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Working Paper

Comparative vigilance: A simple guide

Working Paper, No. 2008-11

Provided in Cooperation with:
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Suggested Citation: Feldman, Allan M.; Singh, Ram (2008) : Comparative vigilance: A simple guide, Working Paper, No. 2008-11, Brown University, Department of Economics, Providence, RI

This Version is available at:
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Comparative Vigilance: A Simple Guide

Brown University Department of Economics Working Paper No. 2008-11

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September 3, 2008

Abstract

In this paper we discuss a new tort liability rule, which we call super-symmetric comparative negligence and vigilance. When both injurer and victim in an accident are *negligent*, it provides for liability shares that depend on the degrees of negligence of the two parties, similar to the standard comparative negligence rule. Unlike standard liability rules, however, when both parties are *vigilant* (i.e., taking more care than is efficient), the rule provides for liability shares that depend on the parties' degrees of vigilance. Moreover, when one party is negligent and the other is non-negligent, our rule provides for *variable* liability shares, that respond to both carefulness and carelessness of the parties. Our liability rule is equitable; it has no discontinuity at the efficient point where both parties are just meeting their standards of care; and it provides incentives that guarantee the injurer and victim will choose the efficient care levels. This paper does not include theorems and proofs; rather it explains the results with the aid of a simple example, laid out in an easy 3 x 3 table.

Keywords: Comparative vigilance, equity, economic efficiency, tort liability rules, Nash equilibrium, social costs, pure comparative vigilance, super-symmetric rule.

JEL classification: K13, D61.

1 INTRODUCTION

In a typical tort case one party, the injurer, has harmed another party, the victim. If it is an accidental tort (rather than an intentional one), the harm is the result of an accident, a random event whose chance of occurring, or probability, depends on the amounts of care taken by one or both parties. The victim's harm is measured in terms of money damages. This measurement might be easy (how much to repair that car?) or difficult (how much to compensate for that death?). Tort law commonly sets a *standard of care*, or an amount of care to be taken by a party which is legally sufficient: If a party takes that much care or more she has met the standard and is *non-negligent*, but if she takes less care, she is *negligent*. A tort liability rule specifies how the money damages should be split between victim and injurer. A negligence-based liability rule splits the damages in a way that generally depends on the negligence or non-negligence of the injurer and the victim. Commonly-used negligence-based liability rules include simple negligence (all damages fall on the injurer if she negligent, otherwise on the victim), negligence with a defense of contributory negligence (all damages fall on the injurer if she is negligent and the victim is non-negligent, otherwise on the victim), and negligence with a defense of comparative negligence (all damages fall on the injurer if she is negligent and the victim is not, are split between them according to degree of fault if both are negligent, and fall on the victim otherwise).

All the standard rules share these properties:

(A) When one party is negligent and the other is not, the negligent party bears all the accident loss.

(B) When both parties are non-negligent, the liability shares do not depend on the degrees of "vigilance" shown by the parties, that is, the care levels above and beyond what is efficient.

(C) When both parties are non-negligent, all the accident loss falls on just one party.[1]

[1] See the modeling of liability rules in Brown (1973), Diamond (1974), Polinsky (1989), Landes and Posner (1987), Shavell (1987), Barnes and Stout (1992), Posner (1992), Levmore (1994), Kaplow (1995), Biggar (1995), Miceli (1997), Cooter and Ulen (1997), Feldman and Frost (1998), Jain and Singh (2002), Kim (2004), Kim and Feldman (2006), and Singh (2007), among others.

In this paper we will describe a new liability rule which drops properties A, B and C. This new rule treats victim and injurer symmetrically when both are negligent, as does any rule incorporating the doctrine of comparative negligence, which splits damages according to degree of fault (or degree of negligence). But it also treats them symmetrically when both are non-negligent, splitting the damages according to their degrees of vigilance. Moreover, the logic of the rule is exactly the same when both parties are negligent and when both parties are non-negligent. For these reasons we call our new rule the *super-symmetric comparative negligence and vigilance rule*, or the *super-symmetric rule* for short.[2]

There are several reasons why we want to drop these properties. First consider property A. Consider auto accidents, assume the single care dimension is vehicle speed, and suppose the standard of care is set at the speed limit of 50 mph. Suppose a collision of 2 vehicles results in $10,000 in damages to the victim. Then if the victim is going exactly 50 mph (and just meeting the standard of care) and the injurer is going 51 mph (slightly too fast), all damages fall on the injurer. But now suppose the injurer is going 100 mph. If an accident occurs she is treated exactly the same way (paying $10,000 in damages) as she would be if she had been going 51 mph. Of course accidents may be more probable at the higher speed, and damages may be greater, all of which the injurer may consider. But our point is this: if the victim is meeting her care standard, the legal treatment of the injurer is the same whether she is slightly negligent, or grossly negligent. Similarly, suppose the injurer is going 51 mph (slightly too fast), and the victim is considering whether to drive 50 mph (just meeting the standard) or 35 mph (being very careful). Under property A, the consequences for injurer and victim are the same in either scenario. If the injurer is failing to meet her standard, the legal treatment of the two parties is the same whether the victim is just meeting her standard, or being exceptionally careful.

