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LIABILITY RULES AND PRETRIAL SETTLEMENT

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ABSTRACT

The effect of different liability rules on the pretrial behavior of litigants to a civil suit is analyzed. The interaction is modeled as a game of incomplete information, where both the plaintiff and the defendant know whether or not they were negligent in actions leading to the accident. Selection criteria are used to refine the set of sequential equilibria of the game.

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1. INTRODUCTION

The interaction of parties prior to and following the occurrence of an accident in which legal recourse to resolve financial liability exists currently lacks a fair degree of cohesion. Authors such as Brown (1973), Green (1976), Diamond (1974a,b), and Shavell (1983) have studied the effect on caretaking of various liability, or cost distribution, rules under the hypothesis that the goal of liability law is to create incentives for the efficient use of resources in the prevention of accidents [Posner (1972)].[1] This work has typically ignored the bargaining opportunities available to the injurer and victim in a civil suit prior to a court decision, assuming instead that the liability rule is enforced without alternative. Conversely, the work of Bebchuk (1984), Samuelson (1983), P'ng (1983, 1984), and Salant (1984) has focused on the proper modeling of the bargaining problem inherent in the legal process subsequent to an accident in the study of the strategic aspects of legal settlements, while avoiding the comparative analysis undertaken by Brown, Green, etc. This is quite understandable given the embryonic nature of bargaining theory and the analysis of strategic interaction of parties holding private and valuable information. However, explicitly incorporating the ability of injurer and victim to come to terms prior to trial identifies an area of generalization in regards to research into caretaking prior to an accident. Papers by Reinganum and Wilde (1985) and Sobel (1985) have focused on the effect of alternative court cost allocation schemes and discovery rules in analyzing pretrial bargaining models with asymmetric information. Similar work in terms of liability rules seems justified.

This paper is an initial step in such a direction. A model is developed which promotes the comparison of liability rules in regards to their influence on settlement decisions of injurers and victims in a civil suit. Though the model itself is somewhat simplistic, it seems to capture the leverage one or another party is granted in terms of pretrial bargaining by the liability rules as well as the differential behavior of negligent or nonnegligent parties.

The paper is organized as follows: the following section presents the model, the equilibrium concept to be employed, and characterizations of the four liability rules to be analyzed: negligence, strict liability with contributory negligence, negligence with contributory negligence, and strict liability with dual contributory negligence.[2] Section 3 describes the equilibria under the four liability rules and compares the conditions and the outcomes of these equilibria, and Section 4 concludes with some areas of further research.

2. THE MODEL

Analysis of the settlement and liability issues is based on the following sequence of actions and events: an accident occurs involving two parties, one of which incurs monetary damages $m' > 0$. This party, called the plaintiff, costlessly initiates a legal suit against the other party, now called the defendant, to recover the damages. At issue in the case is the negligence or nonnegligence of both parties in terms of actions directly related to the occurrence of the accident. It is assumed that the negligence standard in use is common knowledge, but each party's negligence or nonnegligence is known only to that party. Given the state of his negligence the defendant makes a monetary offer $m \in \mathbb{R}_+$ to the plaintiff to drop the suit. If the plaintiff accepts the offer, the amount m is transferred from the defendant to the plaintiff and the case is terminated. If the plaintiff rejects the offer, the parties proceed to court, where it is assumed that the court determines without error the negligence or nonnegligence of each party, and resolves the financial dispute. The monetary payoffs for the parties from the court decision are functions both of the negligence of each party as well as the liability rule in force, where it is assumed that both parties possess a priori knowledge of the liability rule.

We model this interaction as a game of incomplete information [Harsanyi (1967-68)], where the plaintiff, p, can be one of two types, p_1 (not negligent), or p_2 (negligent). Let $P = \{p_1,p_2\}$. Similarly, the defendant, d, can be either d_1 (not negligent) or d_2 (negligent),

where $D = \{d_1,d_2\}$. It is assumed that p_1 occurs with probability γ and d_1 occurs with probability λ, where the random variables p_i and d_i are uncorrelated. The set of pure strategies for d is the nonnegative real line $\mathbb{R}_+$; a <u>strategy</u> for d is a function

$$q : D \to \Delta_{\mathbb{R}_+},$$

where $\Delta_{\mathbb{R}_+}$ is the set of probability distributions on $\mathbb{R}_+$. Thus $q(m|d_i)$ is the probability that d offers m, given that his type is d_i. A pure strategy for p assigns an element of the set $A = \{a_1,a_2\}$ for each possible offer, where

a_1 = accept d's offer, and

a_2 = reject d's offer.

A <u>strategy</u> for p is a function

$$r : \mathbb{R}_+ \times P \to \Delta_A,$$

where Δ_A is the 1-dimensional simplex describing probability distributions over (in this case) A. Thus $r(a_i|m,p_j)$ is the probability that p takes action a_i, given that d has offered m, and p's type is p_j. In general, we can describe the utility functions for d and p as $u(d_i,p_j,m,a_k)$ and $v(d_i,p_j,m,a_k)$, respectively. We extend these functions to the strategy space Δ_A by taking expected values; let

$$u(d_i,p_j,m,r(\cdot,p_j)) = \sum_{a_k \in A} u(d_i,p_j,m,a_k)r(a_k|m,p_j)$$

$$v(d_i,p_j,m,r(\cdot,p_j)) = \sum_{a_k \varepsilon A} v(d_i,p_j,m,a_k)r(a_k|m,p_j).$$

Since d has no opportunity to gain information about p's type, we can suppress the p_j term in d's utility function by redefining the function as:

$$u(d_i,m,r(\cdot,\cdot)) = \gamma u(d_i,p_1,m,r(\cdot,p_1)) + (1 - \gamma)u(d_i,p_2,m,r(\cdot,p_2)).$$

Also, for each $\rho \varepsilon \Delta_D$ (i.e., probability distributions over D), $m \varepsilon \mathbb{R}_+$, and $p_j \varepsilon P$, let

$$BR(\rho,m,p_j) = \underset{r(\cdot,p_j)\varepsilon\Delta_A}{\operatorname{argmax}} \sum_{d_i \varepsilon D} v(d_i,p_j,m,r(\cdot,p_j))\rho(d_i)$$

be the best response correspondence for p, given his type.

