Efficient 'simple' liability rules: when courts make erroneous estmation of the damage and individuals are imperfectly informed

[First Draft]

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1. Introduction

Liability rules typically concern accidents involving the strangers. A liability rule determines the proportions in which the parties are to bear the loss suffered from an accident, as a function of whether and by how much their care levels were less than the legally required due levels of care. Accuracy in the adjudication of accident cases is considered to be very crucial for the efficiency of liability rules. Inaccurate adjudication can cause various effects depending upon the liability rule in force. One of the issues central to the accuracy problem is the errors made by a court in assessing the harm, suffered by the victims, for the purpose of calculating the damages - the proportion of accident loss to be borne by the injurers. The aim of this paper is to study the effects of court errors in estimating the harm, on the parties' behaviour regarding the levels of care they take to prevent accident, and their decision to buy the information about the court errors. The analysis is carried out in a unified framework.

Formal analysis of the liability rules started with Brown (1973) and has been systematically advanced in Diamond (1974), Landes and Posner (1987), Shavell (1987), Polinsky (1980, 89), Posner (1992), Cooter and Ulen (1997), Miceli (1997), Dari Mattiacci (2001), and Jain and Singh (2002), among others. This work establishes that certain liability rules can induce the parties to take 'efficient' care - the level of care that is appropriate for the objective of minimizing the total social costs of accident. One of the important results about efficiency of liability rules is captured by what has come to be known as the 'efficiency-equivalence' theorem. The theorem says that any liability rule based upon the negligence or due care critarion, whether for the injurer or the victim or both, gives efficient incentives to both the parties with respect to care.[1] However, this result is derived in the setting of accurate adjudication.[2]

Because of the lack of relevant information it is generally difficult for courts to adjudicate the accident cases accurately. Courts can minimize the adjudication errors but only by incurring a cost. Illuminating analyses by Kaplow (1994 & 1998) and Arlen (2000) point out the trade-off between the benefits and the costs of accurate adjudication, and discuss in detail the other issues involved in accurate adjudication. Regarding the effects of court errors in estimating the harm, important contributions have been made by

[1] For a detailed discussion see Dari Mattiacci (2001)

[2] In Jain & Singh (2002), we provide a complete characterization of efficient liability rules under the standard assumption of accurate adjudication by courts.

Cooter (1984), Shavell (1987), Kaplow (1994), Kaplow and Shavell (1992, 1996), Miceli (1997), Cooter and Ulen (1998), and Dari Mattiacci (2001). When the injurers have *ex-ante* knowledge of the harm, Kaplow (1994), Kaplow and Shavell (1992 & 1996), and Dari Mattiacci (2001) in their important contributions have shown that under the rule of strict liability, if the injurers are required to pay a damage (liability payment) that is less than the harm they cause, then the injurers will take care that is less than the optimal level. On the other hand, if the injurers are required to pay a damage that is greater than the harm caused, they will take too much care. It is also argued that the errors by courts in assessment of the harm may motivate the imperfectly informed parties to wastefully spend resources on buying the information about the magnitude of the court errors. In Shavell (1987, pp. 131-32, 151-53), it is proved that unbiased court errors will not affect the efficiency characteristics of liability rules.

An imperfectly informed party will buy the information about court errors if the private value of the information to the party exceeds the price of the information. The social value of the purchase of information by a party is the expected reduction in total social costs, including the cost of information, which will occur as a result of the party's decision to buy information. When the information is costly, from social point of view spending on the information by a party is desirable only if the consequent reduction in the total social costs is greater than the price of information. Again, from the objective of minimizing the total social costs, given the parties' decisions regarding the purchase of information, it is always desirable that the parties take levels of care that minimize the sum of the costs of care and the expected loss. But, having decided whether to the buy information, depending upon the liability rule applicable, a party may or may not take the efficient level of care. Therefore, in the presence of court errors a liability rule may cause inefficiency on the following two counts. First, it may motivate the parties to spend on information when there are no net social gains to be held from such a spending. Second, it may motivate the parties to take inefficient levels of care.

In this paper we study the efficiency properties of *all* what we label as 'simple' liability rules - a subclass of liability rules - in the presence of court errors in estimating the harm.[3] A liability rule is defined to be a *simple liability rule* if under such a rule the liability is never shared between the parties. In the case of accidents involving two parties - one the injurer and other the victim- a simple liability rule can be defined as a rule which specifies the party, the victim or the injurer, which will be held to be fully liable for the accident loss, as a function of proportions of the two parties' (non)negligence.[4] The problem is considered in the standard framework of economic analysis of liability rules. That is, we consider accidents resulting from interaction of two risk-neutral parties who are strangers to each other. Care by both the parties can affect the expected loss.[5] It is assumed that whenever a liability rule specifies the legally binding due level

[3]In the literature on the effects of court errors on the level of precuation taken by parties, the study is mainly confined to the rules of negligence and strict liability. In Singh (2001 a), I analyse the entire class of liability rules.

[4]Most of the rules discussed in the literature on the liability rules, such as the rules of negligence, negligence with the defense of contributory negligence, strict liability with the defense of contributory negligence, also the rules of no liability and strict liability are simple liabilty rules in that these rules do not require sharing of liability between the two parties. The rule of comparative negligence, on the other hand, is not a simple liability rule in this sense.

[5]Kaplow and Shavell (1992, 1996) have studied the efficiency properties of the rules of strict liability and negligence, when

of care for a party, it is set at a level commensurate with the objective of minimizing of the sum of the costs of care plus the expected accident loss.[6]

Retaining most of the assumptions of the standard framework, the problem, however, is considered in a somewhat more general setting. No assumptions are made on the costs of care and expected loss functions, apart from assuming that they are such that minimum of the sum of the costs of care and expected accident loss exists. Unlike the standard framework, we allow the possibility of the existence of more than one configuration of care levels at which this sum is minimized.

Our results show that while the efficiency-equivalence theorem holds in the presence of unbiased errors, biased court errors do change the characterization of efficient liability rules. We show that when court errors are lower-biased, the efficiency-equivalence theorem does not hold. In fact, no liability rule can motivate both the parties to take efficient care, and they might spend on information about court errors. On the other hand, upper-biased court errors do not necessarily mean that the parties will take inefficient care and will spend on the information. We establish that when court errors are upper-biased, the necessary and sufficient condition for a simple liability rule to motivate both the parties to take efficient care and *simultaneously* not to spend on the information is that it satisfies the condition of 'negligent injurer's liability'. The condition of *negligent injurer's liability* requires that a liability rule be such that (i) whenever the injurer is taking at least the due care, the entire loss in the event of an accident is borne by the victim irrespective of the level of care taken by the victim, and (ii) when the injurer is negligent and the victim is not, the entire loss in the event of an accident is borne by the injurer.

That is, in the presence of upper-biased court errors, the efficiency-equivalence theorem holds only for the negligence rules based on no-liability, where the residual loss (when both the parties are nonnegligent) is borne the victim. The theorem does not hold for the strict-liability based negligence rules, where the residual loss is borne the injrer.

Specifically, Theorem 1 demonstrates that when courts make lower-biased errors no liability rule can motivate both the parties to take efficient care in all accident contexts, irrespective of the parties decisions regarding the purchase of information. Theorem 2 and 3, on the other hand, show that when court errors are upper-biased, the rule of negligence, and negligence with the defense of contributory negligence not only ensure the efficient care by both the parties, but also motivate the parties to not to spend on the information about court errors. Rules of no liability, and strict liability with the defense of contributory negligence, on the contrary, do not.

injurers are not indentical and courts make unbiased errors, in the framework of unilateral care - care only by the injurers can affect the probability of accident and, as a consequence, care by the victims is not an issue.

[6]For an analysis of effects of court errors in determining the efficient levels of due care and other related issues see Cooter and Ulen (1997), Craswell & Calfee(1986), Kahan (1989), Miceli (1997), Rasmusen (1995), Shavell (1987), Polinsky and Shavell (1989), Tullock (1994) and Endres and Lüdeke (1998). etc.

2. Definitions and Assumptions

Courts generally make errors while estimating the harm suffered by the victims.[7] We study the effects of these errors on parties' behaviour regarding the levels of care they take, and their decision to buy the information about court errors. The framework of the study is the standard framework of economic analysis of liability rules. That is, we consider the accidents resulting from interaction of two risk-neutral and stranger to each other parties. To start with, the entire loss falls on one party to be called the victim; the other party being the injurer. We denote by $c \geq 0$ the cost of care taken by the victim and by $d \geq 0$ the cost of care taken by the injurer. Cost of care of a party is assumed to be a strictly increasing function of its care level. As a result, cost of care for a party will also represent the level of care for that party. Let $C = \{c \mid c \geq 0$ is the cost of some feasible level of care which the victim can take.$\}$ and $D = \{d \mid \text{d} \geq 0$ is the cost of some feasible level of care which the injurer can take.$\}$. Therefore, $C[D]$ is the set of the care levels which can be taken by the victim [injurer]. We assume that $0 \in C$ and $0 \in D$.

Let, π denote the probability that accident involving two parties will take place, and $H \geq 0$ denote the loss in case accident actually materializes. We assume π and H to be functions of c and d; $\pi = \pi(c, d)$, $H = H(c, d)$. Let, L denote the expected loss due to accident. $L = \pi H$ and is a function of c and d; $L = L(c, d)$. As $H \geq 0$, $L \geq 0$. Further, we assume that a larger care by either party, given the care level of the other party, results in lesser or equal expected accident loss. Formally, we assume:

Assumption A 1 *For all c and d, $c > c' \rightarrow L(c, d) \leq L(c', d)$ and $d > d' \rightarrow L(c, d) \leq L(c, d')$.*

Decrease in L as result of increased care can take place because of decrease in H or π or both. Activity levels of both the parties are assumed to be given.

