may not be efficient. Specifically, Brian Hindley and William Bishop have shown that when the expected number of accidents depends on the total number of people engaged in the activity, none of the standard liability rules can be used to induce the efficient level of the activity; instead, too many people will drive. Hindley & Bishop, *Accident Liability Rules and Externality*, 3 INT'L REV. L. & ECON. 59, 60-61 (1983); see Shavell, *supra* note 11. Hindley and Bishop's analysis suggests that the standard tort rules considered here also may fail to induce individuals to engage in the efficient level of activity in the single activity accident context. Their analysis, however, does not alter the conclusions of this Article that the standard tort rules can induce efficient care-taking and risk spreading. Nor does their analysis alter the central claim of this Article: those interested in efficient tort rules should shift their attention to bilateral risk models.

110. Specifically, the model assumes that individuals suffer the same extent of physical injury. Appendix II addresses the situation in which individuals face the same expected accident losses prior to the accident but may in fact suffer different injuries should the accident occur. Appendix II demonstrates that the results obtained in this Article do not depend on the assumption that parties to an accident suffer identical losses. The final results obtained in Appendix II are identical to those obtained here. See *supra* note 30. For further discussion of the assumption that those involved in an accident suffer the same physical injury, see *infra* note 177.

Neither the text nor the appendices address the issue of efficient damages when the parties to an accident suffer the same injury but one is injured in a more painful manner than the other—for example, one party is conscious during the injury and the other is unconscious. For a discussion of this issue in the context of wrongful death, see Leebron, *Final Moments: Damages for Pain and Suffering Prior to Death*, 64 N.Y.U. L. REV. 256 (1989).

111. The term "pecuniary loss" is defined at *supra* note 64.

112. Utility functions that are altered by the occurrence of a particular event are called "state-dependent" utility functions and are essential to the accurate mathematical characterization of a serious permanent physical injury. See, e.g., S. SHAVELL, *supra* note 9, at 228-35, 245-54; Cooter, *supra* note 33, at 388-91; Friedman, *supra* note 5, at 85-86; see Cook & Graham, *supra* note 64, at 146.

any given level of wealth.¹¹³ It also is assumed that the injury affects the individual's ability to use incremental additions to his wealth to produce utility; that is, it affects his marginal utility of wealth.¹¹⁴

To see these two consequences, consider an individual who is rendered a permanent quadriplegic by an automobile accident. The injury clearly produces pecuniary losses in the form of increased medical expenses and the loss of expected future earnings. In addition, the injury has nonpecuniary consequences in that it alters the victim's ability to use wealth to derive utility; in other words, it alters his utility function. First, the injury makes the victim worse off: at any given level of wealth, the victim would be happier healthy than he is as a quadriplegic. In addition, the injury affects the way in which the victim can use wealth to derive utility. For example, the quadriplegic who once derived pleasure from purchasing and using running shoes, skiing in the Alps, and driving sports cars no longer values such commodities and instead values wheelchairs and voice-activated computers.¹¹⁵ Incorporating the direct impact of the injury on the victim's utility function is essential to an accurate mathematical representation of the effects of physical injury.¹¹⁶ This model is one of the few models of accidents between strangers¹¹⁷ to incorporate this direct impact;¹¹⁸ it is the only model of bilateral risk accidents to do so.¹¹⁹

113. In other words, it is assumed that at any given level of wealth, each individual would rather be healthy than injured.

114. In addition, the model assumes that the absence of injury, in other words that health, is a "normal good." A commodity is a normal good if increases in the individual's wealth, *ceteris paribus*, result in an increase in the individual's demand for that commodity; most commodities are normal goods. See Cook & Graham, *supra* note 64, at 146. Thus, when a commodity is a normal good, the maximum amount an individual would pay for that commodity also increases with wealth. See Cook & Graham, *supra* note 64, at 147 & n.9. This model assumes that the wealthier the individual, the more he will be willing to spend to avoid injury.

115. The direct impact of a physical injury on the victim's utility function is discussed in greater detail in S. SHAVELL, *supra* note 9, ch. 10; Cooter, *supra* note 33; and Friedman, *supra* note 5.

116. *E.g.*, S. SHAVELL, *supra* note 9, at 228-35, 245-54; Cooter, *supra* note 33, at 388-91; Friedman, *supra* note 5, at 85-86; see Cook & Graham, *supra* note 64, at 146.

117. See *supra* note 10.

118. Most of the early economic models of the tort system did not employ state-dependent utility functions. *E.g.*, Brown, *supra* note 11; Diamond, *supra* note 25; Landes & Posner, *supra* note 11; Shavell, *supra* note 11. Moreover, even some recent discussions of efficient accident law for personal injuries do not incorporate state-dependent utility functions. *E.g.*, W. LANDES & R. POSNER, *supra* note 9, ch. 9 (discussing catastrophic personal injuries by using a model that treats the loss associated with an accident as a

As do Diamond's model and most of the economic analyses employing the orthodox unilateral risk model,¹²⁰ this model assumes that all accidents involve only two individuals, each of whom is engaged in the same activity.¹²¹ It also assumes that the probability of an accident between any two people depends only on each of the individual's expenditures on accident prevention, or "care." The expected number of accidents in which any given individual will be involved thus depends on that individual's level of care, the number of other persons engaged in the activity, and the amount of care that each of the other individuals takes. The model assumes that increased expenditures on care lower the number of accidents in which the individual can expect to be involved. Increased care-taking, however, also lowers the benefit an individual receives from the activity.¹²²

As in both the orthodox model of accidents and in Diamond's model, this model assumes that individuals and courts possess

purely pecuniary loss). Because nonpecuniary loss is an important element of the impact of a serious physical injury, one cannot assume that the conclusions of these analyses apply to accidents resulting in physical injury or death. Recent economic analyses of physical injury between strangers that take into account the impact on the utility function include: S. SHAVELL, *supra* note 9, at 228-35, 245-54; Fraser, *supra* note 9; Friedman, *supra* note 5, at 85-86; see Cooter, *supra* note 33, at 388-91 (employing state-dependent utility functions to argue for a market in unmatured tort claims); cf. Cook & Graham, *supra* note 64, at 146 (describing the impact on the utility function of the loss of an irreplaceable commodity). These articles, however, are all unilateral risk analyses.

119. Previous economic analyses of bilateral risks restrict themselves to injuries that result in purely pecuniary losses. *E.g.*, Arlen, *supra* note 25; Diamond, *supra* note 25; Leong, *supra* note 25; Ordovery, *Costly Litigation*, *supra* note 25.

120. *E.g.*, Brown, *supra* note 11; Landes & Posner, *supra* note 11; Shavell, *supra* note 11. But see S. SHAVELL, *supra* note 9, at 164-67 (discussing efficient tort rules for purely pecuniary losses resulting from multiple tortfeasors in a unilateral risk model); Landes & Posner, *Joint and Multiple Tortfeasors: An Economic Analysis*, 9 J. LEGAL STUD. 517 (1980) (same).

121. In other words, it is assumed, for the sake of simplicity, that individuals engaging in this activity impose costs only on others also engaging in the activity; no one else is affected. This assumption that third parties are not affected is a standard assumption of economic models of accidents. *E.g.*, Brown, *supra* note 11; Fraser, *supra* note 9; Landes & Posner, *supra* note 11; Shavell, *supra* note 11. To the extent that the activity being considered does have an impact on third parties, the issue of efficient tort rules for accidents resulting in injury to those third parties is better analyzed in a two-activity accident model. The multipart study of physical injuries, of which this Article is the first part, will include an economic analysis of efficient tort rules for physical injuries resulting from two-activity accidents.

122. This assumption that the benefit of the activity is a decreasing function of care is consistent with the observation that, although both expending resources to maintain a car and driving more slowly reduce the probability of an accident, both efforts at taking care are costly. The former is costly because it requires a direct expenditure of wealth. The latter is costly because it increases travel time, which in turn decreases the time that can be spent in other activities, such as income-producing activities.

perfect information that they obtain without cost. It assumes that litigation and settlement costs are zero,¹²³ that tortfeasors pay damages only if an individual suffers a physical injury,¹²⁴ and that people with identical injuries collect identical damages.¹²⁵ To spread risks, people can purchase accident insurance¹²⁶ and liability insurance¹²⁷ in perfect and fair insurance markets.¹²⁸ The model further assumes that the collateral source rule applies; thus, the tort victim's receipt of insurance benefits does not affect the amount of damages he can collect from the tortfeasor. No-fault insurance laws do not apply to the physical injuries considered here.¹²⁹ Finally, this model assumes that the alternative to the tort system is a system that permits only voluntary exchanges; that each individual is initially entitled to be free from the risk of injury imposed by others engaging in the activity in question;¹³⁰ and that transaction costs are sufficiently high to preclude voluntary exchanges.¹³¹

B. *The Efficient Equilibrium*

The threshold question in an analysis of tort rules under the Pareto criterion is whether the rules are Pareto superior in that

123. For a discussion of litigation costs in the single activity accident context, see Ordoover, *Costly Litigation*, *supra* note 25 (expanding Diamond's single activity accident model to include litigation costs). See also Epstein, *supra* note 29, at 779-84 (discussing the relative administrative costs of fault and no-fault rules for automobile accidents).

124. In other words, only *ex post* damage rules are considered. See *supra* text accompanying notes 83-93.

125. The assumption that individuals with identical losses collect identical damages is consistent with the current law governing damage awards for serious permanent injury. See generally D. DOBBS, *HANDBOOK ON THE LAW OF REMEDIES* 540 (1973).

126. This Article uses the term "accident insurance" to refer to all first-party coverage for losses to the insured resulting from an accident. The term accident insurance thus includes medical insurance against medical expenses resulting from an accident, disability insurance and other forms of insurance against the loss of future wages, and accidental death and dismemberment insurance which provides coverage based on the nature of the injury suffered (\$x for the loss of an arm; \$y for total blindness).

127. This Article uses the term "liability insurance" to refer to all forms of insurance coverage for damages owed to third parties.

128. Insurance markets are fair and perfect when all parties possess perfect information and when the premium charged by insurance companies equals the companies' expected liability on the insurance policy. The assumption that all parties are perfectly informed avoids the moral hazard problem that otherwise would be present. See *infra* note 148 (discussing the assumption that insurance markets are complete).

129. This Article ignores no-fault laws because they do not apply to the serious permanent injuries considered here. See *supra* note 29.

130. See *supra* text accompanying note 9.

131. This model assumes that transaction costs are high because otherwise no reason for the tort system would exist; individuals would achieve the efficient solution through voluntary exchanges. See Coase, *supra* note 46.

they increase the expected utility of at least one individual engaged in the activity but do not make anyone worse off than he would be otherwise, when only voluntary exchanges are permitted.¹³² When only voluntary exchanges are permitted, but high transaction costs preclude such exchanges, no one would be able to engage in the risky activity. Given this, in the case of the single activity accidents, each of the standard tort rules is Pareto superior to a world in which only voluntary transactions are permitted because they present the possibility of welfare-improving exchanges of entitlements (here, risk of injury) and do not threaten to make anyone worse off. The condition that no one be made worse off than he would be otherwise is automatically satisfied because each individual chooses whether to accept the benefits and costs of a tort rule when he chooses whether to engage in the activity. Those who choose to engage in the activity reveal themselves to be better off under the tort rules than they would be otherwise when they are not permitted to engage in the activity and thus do not bear its risks. Those who do not engage in the activity are as well off as they would be in the absence of tort rules because only those who engage in the activity bear its risks and obtain its benefits.¹³³ Accordingly, in the single activity accident context, unlike in the unilateral risk context, each of the standard tort rules is Pareto superior. There is no requirement that those who are injured be fully compensated for their losses.