The utility payoffs for d and p are as follows: if p accepts an offer of m from d, then the payoffs for d and p are $(-m, m - m')$, respectively, regardless of p or d's type. If p rejects d's offer, both parties incur court costs ($c_p, c_d > 0$, resp.) and the payoffs are determined by p and d's types and the liability rule, but not by d's offer. Each liability rule we analyze can be described by a 2 X 2 matrix, constituting the four underlying states with entries of either 0 or 1, where 0 implies that p is liable for the damages and 1 implies that d is liable. The payoffs for d and p, respectively, are:

$$0 : (-c_d, -c_p - m')$$
$$1 : (-c_d - m', -c_p).$$

Thus, if p is held liable, he receives no compensation from d, while

still incurring the court costs, as does d. [We assume that the American system of allocating court costs is in force, where each party pays his own costs irrespective of the court's decision.] Similarly, if d is held liable, he transfers m' to p, as well as paying his court costs (thus, we assume no punitive damages). The four liability rules we analyze are:

1. Negligence[3]

$$\begin{array}{cc} & \begin{array}{cc} p_1 & p_2 \end{array} \\ \begin{array}{c} d_1 \\ d_2 \end{array} & \begin{bmatrix} 0 & 0 \\ 1 & 1 \end{bmatrix} \end{array}$$

Under the negligence rule, the court's decision is contingent only on d's type: i.e., whether or not p was negligent is not at issue.

2. Strict liability with contributory negligence

$$\begin{array}{cc} & \begin{array}{cc} p_1 & p_2 \end{array} \\ \begin{array}{c} d_1 \\ d_2 \end{array} & \begin{bmatrix} 1 & 0 \\ 1 & 0 \end{bmatrix} \end{array}$$

Under this rule, d's type is not at issue; d is assumed a priori (strictly) liable, but can use as a defense p's (contributory) negligence.

3. Negligence with contributory negligence

$$\begin{array}{cc} & \begin{array}{cc} p_1 & p_2 \end{array} \\ \begin{array}{c} d_1 \\ d_2 \end{array} & \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix} \end{array}$$

If d is negligent and p is not, then d is liable for damages; otherwise p is liable.

4. Strict liability with dual contributory negligence

$$\begin{array}{c c} & \begin{array}{cc} p_1 & p_2 \end{array} \\ \begin{array}{c} d_1 \\ d_2 \end{array} & \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \end{array}$$

If p is negligent and d is not, then p is liable: otherwise d is liable.

These rules constitute four of the six "noncomparative" liability rules studies by Brown (1973), nonoomparative implying that the negligence of either party is not a function of the other party's actions. The two remaining rules, no liability and strict liability, can be analyzed as degenerate cases of the strict liability with contributory negligence rule, with prior probabilities $\gamma = 0$ and $\gamma = 1$, respectively.

To analyze these games we use a refinement of the divine equilibrium concept [Banks and Sobel (1985)], which is itself a refinement of sequential equilibrium [Kreps and Wilson (1982)].

Definition: A sequential equilibrium to any of the above games consists of strategies $\{q(\cdot), r(\cdot,\cdot)\}$ for d and p, and beliefs $\mu(\cdot|m) \in \Delta_D$ for p such that

1. $\forall d_i \in D$, $q(m^*|d_i) > 0$ only if

$$u(d_i, m^*, r(m^*,\cdot)) = \max_{m \in \mathbb{R}_+} u(d_i, m, r(m,\cdot))$$

2. $\forall m \in \mathbb{R}_+$, $\forall p_j \in P$, $r(a_k, m, p_j) > 0$ only if

$$\sum_{d_i \in D} v(d_i, p_j, m, a_k)\mu(d_i|m) = \max_{a_k \in A} \sum_{d_i \in D} v(d_i, p_j, m, a)\mu(d_i|m)$$

3. If $\sum_{d_i \in D} q(m|d_i)pr(d_i) > 0$, then

$$\mu(d_i|m) = \frac{q(m|d_i)pr(d_i)}{\sum_{d_i \in D} q(m|d_i)pr(d_i)},$$

where $pr(d_1) = \lambda$, $pr(d_2) = 1 - \lambda$.

Thus, in a sequential equilibrium, $q(\cdot)$ maximizes d's expected utility, given $r(\cdot,\cdot)$, $r(\cdot,\cdot)$ maximizes p's expected utility, given beliefs $\mu(\cdot)$, and p's beliefs are rational given d's strategy in that they satisfy Bayes' rule along the equilibrium path.

By condition (2), we see that the sequential equilibrium concept restricts off-the-equilibrium-path behavior of p in that p is allowed to take actions which are best responses to some beliefs over Δ_D, thus restricting p to undominated actions away from the equilibrium. The beliefs p holds, however, are given no constraints, and as such can lead to implausible or "unintuitive" equilibria (cf. Kreps (1955)). The key to divinity is that restrictions on beliefs are characterized which attempt to embody certain rationality postulates concerning these beliefs vis-a-vis the equilibrium path. Thus, divinity stresses a rational interdependence between the equilibrium path and beliefs at zero-probability events, based on the willingness and ability of (in this case) types of defendants to differentiate themselves by deviating from the equilibrium path. [For a more complete discussion of this topic, as well as divinity's relation to other equilibrium concepts, see Banks and Sobel (1985).]

We can describe p's (mixed) strategies somewhat more simply as an element of $\Delta_A \times \Delta_A \equiv \Delta_A^2$; i.e., a pair of probability distributions over A, one for each type of p. Fix an equilibrium in which d_i obtains utility $u^*(d_i)$, and $q(m|d_i) = 0$, $i = 1,2$. Deleting the argument m from p's strategy, define

$$A_G = \{r \in \Delta_A^2 : u(d_i,m,r) \geq u^*(d_i),\ i = 1 \text{ or } i = 2\},$$

and, for all $r \in \Delta_A^2$, let

$$\bar{\mu}(d_i,r) = \begin{cases} 1 & \text{if } u(d_i,m,r) > u^*(d_i) \\ [0,1] & \text{if } u(d_i,m,r) = u^*(d_i) \\ 0 & \text{if } u(d_i,m,r) < u^*(d_i) \end{cases}$$

be the frequency that d_i would send m if he believes m would induce the response r by p and d_i had a choice between sending m or obtaining $u^*(d_i)$. [Recall that in d's utility function we've suppressed the dependence on p's type by taking expected values.] Next, let

$$\Gamma(r) = \{\rho \in \Delta_D : \exists \mu(d_i) \in \bar{\mu}(d_i,r) \text{ and } c > 0 \text{ s.t.}$$
$$\rho(d_i) = c\mu(d_i)pr(d_i),\ i = 1,2\}, \text{ and}$$
$$\bar{\Gamma}(A) = co[\bigcup_{r \in A} \Gamma(r)].$$