So property A implies that over large ranges of care and/or carelessness, a liability rule is entirely *unresponsive* to changes in care level, neither rewarding additional care nor penalizing additional carelessness. Moreover, although property A makes the liability rule broadly unresponsive, it simultaneously makes it *too responsive* at one critical point. What we mean is apparent from the speeding example: If the injurer is going 51 mph and the victim is going 50 mph, all the damages fall on the injurer. If the injurer slows down very slightly, to 50 mph,

[2] See Feldman and Singh (2008) for an extensive mathematical analysis of the super-symmetric rule.

and the victim speeds up very slightly, to 51 mph, there is an abrupt shift in liability: suddenly all the damages fall on the victim. Such an abrupt change in liability assignments is a mathematical *discontinuity*, and property A requires a discontinuity at the crucial point where victim and injurer are just meeting their standards of care.

When both injurer and victim are negligent, the traditional rule of negligence with a defense of contributory negligence gives the injurer a free pass: all the damages stay with the victim. This creates an obvious inequity. In terms of the speeding example, if both victim and injurer are driving 51 mph in the 50 mph zone, contributory negligence puts all of the damages on the victim. In contrast, the more modern rule of negligence with a defense of comparative negligence splits the damages according to degree of fault, or degree of negligence. For the purposes of economic analysis, degree of negligence it is most naturally defined, for the injurer, as the injurer's amount of carelessness divided by the total amounts of carelessness of the two parties, with an analogous definition for the victim. In the speeding example, it would be easiest to calculate the degrees of negligence as 1 mph / (1 mph + 1 mph) = ½ for each party, and comparative negligence would then split the damages equally. On the other hand, if the speeds were 51 mph for the victim and 59 mph for the injurer, the rule would put 9/10 of the damages on the injurer and 1/10 on the victim. So comparative negligence is appealing for its equitable treatment of victim and injurer when both are negligent, each is penalized based on the relative degree of her carelessness.

But property C implies there is no splitting of damages when both parties are *non-negligent*, and property B implies that the liability assignment when both are non-negligent must be entirely unresponsive to the parties' degrees of care. For instance, under the rule of negligence with comparative negligence as a defense, whether the injurer is driving at 50 mph (just meeting the standard) and the victim is driving at 35 mph (being very careful), or vice versa, all damages fall on the victim. The inequity is clear: negligence with comparative negligence as a defense produces equitable outcomes when both are negligent, but not when both are non-negligent.

This paper builds on the work of many authors.[3] In particular, Calabresi and Cooper (1996), Honoré (1997) and Parisi and Fon (2004) have argued that when parties are either both negligent, or both non-negligent, equity considerations suggest sharing of liability - making only one party bear all the loss is not justified. Parisi and Fon use the term "comparative diligence" for a concept somewhat similar to our "comparative vigilance." Moreover, some studies have shown that courts and juries are inclined toward comparative apportionment of losses when both parties are negligent *and* when both are non-negligent. See Feldman & Singh (2008) for further discussion on this point. Kahan (1989), Grady (1989), Honoré (1997) and Singh (2007) have argued that property A, and the discontinuity in liability assignments it implies, may not be consistent with the doctrine of "causation." On the other hand, some papers have focused on the importance of properties A, B, and C for inducing efficiency; see for instance Jain and Singh (2002), Kim (2004), Parisi and Fon (2004), and Singh (2006). However, as we shall show below, efficiency can be had without these 3 properties.

In this paper we discuss a new liability rule, super-symmetric comparative negligence and vigilance, that drops properties A, B and C. When one party is negligent and the other is non-negligent, the rule provides for *variable* liability shares that respond to degrees of carefulness or carelessness of the two parties. When both parties are *negligent*, the rule provides for liability shares that depend on degrees of negligence of the two parties, as per comparative negligence, but when both parties are *non-negligent* the rule also provides for variable liability shares that depend on the degrees of vigilance of the two parties. The rule is equitable, the rule has no discontinuity at the point where both parties are just meeting their standards of care, and the rule results in the choice of efficient care levels by the two parties.

This paper is meant to be relatively non-mathematical. Our rigorous mathematical results are laid our elsewhere (Feldman & Singh (2008)). Here we try to minimize notation, and we rely on one simple example to explain the new liability rule as well as other related rules. In section 2 we define most of our terms, lay out our example, and discuss the doctrines

[3]Calabresi (1965) noted that fault based liability rules ignore the value of deterring faultless accidents. For criticism of the modeling of liability rules on various grounds, including properties B and C, see Grady (1989), Kahan (1989), Marks (1994), Burrows (1999) and Wright (2002). See Marks (1994) and Miceli (1996) for commentary on Grady (1989). For an analysis of the comparative negligence rule see Schwartz, (1978), Landes and Posner (1980), Cooter and Ulen (1986), Haddock and Curran (1985), Rubinfeld (1987), and Rea (1987). For a critical review of some of these works see Liao and White (2002), and Bar-Gill and Ben-Shahar (2003).

of pure comparative negligence and pure comparative vigilance. In section 3 we use our example to analyze our new super-symmetric rule. In section 4 we summarize and conclude.