In the standard economic analysis of liability rules, generally, it is assumed that courts while deciding on the proportions of accident loss to be borne by the two parties can correctly asses the harm H suffered by the victim. The total social costs of the accident are taken to be the sum of costs of care taken by the parties and the expected loss due to accident; $c + d + L(c, d)$. On the other hand, when courts make errors in estimating the harm, the assessed harm, for the purpose of awarding the damages, will in general be different from the actual harm. Let, $H + \epsilon$ denote the assessed harm when actual harm is H, where ϵ denotes the error term. We assume that $\epsilon = 0$ when $H = 0$. Errors by the courts may be unbiased, i.e., $E(\epsilon) = 0$, in that case expected assessed harm, $E(H + \epsilon) = H + E(\epsilon) = H$, the actual harm. Or, errors may be biased, i.e., $E(\epsilon) \neq 0$, then $E(H + \epsilon) = H + E(\epsilon) \neq H$. Let $H + \epsilon = \alpha H$, or $\alpha = 1 + \epsilon / H$. $E(\alpha) = 1 + E(\epsilon)/H$, or $E(\alpha)H = H + E(\epsilon)$. Therefore, $E(\alpha)H$ also represents the expected assessed harm when actual harm is H.

Let, $E(\alpha) = \bar{\alpha}$. Clearly, $\bar{\alpha} \geq 1$ iff $E(\epsilon) \geq 0$, and $\bar{\alpha} < 1$ iff $E(\epsilon) < 0$. When a court makes errors while assessing the harm, not only the proportion of the loss a party is required to bear but also the magnitude

[7] From economic point of view error could mean awarding a damage award, for whatever reasons, that is not equal to the actual harm.

of errors in estimation of H will affect the party's expected costs and therefore its behaviour, in general. Moreover, when court makes errors in assessing H, the parties may or may not have information about the expected errors made by court, i.e., they may or may not know the value of $E(\epsilon)$ and hence $\bar{\alpha}$.[8] We consider the case when parties do not know $E(\epsilon)$ but have an option of buying the information about the exact value of $E(\epsilon)$ and, therefore, of $\bar{\alpha}$, by spending a fixed amount.[9] Let $\bar{c}_I > 0$ denote the cost of the information about $\bar{\alpha}$ for the victim, and $\bar{d}_I > 0$ for the injurer. When a party does not spend on information it will have its subjective estimates about $E(\epsilon)$ or $\bar{\alpha}$. Let, $\bar{\alpha}_v = 1 + E(\epsilon_v)/H$ denote the value of $\bar{\alpha}$ as perceived by the victim in the absence of the information. Similarly, let $\bar{\alpha}_i = 1 + E(\epsilon_i)/H$ denote the value of $\bar{\alpha}$ as perceived by the injurer in the absence of information.

Depending upon the liability rule and the information cost a party might or might not buy the information. Therefore, when parties have option of buying information total social costs (TSC) of an accident are the sum of costs of information, whenever undertaken, costs of care taken by the parties and the expected accident loss; TSC= $c_I + d_I + c + d + L(c, d)$, where $c_I \in C_I = \{0, \bar{c}_I\}$ and $d_I \in D_I = \{0, \bar{d}_I\}$. $c_I = 0$ [$d_I = 0$] when the victim [injurer] does not spend on the information. Choices of $c_I \in \{0, \bar{c}_I\}$ and $d_I \in \{0, \bar{d}_I\}$ by the victim and injurer are in fact their choices of $\alpha_v \in \{\bar{\alpha}_v, \bar{\alpha}\}$ and $\alpha_i \in \{\bar{\alpha}_i, \bar{\alpha}\}$, respectively. Let $M = \{(\acute{c}, \acute{d}) \mid \acute{c} + \acute{d} + L(\acute{c}, \acute{d})$ is a minimum of $\{c + d + L(c, d) \mid c \in C, d \in D\}\}$. Thus, M is the set of all costs of care configurations $(\acute{c}, \acute{d})$ which are total social cost minimizing, given the parties' decisions regarding the purchase of information. We assume that C, D, L are such that M is non empty:[10]

Assumption A 2 *C, D, and L are such that* $\sharp M \geq 1$.

For expositional simplicity we will assume that when a party does not spend on the information, though it does not know the exact value of $\bar{\alpha}$, it does know whether the errors are upper-biased or lower-biased, i.e., whether $\bar{\alpha} > 1$ or < 1. To put formally, we assume:[11]

Assumption A 3 *When* $c_I = 0$, $[(\bar{\alpha} > 1 \rightarrow \bar{\alpha}_v > 1)$ & $(\bar{\alpha} < 1 \rightarrow \bar{\alpha}_v < 1)]$; *and when* $d_I = 0$, $[(\bar{\alpha} > 1 \rightarrow \bar{\alpha}_i > 1)$ &$(\bar{\alpha} < 1 \rightarrow \bar{\alpha}_i < 1)]$.

Implications of the case $\bar{\alpha} = 1$, i.e., when court errors are unbiased will be considered in between. Let I denote the closed unit interval $[0, 1]$. Given C, D, L, and $(c^*, d^*) \in M$, we define functions $p : C \rightarrow I$ and $q : D \rightarrow I$ such that:
$p(c) = c/c^*$ if $c < c^*$,

[8] In fact, individuals may have many types of uncertainty, for example about the harm their acts could cause or the due levels of care. On these and other related issues see Craswell & Calfee(1986), Kahan (1989), Miceli (1997), Polinsky (1987) Rasmusen (1995), Shavell (1987) etc. In this paper we will focus only on the individuals' uncertainty about the court errors in estimating the harm.

[9] To get the information about $E(\epsilon)$ a party might spend resources, say, in studying the damage awards, law journals, or in consulting some experts, etc. As in Kaplow & Shavell (1992), if we assume that for certain categories of accidents $var(\epsilon) = 0$, by buying information a party will get to know ϵ or α, i.e., the exact value of the error made by the court.

[10] This assumption must be compared with the standard assumption that C, D and L are such that M is a singleton.

[11] We are assuming that from preliminary and largely costless investigation parties get to know the direction of bias in court errors. Kaplow and Shavell (1992, 1996) make similar assumption about a court's misperception. For detailed analysis of the effect of court errors when parties have full information about the errors see Singh (2001 b)

$= 1$ otherwise; and

$q(d) = d/d^*$ if $d < d^*$

$= 1$ otherwise.

A liability rule may specify the due care levels for both the parties, or for only one of them, or for none.[12] If a liability rule specifies the due care levels for both the parties, c^* and d^* used in the definitions of functions p and q will be taken to be identical with the legally specified due care levels for the victim and the injurer respectively. If the liability rule specifies the due care level for only the injurer, d^* used in the definition of function q will be taken to be identical with the legally specified due care level for him and c^* used in the definition of p will be taken as any element of $\{c \in C \mid (c, d^*) \in M\}$. Similarly, if the liability rule specifies due care level for only the victim, c^* used in the definition of function p will be taken to be identical with the legally specified due care level and d^* used in the definition of q will be any element of $\{d \in D \mid (c^*, d) \in M\}$ [13]. If the liability rule does not specify due care level for any party then any element of M can be used in the definitions of p and q. In other words, we are making the assumption that legal due care standard for a party, wherever applicable, is set at a level appropriate for the objective of minimization of total social cost of the accident. This standard assumption is very crucial for efficiency of a liability rule.[14]

Given the above definitions of p and q, $q(d) = 1$ would mean that the injurer is taking at least the due care and he will called nonnegligent. $q(d) < 1$ would mean that the injurer is taking less than the due care, i.e., he is negligent. $1 - q(d)$ will be his proportion of negligence and $q(d)$ would be his proportion of nonnegligence. Similarly for the victim.

Simple Liability Rules:

A liability rule can be defined as a rule which specifies the proportions in which the victim and the injurer will bear the loss, in case accident actually materializes, as a function of proportions of two parties' nonnegligence. Formally, a liability rule is a function f: $[0,1]^2 \to [0,1]^2$, such that:

$$f(p,q) = (x,y) = (x[p(c), q(d)], y[p(c), q(d)]), \quad x + y = 1,$$

where x $[y]$ is the proportion of loss which the victim [injurer] will be required to bear. In the case of accidents involving two parties, a simple liability rule can be defined as a rule which specifies the party

[12] To give few examples, the rule of negligence with the defense of contributory negligence specifies the due care levels for both the parties, the rule of negligence specifies the due care level for only one party, namely, the injurer, and the rules of strict liability and no liability, on the other hand, specify the due care level for neither of the parties.

[13] As we are allowing the possibility that there might be more than one configuration of care levels which minimize the sum $c + d + L(c,d)$, $\{c \in C \mid (c, d^*) \in M\}$ and $\{d \in D \mid (c^*, d) \in M\}$ may contain more than one element.