For the analysis of the model described above, the key feature so far of these restrictions is the following: if $\bar{\mu}(d_i,r) = 1$ implies

$\bar{\mu}(d_j,r) = 1$, $\forall r \in \Delta_A^2$, then for all beliefs in $\bar{\Gamma}(\Delta_A^2)$ it must be that p believes d_j is at least as likely to defect from the equilibrium to m as d_i. If, for example, $i = 1$, then this implies that, at m, $\mu(d_1) \geq \lambda$. We will see below that, given the particular nature of the payoffs in the model, this criterion is the key to divinity's refinement of the set of sequential equilibria. To continue with the definition, let $\Gamma_0 = \Delta_D$, $A_0 = \Delta_A^2$, and for $n > 0$,

$$\Gamma_n \equiv \begin{cases} \bar{\Gamma}(A_{n-1}) & \text{if } \bar{\Gamma}(A_{n-1}) \neq \emptyset \\ \Gamma_{n-1} & \text{if } \bar{\Gamma}(A_{n-1}) = \emptyset, \end{cases}$$

$$A_n \equiv BR(\Gamma_{n,m}),\ \Gamma^* = \bigcap_n \Gamma_n,\ A^* = \bigcap_n A_n.$$

Note that, although divinity was originally conceived for signaling games; i.e., where p can be only one type, generalization to this model is saved from some difficulties by the fact that, under the negligence rule, payoffs are not a function of p's type (so we can without loss of generality assume only one type of plaintiff) whereas, in the other three liability rules at least one type of plaintiff has a dominant strategy, implying that such a type's best response correspondence is (subject to indifference) a singleton. Thus, in using divinity to refine the set of sequential equilibria we will typically need to inspect the beliefs of only one type of plaintiff.

Definition: A sequential equilibrium in the above games is divine if it is supported by beliefs in Γ^*.

One further criterion we employ is that p_1 and p_2 do not take weakly dominated actions in or out of equilibrium. We say that a_k weakly dominates a_ℓ if

$$\sum_{d_i \varepsilon D} v(d_i, p_j, m, a_k)\rho(d_i) \geq \sum_{d_i \varepsilon D} v(d_i, p_j, m, a_\ell)\rho(d_i)$$

for all $\rho \ \varepsilon \ \Delta_D$ with strict inequality for at least one such belief. In the next section it can be seen that the offer that makes this further refinement nonvaccuous is at $m = m' - cp$. Suppose the negligence rule is in force and only d_2 offers $m' - cp$, P is then indifferent between accepting (a_1) and rejecting (a_2) the offer; however, if there were any positive probability of d_1 being the offeror of $m' - cp$, p should accept (see Fig. 1 below). Hence a_1 dominates a_2 for an offer of $m' - cp$.

This restriction is a characteristic of the perfect equilibrium concept [Selten (1975)], which is itself a subset of the set of sequential equilibria.[4]

Definition: A divine equilibrium is perfect divine if no weakly dominated action is taken in or out of equilibrium with positive probability.

We now proceed to calculate the perfect divine equilibria under the four different liability rules.

3. EQUILIBRIUM OUTCOMES

3.1 Negligence

Without loss of generality let $r(\cdot|\cdot,p_1) = r(\cdot|\cdot,p_2) = r(\cdot|\cdot)$.[5] For any offer m, the payoffs for d and p can be characterized by the following bi-matrix:

m	a_1	a_2
d_1	$-m, m - m'$	$-c_d, -c_p - m'$
d_2	$-m, m - m'$	$-c_d - m', -c_p$

Define $\alpha(m) = \dfrac{m' - m - c_p}{m'}$; $\alpha(m)$ is the probability of d_1 such that p is indifferent between accepting and rejecting the offer m. Define $m_\lambda = (1 - \lambda)m' - c_p$; given beliefs λ, p is indifferent between accepting and rejecting m_λ. Note that $m_\lambda \geq 0 \iff \lambda \leq \dfrac{m' - c_p}{m}$. If $m_\lambda > 0$, Fig. 1 describes p's decision problem. Suppose that $m_\lambda \leq c_d$; then both d_1 and d_2 would prefer to offer $m \ \varepsilon \ [m_\lambda, c_d]$ and have it accepted, then make any other offer and have it rejected. By Fig. 1 if both d_1 and d_2 make an offer $m \geq m_\lambda$, p can (in equilibrium) accept. Thus, there exists sequential pooling equilibria $m^* \ \varepsilon \ [\max\{0, m_\lambda\}, c_d]$ of the form:[6]

$$q^*(m^*|d_1) = q^*(m^*|d_2) = 1,$$

$$r^*(a_1|\hat{m}) = 1, \quad \forall \hat{m} \geq m^*,$$

$$r^*(a_1|\hat{\hat{m}}) = 0, \quad \forall \hat{\hat{m}} < m^*.$$

[Figure 1 about here]

To check whether any of these pooling equilibria are divine, we use the following: given equilibrium payoffs $u^*(d_1)$ at m^* define

$$\theta(\bar{m}|m^*) = r(a_1|\bar{m}) \text{ s.t.}$$
$$u^*(d_1) = r(a_1|\bar{m})(-\bar{m}) + (1 - r(a_1|\bar{m})(-c_d);$$

similarly, define

$$\theta_2(\bar{m}|,*) = r(a_1|\bar{m}) \text{ s.t.}$$
$$u^*(d_2) = r(a_1|\bar{m})(-\bar{m}) + (1 - r(a_1|\bar{m}))(-c_d - m').$$

Since the payoffs of d_1 and d_2 are increasing in $r(\cdot)$, d_1 would prefer to deviate if $r(\cdot) > \theta_1$, and d_2 would prefer to deviate if $r(\cdot) > \theta_2$. Recalling the conditions for divinity, $\theta_1 < \theta_2 \Rightarrow \mu(d_1|m) \geq \lambda$, and vice versa. From Fig. 1 we see that, for equilibrium offers $m^* > m_\lambda$ and unsent offer $\bar{m} \varepsilon (m_\lambda, m^*)$, p's beliefs must be such that $\mu(d_1|\bar{m}) < \lambda$, in order to reject the offer $\bar{m}$. Calculating $\theta_1(\bar{m}|m^*)$ and $\theta_2(\bar{m}|m^*)$ we get

$$\theta_1 = \frac{c_d - m^*}{c_d - \bar{m}}$$

$$\theta_2 = \frac{m' - m^* + c_d}{m' - \bar{m} + c_d}.$$

Thus, θ_1, $\theta_2 \leq 1 \Rightarrow \bar{m} \leq m^*$, and $\dfrac{\partial\theta_i}{\partial\bar{m}} > 0$, $i = 1,2$. Cancelling terms we find that, for $\bar{m} \leq m^*$, $\theta_1 \leq \theta_2$, as in Fig. 2.