.

2 THE MODEL, THE TERMINOLOGY, AND THE EXAMPLE INTRODUCED

We assume there are two people, called *X* and *Y*, who are involved in some activity that creates a risk of accidents. An accident is an unintended and unforeseen bad outcome. If an accident occurs, there is one victim, who sustains a money loss $L > 0$, and one injurer, who sustains no loss. We assume that *X* is the injurer and *Y* is the victim.[4]

Parties *X* and *Y* can spend money to reduce the likelihood of accidents. If an accident occurs, a court will measure each party's care by looking at the money she has spent (rather than by looking at her vehicle speed, as in the example of section 1). Let x and y represent the care expenditures of *X* and *Y*. We let $p(x, y)$ represent the probability of an accident, which depends on the care levels of the two people. The average, or expected, accident loss is $p(x, y)L$. We assume the parties are *risk neutral*; this means they only consider expected losses, and do not consider other statistical properties of risk such as standard deviations.

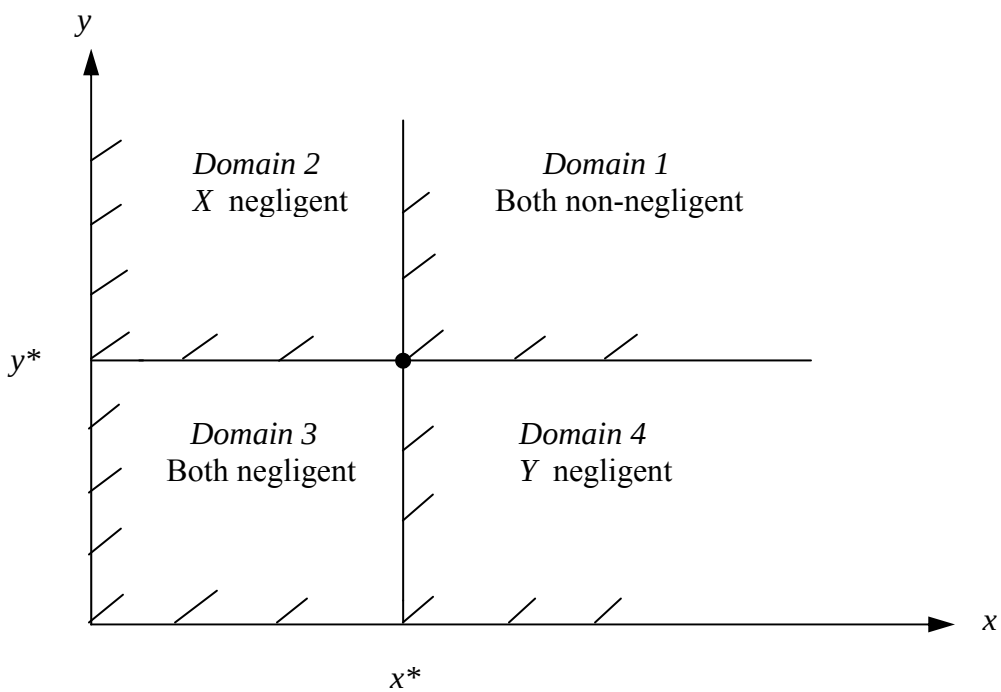
Total social cost (*TSC*) is defined as the sum of care-taking costs of both parties and expected accident costs. That is, $TSC = x + y + p(x, y)L$. We let (x^*, y^*) represent the combination of care levels which *minimizes* total social cost. We assume this care combination is unique. *Efficiency* means minimizing total social cost, and so we call (x^*, y^*) the *efficient* care combination.

If an accident occurs, the victim takes the injurer to court. Victim, injurer and court are all assumed to have full information about care levels, the accident probability function, the loss *L*, and the expected loss. All know x^* and y^*. The court sets a standard of care for each of the parties. If a party's care level falls below that standard, she is *negligent*; if the care level is greater than or equal to the standard, she is *non-negligent*. If she takes *more* care than the standard, she is *vigilant*. We make the standard assumption that, for each party, *the court sets*

[4] See Kim (2003) and Kim and Feldman (2006) for discussions of negligence-based rules when there is uncertainty about who will be the victim and who will be the injurer.

the standard of care at the efficiency level.[5] That is, party *X* is negligent if $x < x^*$, and she is non-negligent if $x \geq x^*$. She is vigilant if $x > x^*$. Similar terminology holds for party *Y*.

Negligence-based liability rules are usually defined by specifying how they operate in 4 different domains: *Domain 1*, where both parties are non-negligent; *domain 2*, where party *X* is negligent and party *Y* is non-negligent; *domain 3*, where both parties are negligent; and *domain 4*, where party *Y* is negligent and party *X* is non-negligent. The figure below shows the 4 domains in a typical model where the variables x and y are allowed to be any number greater than or equal to zero. (Cross-hatching indicates which domains include which boundary lines.)