The question remains whether any of the standard tort rules are Pareto efficient. Because in this model individuals are identically situated *ex ante*, Pareto efficient tort rules are those that induce the equilibrium at which the expected utility of any one individual is maximized. An individual's expected utility is determined by the amount of care the individual takes, which affects both the benefit he gets from the activity and his probability of

132. See *supra* text accompanying notes 34-35, 50-51.

133. See *supra* text accompanying notes 22-24. The conclusion that tort rules do not make individuals worse off follows from the assumption that only those who engage in the activity bear a risk of injury from others who also engage in the activity and from the conclusion that, absent the tort system, no one would be permitted to engage in the activity. See *supra* text accompanying notes 22-24, 102. Although the first assumption is arguably unrealistic, it is consistent with the assumption of the unilateral risk model that all accidents occur between injurers and victims. The use of this assumption thus serves the purpose of this Article, which is to determine whether, at the same level of abstraction employed in the unilateral risk model, shifting the focus to bilateral risks solves the problems for Pareto efficiency. Future analysis considers the effect of tort rules on those engaged in other activities.

being injured; the amount of care other individuals take, which also affects his probability of being injured; and the individual's ability to spread the risk of injury, for example, through the purchase of accident insurance.¹³⁴ The efficient equilibrium thus is determined by finding the equilibrium levels of care and risk spreading, taken by each individual, which maximize the expected utility of any given individual.¹³⁵ A tort rule is efficient if it induces each individual to take the efficient level of care and to engage in efficient risk spreading.¹³⁶

As is shown in Appendix I, maximizing the expected utility of an individual engaged in the activity yields the two conditions for a Pareto efficient equilibrium: the condition for the efficient level of care and the condition for efficient risk spreading.¹³⁷ These two conditions for the efficient equilibrium are the standard conditions for efficient care-taking and efficient risk spreading.¹³⁸ The efficient equilibrium level of care is the level at which the social marginal cost of care of an individual's care-taking equals the social marginal benefit of his care.¹³⁹ Risk spreading is efficient when each individual purchases the insurance coverage at which he derives the same utility from an additional dollar of wealth—that is, the same marginal utility of wealth—whether he is injured or uninjured.¹⁴⁰

134. See *supra* note 55 (discussing risk spreading).

135. See Diamond, *supra* note 25, at 114. Because individuals are assumed to be identical, this Article restricts its analysis to those equilibria at which all individuals take the same level of care, referred to here as "uniform equilibria." A uniform equilibrium is the equilibrium that occurs when all individuals engage in the same behavior. *Id.* Thus, the efficient uniform equilibrium level of care is the level of care which, if taken by everyone, maximizes the expected utility of each person in equilibrium. *Id.* at 115. The efficient level of accident insurance coverage is the level that maximizes each individual's expected utility at the efficient equilibrium level of care. In other words, the efficient uniform equilibrium levels of care and accident insurance are the levels of care and insurance coverage that maximize expected utility as given by Equation (1) in Appendix I, *infra* p. 92.

136. See *supra* text accompanying notes 42-55. Coincidentally, given that the expected utility of each individual is maximized at the Pareto efficient equilibrium, in the single activity accident context Pareto efficient tort rules also are those that maximize total social expected utility. See Diamond, *supra* note 25, at 115 (employing a total social welfare notion of efficiency). The Pareto efficiency criterion is used here instead of the social utility maximization criterion that Diamond used because Pareto efficiency avoids the problems inherent in making interpersonal comparisons of utility. See *supra* note 40. See generally L. ROBBINS, *supra* note 6; A. SEN, *supra* note 6, ch. 9; Cooter, *supra* note 4, at 820-21. Also, many consider the Pareto criterion to be fair. See *supra* text accompanying note 5.

137. See *infra* Equations (1)-(3) in Appendix I, p. 92.

138. See S. SHAVELL, *supra* note 9, ch. 10; *supra* text accompanying notes 67-80.

139. See *infra* Equation (2) and subsequent discussion in Appendix I, p. 92.

140. See *infra* Equations (1)-(3) and accompanying analysis in Appendix I, pp. 91-93.

As "due care" in an efficient tort system equals the efficient level of care for purposes of determining both negligence and contributory negligence, the condition for efficient care-taking warrants more discussion. As Appendix I shows, the social marginal cost of care is the cost to the individual in question of taking care, specifically, the decrease in the benefit that the individual receives from the activity resulting from his additional expenditure on care.¹⁴¹ The social marginal benefit of care is the benefit to the individual in question, and to the other participants in the activity, of the decrease in the probability of an accident that results from an increase in the individual's care-taking.¹⁴² The efficient level of care is therefore the level at which the social marginal cost of care, as measured by the resulting reduced benefit of the activity to the individual, equals the social marginal benefit of care, as measured by the benefit to the individual in question and the other individuals in society of the reduction in the expected number of accidents resulting from an increase in this one individual's care-taking.¹⁴³

Observe that the efficient equilibrium level of care is based on the social marginal costs and benefits of care as perceived by participants in the activity and as determined by the impact on their expected utility; it is not determined, as proponents of the Hand formula suggest, by balancing the *monetary* benefits and costs of an individual's expenditures on care.¹⁴⁴ Observe, in addition, that whereas in the unilateral risk case certain circumstances exist under which the efficient expected number of accidents is zero,¹⁴⁵ in the bilateral risk case efficient care-taking is uniformly associated with a positive expected number of accidents. This conclusion follows from the fact that the social marginal benefit of care invariably is finite and declining; thus, beyond some point, less than the point at which no accidents occur, the benefits of additional care do not justify the costs.¹⁴⁶

The condition for efficient care-taking is consistent with the condition Diamond obtained in his analysis of single activity accidents that result in purely pecuniary losses. Diamond, *supra* note 25, at 115. Diamond did not consider efficient risk spreading.

141. See *infra* Equation (2) in Appendix I, p. 92.

142. *Id.*

143. *Id.*

144. Thus, the efficient level of care cannot be determined, as the Hand formula implies and as proponents of wealth maximization suggest, by weighing the monetary costs and benefits of care.

145. See *supra* text accompanying notes 70-75, 81-82.

146. The social marginal benefit of care is based on the total utility an individual

The second condition for Pareto efficiency—the achievement of efficient risk spreading—is governed by the standard condition for efficient risk spreading: Has the individual allocated his wealth between his life when he is healthy and his life when he is injured (through, for example, the purchase of insurance) so that he derives the same benefit from the last dollar of wealth whether he is injured or healthy?¹⁴⁷ As explained previously, because a serious physical injury involves a nonpecuniary loss, less than full insurance coverage satisfies this condition in the bilateral risk case as in the unilateral risk case.¹⁴⁸ In other words, full coverage against this injury, defined as insurance in an amount sufficient to leave the victim as well off injured as he would be healthy, is not efficient.¹⁴⁹ In the unilateral risk model,

derives from being healthy, as opposed to being injured or dead. *See infra* Equation (2) in Appendix I, p. 92. Although an individual might require infinite compensation before he would agree to being rendered permanently comatose, the total utility he derives from life while healthy, and thus the cost to him of being comatose as opposed to healthy, is finite. *Id.* Thus, the social marginal benefit of care is finite.

In addition, it should be observed that, because in the single activity accident context accident victims do not need to be fully compensated monetarily to be no worse off than otherwise, *see supra* text accompanying notes 132-33, infinite damages, and thus a zero accident rate, are never required. *See supra* text accompanying notes 81-82.

147. *See supra* text accompanying notes 67-80 and Equation (3) in Appendix I, p. 92.

148. Appendix I presents the proof of this conclusion at *infra* note 248. *See supra* text accompanying notes 76-80 (discussing efficient risk spreading in the unilateral risk context).

Appendix I's mathematical analysis of efficient risk spreading implicitly assumes that insurance markets are complete, even though this assumption is completely unrealistic. *See supra* text accompanying notes 89-90. Appendix I assumes that insurance markets are complete purely for ease of analysis. This assumption is not essential to the present analysis, and the conclusions derived in Appendix I generally hold even when insurance markets are not complete. *See infra* note 209. The only circumstance in which incomplete insurance markets affect the conclusions of this Article is when the efficient level of accident insurance coverage is negative. Even when efficient insurance is negative, however, incomplete insurance markets preclude only efficient risk spreading; even with negative efficient insurance coverage and incomplete insurance markets, here the tort system always can induce efficient care-taking. *Id.* In contrast, Friedman's analysis depends on the assumption that insurance markets are complete. Friedman, *supra* note 5.

149. Although efficient insurance coverage is less than full insurance coverage for serious permanent injuries, the precise amount of efficient coverage cannot be determined because a serious permanent physical injury affects the victim's marginal utility of wealth in unpredictable ways. In fact, the possibility that efficient insurance coverage is negative cannot be ruled out. *See infra* note 209. Nevertheless, Alan Schwartz argues that damages in products liability cases should equal the victim's purely pecuniary losses on the grounds that pecuniary losses equal the efficient level of insurance coverage for such injuries. *See Schwartz, supra* note 10, at 362-63. Schwartz claims that intuition indicates that rational individuals would fully insure against pecuniary losses but would want little or no coverage against the purely nonpecuniary element of a serious permanent physical injury. *Id.* at

the conclusion that full insurance coverage is not efficient led to the conclusion that tort rules—in particular, strict liability rules—cannot induce both efficient care-taking and efficient risk spreading.¹⁵⁰ As will be shown, in the case of single activity accidents, this difficulty disappears; no conflict exists between efficient care-taking and efficient risk spreading.

C. *The No-Liability Equilibrium*

Before examining the standard tort rules, a consideration of whether tort liability is necessary for Pareto efficiency is useful. Specifically, it is useful to consider whether Pareto efficiency is possible under a tort rule that permits individuals to engage in the activity without having to pay damages for injuries they

364-67; accord Priest, *The Current Insurance Crisis and Modern Tort Law*, 96 YALE L.J. 1521 (1987). This claim that the efficient amount of insurance is equal to the pecuniary loss is correct, however, only if each individual's marginal utility of wealth is equal when he is injured and uninjured (that is, only if the physical injury has *no* impact on the victim's marginal utility of wealth). There is no reason to believe, however, that serious permanent injuries have no impact on the marginal utility of wealth.

First, current insurance markets suggest that physical injuries affect the victim's marginal utility of wealth and that, for some people, the efficient amount of insurance exceeds the victim's pecuniary losses. Specifically, in a world of rational individuals, were Schwartz correct one would not expect to find insurance companies offering insurance against nonpecuniary losses because demand for such insurance would not exist. The current structure of insurance markets reveals that coverage against nonpecuniary losses is currently available. An individual can insure against pecuniary losses resulting from an accident by purchasing disability insurance against lost expected wages, medical insurance against medical expenses, and, in the case of car accidents, collision insurance against damage to his car. In addition to this coverage against pecuniary losses, the individual can purchase accidental death or dismemberment coverage. Accidental death or dismemberment insurance provides benefits for an accident victim based on the nature of the harm he suffers, irrespective of pecuniary losses. When purchased in addition to coverage against pecuniary losses, this type of coverage allows an individual to obtain coverage for nonpecuniary losses. See generally E. VAUGHN & C. ELLIOTT, *FUNDAMENTALS OF RISK AND INSURANCE* (2d ed. 1978). In addition, in the case of automobile accidents, individuals can purchase "uninsured motorist coverage." This insurance provides benefits when the other party to the accident is uninsured or underinsured equal to the damages the insured is legally entitled to recover for his bodily injury. As these damages include recovery for pain and suffering, a nonpecuniary loss, in addition to recovery for lost expected wages and medical expenses, the purchase of uninsured motorist coverage enables the insured to obtain coverage for some of his nonpecuniary losses.

In addition to this analysis of insurance markets, recent empirical analysis suggests that physical injury does affect the victim's marginal utility of income. Viscusi & Evans, *Utility Functions That Depend on Health Status: Estimates and Economic Implications*, 80 AM. ECON. REV. 353, 371 (1990). Although Viscusi and Evans conclude that the efficient level of insurance is less than the victim's pecuniary loss, *id.* at 371-72, their study is only the first study of the issue. Additional empirical analysis is needed before one can conclude whether efficient insurance ever exceeds purely pecuniary losses.