[Figure 2 about here]

Thus, divinity implies $\mu(d_1|\bar{m}) \geq \lambda$; but $\mu(d_1|\bar{m}) \geq \lambda$ and $\bar{m} > m_\lambda$ imply p should accept $\bar{m}$ with probability one. Thus, the only perfect divine pooling equilibrium offer is at

$$m^* = \max\{\theta, m_\lambda\}.$$

However, an offer of m_λ leaves p indifferent between acceptance and rejection, allowing p to mix between these two actions. Thus, a complete characterization of the equilibria is:

$$q(m_\lambda|d_i) = 1, \quad i = 1,2$$

$$r(a_1|m_\lambda) = \sigma \geq \frac{c_p + c_d}{c_p + \lambda m' + c_d}$$

$$r(a_1|m < m_\lambda) \leq \frac{\sigma(c_d - m_\lambda)}{c_d - m}$$

$$r(a_1|m' - c_p > m > m_\lambda) \leq \frac{\sigma(m' - m_\lambda + c_d)}{m' - m + c_d}$$

$$r(a_1|m \geq m' - c_p) = 1.$$

Since p will accept <u>any</u> offer from d_1 if p knew it was from d_1, there does not exist a sequential separating equilibrium under the negligence rule. There does, however, exist sequential semi-pooling equilibria under certain conditions. It is easily shown that it is not possible to make both d_1 and d_2 indifferent between making two offers; hence the semi-pooling equilibria will consist of d_2 mixing between two offers, d_1 sending one of the offers (the "common" offer) with probability one, and p mixing between acceptance and rejection at the common offer. From Fig. 1 we see that p will accept with probability one an offer of $m \geq m' - c_p$ (by perfection) even if he knows its from d_2; furthermore it must be that $m_\lambda \geq 0$ for p to be indifferent between acceptance and rejection. Thus, if $m_\lambda \geq 0$, there exists (perfect) sequential semi-pooling equilibria with common offer $m^* \in [0,\min\{m_\lambda,c_d\}]$. At m^*, d_2 is indifferent between m^* and $m' - c_p$ if $r(a_1|m^*)$ solves

$$c_p - m' = r(a_1|m^*)(-m^*) + (1 - r(a_1|m^*))(-c_d - m').$$

Calculating through, we get

$$r^*(a_1|m^*) = \frac{c_p + c_d}{m' - m^* + c_d} .$$

$r^*(a_1|m^*)$ is always positive, and

$$r^*(a_1|m^*) \leq 1 \iff m^* \leq m' - c_p.$$

Since $q^*(m^*|d_1) = 1$, to get $\alpha(m^*) = \dfrac{m' - m^* - c_p}{m'}$, $q^*(m^*)|d_2)$ must solve

$$\frac{m' - m^* - c_p}{m'} = \frac{\lambda}{\lambda + (1 - \lambda)q^*(m^*)|d_2)} ,$$

which implies

$$q^*(m^*|d_2) = \frac{\lambda(m^* + c_p)}{(1 - \lambda)(m' - m^* - c_p)} .$$

Thus, the full description of the (perfect) sequential semi-pooling equilibria is: for $m^* \in [0,\min\{m_\lambda,c_d\}]$,

$$q^*(m^*|d_1) = 1$$

$$q^*(m^*|d_2) = \frac{\lambda(m^* + c_p)}{(1 - \lambda)(m' - m^* - c_p)}$$

$$q^*(m' - c_p|d_2) = \frac{(1 - \lambda)m' - m^* - c_p}{(1 - \lambda)(m' - m^* - c_p)}$$

$$r^*(a_1|m^*) = \frac{c_p + c_d}{m' - m + c_d}$$

$$r^*(a_1|\tilde{m} < m' - c_p, \tilde{m} \neq m^*) = 0$$

$$r^*(a_1|\hat{m} \geq m' - c_p) = 1.$$

To check divinity, we can redefine $\theta_1(\bar{m}|m^*)$ in terms of the common offer m^*. Thus, after solving for d_1's equilibrium utility, $\theta_1(\bar{m}|m^*)$ solves

$$\frac{1}{m' - m^* + c_d}\{c_pc_d - m^*c_p - m'c_d\} = \theta_1(\bar{m}|m^*)(-\bar{m}) + (1 - \theta_1)(\bar{m}|m^*))(-c_d),$$

calculating, we get

$$\theta_1(\bar{m}|m^*) = \frac{(c_d + c_p)(c_d - m^*)}{(c_d - \bar{m})(m' - m^* + c_d)} .$$

Since d_2's utility is the same in <u>all</u> the semi-pooling equilibria,

$c_p - m'$, $\theta_2(\bar{m}|m^*)$ is simply the equilibrium mix at $\bar{m}$:

$$\theta_2(\bar{m}|m^*) = \frac{c_p + c_d}{m' - \bar{m} + c_d}\ .$$

Note that, at $m^* = \bar{m}$, $\theta_1 = \theta_2$, and

$$\frac{\partial\theta_1}{\partial\bar{m}} = \frac{(c_d + c_p)(c_d - m^*)}{(c_d - \bar{m})^2(m' - m^* + c_d)} > 0,$$

$$\frac{\partial\theta_2}{\partial\bar{m}} = \frac{(c_p + c_d)}{(m' - \bar{m} + c_d)^2} > 0.$$

Solving for the ordering of θ_1 and θ_2, we get:

$$\theta_1 \leq \theta_2 \iff \bar{m} \leq m^*.$$

Fig. 3 describes the situation. Thus, divinity requires that $\mu(d_1) \geq \lambda$ for $\bar{m} \leq m^*$, and $\mu(d_1) \leq \lambda$ for $\bar{m} \geq m^*$. However, for $m^* \leq m_\lambda$, $\lambda \leq \alpha(m^*)$, so that divinity allows p to reject offers below the common offer. Thus, all the (perfect) sequential semi-pooling equilibria are perfect divine.

[Figure 3 about here]

To summarize the results under the negligence rule:

(i) if $m_\lambda \leq c_d$, there exists a perfect divine pooling equilibrium offer at $m^* = \max\{0,m_\lambda\}$, which p accepts with positive probability.