We will use the following convenient notation: For any x and any y, let $\Delta x = x - x^*$ and $\Delta y = y - y^*$. Note that Δx (or Δy) can be positive, zero, or negative, depending on whether *X* (or *Y*) is vigilant, is at the efficient care level, or is negligent, respectively. If Δx is positive, it represents party *X*'s excess care. If negative, it represents her shortfall in care, or her carelessness.

When both parties are negligent, the defense of comparative negligence places accident losses on each party according to that party's degree of fault. As we see it, the most natural

[5] See Feldman & Kim (2005) for some discussion of this basic assumption.

measure of party *X*'s relative degree of fault, or degree of negligence, is her shortfall in care divided by the sum of shortfalls of the two parties, or $\frac{\Delta x}{\Delta x + \Delta y}$. (Note that each of the Δ terms is a negative number, and so the ratio shown is positive.) Similarly, party *Y*'s degree of negligence is $\frac{\Delta y}{\Delta x + \Delta y}$. Under what is called a *pure comparative negligence liability rule*, losses are allocated to the two parties according to these weights, which sum to 1, when both are negligent.

Now suppose both parties are non-negligent, and suppose at least one is strictly non-negligent, or vigilant. Imagine you are trying to construct a liability rule for splitting the accident loss, a rule which parallels the pure comparative negligence rule, but which works when both parties are non-negligent. It is easy to measure party *X*'s excess care; this is again $\Delta x = x - x^*$, and party *Y*'s is $\Delta y = y - y^*$. Both of these numbers are now non-negative, since we are assuming both parties are non-negligent, and at least one is positive, since we are assuming at least one party is vigilant. Therefore we can easily measure party *X*'s relative degree of *vigilance* using the same ratio as before, namely $\frac{\Delta x}{\Delta x + \Delta y}$, and similarly for *Y*'s degree of vigilance. The denominator of the fraction cannot be zero because we have assumed at least one is vigilant, and the sum of the two degree of vigilance factors is 1.

Under pure comparative negligence, the larger a party's degree of negligence, the larger is the fraction of the loss the court puts on her. Obviously we don't want to have a party's larger degree of *vigilance* to result in a *larger* fraction of the loss on that party. We want the opposite. The straightforward way to do this is to allocate losses, when both are non-negligent and at least one is vigilant, by setting party *Y*'s fraction of the loss equal to party *X*'s degree of vigilance, and vice versa. (That is, *X*'s degree of vigilance becomes *Y*'s share, and vice versa.) We will call a liability rule that does this in the both parties non-negligent domain a *pure comparative vigilance* rule.[6]

[6] The reader may question the wisdom of a rule that rewards care in excess of the efficient level. But care, whether at a less-than-efficient or greater-than-efficient level, is always a "good" rather than a "bad," since it reduces accident probabilities and expected losses. It is beneficial to the person making the expenditure, and it is also beneficial to the other person. Our view is that if it makes sense to reward additional care in domain 3, as comparative negligence does, then it makes sense to reward additional care in the other domains as well.

We can now turn to our simple example. In this example, each party can spend 0, 1, or 2 on care (in dollars or other currency units). That is, we have 3 discrete care levels that can be used by *X* and *Y*. Each pair of care levels (x, y) produces some accident probability $p(x, y)$ and some expected loss $p(x, y)L$. In the tables below we suppress the probability function and only show the expected losses. The example will be presented in a series of almost-self-explanatory tables. Table 1 simply shows expected losses contingent on the care levels. Table 2 shows total social cost in each cell, found by adding together the expected loss and the sum of the corresponding care amounts. It is clear from table 2 that the efficient pair of care levels is $(x^*, y^*) = (1,1)$. Whatever legal rule may be used, the goal is to induce the two parties to get to the efficient combination of care levels. Table 3 shows the 4 domains: domain 1, where both are non-negligent, domains 2 and 4, where one is negligent and the other is non-negligent, and domain 3, where both parties are negligent.

Table 1 Expected Losses

Y's Care:			
2	6	4.5	4
1	7	5	4.5
0	10	7	6
X's Care:	0	1	2

Table 2 Total Social Costs

Y's Care:			
2	8	7.5	8
1	8	7	7.5
0	10	8	8
X's Care:	0	1	2

Note that the efficient point is (1,1).

Table 3 Domains & Total Social Costs

Y's Care:			
2	8	7.5	8
1	8	7	7.5
0	10	8	8
X's Care:	0	1	2

Green	Domain 1 - both non-negligent.
Gold	Domain 2 – *X* negligent
Red	Domain 3 –both negligent
Orange	Domain 4 - *Y* negligent

In the next table we show the amounts of excess care (or, if negative, excess carelessness) for parties X and Y. That is, table 4 shows the pairs $(\Delta x, \Delta y)$. We get these numbers in the obvious way, remembering that the correct amounts of care are 1 and 1. Table 5 shows the degrees of negligence and vigilance of the two parties in domain 1 (both-non-negligent) and domain 3 (both negligent), and is derived from table 4. (Recall the degrees of either negligence or vigilance are $\frac{\Delta x}{\Delta x + \Delta y}$ for party X and $\frac{\Delta y}{\Delta x + \Delta y}$ for party Y. Also note that, when both are non-negligent, the formula is only computed when at least one is vigilant.) In order to make table 5 (and many of our subsequent tables) more transparent, we won't show pairs or *vectors* in the cells of a single table; instead we will show the numbers for X in a table on the left, and the numbers for Y on the right.