[14] It may be argued that if courts make errors in estimating the harm then they might do so in estimating the efficient levels of care as well. Here, apart from appealing to the expository simplicity, we argue that courts may rely on customs or what is called a 'reasonable-man standard' while fixing the due levels of care, or may determine the due levels of care through other methods, e.g., by adopting the levels of care determined to be efficient by regulatory bodies as due levels of care, etc. Therefore, errors in estimation of harm do not necessarily imply errors in estimation of the efficient due levels of care. For arguments and discussion see Landes and Posner (1987, Chapter 5) and Arlen (2000, pp 694-5).

-the victim or the injurer - which will be fully liable for the loss, as a function of proportions of two parties' nonnegligence. In other words, simple liability rules have one additional requirement that liability will never be shared between the parties. Formally, a simple liability rule is a function $f : [0,1]^2 \to \{0,1\}^2$, such that:

$$(\forall p, q \in [0,1])[f(p,q) = (0,1) \ or \ (1,0)].$$

Parties will decide about not only the care levels but also whether to buy information. In the presence of court errors, an accident context is described by the specification of C_I, C, D_I, D, L, and M. And, an application of a liability rule involves specification of the accident-context as also the due care standards, (c^*, d^*). That is an application of a liability rule involves specification of C_I, C, D_I, D, L, and $(c^*, d^*) \in M$. Let C_I, C, D_I, D, L, $(c^*, d^*) \in M$ and $\bar{\alpha}$ be given. Now, if an accident takes place and loss of H materializes, when court made no errors it will require the injurer to bear $y[p(c), q(d)]H(c,d)$. But, if the court makes error then, from the injurer's point of view it will assess the harm to be equal to $\alpha_i H$, and will require him to bear the liability equal to $y[p(c), q(d)]\alpha_i H(c,d)$, $\alpha_i \in \{\bar{\alpha}_i, \bar{\alpha}\}$. As, the entire loss is suffered by the victim initially, $y[p(c), q(d)]\alpha_i H(c,d)$ represents the expected liability payment (from the injurer's point of view) to be made by the injurer to the victim. Similarly, from the victim's point of view the assessed harm will be $\alpha_v H$, where $\alpha_v \in \{\bar{\alpha}_v, \bar{\alpha}\}$. Therefore, the expected liability payments will be perceived to be equal to $y[p(c), q(d)]\alpha_i H(c,d)$ and $y[p(c), q(d)]\alpha_v H(c,d)$ by the injurer and the victim respectively. Given its decision regarding the purchase of information, the expected costs of a party are the sum of the cost of care taken by it plus its expected liability. Thus, given their decision regarding the purchase of information, expected costs of the injurer and the victim are $d + y[p(c), q(d)]\pi(c,d)\alpha_i H(c,d)$ or $d + y[p(c), q(d)]\alpha_i L(c,d)$, and $c + L(c,d) - y[p(c), q(d)]\alpha_v L(c,d)$ respectively.

The rule of negligence holds an injurer liable for the accident loss if and only if he was negligent, notwithstanding the level of care taken by the victim. In the terminology of this paper the rule is defined by: $(q = 1 \to x = 1)$ and $(q < 1 \to x = 0)$.
Similarly, in the terminology of this paper:
The rule of negligence with the defense of contributory negligence is defined by:
$(p < 1 \to x = 1)$ and $(p = 1 \ \ \& q < 1 \to x = 0)$ and $(p = 1 \ \ \& \ q = 1 \to x = 1)$.
The rule of comparative negligence is defined by:
$(q = 1 \to x = 1)$ and $(p = 1 \ \ \& \ q < 1 \to x = 0)$ and $(p < 1 \ \ \& \ q < 1 \to 0 < x < 1)$.
The rule of strict liability is defined by:
$x = 0$, for all $p, q \in [0,1]$.
The rule of strict liability with the defense of contributory negligence is defined by:
$(p < 1 \to x = 1)$ and $(p = 1 \to x = 0)$.
The rule of no liability is defined by:
$x = 1$, for all $p, q \in [0,1]$.

When parties are imperfectly informed about the court errors, depending upon the liability rule and the cost of information a party may or may not buy the information.[15] A party will buy the information about court errors if the private value of the information to the party - the expected reduction in the party's private costs, the cost of care taken by it plus its expected liability- exceeds the price of the information. The social value of the purchase of information by a party is the expected reduction in total social costs, including the cost of information, which will occur as a result of the party's decision to buy information. Errors by courts means that the harm assessed for the purpose of determining the liability payment could be different from the actual harm so, given individuals uncertainty about errors, the private value of the information could be different from its social value. When the information is costly, from social point of view spending on information by a party is desirable only if the consequent reduction in TSC is greater than the price of the information. Further, having decided whether to buy the information, depending upon the liability rule applicable a party may or may not take efficient care. Therefore, a liability rule may cause inefficiency on the following two counts. First, it may motivate the parties to buy information when there are no net social gains to be held from such spending. Second, it may motivate the parties to take inefficient level of care. From the objective of minimization of TSC, given the parties' decisions regarding the purchase of the information, it is always desirable that both the parties opt for levels of care that minimize the sum $c + d + L(c, d)$.

Efficient Liability Rules:
With the standard assumption of full information, a liability rule f is said to be efficient in a given accident context, or for given C, D, L, and $(c^*, d^*) \in M$, iff it motivates both the parties to take levels of care that minimize the sum $c + d + L(c, d)$. Formally, given C, D, L, and $(c^*, d^*) \in M$, f is efficient iff (i) every Nash equilibrium (N.E.) is total social cost minimizing and (ii) there exists at least one Nash equilibrium.[16] A liability rule is said to be ***efficient*** iff it is efficient in every possible accident context.

Let F be the set of those simple liability rules which, irrespective of the parties' decisions regarding the purchase of information, motivate both the parties to take the levels of care that minimize the sum $c + d + L(c, d)$, in all accident contexts. In other words, simple liability rule $f \in F$ iff under f parties might or might not decide to buy the information but they will always take efficient levels of care. Formally, $f \in F$ iff, for every C, C_I, D, D_I, L, and $(c^*, d^*) \in M$:
$(\forall(\bar{c}, \bar{d}) \in C \times D)$ $[(\bar{c}, \bar{d})$ is a NE $\rightarrow (\bar{c}, \bar{d}) \in M]$ & $(\exists(\bar{c}, \bar{d}) \in C \times D)[(\bar{c}, \bar{d})$ is a NE$]$.
Now, suppose that a simple liability rules is such that in every possible accident context it motivates both the parties to not to spend on information and simultaneously to take efficient levels of care. Let F' be the set of such rules. That is, $f \in F'$ iff for every C, C_I, D, D_I, L, and $(c^*, d^*) \in M$:
$c_I = 0$ & $d_I = 0$ & $(\forall(\bar{c}, \bar{d}) \in C \times D)$ $[(\bar{c}, \bar{d})$ is a NE $\rightarrow (\bar{c}, \bar{d}) \in M]$ & $(\exists(\bar{c}, \bar{d}) \in C \times D)[(\bar{c}, \bar{d})$ is a NE$]$.
Clearly, no liability rule can be more efficient than the rules in F'. Also, $F' \subset F$. In the next section we show that when court errors are lower biased both the sets F and F' are empty. On the other hand,

[15]For example, if the liability rule is of no liability, no party will buy information and if the rule is of strict liability then at least one party, namely, the injurer will buy information provided $\bar{\alpha} \neq 1$ and information is not too costly.

[16]We consider only the pure strategy Nash Equilibria. Further, if C, D, and L are such that $\sharp M = 1$, f will be efficient iff (c^*, d^*) is a unique N.E.

unbiased or upper biased court errors do not mean that these sets are necessarily empty. We will study the conditions under which these sets are non-empty.

3. Efficient simple liability rules when court errors are lower-biased

When court errors are biased, i.e., when $E(\epsilon) \neq 0$, and $E(\alpha) = \bar{\alpha} \neq 1$, we assume that $\bar{\alpha} \geq 0$. With $E(\epsilon) \neq 0$, court errors may be upper-biased, i.e., $E(\epsilon) > 0$, in that case we have $\bar{\alpha} > 1$, or errors may be lower-biased, i.e., $E(\epsilon) < 0$, in that case we have $\bar{\alpha} < 1$. Below, we show that when court errors are lower-biased, irrespective of the magnitude of the bias, and irrespective of the parties decision regarding the purchase of information, no liability rule can motivate both the parties to take efficient levels of care in every accident context. That is, in the case of lower-biased errors, the set F is empty. Formally, with $E(\epsilon) < 0$, we have the following result.

Theorem 1 *A simple liability rule belongs to F, only if $\bar{\alpha} \geq 1$.*

Proof: Suppose not. This implies that there exists a simple liability rule such that $0 \leq \bar{\alpha} < 1$ and for every possible choice of C_I, C, D_I, D, L, and $(c^*, d^*) \in M$, the rule motivates both the parties to take efficient care. Let f be the rule.