(ii) if $m_\lambda \geq 0$, there exist perfect divine semi-pooling equilibria with common offer $m^* \in [0,\min\{m_\lambda,c_d\}]$, and where the probability

of trial is

$$\left[\lambda + \frac{(1-\lambda)\lambda(m^* + c_p)}{(1-\lambda)(m' - m^* - c_p)}\right]\cdot\left[\frac{m' - m^* - c_p}{m' - m^* + c_d}\right] = \frac{\lambda m'}{m' - m^* + c_d}\ .$$

3.2 Strict Liability with Contributory Negligence

Without loss of generality let $q(\cdot|d_1) = q(\cdot|d_2) = q(\cdot)$. Given an offer m, the payoffs to d and p are:

m	a_1	a_2
p_1	$-m, m - m'$	$-c_d - m', -c_p$
p_2	$-m, m - m'$	$-c_d, -c_p - m'$

We see that both p_1 and p_2 have (weakly) dominant strategies: p_1 should reject all offers less than $m' - c_p$, and accept all offers greater than or equal to $m' - c_p$ and p_2 should accept any offer. Since the sequential equilibrium concept limits players to undominated strategies off the equilibrium path, p_1 and p_2 cannot threaten to take any other action (e.g., it is not a sequential equilibrium if $r(a_1|m,p_2) < 1$, for any $m \in \mathbb{R}_+$). Thus in a (perfect) sequential equilibrium,

$$r^*(a_1|m,p_2) = 1, \quad \forall m,$$

$$r^*(a_1|m,p_1) = \begin{cases} 0 & \text{if } m < m' - c_p \\ 1 & \text{if } m \geq m' - c_p\ . \end{cases}$$

For d, given $\gamma \in (0,1)$, any offer $m \in (0,m' - c_p)$ is dominated by offering $m = 0$, given p's equilibrium strategy; similarly

$m \in (m' - c_p, \infty)$ is dominated by offering $m = m' - c_p$. Thus, in a (perfect) sequential equilibrium,

$$q^*(m) > 0 \Rightarrow m \in \{0, m' - c_p\}.$$

Now,

$$u(d, m = 0, r^*(\cdot)) = -\gamma c_d - \gamma m';$$

$$u(d, m = m' - c_p, r^*(\cdot)) = c_p - m'.$$

Let $m_\gamma = (1 - \gamma)m' - c_p$. Thus, we get:

(i) if $\gamma c_d < m_\gamma$, then $q^*(m = 0) = 1$;

(ii) if $\gamma c_d > m_\gamma$, then $q^*(m = m' - c_p) = 1$.

In words, if $\gamma c_d < m_\gamma$, then the unique (perfect) sequential (hence perfect divine) equilibrium is for d to offer $m = 0$, for p_1 to reject and go to court, and for p_2 to accept and drop the case. If $\gamma c_d > m_\gamma$, then the unique perfect divine equilibrium involves d offering $m = m' - c_p$, and both p_1 and p_2 accepting. Note that if $\gamma = 0$, (i) always holds; if p is always liable, then d should give p nothing (as in the case of "no liability"). If $\gamma = 1$, (ii) always holds, and d should offer $m' - c_p$ (as in the case of "strict liability").

3.3 Negligence with Contributory Negligence

For an offer m from d, the payoffs to d and p are:

$p = p_1$

m	a_1	a_2
d_1	$-m, m - m'$	$-c_d, -c_p - m'$
d_2	$-m, m - m'$	$-c_p - m', -c_p$

$p = p_2$

m	a_1	a_2
d_1	$-m, m - m'$	$-c_d, -c_p - m'$
d_2	$-m, m - m'$	$-c_p, -c_p - m'$

Note that the decision problem of p_1 is similar to that of p under the negligence rule, while the decision problem of p_2 is similar to that of p_2 under the strict liability with contributory negligence rule. Thus, Fig. 1 characterized p_1's problem, while p_2 has a dominant strategy to accept any offer.

As under the negligence rule, there exists a continuum of pooling sequential equilibria under certain conditions. Here the condition is that $m_\lambda \leq \gamma c_d$, for d_1 can guarantee himself (in expected value terms) γc_d by sending $m = 0$ and having p_1 reject and p_2 accept. Formally, the equilibria are:[7]

for $$m^* \in [m_\lambda, \gamma c_d],$$

$$q^*(m^* | d_1) = q^*(m^* | d_2) = 1,$$

$$r^*(a_1 | \hat{m}, p_1) = 1, \quad \forall \hat{m} \geq m^*$$

$$r^*(a_1|\hat{\hat{m}},p_1) = 0 \quad \forall\hat{\hat{m}} < m^*,$$

$$r^*(a_1|m,p_2) = 1, \quad \forall m.$$

To check for divinity, we calculate $\theta_1(\bar{m}|m^*)$ and $\theta_2(\bar{m}|m^*)$ as under the negligence rule where, since p_2 has a dominant strategy to accept any offer, $\theta_1(\bar{m}|m^*)$ is the probability that p_1 accepts $\bar{m}$ such that d_1 is indifferent between the equilibrium payoffs at m^* and deviating to $\bar{m}$. Thus $\theta_1(\bar{m}|m^*)$ solves

$$-m^* = \gamma(\theta_1(\bar{m}|m^*)(-\bar{m}) + (1 - \theta_1(\bar{m}|m^*))(-c_d)) + (1 - \gamma)(-\bar{m})$$

which gives

$$\theta_1(\bar{m}|m^*) = \frac{(1 - \gamma)\bar{m} - m^* + \gamma c_d}{\gamma(c_d - \bar{m})} .$$

Similarly, $\theta_2(\bar{m}|m^*)$ solves

$$-m^* = \gamma(\theta_2(\bar{m}|m^*)(-\bar{m}) + (1 - \theta_2(\bar{m}|m^*)(-c_d - m')) + (1 - \gamma)(-\bar{m})$$

which gives

$$\theta_2(\bar{m}|m^*) = \frac{(1 - \gamma)\bar{m} - m^* + \gamma(c_d + m')}{\gamma(m' - \bar{m} + c_d)} .$$