Table 4 Excess of (or Shortfall in) Care

$(\Delta x, \Delta y)$

Y's Care:			
2	(-1,1)	(0,1)	(1,1)
1	(-1,0)	(0,0)	(1,0)
0	(-1,-1)	(0,-1)	(1,-1)
X's Care:	0	1	2

Table 5 Degrees of Negligence & Vigilance

Y's Care:			
2		0	0.5
1			1
0	0.5		
X's Care:	0	1	2

Degrees for *X*

Y's Care:			
2		1	0.5
1			0
0	0.5		
X's Care:	0	1	2

Degrees for *Y*

At this point we can use our tables to analyze liability rules. As a preliminary, we will consider negligence with a defense of pure contributory negligence. It places all losses on the victim Y if she is negligent and the injurer X is not. This gives the bottom row, right two cells of the table (domain 4). It also places all losses on Y if both parties are non-negligent. This gives the upper right four cells (domain 1). It places all losses on the injurer X if she is negligent and the victim Y is not. This gives the left column, upper two 2 cells (domain 2).

But if both parties are negligent, as in the lower left cell (domain 3), the losses are split according to relative degrees of negligence, which are $(0.5, 0.5)$ in this easy example. When we apply this allocation of losses, it implies that the expected losses of table 1 above get split between the two parties in the fashion shown in table 6 below. As with table 5, table 6 shows numbers for *X* on the left side and for *Y* on the right. In table 7 which follows, we simply add each party's own care expenditures to the table 6 figures. Therefore table 7 shows, for party *X*, *x* + the part of expected loss allocated to the injurer by the liability rule, and, for party *Y*, *y* + the part of expected losses allocated to the victim by the liability rule. We call these sums the *total burdens* on the respective parties.

Examination of table 7 establishes that the efficient combination of care levels $(x^*, y^*) = (1,1)$ is a Nash equilibrium under negligence with a defense of pure comparative negligence. That is, given that *X* is choosing a care level of 1, it is best for *Y* to choose a care level of 1, in which case her burden (from the right hand table) is 6. Conversely, given that *Y* is choosing a care level of 1, it is best for *X* to choose a care level of 1, in which case her burden (from the left hand table) is 1. This table illustrates a well-known result: negligence with pure comparative negligence as a defense is efficient, in the sense that it induces the parties to settle on the efficient pair of care levels, as a Nash equilibrium.

Table 6 Expected Losses Placed on the Parties, Negligence With Pure Comparative Negligence

Y's Care:			
2	6	0	0
1	7	0	0
0	5	0	0
X's Care:	0	1	2

Losses on *X*

Y's Care:			
2	0	4.5	4
1	0	5	5.5
0	5	7	6
X's Care:	0	1	2

Losses on *Y*

Table 7 Total Burdens on the Parties, Negligence With Pure Comparative Negligence

Y's Care:			
2	6	1	2
1	7	1	2
0	5	1	2
X's Care:	0	1	2

Burden on *X*

Y's Care:			
2	2	6.5	6
1	1	6	6.5
0	5	7	6
X's Care:	0	1	2

Burden on *Y*

Note: The pair (x,y) = (1,1) is efficient, and is a unique Nash equilibrium.

Next we will use our tables to analyze pure comparative *negligence plus vigilance*. In particular, consider a liability rule that (a) places all damages on the negligent party when one party is negligent and the other is non-negligent (property A), (b) uses pure comparative negligence when both parties are negligent, and (c) uses pure comparative vigilance when both parties are non-negligent and at least one is vigilant. We need to also specify the loss allocation at the efficient point (1,1). We will assume: (d) the losses at the efficient point all fall on the victim (as with a standard negligence rule, rather than a strict liability rule). These new assumptions require that we go back to table 6 and modify the top right 4 cells (domain 1) to reflect assumptions (c) and (d). When modifying the 3 cells where at least one party is vigilant, we use table 5, and we remember that under pure comparative vigilance, *X*'s degree of vigilance becomes *Y*'s share, and vice versa. This produces table 8 below. We then add back the care levels of the two parties to get the total burdens on the parties, shown in table 9.

Table 8 Expected Losses Placed on the Parties, Pure Comparative Negligence plus Vigilance

Y's Care:				*Y*'s Care:			
2	6	4.5	2	2	0	0	2
1	7	0	0	1	0	5	4.5
0	5	0	0	0	5	7	6
X's Care:	0	1	2	*X*'s Care:	0	1	2
		Losses on *X*				**Losses on *Y***	

Table 9 Total Burdens on the Parties, Pure Comparative Negligence plus Vigilance

Y's Care:				*Y*'s Care:			
2	6	5.5	4	2	2	2	4
1	7	1	2	1	1	6	5.5
0	5	1	2	0	5	7	6
X's Care:	0	1	2	*X*'s Care:	0	1	2
		Burden on *X*				**Burden on *Y***	

Note: The pair (x,y) = (1,1) is efficient. However the unique Nash equilibrium is at (2,2).