Take any $\bar{\alpha} \in [0, 1)$. Let $f(p(c), q(d)) = (x[p(c), q(d)],\ y[p(c), q(d)])$, where $(x, y) = (0, 1)$ or $(1, 0)$. Let t be a positive number. $\bar{\alpha} < 1$ implies that $\alpha_v < 1$ and $\alpha_i < 1$.[17] As, $\alpha_i < 1$, $\alpha_i t < t$. Choose $r > 0$ such that $\alpha_i t < r < t$. Let $C_I = \{0, \bar{c}_I\}$ and $D_I = \{0, \bar{d}_I\}$.
Now, consider the following specification of C, D, and L;
$C = \{0, c_0\}$, where $c_0 > 0$,
$D = \{0, \alpha_i d_0, d_0\}$, where $d_0 = r/(1 - \alpha_i)$,
$L(0, 0) = t + \alpha_i d_0 + c_0 + \delta$, where $\delta > 0$, $\quad L(0, \alpha_i d_0) = t + c_0 + \delta$,
$L(0, d_0) = c_0 + \delta$, $L(c_0, 0) = t + \alpha_i d_0$, $L(c_0, \alpha_i d_0) = t$ and $L(c_0, d_0) = 0$.
It is clear that (c_0, d_0) is a unique configuration of efficient care levels. Also, (A1)-(A3) are satisfied. Let $(c^*, d^*) = (c_0, d_0)$. Now, given c_0 opted by the victim, if the injurer chooses d_0 his expected costs are d_0. If he opts $\alpha_i d_0$, his expected costs (net of d_I) are $\alpha_i d_0$ if $y[p(c_0), q(\alpha_i d_0)] = 0$, and $\alpha_i d_0 + \alpha_i t$ otherwise. Thus, when the injurer opts $\alpha_i d_0$, his expected are less than or equal to $\alpha_i d_0 + \alpha_i t$. But, $d_0(1 - \alpha_i) > \alpha_i t$ as $r > \alpha_i t$. Thus, $d_0 > \alpha_i d_0 + \alpha_i t$. That is, the injurer's expected costs are less if he opts $\alpha_i d_0$ rather than d_0.

Therefore, the unique pair of efficient care levels, (c_0, d_0), is not a N.E. Therefore, f does not motivate both the parties to take efficient care for the above specification. This, in turn, implies that when $\bar{\alpha} < 1$, it is not the case that f motivates both the parties to take efficient care for every C_I, C, D_I, D, L, and $(c^*, d^*) \in M$. Hence, $f \notin F$. As f is an arbitrary simple liability rule this implies that when $\bar{\alpha} \in [0, 1)$, $F = \phi$. •

[17] We know that $\alpha_i = \bar{\alpha}_i$ or $\bar{\alpha}$. When $\alpha_i = \bar{\alpha}_i$, $\alpha_i < 1$ by (A3), and when $\alpha_i = \bar{\alpha}$, $\alpha_i < 1$ as $\bar{\alpha} < 1$. Similarly for α_v. Note that no assumptions are made about the parties' decision to buy information.

An intuitive explanation of Theorem 1 is as follows. In the presence of lower biased court errors, whenever required to do so the injurers will bear only a fraction of the actual harm H. On the other hand, if they reduce their level of care all the benefits of the reduced cost of care will accrue to them. With this backdrop, consider the accident contexts such that (i) $L(c^*, d^*) = 0$, (ii) $\alpha_i d^* < d^*$ is an element of choice set of the injurer, and (iii) $L(c^*, \alpha_i d^*) - L(c^*, d^*) = L(c^*, \alpha_i d^*) > (1 - \alpha_i)d^* > \alpha_i L(c^*, \alpha_i d^*)$. In the accident contexts satisfying (i)-(iii), suppose (c^*, d^*) is the unique configuration of efficient care levels and the victim is taking care at c^*. Now, consider a shift from the care level d^* to $\alpha_i d^*$ by the injurer. It is clear from (iii) that even if the liability rule concerned holds the injurer to be liable, i.e., even if $y[p(c^*), q(\alpha_i d^*)] = 1$, the expected costs of the injurer at $\alpha_i d^*$ are strictly less than at d^*, i.e., (c^*, d^*) is not a NE. Therefore, in such accident contexts even if the victim takes the efficient care injurer will not. Moreover, such contexts can be constructed for any $\alpha_i = \bar{\alpha}_i$ or $\bar{\alpha}$ as long as $\alpha_i < 1$.

Corollary 1 $\bar{\alpha} < 1 \rightarrow F' = \phi$.

$F' = \phi$ follows from the fact that $F' \subset F$, and $F = \phi$ when $\bar{\alpha} < 1$. Furthermore, it should be noted that even if we assume that the information is costless, that is the parties know the exact value of $\bar{\alpha}$, the claim of Theorem 1 is true.[18] This with the fact that the set F containing all the efficient liability rules is empty implies that the efficiency-equivalence theorem does not hold in the setting of lower-biased court errors.

4. Efficient simple liability rules when court errors are unbiased

Under the standard assumption that the courts can calculate the harm H, correctly we have the following result about the efficiency characterization of liabilty rules.

Theorem (Jain & Singh): A liabilty rule f is efficient for every C, D, L, and $(c^*, d^*) \in M$ iff, whenever one party is negligent and the other is not then under f the negligent party is required bear all the loss, i.e., iff:[19]

$(\forall p \in [0, 1))[f(p, 1) = (1, 0)]$ and $(\forall q \in [0, 1))[f(1, q) = (0, 1)]$.

Now, when court errors are unbaised, i.e., $E(\epsilon) = 0$ and $\mathrm{E}(\alpha) = \bar{\alpha} = 1$, if we assume that $\bar{\alpha}_i = \bar{\alpha}_v = \bar{\alpha} = 1$, the injurer's expected costs are: $d + y[p(c), q(d)]\alpha_i L(c, d) = d + y[p(c), q(d)]L(c, d)$, as $\alpha_i = 1$; and, similarly, victim's expected costs are: $c + L(c, d) - y[p(c), q(d)]L(c, d)$, as $\alpha_v = 1$ Therefore, with $E(\epsilon) = 0$ expected costs of the parties are equal to their respective expected costs when courts made no error. Since, both parties are assumed to be risk-neutral, unbaised errors by courts will not affect their choices of levels of care. As result, the following corollaries can be stated.

Corollary 2 *When errors made by courts are unbaised, i.e., $E(\epsilon) = 0$, a liability rule $f \in F$, iff:* $p < 1 \rightarrow [f(p, 1) = (1, 0)]$, *and* $q < 1 \rightarrow [f(1, q) = (0, 1)]$.

[18] This result should be compared with the claim about the efficiency of the rule of negligence in Cooter (1984), Cooter and Ulen (pp. 284-286), Miceli (1997, pp. 34-35), Arlen (2000) and Dari Mattiacci (2001). These analyses claim that the rule of negligence is efficient when lower-biased court errors are small.

[19] See, Jain S.K. & Singh R. (2002)

From Corolalry 2 it is clear that the liability rules based on the negligence criterion are effcient. This in view of the following corollary shows that the efficiency-equivalence theorem holds in the presence of unbiased court errors.[20]

Corollary 3 *When errors made by courts are unbaised, the rules of negligence, negligence with the defense of contributory negligence, strict liability with the defense of contributory negligence and strict liability with the defense of dual contributory negligence motivate both the parties to take efficient care in every accident context. On the other hand, the rules of no liability and strict liability do not.*

5. Efficient simple liability rules when court errors are upper-biased

Above we demonstrated that when $\bar{\alpha} < 1$, regardless of the parties decisions about the purchase of information no liability rule can motivate both the parties to take efficient levels of care. With upper-biased errors by courts, however, this is not the case. Below we demonstrate that when court errors are upper-biased there do exist liability rules which are efficient in every possible accident contexts. Formally, we show that when $E(\epsilon) > 0$ a simple liability rule f is efficient iff f satisfies the condition of 'negligent injurer's liability' (NIL). This result is established through two easy to prove claims. First, we define the condition NIL.

Condition of Negligent Injurer's Liability (NIL):
A liability rule f is said to satisfy the condition of negligent injurer's liability (NIL) iff its structure is such that (i) whenever the injurer is nonnegligent, i.e., he is taking at least the due care, the entire loss in case of occurrence of accident is borne by the victim irrespective of the level of care taken by the victim, and (ii) when the injurer is negligent and the victim is not, the entire loss in case of occurrence of accident is borne by the injurer. Formally, a liability rule f satisfies NIL iff:

$$(\forall p \in [0,1])[f(p,1) = (1,0)] \ \ \& \ \ (\forall q \in [0,1))[f(1,q) = (0,1)].$$

When court errors are upper-biased, i.e., when $E(\epsilon) > 0$, first we show that under a liability rule satisfying NIL, c^* is a best responce for the victim when the injurer is opting d^*, and vice-versa. Formally, we have the following result about the efficiency of liability rules.

Proposition 1 *If a simple liability rule satisfies condition NIL then for every C_I, C, D_I, D, L, $(c^*, d^*) \in M$ and $\bar{\alpha} > 1$, (c^*, d^*) a Nash equilibrium.*

For proof see Appendix.

Lemma 1 *If a simple liability rule satisfies condition NIL then for every C_I, C, D_I, D, L, $(c^*, d^*) \in M$ and $\bar{\alpha} > 1$, $(\forall(\bar{c}, \bar{d}) \in C \times D)[\ \bar{d} < d^* \rightarrow (\bar{c}, \bar{d})$ is not a N.E.]*

[20]As is described in Dari Mattiacci (2001), no-liability based negligence rules are the the rules of negligence, negligence with the defense of contributory negligence, comparative negligence. Under these rules residual accident loss, when both the parties are nonnegligent, is borne by the victim. The rules of strict liability with the defense of contributory negligence and strict liability with the defense of dual contributory negligence, on the contrary are strict-liability based negligence rules, requiring the injurer to bear the residual loss.

That is, when $\bar{d} < d^*$ for every $(\bar{c}, \bar{d}) \in C \times D$ at least one party will find it advantageous to switch over to some other strategy. For formal proof see the Appendix.