150. See *supra* text accompanying notes 76-80.

cause. This Article refers to this tort rule as a "no-liability rule" and to the equilibrium that results under this rule as the "no-liability equilibrium."¹⁵¹

Under a no-liability rule, each individual bears his own expected accident costs but does not bear the accident costs of others.¹⁵² The no-liability equilibrium thus occurs at the level of care and the level of insurance coverage that maximize an individual's expected utility when he bears his own accident costs but does not have to pay for the accident costs of others.¹⁵³ The no-liability equilibrium is efficient only if a system of no-liability rules induces individuals to take the efficient level of care and to engage efficiently in risk spreading.

As explained previously, care-taking is efficient when each individual takes the level of care at which the social marginal cost of care equals the social marginal benefit of care.¹⁵⁴ The no-liability equilibrium level of care is the level at which the marginal cost of care to each individual equals his marginal benefit of care, absent tort liability to others. Thus, for the no-liability equilibrium to be efficient, the marginal cost and benefit of care that each individual faces in the absence of tort liability must equal the social marginal cost and benefit of care. Because the individuals who take care are the only people adversely affected by the care-taking, the social marginal cost of care taken by an individual is simply the marginal cost to that individual of his expenditures on care.¹⁵⁵ The social marginal cost of care thus equals the private marginal cost of care to the individual in the absence of liability rules. The social marginal benefit of care, however, does not equal the marginal benefit of care to an individual in the absence of liability rules. As discussed previously, the social marginal benefit of care is the benefit to both the individual in question and the other participants in the activity of the reduction in expected accidents resulting from the

151. Again, this Article restricts the discussion to uniform equilibria. The no-liability equilibrium level of care is thus the care level that a rational utility-maximizing individual would choose to take when he is not liable for damages and when he believes that all other individuals also are taking that same level of care. *See* Diamond, *supra* note 25, at 114.

152. *See* Brown, *supra* note 11, at 328, 337; Landes & Posner, *supra* note 11, at 872-73.

153. Equation (4) in Appendix I presents the expected utility of an individual who is not liable for any injuries to others. *See infra* Appendix I, p. 94. Equations (5) and (6) in Appendix I present the conditions for the no-liability equilibrium. *See infra* Appendix I, p. 94.

154. *See supra* text accompanying notes 139-43.

155. *See supra* text accompanying note 141.

individual's increased expenditures on care.¹⁵⁶ Under a no-liability rule, however, the marginal benefit to each individual of his care-taking is simply the direct benefit to him of the resulting reduction in the expected number of accidents. Because the individual is not liable for the costs he imposes on others, he derives no benefit from, and thus will not take into account, the impact of his care-taking on the expected accident costs of others. Accordingly, because under the no-liability rule each individual bears the full social cost of taking care but receives only part of the social benefits, his incentives to take care are inadequate, and he will take less care than is efficient.¹⁵⁷ Thus, even though each individual who imposes risk on others bears an equal risk of harm to himself, the tort system cannot attain Pareto efficiency absent the threat of liability for the losses that others sustain.¹⁵⁸

D. Efficient Tort Liability Rules for Single Activity Accidents

The discussion above raises the issue of whether any of the four standard tort rules¹⁵⁹ are Pareto efficient in that they can be used to induce efficient care-taking and risk spreading under the bilateral risk model that this Article employs.¹⁶⁰ This issue is particularly important because none of these tort rules satisfy the Pareto criterion under the unilateral risk model: negligence liability rules are not Pareto superior to a system of purely voluntary transactions,¹⁶¹ and strict liability rules are not Pareto efficient because they induce efficient care-taking only at the expense of efficient risk spreading¹⁶² and because under certain circumstances efficient damages are infinite.¹⁶³

1. Pure Strict Liability

Pure strict liability permits individuals to engage in the activity provided that each party to any accident that occurs pays the

156. See *supra* text accompanying notes 142-43.

157. See *infra* note 253. The text following Equation (6) in Appendix I discusses the no-liability equilibrium level of risk spreading. See *infra* Appendix I, pp. 94-95.

158. Given that, as will be shown, three negligence-inclusive liability rules are Pareto efficient, the fact that the no-liability equilibrium is not Pareto efficient implies (in the context of this model) that the three negligence-inclusive liability rules are Pareto superior to a rule of no-liability.

159. See *supra* note 33 and accompanying text.

160. Because this Article has already determined that all four tort rules are Pareto superior to a system of purely voluntary transactions, the only issue considered here is whether they are Pareto efficient.

161. See *supra* text accompanying notes 62-63.

162. See *supra* text accompanying notes 76-80.

163. See *supra* text accompanying notes 70-75.

other for his injuries according to an award schedule that the damage rules determine. Because this single activity accident model assumes that each party to an accident suffers the same injury,¹⁶⁴ under pure strict liability the parties to an accident are reciprocally liable to each other for the same amount of damages.¹⁶⁵ In other words, regardless of each individual's expenditures on care, in the event of an accident each party is reciprocally and identically liable to the other for damages, and damages paid and received always net to zero.¹⁶⁶ Because the parties to an accident neither pay nor receive net damages, each individual's expected utility under strict liability equals his expected utility were he not liable at all.¹⁶⁷ In other words, each individual has the same expected utility under a rule of pure strict liability that he would have under a rule of no-liability. Thus, the equilibrium resulting under pure strict liability is the no-liability equilibrium. Accordingly, because the no-liability equilibrium is inefficient,¹⁶⁸ the pure strict liability equilibrium is also inefficient.¹⁶⁹

This result, that under pure strict liability care-taking is inefficient and risk spreading is efficient, differs from the result obtained by the orthodox analysis of pure strict liability: strict liability can induce either efficient care-taking or efficient risk spreading, but not both.¹⁷⁰ This contrast, although interesting, does not present us with the possibility of Pareto efficient tort rules. We proceed, therefore, to consider the three remaining tort liability rules—pure negligence, negligence with contributory

164. See *supra* note 110 and accompanying text. For a discussion of the application of pure strict liability to a situation in which individuals do not necessarily suffer the same injury, see Appendix II, *supra* note 30 (demonstrating that pure strict liability is not efficient).

165. The conclusion that the parties are awarded identical, offsetting damages flows from the assumption that damage rules are such that parties with identical injuries receive identical damage awards. See *supra* note 125 and accompanying text.

166. Damages paid always equal damages received so long as one ignores the problem of judgment-proof defendants, as do this model and most analyses under the unilateral risk model. See, e.g., Brown, *supra* note 11, at 327; Landes & Posner, *supra* note 11, at 874; cf. Diamond, *supra* note 25, at 109 (analyzing single activity accidents under the assumption that neither party to an accident is judgment-proof).

167. See *infra* the discussion of pure strict liability in Appendix I, p. 96.

168. See *supra* text accompanying notes 152-58 and *infra* the discussion following Equations (5)-(6) in Appendix I, pp. 94-95.

169. See *infra* text accompanying notes 256-58; accord Diamond, *supra* note 25, at 117 (arguing that pure strict liability does not result in efficient care-taking for single activity accidents resulting in purely pecuniary losses). Pure strict liability is also inefficient when individuals have identical *expected* accident costs but may in fact suffer different injuries should an accident result. See *supra* note 30.

170. See *supra* text accompanying notes 76-80.

negligence, and strict liability with contributory negligence¹⁷¹—to determine whether they are Pareto efficient under the single activity accident model.

2. *Negligence-Inclusive Liability Rules*

This Article considers the remaining tort rules together under the term “negligence-inclusive liability rules” because under each of these rules an individual can dramatically affect his expected costs, either as a potential injurer or as a potential victim, by being nonnegligent; that is, by taking due care. The question presented is whether any of these rules are Pareto efficient. This discussion assumes that due care for purposes of both negligence and contributory negligence equals the efficient equilibrium level of care.¹⁷²

In the unilateral risk context, none of these rules satisfy the Pareto criterion, but for different reasons. Neither pure negligence nor negligence with contributory negligence is Pareto superior because these liability rules leave potential victims worse off than they would have been otherwise.¹⁷³ Strict liability rules, including strict liability with contributory negligence, are not Pareto efficient because they cannot induce both efficient care-taking and efficient risk spreading;¹⁷⁴ moreover, in some cases efficient damages under strict liability rules are infinite.¹⁷⁵

As shown below, these familiar conclusions as to the inefficiency of negligence-inclusive liability rules are not general conclusions about negligence-inclusive liability rules. They are, rather, conclusions about tort rules as applied to the unilateral risk model; they do not hold for single activity accidents. Analysis of the single activity accident model reveals three different conclusions. First, in contrast with the unilateral risk case, the three negligence-inclusive liability rules are identically efficient: when any one of the rules is efficient, the others are efficient, and should one rule be inefficient, the others will be as well. Second, in the case of single activity accidents, the three negligence-inclusive liability rules can induce both efficient care-taking and

171. See *supra* note 33 and accompanying text.

172. This assumption is standard in law and economics models. See, e.g., Brown, *supra* note 11, at 332; Diamond, *supra* note 25, at 114; Landes & Posner, *supra* note 11, at 868; Shavell, *supra* note 11, at 10.

173. See *supra* text accompanying notes 62-63.

174. See *supra* text accompanying notes 76-80.

175. See *supra* text accompanying notes 70-75.

efficient risk spreading. Finally, optimal tort rules for single activity accidents never require infinite damages.

The conclusion that the three negligence-inclusive liability rules are identically efficient follows from the fact that the individual's expected utility is identical regardless of which of the three negligence-inclusive liability rules are employed.¹⁷⁶ The conclusion that each individual's expected utility is identical under each of the three negligence-inclusive liability rules follows from the assumption that each party to an accident suffers the same physical injury.¹⁷⁷ Given this assumption, each negligence-inclusive liability rule results in an individual owing damages on net only when one party is negligent and the other is not; when both parties to an accident are either negligent or nonnegligent, neither party owes or receives damages on net.¹⁷⁸

Because the individual's expected utility function is the same under each of the three negligence-inclusive liability rules, it is not necessary to differentiate between the three rules to determine whether any of them are Pareto efficient. The condition that renders any one of the negligence-inclusive tort rules Pareto efficient renders them all Pareto efficient.¹⁷⁹ Whether these three

176. See *infra* Equation (7) in Appendix I, pp. 97-98. The fact that the individual's expected utility is the same under each of the three negligence-inclusive liability rules produces, but is not essential for, the conclusion that the three liability rules are identically efficient. Appendix II shows that when individuals may suffer different injuries should an accident occur, each individual's expected utility differs under the three negligence-inclusive liability rules, yet the three negligence-inclusive liability rules are nevertheless identically efficient. See *supra* note 30.

177. See *supra* note 110 and accompanying text. This assumption that both parties suffer the same injury is less artificial than it might at first seem once the focus shifts from disequilibrium conditions to the situation of the parties at the uniform equilibrium. At the uniform equilibrium, each individual engaged in the activity takes the same level of care. See *supra* note 135 (discussing uniform equilibria). It is not unreasonable to assume that when individuals are taking the same level of care, those involved in an accident will reasonably expect to suffer the same injuries. Moreover, this assumption that the injuries are the same produces, but is not essential to, the conclusion that the three negligence-inclusive liability rules are identically efficient. See *supra* note 176.

178. See *infra* Equation (7) in Appendix I, pp. 97-98.

179. See *id.* This conclusion, that if negligence with contributory negligence is efficient then pure negligence is also, contrasts with Diamond's results regarding the relative efficiency of pure negligence and negligence with contributory negligence as applied to purely pecuniary losses resulting from single activity accidents. In his analysis of single activity accidents, Diamond suggested that pure negligence will not be efficient because pure negligence has the "unsatisfactory nature" that when both individuals are negligent, the damages each individual owes and the damages he is entitled to receive net to zero. From this, Diamond concluded that pure negligence, like pure strict liability, does not induce efficient care-taking. See Diamond, *supra* note 25, at 117. Negligence with contributory negligence, on the other hand, always will induce efficient behavior under full

rules are identically Pareto efficient or identically inefficient remains to be seen.