Table 9 provides important results: ***Adding pure comparative vigilance in the straightforward way to pure comparative negligence produces a liability rule that does not work.*** That is, ***the efficient point may not be a Nash equilibrium***, and ***there may be an inefficient combination of care levels that is a Nash equilibrium***.

3 THE SUPER-SYMMETRIC RULE

We now describe the super-symmetric comparative negligence and vigilance rule. It works as follows:

(a) At the efficient point $(x^*, y^*) = (1,1)$, the liability rule will assign a specific share of losses $\overline{w}_X$ to party *X*, and a specific share $\overline{w}_Y$ to party *Y*. The law must specify these weights in advance; once chosen, they become an integral part of the rule. The weights are non-negative and sum to 1. If an accident occurs at the efficient care levels, the court splits the losses between the two parties according to $\overline{w}_X$ and $\overline{w}_Y$. A "negligence-style" super-symmetric rule sets $(\overline{w}_X, \overline{w}_Y) = (0,1)$. ("No liability without fault.") A "strict-liability-style" super-symmetric rule sets $(\overline{w}_X, \overline{w}_Y) = (1,0)$. ("If victim is non-negligent, injurer pays.") A "strictly equitable" super-symmetric rule sets $(\overline{w}_X, \overline{w}_Y) = (0.5, 0.5)$. ("At the efficient point, divide the losses equally.") For the purposes of our example, we will generally assume $(\overline{w}_X, \overline{w}_Y) = (0,1)$, making most of what follows comparable to what we have already done in tables 8 and 9 above. (At the end, however, we will briefly consider the $(\overline{w}_X, \overline{w}_Y) = (0.5, 0.5)$ super-symmetric rule.) Note that our results do not depend on what $\overline{w}_X$ and $\overline{w}_Y$ are set at, as long as they are set in advance and fixed.

(b) For any point (x, y), in any of the domains, if an accident occurs the court must calculate several terms involving ratios of probabilities (or, equivalently in our model, expected losses). The terms of interest are $\frac{p(x^*, y^*)}{p(x, y)}$, $1 - \frac{p(x^*, y^*)}{p(x, y)}$, $\frac{p(x^*, y)}{p(x, y)}$, and $\frac{p(x, y^*)}{p(x, y)}$. Consider first $\frac{p(x^*, y^*)}{p(x, y)}$. In domain 3, where both parties are negligent, $p(x, y) > p(x^*, y^*)$ (i.e., the accident probability is too high), and so the ratio is less than 1. In domain 1, if both parties are non-negligent and at least one is vigilant, then

$p(x,y) < p(x^*, y^*)$ (i.e., the accident probability is too low) and the ratio is greater than 1. In domains 2 and 4, when one party is negligent and the other is non-negligent, this ratio can be less than 1, equal to 1, or greater than 1. What we call the *difference term*, namely $1 - \frac{p(x^*, y^*)}{p(x,y)}$, must be positive in domain 3, when both parties are negligent, and it must be negative in domain 1, if at least one party is vigilant.

(c) Whenever any accident occurs, no matter where (x, y) may be, the court calculates partial liability shares to place on the parties: For party *X* the partial share is $\overline{w}_X \frac{p(x^*, y^*)}{p(x,y)}$, and for *Y* it is $\overline{w}_Y \frac{p(x^*, y^*)}{p(x,y)}$. These terms, however, represent just *parts* of their liability shares; they will generally not sum to 1. Translating to expected values, these terms will add $\overline{w}_X p(x^*, y^*)L$ to party *X*'s burden, and $\overline{w}_Y p(x^*, y^*)L$ to party *Y*'s burden. Note that these partial burden terms are constant, and do not vary with (x, y).

(d) When both parties are negligent (domain 3) and an accident occurs, the court will add an additional term to the liability share of each party. Party *X's additional liability share* will be equal to her *relative degree of negligence* times *the difference term*, and similarly for party *Y*. Remember that the difference term is positive when both parties are negligent. The increment to *X*'s liability share is $\frac{\Delta x}{\Delta x + \Delta y}\left(1 - \frac{p(x^*, y^*)}{p(x,y)}\right)$; party *Y*'s is similar. In terms of expected values, these incremental terms add

$\frac{\Delta x}{\Delta x + \Delta y}(p(x,y)L - p(x^*, y^*)L)$ to party *X*'s burden, and

$\frac{\Delta y}{\Delta x + \Delta y}(p(x,y)L - p(x^*, y^*)L)$ to party *Y*'s burden. When both parties are negligent, both these increments are positive.

(e) When both parties are non-negligent (domain 1), and at least one is vigilant, the court will add precisely the same terms to liability shares and expected values as in the both-parties-negligent case. That is, exactly the same formulas will apply. This works

because the difference term $1-\frac{p(x^*,y^*)}{p(x,y)}$ is *negative* when both are non-negligent and at least one is vigilant, whereas it is *positive* when both are negligent.