The following proposition says that if a simple liability rule satisfies condition NIL then under it, given the parties' decisions regarding the purchase of information, every Nash equilibrium is TSC minimizing.

Proposition 2 *If a simple liability rule satisfies condition NIL then for every C_I, C, D_I, D, L, $(c^*, d^*) \in M$ and $\bar{\alpha} > 1$, $(\forall(\bar{c}, \bar{d}) \in C \times D)[(\bar{c}, \bar{d})$ is a N.E.$\rightarrow (\bar{c}, \bar{d}) \in M]$.*

Proof: Let the simple liability rule f satisfy condition NIL. Take any arbitrary $C_I, C, D_I, D, L, (c^*, d^*) \in M$ and $\bar{\alpha} > 1$. As before, $\bar{\alpha} > 1 \rightarrow (\alpha_v > 1$ and $\alpha_i > 1)$, where $\alpha_v \in \{\bar{\alpha}_v, \bar{\alpha}\}$, and $\alpha_i \in \{\bar{\alpha}_i, \bar{\alpha}\}$. Suppose, $(\bar{c}, \bar{d}) \in C \times D$ is a N.E. $(\bar{c}, \bar{d})$ is a N.E implies that given $\bar{d}$ opted by injurer, expected costs of the victim are minimum at care level $\bar{c}$, i.e.,

$$(\forall c \in C)[\bar{c} + L(\bar{c}, \bar{d}) - y[p(\bar{c}), q(\bar{d})]\alpha_v L(\bar{c}, \bar{d}) \leq c + L(c, \bar{d}) - y[p(c), q(\bar{d})]\alpha_v L(c, \bar{d})] \tag{1}$$

and given $\bar{c}$ opted by victim, expected costs of the injurer are minimum at $\bar{d}$, i.e.,

$$(\forall d \in D)[\bar{d} + y[p(\bar{c}), q(\bar{d})]\alpha_i L(\bar{c}, \bar{d}) \leq d + y[p(\bar{c}), q(d)]\alpha_i L(\bar{c}, d)] \tag{2}$$

Now, (1), in particular, $\rightarrow$

$$\bar{c} + L(\bar{c}, \bar{d}) - y[p(\bar{c}), q(\bar{d})]\alpha_v L(\bar{c}, \bar{d}) \leq c^* + L(c^*, \bar{d}) - y[p(c^*), q(\bar{d})]\alpha_v L(c^*, \bar{d}) \tag{3}$$

and (2)$\rightarrow$

$$\bar{d} + y[p(\bar{c}), q(\bar{d})]\alpha_i L(\bar{c}, \bar{d}) \leq d^*, \tag{4}$$

as condition NIL implies $y[p(\bar{c}), q(d^*)] = 0$. Adding (3) and (4),

$$\bar{c} + \bar{d} + L(\bar{c}, \bar{d}) + (\alpha_i - \alpha_v)y[p(\bar{c}), q(\bar{d})]L(\bar{c}, \bar{d}) \leq c^* + d^* + L(c^*, \bar{d}) - y[p(c^*), q(\bar{d})]\alpha_v L(c^*, \bar{d}) \tag{5}$$

Case 1: First, consider the case: $\bar{d} \geq d^*$: When $\bar{d} \geq d^*$ from (5) we get
$\bar{c} + \bar{d} + L(\bar{c}, \bar{d}) \leq c^* + d^* + L(c^*, \bar{d})$, because $\bar{d} \geq d^*$ and condition NIL imply $y[p(c), q(\bar{d})] = 0$. Also, $\bar{d} \geq d^* \rightarrow L(c^*, \bar{d}) \leq L(c^*, d^*)$. That is,
$\bar{c} + \bar{d} + L(\bar{c}, \bar{d}) \leq c^* + d^* + L(c^*, d^*)$. But, as $(c^*, d^*) \in M$ it must be the case that accident costs at $(\bar{c}, \bar{d})$ are at least as large as at (c^*, d^*), i.e., $\bar{c} + \bar{d} + L(\bar{c}, \bar{d}) \geq c^* + d^* + L(c^*, d^*)$. Therefore, $\bar{c} + \bar{d} + L(\bar{c}, \bar{d}) = c^* + d^* + L(c^*, d^*)$. Which, in turn, means that $(\bar{c}, \bar{d}) \in M$. Thus,

$$(\bar{c}, \bar{d}) \textit{ is a N.E. and } \bar{d} \geq d^* \rightarrow (\bar{c}, \bar{d}) \in M. \tag{6}$$

Case 2: $\bar{d} < d^*$:
In this case from Lemma 1 we know that

$$\bar{d} < d^* \rightarrow (\bar{c}, \bar{d}) \textit{ is not a N.E.} \tag{7}$$

Finally, (6) & (7) establish that $(\bar{c}, \bar{d})$ *is a N.E.* $\rightarrow (\bar{c}, \bar{d}) \in M$.•

Remark 1 *In the case of simple liability rules,* (c,d) *is a N.E.*$\rightarrow d = d^*$.

For explanation of this and the following remark the see Appendix.

Remark 2 $(\bar{c},\bar{d})$ *is a N.E. with* α_i *and* $\alpha_v \rightarrow (\bar{c},\bar{d})$ *is a N.E. with* $\acute{\alpha}_i \in \{\bar{\alpha}_i, \bar{\alpha}\}$ *and* $\acute{\alpha}_v \in \{\bar{\alpha}_v, \bar{\alpha}\}$.

Proposition 1 and 2 show that the condition NIL is a sufficient condition for any liability rule to be efficient. The following proposition shows that if a simple liabilty rule motivates both the parties to take efficient levels of care in every accident context then this rule necessarily satisfies the condition NIL. First, consider the following lemma.

Lemma 2 *If for a simple liability rule* f, $[(\exists p \in [0,1))[f(p,1) = (0,1)]$, *or* $(\exists q \in [0,1))[f(1,q) = (1,0)]]$ *holds then there exist a specification of* C_I, C, D_I, D, L $(c^*,d^*) \in M$ *and* $\bar{\alpha} > 1$ *satisfying A1-A3, such that* (c^*,d^*) *is not a N.E.*

For a formal proof see Appendix. Intuitively the claim of Lemma 2 is obvious. Suppose, for some level of care by the victim which is less than the due level of care, a liability rule is such that it holds a nonnegligent injurer fully liable, i.e., $f(p,1) = (0,1)$ for some $p \in [0,1)$. Under such a liability rule, irrespective of its value at (c^*,d^*) whenever $pc^* \in C$ it is always advantageous for the victim to not to opt for c^*- that is (c^*,d^*) is not a N.E. Similary, if $f(1,q) = (1,0)$ for some $q \in [0,1)$, whenever $qd^* \in D$ it is always advantageous for the injurer to not to opt d^*, again (c^*,d^*) is not a N.E.

Proposition 3 *If a simple liability rule is such that for every* C_I, C, D_I, D, L, $(c^*,d^*) \in M$, *and* $\bar{\alpha} > 1$, $(\forall(\bar{c},\bar{d}) \in C \times D)[(\bar{c},\bar{d})$ *is a N.E.* $\rightarrow (\bar{c},\bar{d}) \in M]$ *&* $(\exists(\bar{c},\bar{d}) \in C \times D)[(\bar{c},\bar{d})$ *is a N.E.* $]$ *holds, then it satisfies NIL.*

Proof: Suppose not. That is, suppose there exists a simple liabilty rule such that for every possible choice of C_I, C, D_I, D, L $(c^*,d^*) \in M$ and $\bar{\alpha} > 1$ satisfying A1-A3, it motivates both the parties to take efficient levels of care and at the same time it violates NIL. Let f be the simple liabilty rule.
f violates NIL implies that

$(\exists p \in [0,1])[f(p,1) \neq (1,0)]$, or $(\exists q \in [0,1))[f(1,q) \neq (0,1)]$. This and f is a simple liability rule imply that

$$(\exists p \in [0,1])[f(p,1) = (0,1)], \tag{8}$$

or

$$(\exists q \in [0,1))[f(1,q) = (1,0)]. \tag{9}$$

Case 1: Suppose, (8), i.e., $(\exists p \in [0,1])[f(p,1) = (0,1)]$ holds.
Subcase 1: p=1:
$p = 1$& (8)$\rightarrow f(1,1) = (0,1)$.
Let, $\bar{\alpha} > 1$. As before $\bar{\alpha} > 1$ and (A3) $\rightarrow \alpha_i > 1$ and $\alpha_v > 1$. Take any $\alpha_i > 1$. Let, $t > 0$. Clearly, $\alpha_i t > t$. Let r, be such that $\alpha_i t > r > t$.