Whether all three negligence-inclusive liability rules are Pareto efficient depends on whether these rules can induce an equilibrium at which each individual takes the efficient level of care and engages in efficient risk spreading.¹⁸⁰ Under the negligence-inclusive liability rules, two possible equilibria exist: one at which all individuals are negligent, the negligent equilibrium, and one at which each individual takes care greater than or equal to due care, the nonnegligent equilibrium.¹⁸¹ For the negligence-inclusive liability rules to be efficient, one of these equilibria must occur at the efficient equilibrium.

Consider first the negligent equilibrium. Under the negligence-inclusive liability rules, when both parties to an accident are negligent, each is liable to the other for damages. Because the parties suffer identical injuries, however, their net liability is zero. Each individual's expected utility when everyone is negligent is therefore identical to his expected utility under the no-liability rule.¹⁸² The negligent equilibrium accordingly occurs at the no-liability equilibrium, which is inefficient.¹⁸³

Consider now the nonnegligent equilibrium. Under each of the three negligence-inclusive liability rules, no one either receives or pays net damages when all individuals are nonnegligent; under both pure negligence and negligence with contributory negligence, no one is liable when both parties to an accident take due care; under strict liability with contributory negligence, each party is always liable to the other, but damages owed and received net to zero. Given this, it might appear that the nonnegligent equilibrium also occurs at the no-liability equilibrium and is inefficient. This conclusion, however, overlooks the fact that the nonnegligent equilibrium is not simply the levels of care and insurance that maximize the individual's expected utility when no one is liable for damages. Rather, it is the level of care

compensation damage rules when due care is set equal to the efficient level of care. *Id.* at 120. Diamond focused his analysis on negligence with contributory negligence, however, and did not fully analyze pure negligence. The results of this Article suggest that Diamond's analysis of pure negligence should be reexamined.

180. *See supra* note 135.

181. Once again we restrict our attention to the uniform equilibrium, at which all individuals exercise the same level of care. *See supra* note 135.

182. Compare Equation (8), *infra* Appendix I, p. 99, with Equation (6), *infra* Appendix I, p. 94.

183. *See infra* the discussion following Equations (4)-(6) and (8) in Appendix I, pp. 94-95, 99.

greater than or equal to due care and the level of insurance coverage that maximize an individual's expected utility when all others take the same level of care.¹⁸⁴ We have already determined that the no-liability equilibrium level of care is less than the efficient equilibrium level of care.¹⁸⁵ The no-liability equilibrium is therefore less than due care.¹⁸⁶ Thus, the nonnegligent equilibrium cannot occur at the no-liability equilibrium because an individual cannot take the no-liability equilibrium level of care and be nonnegligent. Given this, it can be shown that each individual maximizes his expected utility by taking the lowest amount of care that enables him to be nonnegligent.¹⁸⁷ Each individual, in other words, takes due care, which is equal to the efficient level of care.¹⁸⁸ As for efficient risk spreading, under each of the negligence-inclusive liability rules, neither party to an accident receives or pays net damage awards when all individuals take the efficient level of care.¹⁸⁹ When care-taking is efficient, therefore, damages do not affect an individual's ability to efficiently spread the risk of loss through the purchase of accident insurance. Accordingly, each individual, acting in his own best interest, will purchase efficient insurance coverage against the loss.¹⁹⁰ Thus, at the nonnegligent equilibrium, both care-taking and risk spreading are efficient.¹⁹¹ The possibility therefore exists that the three negligence-inclusive liability rules are efficient.

E. Efficient Damage Rules

The employment of efficient liability rules is not enough to realize this possibility of efficiency; damage rules also must be

184. See *infra* Equation (9) in Appendix I, p. 99.

185. See *supra* text accompanying notes 151-58 and *infra* note 253.

186. See *supra* note 172.

187. See *infra* Equations (9)-(12) in Appendix I, p. 99.

188. *Id.*

189. Damages paid and received under strict liability with contributory negligence cancel out.

190. See *infra* the discussion following Equations (9)-(12) in Appendix I, pp. 99-100.

Observe that the conclusion that under strict liability with contributory negligence risk spreading is efficient at the nonnegligent equilibrium follows from the assumption that the collateral source rule applies. Under this liability rule, net tort liability is zero and, given the collateral source rule, the injured individual is able to achieve efficient risk spreading through the purchase of insurance coverage. Thus, it is not the case, as some have suggested, see Cooter, *supra* note 33, at 393, that the collateral source rule invariably results in inefficient excessive compensation. Rather, circumstances exist, such as those considered here, in which the collateral source rule is efficient.

191. See Cooter, *supra* note 33, at 393.

efficient. Efficient damage rules are those that induce an equilibrium at which all individuals take the efficient level of care and engage in efficient risk spreading. This Article previously showed that the nonnegligent equilibrium is efficient and the negligent equilibrium is not efficient. Thus, to induce efficient behavior, damages must preclude an equilibrium at which all parties are negligent and induce the nonnegligent equilibrium.¹⁹²

The requirement that damages preclude the negligent equilibrium and induce the nonnegligent equilibrium establishes two conditions for efficient damage rules. To preclude the negligent equilibrium, damages must be such that an individual who thinks that everyone else is being negligent will nevertheless find it in his own best interests to exercise due care. To induce the nonnegligent equilibrium, damages must be such that an individual who thinks that everyone else is being nonnegligent will himself choose to be nonnegligent.

As previously established, the negligent equilibrium occurs at the no-liability equilibrium.¹⁹³ Accordingly, to satisfy the first condition, damages must be such that an individual who believes that others are taking the no-liability equilibrium level of care will himself elect to take due care, which is the efficient level of care.¹⁹⁴ To satisfy the second condition for efficient damages, damages must induce the nonnegligent equilibrium, which occurs at the efficient levels of care and insurance coverage.¹⁹⁵ To satisfy this condition, damages must be such that an individual who believes that everyone else is exercising due care will himself decide to take due care.¹⁹⁶ Efficient damage awards include all awards that equal or exceed the damage award necessary to satisfy both conditions, which are based on the liability necessary

192. This approach to efficient damages views damages as a "cost" of behaving other than as desired—in other words, as a sanction. It is therefore consistent with the approach to efficient damages under negligence liability rules presented by Robert Cooter in Cooter, *Prices and Sanctions*, 84 COLUM. L. REV. 1523, 1538-40 (1984). Observe, however, that here, where the risk is bilateral, the efficient damages rule under strict liability with contributory negligence also is a "sanction," whereas in Cooter's unilateral risk analysis, damages under a strict liability rule must equal the "price" of the injured entitlement in order to be efficient. *Id.*

193. See *infra* Equation (8) in Appendix I, p. 99.

194. In other words, damages must equal or exceed the amount that satisfies Equation (13) in Appendix I. See *infra* Appendix I, p. 101.

195. See *supra* text accompanying notes 184-91.

196. In other words, damages must equal or exceed the amount, D, that satisfies Equation (14) in Appendix I. See *infra* Appendix I, p. 101.

to induce an individual to incur the costs of exercising due care, instead of some lesser amount of care.¹⁹⁷

This analysis suggests that efficient damages for physical injuries to strangers resulting from single activity accidents differ substantially from those for physical injuries to strangers resulting from unilateral risks. In the unilateral risk context, in order to satisfy the Pareto criterion, damage awards must fully compensate victims for the injuries they suffer. Full compensation damages are necessary to ensure that tort rules do not make victims worse off and to ensure that injurers exercise the efficient level of care.¹⁹⁸ By contrast, the above analysis demonstrates that the three negligence-inclusive liability rules are optimal when applied to single activity accidents, even without full compensation damages.¹⁹⁹ This Article previously showed that full compensation damages are not needed to ensure that victims are no worse off than otherwise because tort rules for single activity accidents do not operate to anyone's detriment.²⁰⁰ Nor, as the discussion above reveals, are full compensation damages necessary to induce efficient care-taking in the case of single activity accidents. Minimum efficient damages for single activity accidents are based on the amount necessary to induce the individual to incur the costs of taking due care as opposed to taking a lesser level of care.²⁰¹ The full compensation value of the loss to the

197. See *infra* text accompanying Equations (13)-(15) in Appendix I, pp. 101-02. The conclusion that the same damage rule induces efficiency under each of the negligence-inclusive liability rules holds even when individuals may suffer different injuries. See *supra* note 30.

198. See *supra* text accompanying notes 62-63, 76-80.

199. The conclusion that full compensation damages are not necessary for efficiency contrasts dramatically with the conclusion of William Vickrey that, to induce efficient care-taking for automobile accidents, each party to the accident should be charged the full costs of the accident in that each party's damages should equal his own accident costs plus the accident costs of others. See Vickrey, *Automobile Accidents, Tort Law, Externalities, and Insurance: An Economist's Critique*, 33 LAW & CONTEMP. PROBS. 464, 465-67 (1968). His conclusion, which apparently was not derived using an explicit economic model of automobile accidents, conflicts with both the conclusions of this Article and with Diamond's conclusion that in the case of single activity accidents resulting in purely pecuniary losses, full compensation damages are sufficient—*albeit* not necessary—to induce efficient care-taking. See Diamond, *supra* note 25, at 116.

200. See *supra* text accompanying notes 22-24 and 132.

201. See *supra* text accompanying note 197 and Equations (13)-(16) in Appendix I, pp. 101-03. The conclusion that efficient damages are the amount that induces the defendant to take due care, instead of the amount that fully compensates the victim, is consistent with that reached by Haddock, McChesney, & Spiegel, *supra* note 9, at 17-21. Analyzing the issue of efficient risk taking in those situations in which a voluntary exchange between potential injurers and potential victims is possible (for example, when transaction

victim therefore is not relevant to the determination of efficient damages,²⁰² and thus full compensation damages are not necessary to induce efficient care-taking, even in the case of strict liability with contributory negligence.

The fact that single activity accidents do not require full compensation damages, as do unilateral risk accidents, leads to a number of other essential differences between efficient tort rules in the two situations.²⁰³ In the unilateral risk context, the full compensation requirement precludes pure negligence and negligence with contributory negligence from being Pareto su-

costs are low), they conclude that when voluntary transactions are possible, tort rules should induce injurers to bargain for the right to impose risk on the victim by dissuading the potential injurer from opting for the involuntary exchanges that tort law permits. To do this, they argue, damage rules for wrongful death should strive to strip away all gains to the defendant from his actions (that is, should "make the defendant whole"), rather than striving to make the victim "whole." *Id.* at 45-48. In the unilateral risk model that the authors implicitly employ, their damage rule is Pareto efficient only in the cases they explicitly consider: when prohibiting the imposition of risk without the potential victim's consent is desirable (because, for example, voluntary exchange is possible). Their analysis does not extend to the cases considered here, in which voluntary exchange is not possible and the goal is to reduce, but not eliminate, the amount of the risk imposed.

202. See *infra* Equations (13)-(16) in Appendix I, pp. 101-02. We obtain the same result when we assume that parties to an accident do not necessarily suffer the same injury. See *supra* note 30.

This is not to say, however, that the full compensation value of the loss is irrelevant. The cost to an individual of being injured, and *not* the efficient damage award, serves as the basis for determining the standard of due care. Even here, however, the relevant cost of the injury is the loss as the individual perceives it, not the full compensation *monetary* value of the loss. See *supra* text accompanying notes 139-43.