Ordering $\theta_1(\cdot)$ and $\theta_2(\cdot)$, we get, as under the negligence rule,

$$\theta_1(\cdot) \leq \theta_2(\cdot) \iff \bar{m} \leq m^*,$$

as in Fig. 2. Thus, the only perfect divine pooling equilibrium offer which both p_1 and p_2 accept with positive probability is at $m^* = m_\lambda$. There are, however, conditions under which another perfect divine pooling equilibrium exists. Suppose that both d_1 and d_2 offer $m = 0$. If $m_\lambda > 0$, then p_1 will reject the offer (see Fig. 1), and p_2 will accept, giving d_1 a utility of $-\gamma c_d$ and d_2 a utility of $-\gamma(c_d + m')$. If $r(a_1|m,p_1) = 0$, $\forall m < m' - c_p$, then the only deviation viable to d_2 is $m = m' - c_p$, which both p_1 and p_2 will accept. Thus, the condition for $m^* = 0$ to be a (perfect) sequential pooling equilibrium is that

$$-\gamma(c_d + m') \geq c_p - m', \text{ or}$$
$$m_\gamma \geq \gamma c_d.$$

Checking divinity, we get that

$$\theta_1(\bar{m}|m^*) = \frac{(1 - \gamma)\bar{m}}{\gamma(c_d - \bar{m})} , \text{ and}$$

$$\theta_2(\bar{m}|m^*) = \frac{(1 - \gamma)\bar{m}}{\gamma(m' - m^* + c_d)} .$$

Hence, $\theta_1(0|0) = \theta_2(0|0) = 0$, $\frac{\partial\theta_i}{\partial\bar{m}} > 0$, $i = 1,2$, and $\theta_1(\cdot) > \theta_2(\cdot)$ implying Fig. 4.

[Figure 4 about here]

Divinity implies that $\mu(d_1|\bar{m}) \leq \lambda$, $\forall\bar{m} \in (0,\gamma(m' + c_d))$, so that p_1 can reject all offers less than $m' - c_p$ in a perfect divine pooling equilibrium at $m^* = 0$.

As in the negligence case there exists (perfect) sequential semi-pooling equilibria in which d_2 is indifferent between offers $m^* \leq m_\lambda$ and $m' - c_p$ and mixes between them, and d_1 sends m^* with probability one. Recall that p_2 has a dominant strategy: $r^*(a_1|m,p_2) = 1$, $\forall m$, so that only p_1-type plaintiffs mix between acceptance and rejection. For p_1 to be indifferent he must believe that d_1 occurs with probability $\alpha(m^*) = \dfrac{m' - m^* - c_p}{m'}$. For d_2 to be indifferent between m^* and $m' - c_p$ it must be that $r(a_1|m^*,p_1)$ solves

$$c_p - m' = \gamma(r(a_1|m^*,p_1)(-m^*) + (1 - r(a_1|m^*,p_1))(-c_d - m')) + (1 - \gamma)(-m^*),$$

so that

$$r^*(a_1|m^*,p_1) = \frac{(1 - \gamma)(m^* - m') + \gamma c_d + c_p}{\gamma(m' - m^* + c_d)} .$$

Now $r^*(a_1|m^*,p_1) \leq 1$ implies $m^* \leq m' - c_p$, while $r^*(a_1|m^*,p_1) \geq 0$ implies

$$m^* \geq \frac{(1 - \gamma)m' - \gamma c_d - c_p}{(1 - \gamma)} \equiv \tilde{m}.$$

Since (as in the negligence case) d_2 can only make p_1 indifferent for offers less than m_λ, a condition for the existence of sequential semi-pooling equilibria is that

$$\tilde{m} \leq m_\lambda.$$

Also, it must be that $\tilde{m} \leq \gamma c_d$; otherwise d_1 would be better off offering $m = 0$ and having p_1 reject and p_2 accept.

Since p_1 is indifferent at m^* in the semi-pooling equilibrium and $q^*(m^*|d_1) = 1$, $q^*(m^*|d_2)$ must solve

$$\alpha(m^*) = \frac{m' - m^* - c_p}{m'} = \frac{\lambda}{\lambda + (1 - \lambda)q^*(\cdot)} , \text{ or}$$

$$q^*(m^*|d_2) = \frac{\lambda(m^* + c_p)}{(1 - \lambda)(m' - m^* - c_p)} ,$$

which is the same as under the negligence rule.

To check for divinity, we calculate $\theta_1(\bar{m}|m^*)$ and $\theta_2(\bar{m}|m^*)$. As under the negligence rule,

$$\theta_2(\bar{m}|m^*) = r^*(a_1|\bar{m},p_1) = \frac{(1 - \gamma)(\bar{m} - m') + \gamma c_d + c_p}{\gamma(m' - \bar{m} + c_d)} ,$$

while $\theta_1(\bar{m}|m^*)$ solves

$$\frac{c_p c_d - m'c_d - m^* c_p}{m' - m^* + c_d} = \gamma[\theta_1(\bar{m}|m^*)(-\bar{m}) + (1 - \theta_1(\bar{m}|m^*))(-c_d)] + (1 - \gamma)(-\bar{m}),$$

which gives

$$\theta_1(\bar{m}|m^*) = \frac{(1 - \gamma)[\bar{m}(c_d - m^*) - m'(c_d - \bar{m})] + (c_d - m^*)(\gamma c_d + c_p)}{\gamma(c_d - \bar{m})(m' - m^* + c_d)} .$$

As a check, we see that, at $m^* = \bar{m}$,

$$\theta_1(\cdot) = \theta_2(\cdot); \text{ also}$$

$$\frac{\partial \theta_1}{\partial \bar{m}} = \frac{(c_d - m^*)(c_d + c_p)}{\gamma(c_d - \bar{m})^2(m' - m^* + c_d)} > 0,$$

$$\frac{\partial\theta_2}{\partial\bar{m}} = \frac{(c_d + c_p)}{\gamma(m' - \bar{m} + c_d)^2} > 0.$$

Note that these partial derivatives are the same as in the semi-pooling equilibria under the negligence rule multiplied by $1/\gamma$. Thus, all the (perfect) sequential semi-pooling equilibria under the rule of negligence with contributory negligence are perfect divine. To summarize:

(i) if $m_\lambda \leq \gamma c_d$, there exists a perfect divine pooling equilibria at $m^* = \max\{0, m_\lambda\}$, where both p_1 and p_2 accept with positive probability;

(ii) if $m_\lambda > 0$ and $\gamma c_d \leq m_\gamma$, there exists a perfect divine pooling equilibria at $m^* = 0$ where p_1 rejects and p_2 accepts;

(iii) if $m_\lambda > 0$, $\tilde{m} \leq m_\lambda$, $\tilde{m} \leq \gamma c_d$, there exists semi-pooling divine equilibria with common offer $m^* \varepsilon [\tilde{m}, \min\{m_\lambda, \gamma c_d\}]$ and where the probability of trial is

$$\left[\lambda + \frac{(1-\lambda)\lambda(m^* + c_p)}{(1-\lambda)(m' - m^* - c_p)}\right] \cdot \left[\frac{\gamma(m' - m^* - c_p)}{\gamma(m' - m^* + c_d)}\right] = \frac{\lambda m'}{m' - m^* + c_d} .$$