Take any C_I and D_I. Now consider the following specification of C, D, and L:
$C = \{0, c_0\}, c_0 > 0$,
$D = \{0, d_0, \alpha_i d_0\}$, where $d_0 = r/(\alpha_i - 1)$
$L(0,0) = t + \alpha_i d_0 + c_0 + \delta$, where $\delta > 0$,
$L(c_0, 0) = t + \alpha_i d_0$, $\mathrm{L}(0, \mathrm{d}_0) = t + c_0 + \delta$,
$L(0, \alpha_i d_0) = c_0 + \delta$, $L(c_0, d_0) = t$, $\mathrm{L}(\mathrm{c}_0, \alpha_i d_0) = 0$.
Obviously, (c_0, d_0) is the unique total social cost minimizing configuration and the specificaton satisfies (A1)-(A3). Let $(c^*, d^*) = (c_0, d_0)$. Given c_0 opted by the victim if injurer chooses $\alpha_i d_0$ his expected costs are $\alpha_i d_0$. On the other hand, if chooses d_0 his expected costs are $d_0 + \alpha_i t$, as $y[p(c^*), q(d^*)] = y[1,1] = 1$. But, $\alpha_i d_0 < d_0 + \alpha_i t$, by construction. Thus, his expected costs of choosing $\alpha_i d_0$ are strictly less that of choosing d_0. Which means, (c_0, d_0) is not a N.E. Thus, there exist a configuration of C_I, C, D_I, D, L, $(c^*, d^*) \in M$, and $\bar{\alpha} > 1$ satisfying A1-A3, such that

$$(8) \ \& \ p = 1 \rightarrow (c^*, d^*) \ \textit{is not a N.E.} \tag{10}$$

Subcase 2: $p < 1$:
In this case $p < 1$ & $(8) \rightarrow f(p, 1) = (0, 1)$.
From Lemma 2 (Case 1), there exist a configuration of C_I, C, D_I, D, L, $(c^*, d^*) \in M$, and $\bar{\alpha} > 1$ satisfying A1-A3, such that

$$p < 1 \ \& \ (8) \rightarrow (c^*, d^*) \ \textit{is not a N.E.} \tag{11}$$

Case 2: Suppose (9), i.e., $(\exists q \in [0, 1))[f(1, q) = (1, 0)]$ holds.
Again from Lemma 2 (Case 2), there exist a specifications of C_I, C, D_I, D, L, $(c^*, d^*) \in M$, and $\bar{\alpha} > 1$ satisfying A1-A3, such that

$$(9) \rightarrow (c^*, d^*) \ \textit{is not a N.E.} \tag{12}$$

Finally, (10) - (12) imply that if f violates the condition NIL then there exists at least one specification of C_I, C, D_I, D, L, $(c^*, d^*) \in M$, and $\bar{\alpha} > 1$, satisfying A1-A3, such that (c^*, d^*) is not a N.E. This in conjunction with the fact that (c^*, d^*) is the unique configuration of efficient care levels in the above specifications implies that it is not the case that f violates NIL and it motivates both the parties to take efficient levels of care for every possible choice of C_I, C, D_I, D, L, $(c^*, d^*) \in M$, and $\bar{\alpha} > 1$, satisfying A1-A3. Or, if f violates NIL then for every possible choice of C_I, C, D_I, D, L, $(c^*, d^*) \in M$, and $\bar{\alpha} > 1$, satisfying A1-A3, $(\forall \bar{c}, \bar{d} \in C \times D)[(\bar{c}, \bar{d})$ is a N.E. $\rightarrow (\bar{c}, \bar{d}) \in M]$ & $(\exists (\bar{c}, \bar{d}) \in C \times D)[(\bar{c}, \bar{d})$ is a N.E.] does not hold. •

Proposition 3 establishes the necessity of NIL for f to be an element of F or to motivate both the parties to take efficient care for every possible choice of C_I, C, D_I, D, L, $(c^*, d^*) \in M, \bar{\alpha} > 1$, satisfying (A1) -(A3). The following theorem shows that when courts make upper-biased errors, the condition NIL is both necessary and sufficient for a liability rule to motivate both the parties to take efficient levels.

Theorem 2 $\bar{\alpha} > 1 \rightarrow [$ *A simple liability rule f belongs F iff f satisfies the condition of Negligent Injurer's Liabilty* $]$.

Proof: Let simple liability rule f satisfy NIL. Propositions 1 and 2 show that for every possible choice of C_I, C, D_I, D, L, $(c^*, d^*) \in M$, and $\bar{\alpha} > 1$, satisfying A1-A3,
$(\exists(c,d) = (c^*, d^*) \in C \times D)[(c,d)$ is a N. E. $]$ & $(\forall(\bar{c},\bar{d}) \in C \times D)[(\bar{c},\bar{d})$ is a N.E. $\rightarrow (\bar{c},\bar{d}) \in M]$. Therefore, $f \in F$.

On the other hand, if $f \in F$, i.e., if for every possible choice of C_I, C, D_I, D, L, $(c^*, d^*) \in M$, and $\bar{\alpha} > 1$, satisfying A1-A3,
$(\forall(\bar{c},\bar{d}) \in C \times D)[(\bar{c},\bar{d})$ is a N.E. $\rightarrow (\bar{c},\bar{d}) \in M]$ & $(\exists(\bar{c},\bar{d}) \in C \times D)[(\bar{c},\bar{d})$ is a N.E.$]$ holds, then by Proposition 3, f satisfies NIL. •

Theorem 2 with its following corollary shows that only the no-liability based (and not the strict-liability based) simple liability rules are efficient. So, the efficiency-equivalence theorem holds only partly.

Corollary 4 *When courts make upper-biased errors in assessment of the harm and parties are imperfectly informed about the courts' errors, the rules negligence and negligence with the defence of contributory negligence motivate both the parties to take efficient levels of care in all accident contexts irrespective of their decision to buy information. On the other hand, rules of no liability, strict liability, and strict liability with the defence of contributory negligence do not.*

Example 1 *Consider the following specification:*
Let, $\bar{\alpha} > 1, C_I = \{0, \bar{c}_I\}, D_I = \{0, \bar{d}_I\}, where, c_I > 0$ *and* $d_I > 0$,
C={0, .9, 1},
D={0, .1, 1},
L(0, 0)=2.4, L(0, .1)=2.3, L(0, 1)=1.2,
L(.9, 0)=1.35, L(.9, .1)=1.25,
L(.9, 1)=0.25, L(1, 0)= 1.2, L(1, .1)=1.1, L(1, 1)=0.
Let, $\bar{\alpha}_v = 1.70$ *and* $\bar{\alpha}_i = 1.01$.

Now, consider the following liability rule f such that
$f(0,0) = (1/2, 1/2)$, $f(0,.1) = (1/2, 1/2)$, $f(0,1) = (1,0)$, $f(.9,0) = (0,1)$, $f(.9,.1) = (2/5, 3/5)$, $f(.9,1) = (1,0)$, $f(1,0) = (0,1)$, $f(1,.1) = (0,1)$, $f(1,1) = (1,0)$.
Clearly, f satisfies NIL, and for the specification in Example 1, $(1,1)$ is the unique profile of efficient care levels. But, when neither of the parties buy information it is easy to see that $(.9, .1)$ which is not an efficient configuration is also a N.E.[21] Therefore, $f \notin F$. The example shows that Theorem 2 can not be stated in the case of general liability rules satisfying NIL. For the general liability rules satifying NIL.

Proposition 4 *If a simple liability rule satisfies NIL then for every* C_I, C, D_I, D, L, $(c^*, d^*) \in M$, *and* $\bar{\alpha} > 1$, *not buying information is a strictly dominant strategy for each party.*

[21] Given, 0.9 opted by the victim, expected costs of the injurer of choosing 0.1, $(0.1 + 0.6 \times 1.01 \times 1.25 = 0.8575)$ are strictly less than that of choosing 1 or 0. Similarly, given 0.1 opted by the injurer expected costs of the victim of choosing 0.9, $(0.9 + 1.25 - 0.6 \times 1.7 \times 1.25 = 0.875)$ are strictly less than that of choosing 1 or 0.

For proof see Appendix. Intuitive explanation of the claim as follows. Consider any simple liability rule satisfying NIL. From Proposition 1 and Remark 1 we know that (c^*, d^*) is a N.E. and $(\bar{c}, \bar{d})$ is a N.E. means that $\bar{d} = d^*$, i.e., in equilibrium the injurer will opt for d^*. So, in view of NIL he is not required to pay any damage to the victim. This holds true for any level of upper-biased errors. Thus, magnitude of the errors is irrelevant for the injurer and hence he will not spend on the information. Similarly, magnitude of the error is irrelevant for the victim (as he is not getting any compensation at all) and hence he also will not spend on the information.

Finally, the following theorem shows that NIL ensures both the efficient care and also no spending on the information about court errors.

Theorem 3 $\bar{\alpha} > 1 \rightarrow$ [*A simple liability rule belongs to* F' *iff it satisfies the condition of Negligent Injurer's Liabilty*].

Proof: Let $\bar{\alpha} > 1$ and the simple liability rule f satisfy NIL. Now, Proposition 1, 2 and 4 in conjunction imply that $f \in F'$. On the other hand, if $f \in F'$, then $f \in F$, as $F' \subset F$. Proposition 3 and $f \in F$ imply that f satisfies NIL. •

Corollary 5 *When courts make upper-biased errors and parties are imperfectly informed about the court errors, the rules negligence, and negligence with the defence of contributory negligence motivate both the parties to take efficient levels of care and at the same time to not to buy the information, in all accident contexts. On the other hand, the rules of no liability, strict liability, strict liability with the defence of contributory negligence do not.*

4. Concluding Remarks

Our analysis shows that the efficiency-equivalence theorem holds when court errors are un-biased. In fact, un-biased court errors do not affect the effciency characterization of efficient liability rules. Theorem 1 shows that in the presence of lowe-biased court errors, no liability rule can be efficeint. Thus, the efficiency-equivalence theorem does not hold at all in this case. Theorem 3 establishes that in the setting of upper-bised errors by courts; (I) if a simple liability rule f satisfies the condition NIL then in every accident context it is efficient in that it motivates both the parties to take efficient levels of care, and at the same time to not to spend on the information about court errors, (II) if f violates NIL then in some accident contexts it will not motivate both the parties to take efficient levels of care (From the proof of Proposition 3 it should be noted that in principle one can construct infinitely many such contexts.), (III) if f violates NIL then depending upon f and the cost of information, parties might spend on the information about the court errors and still not take efficient levels of care, for example under the rule of strict liability. On the other hand, from Corollary 2 we know that when courts do not make errors or make unbiased errors, the necessary and sufficient condition for a liabilty to be efficient is that it be such that whenever one party is negligent and the other is not then the negligent party should bear all the loss. As only the no-liability based NIL satisfying simple liability rules (and not the strict-liability based) are efficient, the efficiency-equivalence theorem holds only partly in the presence of upper-biased errors. Therefore, biased court errors affect the efficiency characterization of simple liability rules. In particular, the rule of strict liability with the defence of contributory negligence which otherwise induces efficient care does not do so when courts make biased errors.