Although efficient damage awards do not depend on the full compensation value of the loss, they may depend on the wealth of the defendant. In the single activity accident context, the purpose of damage awards is to induce potential injurers to spend money on taking due care. Here, the individual has two incentives to spend money on care: first, his desire to avoid tort liability and second, his desire to reduce his own expected accident costs. We previously assumed that an individual's wealth affects his willingness to spend resources to avoid the risk of injury. See *supra* note 114. Given this assumption, the individual's wealth will impact on the amount of care he will take to avoid injury to himself. Thus, the wealthier he is, the more he will spend on care in the absence of tort liability. This suggests that an individual's wealth will affect the size of the damage award necessary to induce an individual to take due care. Consequently, current rules precluding juries from taking into account the defendant's wealth in setting compensatory damages should be reexamined. See Arlen, *Should Defendant's Wealth Matter?* 21 J. LEGAL STUD. ____ (forthcoming 1992) (examining the role of wealth differences for accidents resulting in purely pecuniary losses). But see Abraham & Jeffries, *Punitive Damages and the Rule of Law: The Role of Defendant's Wealth*, 18 J. LEGAL STUD. 415, 416-18 (1989) (agreeing with the current law of compensatory tort damages that precludes consideration of defendant's wealth based on an analysis that implicitly assumes that all losses are purely pecuniary).

203. The analysis below suggests that although the same tort damage rules currently govern unilateral risk and bilateral risk activities, efficiency may require different damage rules for these two classes of activities.

perior,²⁰⁴ creates a conflict under the strict liability rules between efficient care-taking and efficient risk spreading,²⁰⁵ and raises the possibility of infinite damage awards.²⁰⁶ In the single activity accident context, by contrast, none of these problems exist.

Single activity accidents do not require full compensation damages for Pareto superiority, and all three negligence-inclusive liability rules, including pure negligence and negligence with contributory negligence, are Pareto superior. Moreover, because the primary purpose of damages in this context is to induce efficient deterrence and not to compensate victims, no conflict exists between efficient care-taking and efficient risk spreading. In the unilateral risk model, Pareto efficiency requires that damages induce efficient care-taking and also compensate victims for their losses. This requirement creates problems because the nature of physical injuries is such that the damages that fully compensate victims produce efficient care-taking but preclude efficient risk spreading.²⁰⁷ In the single activity accident context, by contrast, damage awards function as a sanction for failing to exercise optimal care and not as a mechanism for compensating the victim,²⁰⁸ as demonstrated by the fact that under each of the three negligence-inclusive liability rules no one receives net damage awards at the efficient equilibrium. Thus, regardless of the magnitude of damage awards, at equilibrium, tort damages do not interfere with the ability of individuals to spread the risk of loss efficiently through the purchase of accident insurance. Both risk spreading and care-taking are therefore efficient.²⁰⁹ Further,

204. See *supra* text accompanying notes 62-63.

205. See *supra* text accompanying notes 76-80.

206. See *supra* text accompanying notes 70-75.

207. See *supra* text accompanying notes 76-80.

208. See *supra* note 192.

209. See *supra* text accompanying notes 188-91; *infra* Equations (9)-(12) and accompanying text in Appendix I, pp. 99-100. The conclusion that both care-taking and risk spreading are efficient also holds when individuals do not suffer the same injury. See *supra* note 30.

The conclusion as to efficient risk spreading must be qualified in one instance. An examination of Equation (3), *infra* Appendix I, p. 92, reveals that it is theoretically possible for the efficient equilibrium level of insurance to be negative. Should the efficient level of insurance coverage be negative, tort rules can be used to induce the efficient level of care. Individuals will not be able to achieve efficient risk spreading through the use of private insurance markets, however, because insurance markets are incomplete. Although the cases in which efficient insurance is negative are probably the exception, these cases are not just a theoretical fantasy. For example, it would be efficient for an individual facing the risk of being rendered permanently comatose to sell, rather than purchase, insurance against this risk if his postaccident wealth exceeds the amount

because efficient damages are based on the cost of care and not on the monetary full compensation value of the loss, minimum efficient damages for single activity accidents are never infinite.²¹⁰

Finally, in contrast with the unilateral risk case, the single activity accident context raises no concern about excessive damages. In this context, the two above conditions for efficient damages are the conditions for the *minimum* damage awards necessary to induce efficient care-taking and efficient risk spreading. Because in the single activity accident model, unlike in the unilateral risk model, an individual can avoid all damage liability by taking due care, damages are never too high.²¹¹ In other words, this model presents no efficiency concern about excessive damages.²¹²

CONCLUSION

The apparent impossibility of formulating tort rules for serious physical injuries to strangers that satisfy the Pareto criterion has troubled scholars since their earliest efforts to apply economics to law. The requirement that victims be fully compensated has precluded optimal tort rules, except in the unrealistic world of *ex ante* damages or complete insurance markets. Although full compensation damages are required for optimality in the unilateral risk context, this Article has shown that full compensation of victims for their losses is not essential for optimality in the class of bilateral risk activities known as single activity accidents. Moreover, this Article has shown that, in the single activity accident context, all three negligence-inclusive liability rules induce both efficient care-taking and efficient risk spreading, and that a single damage rule induces efficiency under each of these liability rules.

necessary to keep him alive—assuming he would prefer to be alive than dead. Even in the single activity accident context, then, circumstances will exist under which efficient risk spreading is unattainable as a practical matter. Theoretically, solutions to this problem exist, such as complete insurance markets and a market in “unmatured tort claims.” The problems with such solutions are discussed *supra* at text accompanying notes 89-93.

210. See *infra* Equations (13)-(15) in Appendix I, pp. 101-02. This conclusion follows because the cost of being nonnegligent, as opposed to being negligent, is finite, and thus the amount needed to induce the nonnegligent uniform equilibrium and to preclude the negligent uniform equilibrium invariably will be finite.

211. See *infra* Equations (13)-(16) in Appendix I, pp. 101-02.

212. Although full compensation damages are not necessary for efficiency, in a perfect world there is no efficiency argument against employing full compensation damages, or some other damage award in excess of minimum efficient damages, in order to serve some policy goal other than efficiency, so long as full compensation damages are possible.

The optimality of the tort system in this context results from the explicit recognition that the tort system does not, and need not, function as an involuntary market in health in which damages equal the value of the commodity destroyed. Rather, the tort system is a set of abstract rules, applicable to all individuals, that determine the conditions under which members of society may engage in a risky activity. Under this view of the tort system, the transaction permitted by the tort system is a non-market exchange in which individuals exchange the right to impose risk on each other. Damages, instead of measuring the price of an entitlement that another has taken involuntarily, serve as the mechanism by which individuals ensure that their fellows engage efficiently in the risky activity.

A question remains whether this analysis applies only to single activity accidents or whether it extends to most, or indeed all, bilateral risk activities. If the analysis applies only to single activity accidents, then we know that efficiency is possible in the single largest class of tort cases, but we have said little about the efficiency of the tort system in general. If the conclusions of this Article apply to bilateral risks generally, however, then a reexamination of the orthodox economic approach to tort law is in order. Addressing these issues will require considerable additional research on bilateral risks.

APPENDIX I

This Appendix presents the basic single activity accident model used in this Article and the proofs of the results discussed in the text. Appendix II²¹³ extends the model to the situation in which parties to an accident do not necessarily suffer the same losses.²¹⁴

I. THE MODEL

The model employed is based on Diamond's model of single activity accidents,²¹⁵ extended here to risk-averse individuals who face the possibility of suffering a serious permanent physical injury. Following Diamond, it is assumed that the relevant world is composed of a fixed²¹⁶ and large number ($n + 1$) of identical risk-averse²¹⁷ individuals. Each individual is endowed with wealth, W ,²¹⁸ and engages in an activity from which he derives a monetary benefit, $b(x)$. The enjoyment the person derives from engaging in the activity is greater the lower his expenditures on efforts to reduce accidents, referred to here as "care" and given by x .²¹⁹

Like automobile driving, this activity presents to those who engage in it a risk of being injured in an accident with another person.²²⁰ As in Diamond's model, and as in most analyses employing the orthodox model, this analysis assumes that all accidents involve only two individuals. It also assumes that the

213. See *supra* note 30.

214. *Id.*

215. Diamond, *supra* note 25.

216. The present Article considers only the issues of efficient care-taking and risk spreading. It does not consider the efficient level of activity, measured here by the number of drivers. See *supra* note 109.

217. The assumption that individuals are risk-averse is one of the assumptions that distinguishes this model from previous models of single activity accidents, all of which assume that individuals are risk-neutral. See Diamond, *supra* note 25, at 107; Ordoover, *Costly Litigation*, *supra* note 25, at 247.

218. W represents both the monetary value of the bundle of all other commodities that the individual possesses and the net present value of the individual's expected lifetime income. This Article assumes that wealth differences do not exist. See Arlen, *supra* note 202, for an examination of the role of wealth differences in determining efficient tort rules for accidents resulting in purely pecuniary losses.

219. Specifically, it is assumed that $b(x)$ is a decreasing, twice-differentiable, concave function of x . In other words, $b'(x) < 0$, $b''(x) < 0$ for all x . See Diamond, *supra* note 25, at 113 n.8.

220. It is assumed for the sake of simplicity that individuals engaging in this activity impose costs only on others engaging in the activity and that no one else is affected.

probability of an accident between any two people depends only on the amount of care³ that those individuals exercise. Thus, the expected number of accidents between one person and another (per unit time) is given by $p(x,y)$, where, as before, x represents the level of care taken by the individual in question and y represents the level of care exercised by the other person.²²¹ The expected number of accidents (per unit time) between a given person and the n other people involved in the activity, each of whom takes care level y , is $np(x,y)$.²²²

Should an accident occur between two people, both people suffer the same serious permanent physical injury.²²³ This physical injury has two distinct impacts on the victim: first, the injury results in a pecuniary loss,²²⁴ and second, the injury directly alters the victim's utility function.²²⁵ The text describes the nature of these two effects. The model represents these effects mathematically as follows. The purely pecuniary loss is represented by a reduction of m in the injured individual's wealth, where m is measured in dollars. The direct impact of the injury on the victim's utility function is represented by the use of the term $U_1(W)$ to describe the utility function of the individual when

221. It is assumed that the expected number of accidents declines, at a decreasing rate, with increases in the care taken by either party to the accident: in other words, that $p_1(x,y), p_2(x,y) < 0$, $p_{11}(x,y), p_{22}(x,y) > 0$, and $p_{11}(x,y)p_{22}(x,y) - p_{12}(x,y)^2 > 0$. In addition, it is assumed that the higher the care level of one potential party to an accident, the lower the impact on $p(x,y)$ of a given increase in care by the other potential party, that is $p_{12}(x,y) > 0$. It is also assumed that $p(x,y)$ is symmetric in that $p(x,y) = p(y,x)$, for all x, y . This latter assumption follows because any accident that occurs between two individuals occurs to each of them. See Diamond, *supra* note 25, at 114.

222. Because $np(x,y)$ represents the expected number of accidents between one individual and another individual, as opposed to the probability of an accident between one individual and another individual, $np(x,x)$ does not have to be less than 1. As an empirical matter, however, the expected number of accidents resulting in serious permanent physical injury in which any given individual will be involved (per unit time) is less than 1. See E. Landes, *supra* note 29, at 254.

223. See *supra* note 110. Appendix II relaxes the assumption that the two parties suffer the same physical injury, see *supra* note 30, and assumes that individuals face the same expected accident losses prior to the accident but may in fact suffer different injuries should the accident occur. Appendix II shows that this change in the model does not alter the basic conclusions of this Article.