(f) When one party is negligent and the other is not (domains 2 and 4), the court will add a positive increment to the liability share of the negligent party, and a negative (or zero) increment to the liability share of the non-negligent party. If particular, in domain 2, where *X* is negligent and *Y* is not, $1-\frac{p(x^*,y)}{p(x,y)}>0$ is added to *X*'s liability share, and $\frac{p(x^*,y)}{p(x,y)}-\frac{p(x^*,y^*)}{p(x,y)}$ to *Y*'s. The shares in domain 4, where *Y* is negligent and *X* is not, are similarly defined, switching the identities of the negligent and non-negligent parties. These liability share increments give rise to expected loss increments, and therefore increments to the parties' burdens. In domain 2 the expected loss increments are $p(x,y)L-p(x^*,y)L>0$ for *X* and $p(x^*,y)L-p(x^*,y^*)L\le 0$ for *Y*. The expected loss increment for *X* has a nice intuitive interpretation: It is the extra expected loss resulting from *X*'s negligence (in choosing $x<x^*$, instead of x^*), given that *Y* is at a non-negligent y. In domain 4, where *Y* is negligent and *X* is not, the expected loss increments are similar, $p(x,y)L-p(x,y^*)L>0$ for the negligent party *Y* and $p(x,y^*)L-p(x^*,y^*)L\le 0$ for the non-negligent party *X*.

Now are ready to apply the super-symmetric liability rule to our simple example. We will focus on expected losses, rather than liability shares, as we have done previously with the numerical example. Recall we are assuming $(\overline{w}_X,\overline{w}_Y)=(0,1)$. Table 10 below shows the parts of the burdens on the two parties that result from (1) their care expenditures *x* and *y*, respectively, and (2) the constant expected loss terms from (c) above, namely $\overline{w}_X\,p(x^*,y^*)L=0$ for party *X* and $\overline{w}_Y\,p(x^*,y^*)L=5$ for party *Y*.

Table 10 Partial Burdens on the Parties, Super-Symmetric Rule, Care Costs Plus Constant Term $\overline{w}_Y = 1$

Y's Care:			
2	0	1	2
1	0	1	2
0	0	1	2
X's Care:	0	1	2

Partial Burden on *X*

Y's Care:			
2	7	7	7
1	6	6	6
0	5	5	5
X's Care:	0	1	2

Partial Burden on *Y*

Table 11 shows relative degrees of vigilance or negligence in domains 1 and 3, taken directly from table 5. Table 12 shows the $p(x,y)L - p(x^*,y^*)L$ increments, easily derived from table 1, and table 13 multiples the degrees of vigilance or negligence by the $p(x,y)L - p(x^*,y^*)L$ increments.

Table 11 Degrees of Negligence and Vigilance

Y's Care:			
2		0	0.5
1			1
0	0.5		
X's Care:	0	1	2

Degrees for *X*

Y's Care:			
2		1	0.5
1			0
0	0.5		
X's Care:	0	1	2

Degrees for *Y*

Table 12 Expected Losses – Efficient Expect. Losses

Y's Care:			
2	1	-0.5	-1
1	2	0	-0.5
0	5	2	1
X's Care:	0	1	2

Table 13 Increments to Burdens Based on Degrees of Negligence and Vigilance

Y's Care:			
2		0	-0.5
1			-0.5
0	2.5		
X's Care:	0	1	2

Increments for *X*

Y's Care:			
2		-0.5	-0.5
1			0
0	2.5		
X's Care:	0	1	2

Increments for *Y*

The final calculations are for domains 2 and 4, where one party is negligent and the other is non-negligent. In domain 2, where *X* is negligent ($x = 0$) and *Y* is not ($y = 1, 2$), the

expected loss increments are $p(x,y)L - p(x^*,y)L = p(0,y)L - p(1,y)L$ for *X* and $p(x^*,y)L - p(x^*,y^*)L = p(1,y)L - 5$ for *Y*. Checking back to table 1, with *X* negligent we have $x = 0$, and we see that the first term is 7 – 5 = 2 at $y = 1$, and 6 – 4.5 = 1.5 at $y = 2$. The second term is 5 – 5 = 0 at $y = 1$, and 4.5 – 5 = -0.5 at $y = 2$. Since this example is symmetric, very similar results apply in domain 4. All this gives rises to table 14, which shows increments to burdens based on the super-symmetric rule when one party is negligent and the other is not. Note some interesting properties of table 14, which illustrate important general results for the super-symmetric rule: ***When one party is negligent and the other is not, the increment to her burden is positive for the negligent party, but zero or negative for the non-negligent party. Second, these increments vary; and as the non-negligent party increases her vigilance, the incremental burdens on both parties fall.***

Table 14 Increments to Burdens, Super-Symmetric, One Party Negligent and One Party Non-Negligent

Y's Care:			
2	1.5		
1	2		
0		0	-0.5
X's Care:	0	1	2

Increments for *X*

Y's Care:			
2	-0.5		
1	0		
0		2	1.5
X's Care:	0	1	2

Increments for *Y*

Now we are ready to see how the super-symmetric rule governs the behavior of the parties. We add together table 10 (which shows $x + \overline{w}_X\, p(x^*,y^*)L$ and so on); table 13, which shows increments to burdens based on comparative negligence and vigilance under the super-symmetric rule; and table 14, which shows increments to burdens when one party is negligent and the other is non-negligent under the super-symmetric rule. All this gives table 15 below.