From the proofs in the paper it should be noted that the claims of the theorems will not change even if in stead of our more general assumption $(A2)$ - the cost of care and expected loss functions are such that there exists at least one configuration of care levels at which total social costs are minimized - we make the standard assumption that the configuration of care levels at which total social costs are minimized is unique. In the latter case sufficiency results follow immediately. Necessity claims will follow from observing that in the necessity proofs the cost of care and expected loss functions, in addition to being consistent with $(A2)$, are such that the total social costs minimizing configuration is unique. Therefore, the standard assumption is irrelevant for the efficiency characterization of simple liability rules. Finally, it should be noted that if we assume that the information cost is zero, that is, the parties are fully informed about the exact value of $\bar{\alpha}$, the analysis will hold as such.

Appendix

Proof of Proposition 1

Let the simple liability rule f satisfy condition NIL. Take any C_I, C, D_I, D, L, $(c^*, d^*) \in M$ and $\bar{\alpha} > 1$. $\bar{\alpha} > 1$ and (A3) imply that $\alpha_v > 1$ and $\alpha_i > 1$. Suppose, (c^*, d^*) is not a N.E. (c^*, d^*) is not a N.E.$\rightarrow$

$$(\exists d' \in D)[d' + y[p(c^*), q(d')]\alpha_i L(c^*, d') < d^* + y[p(c^*), q(d^*)]\alpha_i L(c^*, d^*)] \tag{13}$$

or

$$(\exists c' \in C)[c' + L(c', d^*) - y[p(c'), q(d^*)]\alpha_v L(c', d^*) < c^* + L(c^*, d^*) - y[p(c^*), q(d^*)]\alpha_v L(c^*, d^*)], \tag{14}$$

where $\alpha_v \in \{\bar{\alpha}_v, \bar{\alpha}\}$ and $\alpha_i \in \{\bar{\alpha}_i, \bar{\alpha}\}$.[22]

Suppose (13) holds. As $y[p(c^*), q(d^*)] = 0$ by condition NIL, (13) $\rightarrow$
$(\exists d' \in D)[d' + y[p(c^*), q(d')]\alpha_i L(c^*, d') < d^*]$.
First, consider the case: $d' > d^*$:
$d' > d^*$ and condition NIL imply $y[p(c^*), q(d')] = 0$. Therefore, from (13) we get $d' < d^*$, contradicting the hypothesis that $d' > d^*$. Hence, we show that

$$d' > d^* \rightarrow (13) \textit{ can not hold} \tag{15}$$

[22] $\alpha_v = \bar{\alpha}_v$ when the victim does not buy the information and $\alpha_v = \bar{\alpha}$ when he does. Similarly, about α_i. Note that we are not making any assumption about parties' decisions to buy the information.

Now, consider the case: $d' < d^*$:

$d' < d^*$ and condition NIL →y[p(c*), $q(d')$] $= 1$. Therefore, (13) $\rightarrow d' + \alpha_i L(c^*, d') < d^*$, or $c^* + d' + \alpha_i L(c^*, d') < c^* + d^*$. But, $d' < d^* \rightarrow L(c^*, d') > 0$.[23] This with $\alpha_i > 1 \rightarrow$ $c^* + d' + L(c^*, d') < c^* + d' + \alpha_i L(c^*, d')$. Therefore, $c^* + d' + L(c^*, d') < c^* + d^* \leq c^* + d^* + L(c^*, d^*)$. That is accident costs (minus information cost) at (c^*, d') are less than accident costs at (c^*, d^*). Which is a contradiction as $(c^*, d^*) \in M$.

This contradiction establishes that

$$d' < d^* \rightarrow (13) \textit{ can not hold.} \tag{16}$$

Similarly, we can show that

$$(14) \textit{ can not hold.} \tag{17}$$

Finally, (15) – (17) → (c*, d^*) is a N.E. •

Proof of Lemma 1

Let the simple liability rule f satisfy condition NIL. Take any arbitrary C_I, C, D_I, D, L, $(c^*, d^*) \in M$ and $\bar{\alpha} > 1$. As before, $\bar{\alpha} > 1 \rightarrow (\alpha_v > 1$ and $\alpha_i > 1)$, where $\alpha_v \in \{\bar{\alpha}_v, \bar{\alpha}\}$, and $\alpha_i \in \{\bar{\alpha}_i, \bar{\alpha}\}$. Suppose, $(\bar{c}, \bar{d}) \in C \times D$ is a N.E. $(\bar{c}, \bar{d})$ is a N.E.→

$$(\forall c \in C)[\bar{c} + L(\bar{c}, \bar{d}) - y[p(\bar{c}), q(\bar{d})]\alpha_v L(\bar{c}, \bar{d}) \leq c + L(c, \bar{d}) - y[p(c), q(\bar{d})]\alpha_v L(c, \bar{d})] \tag{18}$$

and

$$(\forall d \in D)[\bar{d} + y[p(\bar{c}), q(\bar{d})]\alpha_i L(\bar{c}, \bar{d}) \leq d + y[p(\bar{c}), q(d)]\alpha_i L(\bar{c}, d)] \tag{19}$$

Now, (18), in particular, →

$$\bar{c} + L(\bar{c}, \bar{d}) - y[p(\bar{c}), q(\bar{d})]\alpha_v L(\bar{c}, \bar{d}) \leq c^* + L(c^*, \bar{d}) - y[p(c^*), q(\bar{d})]\alpha_v L(c^*, \bar{d}) \tag{20}$$

and (19)→

$$\bar{d} + y[p(\bar{c}), q(\bar{d})]\alpha_i L(\bar{c}, \bar{d}) \leq d^*, \tag{21}$$

as condition NIL implies $y[p(\bar{c}), q(d^*)] = 0$.

When $\bar{d} < d^*$ there are three possible cases.

Case 1: $\bar{c} > c^*$:

When $\bar{c} > c^*$, we have $L(\bar{c}, \bar{d}) \leq L(c^*, \bar{d})$. Which means $(1 - \alpha_v)L(\bar{c}, \bar{d}) \geq (1 - \alpha_v)L(c^*, \bar{d})$, as $(1 - \alpha_v) < 0$. This further implies $\bar{c} + (1 - \alpha_v)L(\bar{c}, \bar{d}) > c^* + (1 - \alpha_v)L(c^*, \bar{d})$, as $\bar{c} > c^*$.

But, $\bar{d} < d^*$, $\bar{c} > c^*$ and $(\bar{c}, \bar{d})$ is a N.E., through (20), →

[23] $L(c^*, d' < d^*) > 0$ is easy to see, as $L(c^*, d' < d^*) \geq 0$ and $L(c^*, d' < d^*) = 0$ would imply that $(c^*, d^*) \notin M$, a contradiction.

$\bar{c}+(1-\alpha_v)L(\bar{c},\bar{d}) \leq c^*+(1-\alpha_v)L(c^*,\bar{d})$, as $\bar{d} < d^*$, $\bar{c} > c^*$ and condition NIL imply that $y(p(c^*), q(\bar{d})) = 1$ and $y(p(\bar{c}), q(\bar{d})) = 1$. Thus, the assumption $(\bar{c}, \bar{d})$ is a N.E. leads to contradiction in this case. Therefore,

$$\bar{d} < d^* \ \& \ \bar{c} > c^* \rightarrow (\bar{c}, \bar{d}) \ is \ not \ a \ N.E. \tag{22}$$

Case 2: $\bar{c} = c^*$:
$\bar{d} < d^*$, $\bar{c} = c^*$, and $(\bar{c}, \bar{d})$ is a N.E., through (21), $\rightarrow$
$\bar{d} + \alpha_i L(\bar{c}, \bar{d}) \leq d^*$, as $y[p(\bar{c} = c^*), q(\bar{d} < d^*)] = 1$, by condition NIL. Or,
$c^* + \bar{d} + \alpha_i L(\bar{c} = c^*, \bar{d}) \leq c^* + d^* + L(c^*, d^*)$.
But, $\bar{d} < d^* \rightarrow L(\bar{c} = c^*, \bar{d}) > 0$. Further, $L(c^*, \bar{d}) > 0$ and $\alpha_i > 1 \rightarrow$
$c^* + \bar{d} + L(c^*, \bar{d}) < c^* + \bar{d} + \alpha_i L(c^*, \bar{d}) \leq c^* + d^* + L(c^*, d^*)$.
That is, $c^* + \bar{d} + L(c^*, \bar{d}) < c^* + d^* + L(c^*, d^*)$, a contradiction as $(c^*, d^*) \in M$. Therefore,

$$\bar{d} < d^* \ \& \ \bar{c} = c^* \rightarrow (\bar{c}, \bar{d}) \ is \ not \ a \ N.E. \tag{23}$$