224. See *supra* note 64 for a definition of the term "pecuniary loss."

225. See, e.g., S. SHAVELL, *supra* note 9, at 228-35, 245-54; Cooter, *supra* note 33, at 388-91; Friedman, *supra* note 5, at 85-86; see also Cook & Graham, *supra* note 64, at 146 (describing the impact on the utility function of the loss of an irreplaceable commodity). The assumption that the injury affects the victim's marginal utility of wealth is consistent with recent empirical analysis of utility functions that depend on health. Viscusi & Evans, *supra* note 149, at 371.

healthy and $U_2(W)$ to describe his utility function once injured.²²⁶ It is assumed that an individual is better off healthy than injured (i.e., $U_1(W) > U_2(W)$). In addition, it is assumed that the injury affects the individual's ability to use incremental additions to his wealth to produce utility; in other words, the injury affects the victim's marginal utility of wealth.²²⁷ Finally, the model assumes that not being injured, in other words that health, is a "normal good," which implies that the wealthier the individual becomes, the more he will be willing to spend to avoid the possibility of injury.²²⁸

Both individuals and courts are assumed to possess perfect information that is obtained costlessly. It also is assumed that there are no litigation or settlement costs.²²⁹ It is assumed that one who imposes risk on another pays damages only if the other suffers a physical injury²³⁰ and that people with identical injuries collect identical damages, as in the current tort system.²³¹ To spread risks, people can purchase accident insurance²³² and liability insurance²³³ in perfect and fair insurance markets.²³⁴ It is assumed that the collateral source rule applies; thus, a tort victim's receipt of insurance benefits does not affect the amount of damages he can collect from the tortfeasor. It is further assumed that no-fault insurance laws do not apply to the physical injuries considered here.²³⁵ Finally, it is assumed that the alter-

226. This notation is based on the following description of each individual's utility function. Each individual's preferences can be represented by the von Neumann-Morgenstern utility function, $U(W, \Theta)$, in which W is wealth and is measured in dollars and Θ is the state variable and is not measured in dollars. It is assumed that $\Theta = 1$ when the individual is healthy, and $\Theta = 0$ when the individual is injured. The notation that the text employs is based on the following definitions:

$U_1(W) \equiv U(W, 1)$

$U_2(W) \equiv U(W, 0)$.

See Cook & Graham, *supra* note 64, at 146. The assumption that individuals are risk-averse implies that $U_i''(W_i) < 0 < U_i'(W_i)$, where $i = 1, 2$.

227. See Cooter, *supra* note 33 (discussing the impact of an injury on the victim's marginal utility of wealth).

228. See *supra* note 114.

229. For a discussion of litigation costs in the single activity accident context, see Ordoover, *Costly Litigation*, *supra* note 25 (which expands Diamond's single activity accident model to include litigation costs).

230. In other words, the model considers only *ex post* damage rules. See *supra* text accompanying notes 92-93 (discussing the impracticability of *ex ante* damage rules). In addition, consistent with Diamond, the possibility of bankruptcy is ignored.

231. See *supra* note 125.

232. See *supra* note 126.

233. See *supra* note 127.

234. See *supra* note 128.

235. This Article ignores no-fault laws because the concern here is with an optimal tort system and because no-fault laws do not apply to the serious permanent injuries considered here. See *supra* note 29.

native to the tort system is a system that permits only voluntary exchanges and that high transaction costs preclude such voluntary exchanges.²³⁶ It is assumed that each individual is entitled initially to be free from any risk of injury that others engaging in the activity create.²³⁷

II. THE EFFICIENT EQUILIBRIUM

Because the text considers whether tort rules for single activity accidents are Pareto superior to a system that permits only voluntary exchanges, the Appendix does not examine this issue.²³⁸ Rather, the analysis that follows examines which, if any, of the standard tort rules are Pareto efficient.

As is explained in the text, to determine which, if any, tort rules are Pareto efficient, one must first determine the Pareto efficient equilibrium levels of care-taking and risk spreading.²³⁹ As the text explains, because the individuals engaged in the single activity are identically situated, the Pareto efficient equilibrium is determined by finding the equilibrium levels of care and insurance coverage that maximize the expected utility of an individual engaged in the activity.²⁴⁰

As is reflected in Equation (1), following Diamond, the analysis of efficient equilibria in this Article is limited to the equilibrium at which all individuals engage in the same behavior; that is, uniform equilibrium.²⁴¹ The efficient uniform equilibrium level of care, x^* , is the level of care taken by everyone that maximizes the expected utility of each person in equilibrium.²⁴² The efficient level of accident insurance coverage, A^* , is the level of coverage that maximizes each individual's expected utility at the efficient equilibrium level of care. Accordingly, the efficient uniform equilibrium levels of care and accident insurance are the levels of care, x , and insurance coverage, A , that maximize an individual's expected utility as given by Equation (1):²⁴³

236. The Article assumes that transaction costs are high because otherwise no reason for the tort system exists; individuals would achieve the efficient solution through voluntary exchanges. See Coase, *supra* note 46.

237. See *supra* text accompanying notes 9, 50.

238. See *supra* text accompanying notes 132-33.

239. See *supra* text accompanying notes 40-41.

240. See *supra* text accompanying notes 133-36.

241. Diamond, *supra* note 25, at 114.

242. *Id.* at 115.

243. The expected utility of each individual at the uniform equilibrium is given by his utility if uninjured minus his expected accident costs: $U_1(W_1) - np(x,x)[U_1(W_1) - U_2(W_2)]$. This is equivalent to Equation (1). The term $p(x,x)$ represents the expected number of accidents (per unit time) between two individuals who are both taking care level x .

$$[1] \quad EV(x,A) = (1-np(x,x))U_1(W_1) + np(x,x)U_2(W_2)$$

where

$$W_1 \equiv W + b(x) - np(x,x)A$$

$$W_2 \equiv W + b(x) - m + (1-np(x,x))A.$$

Maximizing Equation (1), we find that the efficient equilibrium levels of care and insurance are the levels of care, x^* , and insurance coverage, A^* , that satisfy Equations (2) and (3).²⁴⁴

$$[2] \quad b'(x)z = 2np_1(x,x)[U_1(W_1)-U_2(W_2)+Az]$$

$$[3] \quad U_1'(W_1) = U_2'(W_2)$$

where

$$z \equiv (1-np(x,x))U_1'(W_1) + np(x,x)U_2'(W_2).$$

The conditions for the Pareto efficient levels of care and insurance as given by Equations (2) and (3) are similar to those in the unilateral risk case. Equation (2) implies that here, as in the case of unilateral risks, care-taking is efficient when each individual takes the level of care, x^* , at which the social marginal cost of care equals the social marginal benefit of care.²⁴⁵ We may more readily see the nature of the social costs and benefits of care by rewriting Equation (2) to incorporate Equation (3) as follows:

$$b'(x)U_1'(W_1) = 2np_1(x,x)[U_1(W_1)-U_2(W_2)+AU_1'(W_1)].$$

From this equation we see that the social marginal cost of care is the cost to the individual in question of exercising care, $b'(x)U_1'(W_1)$. The social marginal benefit of care is the benefit to everyone engaged in the activity of an increase in the care by the individual in question. This benefit is composed of both the benefit to the individual himself of the resulting decrease in his expected number of accidents, $np_1(x,x)[U_1(W_1)-U_2(W_2)+AU_1'(W_1)]$, as well as the benefit to each of the n other individuals of the resulting reduction in the expected number of accidents between each of them and the individual in question, $np_1(x,x)[U_1(W_1)-U_2(W_2)+AU_1'(W_1)]$.²⁴⁶

As for efficient insurance coverage, Equation (3) implies that the efficient level of coverage, A^* , is the level at which the

244. It is assumed that the second-order conditions for x^* and A^* to be maxima of Equation (1) hold. This assumption requires that $np(x^*,x^*)U_2''(W_2^*) < (1+np(x^*,x^*))U_1''(W_1^*)$. It also is assumed that the efficient uniform equilibrium is unique.

245. See Diamond, *supra* note 25, at 115.

246. The term $U_1(W_1)-U_2(W_2)+AU_1'(W_1)$ represents the cost to the individual of being injured plus the cost of purchasing insurance. The actual cost to an individual of being injured is $U_1(W_1)-U_2(W_2)$. The term $AU_1'(W_1)$ is the cost to the individual of the insurance coverage he purchases in order to spread the risk of being injured.

insured individual's marginal utility of wealth if he is healthy, $U_1'(W_1)$, equals his marginal utility of wealth should he be injured, $U_2'(W_2)$. In other words, to be efficient, insurance coverage must be such that the utility an individual would derive from the last dollar of wealth he has available to him is the same whether he is healthy or injured. This is the standard condition for efficient insurance coverage. Here, however, as in the case of unilateral risks,²⁴⁷ the efficient level of insurance coverage for physical injuries is a level of coverage that provides less than full compensation for the loss.²⁴⁸ It will be shown that even though efficient coverage is less than full coverage, here, unlike the unilateral risk case, there is no conflict between efficient care-taking and efficient risk spreading.

III. THE NO-LIABILITY EQUILIBRIUM

Before turning to our consideration of the standard tort rules, we first consider whether tort liability is necessary by consid-

247. *E.g.*, S. SHAVELL, *supra* note 9, ch. 9.

248. The proof of this conclusion, which is presented below, is based on the proof contained in Cook & Graham, *supra* note 64, at 148-50, and depends on the assumption of this model that health is a normal good. *See supra* note 114.

Following Cook and Graham, we define $R(W_2)$ as the maximum amount the individual would be willing to pay to exchange a certainty of being injured for a certainty of being uninjured,

[3A] $U_2(W_2) = U_1[W_1 - R(W_2)] = U_1[W_2 + m - R(W_2)]$.

The assumption of this model that health is a normal good implies that $R'(W_2) > 0$. *See supra* note 114. $R'(W_2) > 0$ in turn implies that

[3B] $U_2'(W_2) < U_1'[W_2 + m - R(W_2)] = U_1'(W_1 - R(W_2))$.

See Cook & Graham, *supra* note 64, at 147.

Now, consider Equation (3B) when the individual has purchased full insurance coverage A' . Defining full insurance coverage, A' , as the amount that equates the total utility in the injury and no-injury states of the world,

$$U_1[W + b(x) - np(x, x)A'] = U_2[W + b(x) + (1 - np(x, x))A' - m],$$

Equation [3A] can be rewritten as follows:

$$U_1[W_2' + m - A'(W_2')] = U_1(W_1') = U_2(W_2')$$

where

$$W_1' \equiv W_1 \text{ at } A = A'$$

$$W_2' \equiv W_2 \text{ at } A = A'.$$

Given this, $R'(W_2) > 0$ implies $U_2'(W_2') < U_1'(W_1')$. Thus, at $A = A'$, $U_1'(W_1) \neq U_2'(W_2)$, and therefore full insurance coverage is not efficient. *See* Cook & Graham, *supra* note 64.

To determine whether efficient coverage, A^* , is less than or greater than full coverage, A' , we consider the impact of a change in insurance coverage on $U_1'(W_1)$ and $U_2'(W_2)$. The total derivatives of $U_2'(W_2)$ and $U_1'(W_1)$ when care is efficient and $A = A'$ are:

$$dU_1'(W_1)/dA = -np(x^*, x^*)U_1''(W_1) > 0$$

and

$$dU_2'(W_2)/dA = (1 - np(x^*, x^*))U_2''(W_2) < 0.$$

Accordingly, because at A' , $U_2'(W_2') < U_1'(W_1')$, to satisfy the requirement of Equation (3B), A^* must be less than A' .

ering whether Pareto efficiency is possible under a tort rule that permits individuals to engage in the activity without having to pay damages for injuries they cause. The uniform equilibrium that results under this rule is called the no-liability equilibrium.²⁴⁹

The expected utility of a person who, with all others, may engage in the activity without having to pay damages for any injuries that result is given by Equation (4), which describes the expected utility of someone who must bear the cost of his own, but not of anyone else's, injuries:

$$[4] \quad EV(x,A) = (1-np(x,y))U_1[W + b(x)-np(x,y)A] + \\ np(x,y)U_2[W + b(x)-m + (1-np(x,y))A].$$

The no-liability uniform equilibrium occurs at the level of care and the amount of insurance coverage that maximize each individual's expected utility as given by Equation (4), when everyone takes the same level of care (i.e., when $y = x$).²⁵⁰ The no-liability equilibrium thus occurs at the level of care, x° , and insurance coverage, A° , that satisfy Equations (5) and (6), when y equals x :²⁵¹

$$[5] \quad b'(x)z = np_1(x,x)[U_1(W_1) - U_2(W_2) + Az]$$

$$[6] \quad U_1'(W_1) = U_2'(W_2).$$

A comparison of Equation (6) and Equation (3) reveals that the condition for the no-liability equilibrium level of insurance is the same as that for the efficient uniform equilibrium level of insurance: each individual purchases the insurance coverage at which his marginal utility of wealth is the same whether he is injured

249. Again we restrict the discussion to uniform equilibria. We define the no-liability equilibrium level of care as the care level, x° , that a rational utility-maximizing individual would choose to take when he is not liable for damages and when he believes that all other individuals also are taking care level x° . Diamond, *supra* note 25, at 114. This use of the term "no-liability equilibrium" differs from Diamond's. Diamond used the term "no-liability equilibrium" to refer to the equilibrium that results absent liability rules. *Id.* at 113. When the efficiency criterion employed is the Pareto criterion, such a construction of the no-liability equilibrium implicitly assumes that individuals are not initially entitled to be free from the risk in question. Here, it is assumed that individuals are entitled to be free from the risk in question, with the result that absent liability rules no one can engage in the activity. See *supra* text accompanying notes 132-33. Thus, here the term "no-liability equilibrium" refers to the situation in which individuals engage in the activity but do not pay damages.