3.4 Strict Liability with Dual Contributory Negligence

Given an offer m, the payoffs to d and p are:

$p = p_1$

m	a_1	a_2
d_1	$-m, m - m'$	$-c_d - m', -c_p$
d_2	$-m, m - m'$	$-c_d - m', -c_p$

$p = p_2$

m	a_1	a_2
d_1	$-m, m - m'$	$-c_d, -c_p - m'$
d_2	$-m, m - m'$	$-c_d - m', -c_p$

Thus the undominated strategies for p_1 can be characterized as

$$r(a_1|m, p_1) = \begin{cases} 0 & \text{if } m < m' - c_p \\ 1 & \text{if } m \geq m' - c_p \end{cases},$$

while p_2 faces a decision problem similar to that of p in the negligence case (see Fig. 1). Again there exist sequential pooling equilibria $m^* \geq m_\lambda$ with the following constraints:

(i) $m^* \leq c_d + \gamma m'$; since p_1 will reject any offer less than $m' - c_p$, and in a pooling equilibrium p_2 will typically reject all offers lower than the equilibrium offer; and

(ii) $m^* \leq \tilde{m}$; since both d_1 and d_2 obtain $\gamma(-c_d - m') + (1-\gamma)(-m^*)$ in a pooling equilibrium at m^*, it must be that d_1 and d_2 prefer this payoff to that which they would receive by offering $m = m' - c_p$ and having it accepted with probability one. Thus, $\gamma(-c_d - m') + (1-\gamma)(-m^*) \geq c_p - m'$, which implies

$$m^* \leq \frac{(1-\gamma)m' - \gamma c_o - c_p}{(1-\gamma)} \equiv \tilde{m}.$$

In terms of divinity,

$$\theta_1(\bar{m}|m^*) = \frac{c_d - m^*}{c_d - \bar{m}} \text{ , while}$$

$$\theta_2(\bar{m}|m^*) = \frac{m' - m^* + c_d}{m' - \bar{m} + c_d}, \text{ so that,}$$

for $m^* < \bar{m}$, $\theta_1 < \theta_2$ and the only perfect divine pooling equilibrium offer of this type is at $m^* = m_\lambda$.

Suppose now that $\tilde{m} < m_\lambda$, so that an equilibrium with the above conditions fails to exist. Hence both d_1 and d_2 prefer to offer $m = m' - c_p$ and have it accepted by p_1 and p_2 than to offer $m = m_\lambda$ and have it accepted only by p_2. Furthermore, if d_1 (and hence d_2) prefer to offer $m = m' - c_p$ than $m = 0$ and having the offer rejected by both p_1 and p_2, it must be that

$$\gamma(-c_d - m') + (1 - \gamma)(-c_d) < c_p - m',$$

which implies

$$m_\gamma < c_d.$$

Under these conditions there exists a perfect divine pooling equilibrium at $m^* = m' - c_p$ which p_1 accepts and where p_2 adopts the strategy

$$r^*(a_1|m,p_2) = \begin{cases} 0 & \text{if } m < m_\lambda \\ 1 & \text{if } m \geq m_\lambda \end{cases}.$$

To check for divinity, we see that $\theta_1(\bar{m}|m' - c_p)$ solves

$$c_p - m' = \gamma(-c_d - m') + (1 - \gamma)[\theta_1(\bar{m}|m' - c_p)(-\bar{m}) + (1 - \theta_1(\bar{m}|m' - c_p))(-c_d)]$$

which implies

$$\theta_1(\bar{m}|m' - c_p) = \frac{c_d + c_p - (1 - \gamma)m'}{(1 - \gamma)(c_d - \bar{m})}.$$

$\theta_2(\bar{m}|m' - c_p)$ solves

$$c_p - m' = \gamma(-c_d - m') + (1 - \gamma)[\theta_2(\bar{m}|m' - c_p)(-\bar{m}) + (1 - \theta_2(\bar{m}|m' - c_p))(-c_d - m')]$$

which gives

$$\theta_2(\bar{m}|m' - c_p) = \frac{c_p + c_d}{(1 - \gamma)(m' - \bar{m} + c_d)}.$$

If $\theta_1(\cdot)$, $\theta_2(\cdot) > 1$, $\forall \bar{m}$, then divinity places no restrictions on beliefs. From the above equations we see that

$$\theta_1(\bar{m}|m' - c_p) \leq 1 \iff \bar{m} \leq \tilde{m},$$
$$\theta_2(\bar{m}|m' - c_p) \leq 1 \iff \bar{m} \leq \tilde{m},$$

so there does not exist an offer $\hat{m}$ such that d_1 would prefer to send $\hat{m}$ under some mixed strategy by p_2 while d_j would never prefer to deviate to $\hat{m}$. Since divinity allows p_2 to use the prior probability over D when the issue is only the <u>ordering</u> of θ_1 and θ_2, and since the prior supports p_2's equilibrium strategy (see Fig. 1), the equilibrium is perfect divine.

The (perfect) sequential semi-pooling equilibria in this case will involve p_1 rejecting the common offer and accepting $m = m' - c_p$, p_2 indifferent between accepting and rejecting the common offer, d_1

sending the common offer with probability one, and d_2 indifferent between the common offer and $m = m' - c_p$. Thus, d_2 is indifferent at m^* if $r(a_1|m^*,p_2)$ solves

$$c_p - m' = \gamma(-c_d - m') + (1 - \gamma)[r(a_1|m^*,p_2)(-m^*) + (1 - r(a_1|m^*,p_2))(-c_d - m')]$$

or,

$$r^*(a_1|m^*,p_2) = \frac{c_p + c_d}{(1 - \gamma)(m' - m^* + c_d)} .$$

Now $r^*(\cdot) > 0$, $\forall m^*$, while $r^*(\cdot) \le 1 \Leftrightarrow m^* \le \tilde{m}$, so that $\tilde{m} < 0$ implies there does not exist any sequential semi-pooling equilibria. [Note: $\tilde{m} \le 0 \Leftrightarrow \gamma c_d \ge m_\gamma$.]