Case 3: $\bar{c} < c^*$: In this case $\bar{c} < c^* \& \bar{d} < d^*$.
As f is a simple liability rule, $y[p(\bar{c}), q(\bar{d})] = 0$ or 1. Let, $y[p(\bar{c}), q(\bar{d})] = 0$.
From (20), $(\bar{c}, \bar{d})$ is a N.E.$\rightarrow$ $\bar{c} + L(\bar{c}, \bar{d}) \leq c^* + L(c^*, \bar{d}) - \alpha_v L(c^*, \bar{d})$, as $y[p(\bar{c}), q(\bar{d})] = 0$ and $y[p(c^*), q(\bar{d} < d^*)] = 1$, by condition NIL. Therefore,
$\bar{c} + L(\bar{c}, \bar{d}) < c^*$, as $\alpha_v > 1$ and $L(c^*, \bar{d} < d^*) > 0$. Or $\bar{c} + \bar{d} + L(\bar{c}, \bar{d}) < c^* + d^*$, as $\bar{d} < d^*$, a contradiction. Similarly, we get a contradiction when $y[p(\bar{c}), q(\bar{d})] = 1$. Thus

$$\bar{d} < d^* \ \& \ \bar{c} < c^* \rightarrow (\bar{c}, \bar{d}) \ is \ not \ a \ N.E. \tag{24}$$

Finally, (22) - (24) establish that $\bar{d} < d^* \rightarrow (\bar{c}, \bar{d})$ *is not a N.E.*•

Explanation of Remark 1

From the proof of Lemma 1 we note that in the case of simple liability rules (c, d) can be a N.E. only if $d \geq d^*$. When $d \geq d^*$, expected costs of the injurer are $d + y[p(c), q(d \geq d^*)]\alpha_v L(c, d) = d$, as NIL implies $y[p(c), q(d \geq d^*)] = 0$. Obviously, expected costs of the injurer are strictly less if he chooses $d = d^*$ rather than any $d > d^*$, irrespective of the c chosen by the victim. It means, $(c, d > d^*)$ can not be a N.E. Therefore, (c, d) is a N.E.→d=d*.

Explanation of Remark 3

Let, $(\bar{c}, \bar{d})$ be a N.E. with α_i and α_v. In view of Remark 1, for any $\acute{\alpha}_i \in \{\bar{\alpha}_i, \bar{\alpha}\}$, $(\bar{c}, \bar{d})$ is a N.E.$\rightarrow \bar{d} = d^*$. Also, from (1) $(\bar{c}, \bar{d})$ is a N.E. with α_i & α_v $\rightarrow$

$$(\forall c \in C)[\bar{c} + L(\bar{c}, d^*) - y[p(\bar{c}), q(d^*)]\alpha_v L(\bar{c}, d^*) \leq c + L(c, d^*) - y[p(c), q(d^*)]\alpha_v L(c, d^*)],$$

as $\bar{d} = d^*$. But, this inequality is true for any $\acute{\alpha}_v \in \{\bar{\alpha}_v, \bar{\alpha}\}$, as $y[p(c), q(d^*)] = 0$. Therefore, $(\bar{c}, \bar{d})$ is a N.E. $\forall (\alpha_i, \ \alpha_v) \in \{\bar{\alpha}_i, \bar{\alpha}\} \times \{\bar{\alpha}_v, \bar{\alpha}\}$.

Proof of Lemma 2

Let f be any simple liability rule. Let under f, $[(\exists p \in [0,1))[f(p,1) = (0,1)]$ or $(\exists q \in [0,1))[f(1,q) = (1,0)]]$ hold. There are two possible cases.
Case 1: Suppose, $(\exists p \in [0,1))[f(p,1) = (0,1)]$ holds.
In this case, $f(p,1) = (0,1)$ for some $p < 1$.
Take any $\bar{\alpha} > 1$, $\bar{\alpha}_i > 1$ and $\bar{\alpha}_v > 1$. Let, $t > 0$. Choose a positive number r such that $0 < r < t$. Take any C_I and D_I. Now consider the following specification of C, D, and L:
$C = \{0, pc_0, c_0\}$, where $c_0 = r/(1-p)$,
$D = \{0, d_0\}$, where $d_0 > 0$,
$L(0,0) = t + pc_0 + d_0 + \delta$, where $\delta > 0$,
$L(pc_0, 0) = t + d_0 + \delta,\ \ L(c_0, 0) = d_0 + \delta,\ \ L(0, d_0) = t + pc_0$,
$L(pc_0, d_0) = t,\ \ L(c_0, d_0) = 0$.
Clearly, (c_0, d_0) is the unique configuration of efficient care levels and the specification satisfies (A1)- (A3). Let $(c_0, d_0) = (c^*, d^*)$. From the above specification it is immediately clear that given d_0 opted by the injurer, the victim is strictly better off by choosing pc_0 rather than choosing c_0. Therefore, for the above specification of C_I, C, D_I, D, L, $(c^*, d^*) \in M$ and $\bar{\alpha} > 1$ satisfying A1-A3, (c^*, d^*) is not a N.E.

Case 2: $(\exists q \in [0,1))[f(1,q) = (1,0)]$ holds.
Take any $\bar{\alpha} > 1$, $\bar{\alpha}_i > 1$ and $\bar{\alpha}_v > 1$. Let $t > 0$. Clearly, $qt < t$. Let, $r > 0$ be such that $qt < r < t$.
Take any C_I and D_I. Now consider the following specification of C, D, and L:
$C = \{0, c_0\}, c_0 > 0$,
$D = \{0, qd_0, d_0\}$, where $d_0 = r/(1-q)$,
$L(0,0) = t + qd_0 + c_0 + \delta$, where $\delta > 0$
$L(c_0, 0) = t + qd_0$, $L(0, qd_0) = t + c_0 + \delta$, $L(0, d_0) = c_0 + \delta$,
$L(c_0, qd_0) = t$, $L(c_0, d_0) = 0$.
Clearly, (c_0, d_0) is the unique configuration of efficient care levels. Let $(c_0, d_0) = (c^*, d^*)$. Again, (c^*, d^*) is not a N.E. •

Proof of Proposition 4:

Let the simple liabilty rule f satisfy NIL. Take any $C_I, C, D_I, D, L, (c^*, d^*) \in M$, and $\bar{\alpha} > 1$. From Propositions 1 and 2 we know that (c^*, d^*) is a N.E. and $(c, d) \in C \times D$ is a N.E. $\rightarrow (c, d) \in M$. Further, from Remark 1 we have, (c, d) is N.E $\rightarrow d = d^*$. Therefore,
(c, d) is N.E $\rightarrow c + d + L(c, d) = c + d^* + L(c, d^*)$.
But, $c + d^* + L(c, d^*) = c^* + d^* + L(c^*, d^*)$, as (c, d) is N.E $\rightarrow (c, d) \in M$ and $(c^*, d^*) \in M$. So,

$$c + L(c, d^*) = c^* + L(c^*, d^*) \tag{25}$$

In view of the above, if (c, d) is N.E , for $\alpha_i \in \{\bar{\alpha}_i, \bar{\alpha}\}$, expected costs of the injurer are

$d + y[p(c), q(d)]\alpha_i L(c,d) = d^* + y[p(c), q(d^*)]\alpha_i L(c,d^*)$, as $d = d^*$. But, $d^* + y[p(c), q(d^*)]\alpha_i L(c,d^*) = d^*$, as $y[p(c), q(d^*)] = 0$ by condition NIL. Therefore, (c,d) is N.E implies that the expected costs of the injurer are d^*.

Similarly, for $\alpha_v \in \{\bar{\alpha}_v, \bar{\alpha}\}$, when (c,d) is N.E, the expected costs of the victim are
$c + L(c,d) - y[p(c), q(d^*)]\alpha_v L(c,d^*) = c + L(c,d^*)$. From (25), (c,d) is N.E $\rightarrow$
the expected costs of the victim are $c^* + L(c^*, d^*)$.

Thus, we have demonstrated that (c^*, d^*) is a N.E. and the expected costs of the injurer and the victim viz. d^* and $c^* + L(c^*, d^*)$, remain invariant irrespective of the resulting N.E. Moreover, whether parties buy information or not, i.e., whether $\alpha_i = \bar{\alpha}$ or $\alpha_i = \bar{\alpha}_i$, and $\alpha_v = \bar{\alpha}$ or $\alpha_v = \bar{\alpha}_v$ has no effect on expected costs of the parties.[24]

But, if the injurer buys information his total costs, $\bar{d}_I + d^*$, are strictly greater than his total costs when he does not, i.e., d^*. Therefore, not buying information is a strictly dominant strategy for the injurer. Similarly, not buying information is a strictly dominant strategy for the victim.•

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[24] In fact, in view of Remark 2 if (c,d) is N.E with α_v and α_i , then (c,d) is N.E with $(\alpha'_v, \alpha'_i) \in \{\bar{\alpha}_v, \bar{\alpha}\} \times \{\bar{\alpha}_i, \bar{\alpha}\}$. In other words, existence of N.E. does not depend upon whether the parties are buying information or not.

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