250. This analysis of individuals' behavior, and the analysis in the rest of this Article, assumes that each person takes the behavior of others, as he perceives it, as given and that each person's expectations about others' behavior are correct. See Diamond, *supra* note 25, at 113.

251. It is assumed that the second-order conditions for x° and A° to be maxima of Equation (4) hold, and that the no-liability equilibrium is unique.

or uninjured. The actual level of insurance coverage purchased at the no-liability equilibrium differs from the efficient equilibrium level of coverage, however, because care-taking, and thus wealth, at the no-liability equilibrium differs from care-taking, and thus wealth, at the efficient equilibrium.

The text below presents the intuitive explanation of why the no-liability equilibrium level of care is different from, and in fact less than, the efficient level of care.²⁵² The mathematical proof follows from a comparison of Equations (2) and (5) and is presented in the footnotes. As Equation (5) reveals, each individual at the no-liability equilibrium takes the level of care at which his marginal cost of care equals his marginal benefit of care. As Equations (2) and (5) show, the individual's marginal cost of care, $b'(x)z$, equals the social marginal cost of care, but because the individual does not bear the cost of the risks he imposes on others, his marginal benefit of care, $np_1(x,x)[U_1(W_1) - U_2(W_2) + Az]$, is only half the social marginal benefit of care, $2np_1(x,x)[U_1(W_1) - U_2(W_2) + Az]$. As a result, his incentives to take care are inadequate, and he will exercise less care than is efficient.²⁵³ Accordingly, the no-liability equilibrium is inefficient.

252. See *supra* text accompanying notes 153-58.

253. The precise proof that the no-liability equilibrium level of care, x° , is less than the efficient level of care, x^* , proceeds as follows. By definition, each individual's expected utility at the efficient uniform equilibrium, $EV(x^*, A^*)$, exceeds his expected utility at the no-liability equilibrium, $EV(x^\circ, A^\circ)$. This implies that if care must be increased in order to move from $EV(x^\circ, A^\circ)$ to $EV(x^*, A^*)$, then $x^* > x^\circ$. In other words, if $dEV/dx > 0$ at (x°, A°) , then $x^* > x^\circ$.

The total derivative of each individual's expected utility with respect to x , evaluated at (x°, A°) , is given by:

$$dEV/dx \text{ (at } x^\circ, A^\circ) = np_1(x^\circ, x^\circ)[U_2(W_2^\circ) - U_1(W_1^\circ) - A^\circ z^\circ].$$

Given that $np_1(x^\circ, x^\circ) < 0$, dEV/dx implies that the no-liability equilibrium level of care, x° , is less than the efficient level of care, x^* , if $U_2(W_2^\circ) - U_1(W_1^\circ) - A^\circ z^\circ < 0$.

It is easily determined that when the no-liability equilibrium level of insurance coverage is nonnegative, then $U_2(W_2^\circ) - U_1(W_1^\circ) - A^\circ z^\circ < 0$. From Equation (6), we know that at the no-liability equilibrium $U_2'(W_2^\circ) = U_1'(W_1^\circ)$. This in turn implies that $z^\circ = U_1'(W_1^\circ) = U_2'(W_2^\circ) \geq 0$. Given this, the fact that the no-liability equilibrium level of insurance coverage, A° , is less than full coverage, A^* , see *supra* note 248, implies that $U_2(W_2^\circ) - U_1(W_1^\circ) < 0$. Thus, whenever the no-liability equilibrium level of insurance coverage is nonnegative, the no-liability equilibrium level of care is less than the efficient level of care.

In certain circumstances, the no-liability equilibrium level of insurance coverage is negative, however. See *supra* note 209. It can be shown that when insurance coverage is negative, it is possible that $U_2(W_2) - U_1(W_1) - Az > 0$. It thus might appear that x° sometimes exceeds x^* . This is not the case, however. Although $U_2(W_2) - U_1(W_1) - AU_1'(W_1) > 0$ is possible, this condition never holds at the no-liability equilibrium. In other words, it is never the case that $U_2(W_2^\circ) - U_1(W_1^\circ) - A^\circ U_1'(W_1^\circ) > 0$. This claim follows from Equation (5), the first-order condition for the no-liability equilibrium level of care. Equation (5)

IV. EFFICIENT TORT LIABILITY RULES

We turn now to the issue of Pareto efficient tort liability rules. Tort rules are efficient if they induce individuals to take the efficient level of care and to engage in the efficient amount of risk spreading.²⁵⁴ This Section examines the four standard tort liability rules²⁵⁵ to see whether they induce Pareto efficient care-taking and risk spreading.

A. *Pure Strict Liability*

Pure strict liability permits individuals to engage in an activity provided that each party to an accident pays the other for his injuries according to an award schedule determined by the damage rules. The model employed here assumes that each party to an accident suffers the same injury.²⁵⁶ Under pure strict liability, therefore, the parties to an accident are reciprocally liable to each other for the same amount of damages.²⁵⁷ As a result, when all other individuals take care level y , the expected liability of an individual under pure strict liability is

$$EV(x,A) = (1-np(x,y))U_1[W + b(x)-np(x,y)A] + np(x,y)U_2[W + b(x)-m + (1-np(x,y))A].$$

Comparing this equation with Equation (4) reveals that an individual's expected utility under a pure strict liability rule is identical to his expected utility under a no-liability rule. Given this, the uniform equilibrium under pure strict liability occurs at the levels of care and insurance coverage that satisfy Equations (5) and (6). The pure strict liability equilibrium, in other words, occurs at the no-liability equilibrium and is not efficient.²⁵⁸

implies that at the no-liability equilibrium:

$$b'(x^0)z^0 = np_1(x^0, x^0)[U_1(W_1^0) - U_2(W_2^0) + A^0 z^0].$$

Examining Equation (5) we see that, because $b'(x^0)z^0 < 0$ and $np_1(x^0, x^0) < 0$, for Equation (5) to hold it must be the case that $U_1(W_1^0) - U_2(W_2^0) + A^0 z^0 > 0$. Thus, when the no-liability uniform equilibrium exists, it will always be the case that $x^0 < x^*$.

254. See *supra* text accompanying notes 134-36.

255. See *supra* note 33.

256. See *supra* note 110 and accompanying text.

257. The conclusion that the court awards parties identical, offsetting damages flows from the assumption that damage rules are such that parties with identical injuries receive identical damage awards. See *supra* text accompanying note 125.

258. See *supra* note 253 and text accompanying notes 252-53. Appendix II shows that even when individuals do not necessarily suffer the same injury, pure strict liability is inefficient. See *supra* note 30.

B. Negligence-Inclusive Liability Rules

The question arises whether the three remaining liability rules—pure negligence, negligence with contributory negligence, and strict liability with contributory negligence—are Pareto efficient. Because under each of these rules an individual can dramatically affect his expected liability by being nonnegligent—that is, by exercising due care—we refer to these rules as “negligence-inclusive liability rules.”

In the case of single activity accidents that result in identical injuries, the three negligence-inclusive liability rules are identically efficient. This conclusion follows from the fact that the expected utility of an individual is the same, regardless of which of the three negligence-inclusive liability rules is employed.²⁵⁹ Equation (7) presents the expected utility of an individual under each of the negligence-inclusive liability rules. To demonstrate the generality of the conclusion that an individual's expected utility is the same under each of the three rules, Equation (7) abandons the assumption that all other individuals take the same level of care:²⁶⁰

$$\begin{aligned}
 [7] \quad EV(x, A) = & \sum_{i=1}^n (1-p(x, y_i)) U_1[W + b(x) - \sum_{i=1}^n p(x, y_i) A] \\
 & + \sum_{i=1}^n p(x, y_i) g(y_i) U_2[W + b(x) - m + D + (1 - \sum_{i=1}^n p(x, y_i)) A] \\
 & + \sum_{i=1}^n p(x, y_i) f(y_i) U_2[W + b(x) - m + (1 - \sum_{i=1}^n p(x, y_i)) A]
 \end{aligned}$$

if the individual takes due care and

259. See *infra* note 260.

260. The following assumptions form the basis for Equation (7): the collateral source rule governs; due care for purposes of determining both negligence and contributory negligence equals the efficient uniform equilibrium level of care, x^* ; and people with identical injuries receive identical damages.

When individuals are identically situated before the accident occurs but may not be identically situated afterwards in that they may suffer different injuries, then the individual's expected utility function differs under each of the three negligence-inclusive liability rules. Even in this situation, however, the same damage rule induces efficient behavior under each of the three negligence-inclusive liability rules. See *supra* note 30.

$$\begin{aligned}
& \sum_{i=1}^n (1-p(x, y_i)) U_1[W + b(x) - \sum_{i=1}^n p(x, y_i)A] \\
& + \sum_{i=1}^n p(x, y_i) g(y_i) U_2[W + b(x) - m + (1 - \sum_{i=1}^n p(x, y_i))A] \\
& + \sum_{i=1}^n p(x, y_i) f(y_i) U_2[W + b(x) - m + (1 - \sum_{i=1}^n p(x, y_i))A - D]
\end{aligned}$$

otherwise, where y_i is the level of care taken by the i^{th} of the n other individuals ($1 \leq i \leq n$); $f(y_i)$ is a function that selects for those of the other n individuals who are not negligent,

$$f(y_i) = \begin{cases} 1 & \text{if } y_i \geq x^* \\ 0 & \text{if } y_i < x^* \end{cases}$$

and $g(y_i) = 1 - f(y_i)$ is the function that selects for those of the other n individuals who are negligent.²⁶¹

Because an individual's expected utility function is the same under each of the three negligence-inclusive liability rules, differentiating between the three rules to determine whether any of them are Pareto efficient is unnecessary; if any one of them is efficient, they all are efficient.²⁶² What remains to be determined is whether all three rules are identically Pareto efficient or identically inefficient. This determination depends on whether these rules produce a uniform equilibrium such that individuals take the efficient level of care and engage in efficient risk spreading.

Under the negligence-inclusive liability rules, two potential uniform equilibria exist. The first, the negligent uniform equilibrium, occurs when all individuals are negligent. The second, the nonnegligent uniform equilibrium, occurs when each individual exercises care greater than, or equal to, due care.