Table 15 Total Burdens on the Parties, Under the Super-Symmetric Rule $\overline{w}_Y = 1$

Y's Care:			
2	1.5	1	1.5
1	2	1	1.5
0	2.5	1	1.5
X's Care:	0	1	2

Burden on *X*

Y's Care:			
2	6.5	6.5	6.5
1	6	6	6
0	7.5	7	6.5
X's Care:	0	1	2

Increments for *Y*

Note: The pair (x,y) = (1,1) is efficient. It is also the unique Nash equilibrium. In fact, it is a dominant-strategy equilibrium!

Table 15 illustrates some general results: ***Under the super-symmetric comparative negligence and vigilance rule, the efficient care levels constitute a Nash equilibrium. Moreover, there is no inefficient Nash equilibrium.*** That is, the efficient point is the unique point where party *X* is minimizing her own burden, given the care level chosen by party *Y*, and simultaneously, party *Y* is minimizing her own burden, given the care level chosen by party *X*. Proofs for the general model are in Feldman & Singh (2008). Note also for this particular example that the efficient pair of care levels is actually a dominant-strategy equilibrium: No matter what party *Y* is doing, it is best for *X* to choose $x = 1$, and similarly for *Y*. Finally, note the apparent absence of jumps, or discontinuities, in the burden levels. This also is an interesting general result: ***The super-symmetric comparative negligence and vigilance rule gives continuous burden functions for the two parties.***

Tables 10 and 15 above were based on the assumption that $(\overline{w}_X, \overline{w}_Y) = (0,1)$; that is, at the efficient point, all the accident costs fall on the victim *Y*. This is what we earlier called a "negligence-style" super-symmetric rule. We now briefly consider a "strictly equitable" super-symmetric rule, in which the losses at the efficient point are divided equally: $(\overline{w}_X, \overline{w}_Y) = (0.5, 0.5)$. We will leave it to the reader to produce the analog to table 10. The total burden table, corresponding to table 15 above, is the following:

Table 16 Total Burdens on the Parties, Under the Super-Symmetric Rule $\overline{w}_X = \overline{w}_Y = 1/2$

Y's Care:				*Y*'s Care:			
2	4	3.5	4	2	4	4	4
1	4.5	3.5	4	1	3.5	3.5	3.5
0	5	3.5	4	0	5	4.5	4
X's Care:	0	1	2	*X*'s Care:	0	1	2
	Burden on *X*				**Increments for *Y***		

Note: The pair (x,y) = (1,1) is efficient. It is also the unique Nash equilibrium. In fact, it is a dominant-strategy equilibrium!

Once again, under the super-symmetric comparative negligence and vigilance rule, the efficient pair of care levels constitute a unique Nash equilibrium. In fact, in the example they are a dominant-strategy equilibrium. And now we have a remarkably equitable distribution of

total burdens, quite different from the distribution of total burdens in table 15, because here we assumed $(\overline{w}_X, \overline{w}_Y) = (0.5, 0.5)$ to start.

4 CONCLUSIONS

Various legal scholars have suggested an equitable division of liability between the parties when both injurer and victim are non-negligent, similar to the comparative negligence division when both are negligent. We have shown in this paper that such a division will not work if it is based on a naïve conjunction of pure comparative negligence and pure comparative vigilance. However, if done in a subtle way, comparative vigilance can be combined with comparative negligence; in fact they can be combined in a way that makes them perfectly symmetric.

For standard liability rules, if one party is negligent and the other is non-negligent, all liability falls on the negligent party, no matter how careless the negligent party or how careful the non-negligent party. We think this is a crude property, which our super-symmetric rule does not share. Under the super-symmetric rule, liability shares vary as the two parties vary their care levels, even when they remain in domain 2 (*X* negligent, *Y* not) or in domain 4 (*Y* negligent, *X* not). And when one party is negligent and the other is not, increased carelessness by the negligent party is penalized with a higher liability share, and increased care by the non-negligent party is rewarded with a lower liability share.

Some scholars have observed that the discontinuous shift in liability shares at the efficient point under standard rules is discomforting. It is obviously not possible to rigorously discuss continuity and discontinuity in the context of a discrete example. However in Feldman & Singh (2008) we provide the continuous version of the super-symmetric rule, and continuity for the rule in this paper can be appreciated by comparing table 7, showing total burdens on the parties under negligence with comparative negligence as a defense, and table 15, showing total burdens on the parties under the super-symmetric rule. The former shows a discontinuity in burdens (look at the burdens on *X*, as she shifts between $x = 0$ and $x = 1$), and the latter shows no such discontinuity.

Finally, our super-symmetric rule, which uses exactly the same logic in the both-vigilant domain as in the both-negligent domain, which provides for varying liability shares within each of the one-party-negligent and other-party-non-negligent domains, and which avoids

abrupt jumps in liability shares and burdens, succeeds in providing the proper incentives to the two parties, incentives which should induce them to find the point which minimizes total social costs.

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