261. Those familiar with Diamond's model of single activity accidents will observe that Diamond, in representing the individual's expected utility function under a negligence with contributory negligence liability rule, integrated the "distribution" $n(y)$ of individuals taking care level y over y . Diamond, *supra* note 25, at 117. In Equation (7), Diamond's integrals have been replaced with summations because this Article, like Diamond's model, assumes the existence of a finite number of individuals. Accordingly, the "distribution" function $n(y)$ employed by Diamond is zero almost everywhere, and thus the integral of $n(y)$ over the range $y=0$ to $y=1$ is zero. Therefore, integrating over the "distribution" $n(y)$ as Diamond did will not yield the individual's expected utility. To obtain the individual's expected utility when the number of individuals is finite it is necessary to sum, as is done here, over the level of care taken by the individuals.

262. See *supra* note 179.

Consider, first, the negligent uniform equilibrium. Under the negligence-inclusive liability rules, when both parties to an accident are negligent, each is liable to the other for damages. Because the parties suffer identical injuries, however, the damages each individual owes equal those he is entitled to receive. Thus, damages owed and received net to zero. Equation (8) presents each individual's expected utility when everyone is negligent:

$$[8] \quad EV(x,A) = (1-np(x,y))U_1(W_1) + np(x,y)U_2(W_2).$$

The negligent uniform equilibrium thus occurs at the levels of care and insurance that maximize Equation (8), when all individuals take the same level of care.

Equation (8) is identical to Equation (4), the individual's expected utility in the absence of liability. Equation (8), therefore, is maximized at the levels of care and insurance coverage that satisfy Equations (5) and (6): that is, at the no-liability equilibrium levels of care and insurance, x^0 , A^0 . The negligent uniform equilibrium accordingly is inefficient.²⁶³

As the negligent uniform equilibrium is never efficient, the efficiency of the negligence-inclusive liability rules depends on whether the nonnegligent uniform equilibrium is efficient. Under each of the three negligence-inclusive liability rules, when all individuals are nonnegligent, no one either receives or pays net damages.²⁶⁴ The nonnegligent uniform equilibrium thus occurs at the levels of care and insurance that maximize Equation (9), when everyone exercises the same level of care:

$$[9] \quad EV(x,A) = (1-np(x,y))U_1(W_1) + np(x,y)U_2(W_2) + \lambda(x-x^*),$$

where Equation (9) incorporates the condition that each individual takes due care (i.e., that $x \geq x^*$).

Maximizing Equation (9) when all individuals take the same level of care yields the following three conditions that determine the nonnegligent uniform equilibrium levels of care and insurance:²⁶⁵

$$[10] \quad U_1'(W_1) = U_2'(W_2)$$

263. See *supra* note 253 and text accompanying notes 252-53.

264. Under both pure negligence and negligence with contributory negligence, no one is liable when both parties to an accident take due care; under strict liability with contributory negligence, each party is liable to the other but the damages owed and received net to zero.

265. See generally E. SILBERBERG, *THE STRUCTURE OF ECONOMICS* 374-77 (1978) (describing the solution to constrained maximization problems, such as this one).

$$[11] \quad b'(x)z - np_1(x,x)[U_2(W_2) - U_1(W_1) - Az] + \lambda \leq 0$$

$$[12] \quad x - x^* \geq 0; \lambda = 0 \text{ if } x - x^* > 0,$$

where λ , the Lagrange multiplier, is used to incorporate the constraint that care-taking at the nonnegligent equilibrium must equal or exceed due care.²⁶⁶

Because the no-liability equilibrium level of care is less than the efficient equilibrium level of care ($x^0 < x^*$),²⁶⁷ we see from Equation (11) that the constraint that care must equal or exceed due care is binding. Given this, Equations (11) and (12) imply that $\lambda > 0$ and thus that the nonnegligent equilibrium level of care equals the efficient equilibrium level of care. In other words, individuals at the nonnegligent uniform equilibrium take the efficient level of care. A comparison of Equation (10) and Equation (3) reveals that because care-taking is efficient, risk spreading is also efficient, and that individuals at the nonnegligent equilibrium purchase insurance coverage of A^* . Thus, if it is possible to induce individuals to be nonnegligent, the resulting uniform equilibrium will occur at the efficient levels of care and insurance. The possibility accordingly exists that the three negligence-inclusive liability rules are efficient.

C. *Efficient Damage Rules*

To realize this possibility of efficiency, more is needed than efficient liability rules; damage rules also must be efficient. Efficient damage rules are those rules that induce an equilibrium at which all individuals take the efficient level of care and engage efficiently in risk spreading. This Appendix previously showed that the nonnegligent uniform equilibrium is efficient and the negligent uniform equilibrium is not efficient. To induce efficient behavior, therefore, damages must preclude the equilibrium at which all parties are negligent and induce an equilibrium at the nonnegligent uniform equilibrium.

As the text explains, the requirement that damages preclude the negligent equilibrium and induce the nonnegligent equilibrium establishes two conditions for efficient damage rules. To preclude

266. See generally A. CHIANG, FUNDAMENTAL METHODS OF MATHEMATICAL ECONOMICS 376-79 (1974) (describing the essentials of the Lagrange-multiplier method of solving constrained maximization problems); E. SILBERBERG, *supra* note 265, ch. 12 (describing the essentials of the Lagrange-multiplier method of solving constrained maximization problems).

267. See *supra* note 253 text accompanying notes 252-53.

the negligent equilibrium, damages must be such that an individual who thinks that everyone else is being negligent will nevertheless find it in his own best interests to exercise due care. To induce the nonnegligent equilibrium, damages must be such that an individual who thinks that everyone else is being nonnegligent will himself choose to be nonnegligent.

This Appendix previously showed that the negligent uniform equilibrium occurs at the no-liability uniform equilibrium. Accordingly, to satisfy the first condition, damages must be such that an individual who believes that others are taking the no-liability equilibrium level of care, x^o , will himself elect to take due care, x^* . In other words, damages must equal or exceed the amount, D^r , that satisfies Equation (13):

$$[13] \quad EV(x^*, \hat{A}; y = x^o) = EV(x^o, A^o; y = x^o)$$

where

$$EV(x^*, \hat{A}; y = x^o) = (1 - np(x^*, x^o))U_1[W + b(x^*) - np(x^*, x^o)\hat{A}] + np(x^*, x^o)U_2[W + b(x^*) - m + (1 - np(x^*, x^o))\hat{A} + D^r]$$

is the individual's expected utility under a negligence-inclusive liability rule when he takes level of care x^* , purchases insurance \hat{A} , and when all other individuals take level of care x^o (i.e., $y = x^o$); where \hat{A} is the level of insurance coverage that maximizes $EV(x^*, A; y = x^o)$; and where

$$EV(x^o, A^o; y = x^o) = (1 - np(x^o, x^o))U_1(W_1^o) + np(x^o, x^o)U_2(W_2^o)$$

is the individual's expected utility at the no-liability uniform equilibrium.

To satisfy the second condition for efficient damages, damages must induce the nonnegligent uniform equilibrium, which occurs at the efficient levels of care and insurance coverage. To satisfy this condition, damages must be such that an individual who believes that everyone else is taking due care will himself decide to take due care. In other words, damages must equal or exceed the amount, D^p , that satisfies Equation (14):

$$[14] \quad EV(x^*, A^*; y = x^*) = EV(x^n, I^n; y = x^*)$$

where

$$EV(x^*, A^*; y = x^*) = (1 - np(x^*, x^*))U_1(W_1^*) + np(x^*, x^*)U_2(W_2^*)$$

is the individual's expected utility under a negligence-inclusive liability rule at the efficient uniform equilibrium; and

$$EV(x^n, I^n; y = x^*) = (1 - np(x^n, x^*))U_1[W + b(x^n) - np(x^n, x^*)I^n] + np(x^n, x^*)U_2[W + b(x^n) - m + (1 - np(x^n, x^*))I^n - D^p]$$

is the individual's expected utility under a negligence-inclusive

liability rule when all other individuals take due care, but the individual in question takes care $x^n < x^*$ and purchases insurance coverage of I^n , where $x^n < x^*$ is the level of care, and I^n is the amount of accident and liability insurance that maximizes $EV(x, I; y = x^*)$.²⁶⁸

To be efficient, damage rules must satisfy both Equations (13) and (14). Efficient damage awards therefore include all awards that equal or exceed the greater of D^r or D^p . In other words, under each of the negligence-inclusive liability rules, all damage awards greater than or equal to D^* , where

$$[15] \quad D^* = \text{Max } [D^r, D^p],$$

will induce individuals to exercise the efficient level of care and consequently to purchase the efficient amount of insurance.²⁶⁹

An examination of Equations (13)-(15) reveals that minimum efficient damages are based on each individual's costs of care—on the amount needed to induce him to be nonnegligent—and not on the costs of the injury. As a result, full compensation damages are not necessary for efficiency; in fact, the full compensation value of the injury (which is the C such that $U_1(W_1) = U_2(W_2 + C)$) does not even enter into the analysis.

The following example reveals the irrelevance of the full compensation value of the injury to the measure of efficient damages. Consider the case in which a serious permanent injury reduces the victim's total utility of wealth but does not affect his marginal utility of wealth. In other words, assume that $U_1'(W) = U_2'(W)$, for all W . In this case, Equation (15) implies that damages are guaranteed to be efficient if they satisfy Equation (16):²⁷⁰

268. In other words, I^n is such that $U_1'[(W + b(x^n) - np(x^n, x^*))I^n] = U_2'[W + b(x^n) - m + (1 - np(x^n, x^*))I^n - D^p]$.

269. The conclusion that the same damage rule induces efficiency under each of the negligence-inclusive liability rules holds even when individuals are identically situated *ex ante* but may not be identically situated *ex post* in that they may suffer different injuries. See *supra* note 30.

270. When $U_1'(W) = U_2'(W)$ for all W , we can define $U_1(W) = U_2(W) + k$, where $k > 0$ and is not measured in monetary terms. In this situation, the requirement of efficient insurance that $U_1'(W_1) = U_2'(W_2)$ implies that insurance coverage will be such that the individual's wealth in the healthy and injured states of the world are equal, that is, $W_1 = W_2$. Equations (13) and (14) can now be rewritten as Equations (13a) and (14a):

[13a] $U_1[W + b(x^*) - np(x^*, x^o)(m - D^r)] - np(x^*, x^o)k = U_1[W + b(x^o) - np(x^o, x^o)m] - np(x^o, x^o)k$

[14a] $U_1[W + b(x^*) - np(x^*, x^*)m] - np(x^*, x^*)k = U_1[W + b(x^n) - np(x^n, x^*)(m + D^p)] - np(x^n, x^*)k$.

Because $np(x^*, x^o)k < np(x^o, x^o)k$, damages are guaranteed to exceed those that satisfy Equation (13a) and therefore are guaranteed to satisfy the first requirement for efficient damages if damages equal

$$\frac{b(x^o) - b(x^*)}{np(x^*, x^o)}$$

Because $np(x^*, x^*)k < np(x^n, x^*)k$, damages are guaranteed to exceed those that satisfy

$$[16] \quad D^* \geq \text{Max} \left[\frac{b(x^n) - b(x^*)}{np(x^n, x^*)}, \frac{b(x^o) - b(x^*)}{np(x^o, x^*)} \right]$$

Damages as determined by Equation (16) are clearly based on the individual's cost of care function, $b(x)$, and not on the full compensation value of the loss, C . In fact, calculating efficient damages in this case does not require knowledge of the full compensation value of the injury.

The fact that single activity accidents do not require full compensation damages, as does the unilateral risk case, leads to a number of other essential differences between efficient damages in the two situations. Section III, part E of the text discusses in detail these differences between the conclusions of the orthodox model and those of the single activity accident model.

Equation (14a) and therefore are guaranteed to satisfy the second requirement for efficient damages if damages equal

$$\frac{b(x^n) - b(x^*)}{np(x^n, x^*)}$$

where x^n is defined as in the text. Damages therefore are guaranteed to be efficient if they equal the larger of

$$\frac{b(x^o) - b(x^*)}{np(x^*, x^o)} \quad \text{or} \quad \frac{b(x^n) - b(x^*)}{np(x^n, x^*)}$$

Which of these is larger cannot be determined absent additional restrictions.