As above, p_2 is indifferent at m^* is $\mu(d_1|m^*) = \alpha(m^*) \equiv \dfrac{m' - m^* - c_p}{m'}$, so that

$$q^*(m^*|d_2) = \frac{\lambda(m^* + c_p)}{(1 - \lambda)(m' - m^* - c_p)} \text{, while}$$

$$q^*(m^*|d_1) = 1.$$

Completing the equilibrium strategies,

$$r^*(a_1|m,p_1) = \begin{cases} 0 & \text{if } m < m' - c_p \\ 1 & \text{if } m \ge m' - c_p \end{cases},$$

$$r^*(a_1|m,p_2) = \begin{cases} 0 & \text{if } m \ne m^*, m < m' - c_p \\ 1 & \text{if } m \ne m^*, m \ge m' - c_p \end{cases}.$$

Checking divinity, $\theta_2(\bar{m}|m^*)$ is simply p_2's equilibrium mix at $\bar{m}$:

$$\theta_2(\bar{m}|m^*) = \frac{c_p + c_d}{(1 - \gamma)(m' - \bar{m} + c_d)} ,$$

while (omitting the algebra)

$$\theta_1(\bar{m}|m^*) = \frac{(c_d + c_p)(c_d - m^*)}{(1 - \gamma)(c_d - \bar{m})(m' - m^* + c_d)} .$$

Note that for $m^* = \bar{m}$, $\theta_1(\cdot) = \theta_2(\cdot)$, and

$$\frac{\partial\theta_1}{\partial\bar{m}} = \frac{(c_d + c_p)(c_d - m^*)}{(1 - \gamma)(c_d - \bar{m})^2(m' - m^* + c_d)} > 0,$$

$$\frac{\partial\theta_2}{\partial\bar{m}} = \frac{(c_p + c_d)}{(1 - \gamma)(m' - \bar{m} + c_d)^2} > 0,$$

which are the partial derivatives of $\theta_1(\cdot)$ and $\theta_2(\cdot)$ under the negligence rule multiplied by $1/(1 - \gamma)$. Hence the semi-pooling sequential equilibria, with common offer $m^* \in [0, \min\{\tilde{m}, m_\lambda, c_d + \gamma m'\}]$ are perfect divine. In summary:

(i) if $m_\lambda \le \tilde{m}$, $m_\lambda \le c_d + \gamma m'$, there exists a perfect divine pooling equilibria at $m = m_\lambda$ which p_1 rejects and p_2 accepts;

(ii) if $\tilde{m} < m_\lambda$ and $m_\gamma < c_d$, there exists a perfect divine pooling equilibria at $m = m' - c_p$, which both p_1 and p_2 accept;

(iii) if $m_\lambda \ge 0$ and $\tilde{m} \ge 0$ there exist perfect divine semi-pooling equilibria with common offer $m^* \in [0, \min\{\tilde{m}, m_\lambda, c_d + \gamma m'\}]$. The probability of trial is

$$\left[\lambda + \frac{(1-\lambda)\lambda(m^* + c_p)}{(1-\lambda)(m' - m^* - c_p)}\right] \cdot \left[\gamma + \frac{(1-\gamma)(m' - m^*) - \gamma c_d - c_p}{m' - m^* + c_d}\right]$$

$$= \left[\frac{\lambda m'}{m' - m^* - c_p}\right] \cdot \left[\frac{m' - m^* - c_p}{m' - m^* + c_d}\right] = \frac{\lambda m'}{m' - m^* + c_d} .$$

3.5 Summary

The perfect divine equilibrium paths under the four liability rules are:

1. negligence

(i) if $m_\lambda \leq c_d$, there exists a pooling equilibrium offer at $m^* = \max\{0, m_\lambda\}$, which p accepts with positive probability; the maximum probability of rejection is $\frac{\lambda m'}{c_p + \lambda m' + c_d}$;

(ii) if $m_\lambda \geq 0$, there exist semi-pooling equilibria with common offer $m^* \varepsilon [0, \min\{m_\lambda, c_d\}]$, where p mixes between acceptance and rejection; the probability of rejection (hence a trial decision) at m^* is $\frac{\lambda m'}{m' - m^* + c_d}$.

2. strict liability with contributory negligence

(i) if $\gamma c_d < m_\gamma$, the equilibrium offer by d is at $m^* = 0$, which p_1 rejects and p_2 accepts; thus the probability of trial is $\Pr(p_1) = \gamma$;

(ii) if $\gamma c_d > m_\gamma$, the equilibrium offer is at $m^* = m' - c_p$, which both p_1 and p_2 accept.

3. negligence with contributory negligence

(i) if $m_\lambda \leq \gamma c_d$, there exists a pooling equilibrium offer at $m^* = \max\{0, m_\lambda\}$, which p_2 accepts with probability one and p_1 accepts with positive probability. The maximum probability of rejection by p_1 is $\frac{\lambda m'}{c_p + \lambda m' + c_d}$;

(ii) if $m_\lambda > 0$ and $\gamma c_c < m_\gamma$, there exists a pooling equilibrium offer at $m^* = 0$, which p_1 rejects and p_2 accepts; thus the probability of trial is $\Pr(p_1) = \gamma$;

(iii) if $m_\lambda \geq 0$, $\tilde{m} \leq m_\lambda$, $\tilde{m} \leq \gamma c_d$, there exist semi-pooling equilibria with common offer $m^* \varepsilon [\tilde{m}, \min\{m_\lambda, \gamma c_d\}]$ which p_2 accepts and p_1 mixes between acceptance and rejection; the probability of trial at m^* is $\frac{\lambda m'}{m' - m^* + c_d}$.

4. strict liability with dual contributory negligence

(i) if $m_\lambda \leq \tilde{m}$ and $m_\lambda \leq c_d + \gamma m'$, there exists a pooling equilibrium offer at $m^* = \max\{0, m_\lambda\}$, which p_1 rejects and p_2 accepts with positive probability; the probability of trial is at least $\Pr(p_1) = \gamma$;

(ii) if $\tilde{m} \leq m_\lambda$ and $m_\gamma \leq c_d$, there exists a pooling equilibrium offer at $m^* = m' - c_p$, which both p_1 and p_2 accept;

(iii) if $\tilde{m} \geq 0$, $m_\lambda \geq 0$, there exist semi-pooling equilibria with common offer $m^* \varepsilon [0, \min\{\tilde{m}, m_\lambda, c_d + \gamma m'\}]$, where the probability of trial at m^* is $\frac{\lambda m'}{m' - m^* + c_d}$.

Since $\gamma c_d \geq m_\gamma \Leftrightarrow \tilde{m} \leq 0$, there exist comparisons between the perfect divine equilibria of different liability rules in terms of the set of parameters for which the equilibria exist. The most interesting comparison seems to be negligence v. negligence with contributory negligence, and strict liability with contributory negligence v. strict liability with dual contributory negligence, which for notational simplicity we label n, ncn, slcn, sldcn, respectively. We begin by partitioning the space of parameters into two sets.

A. $m_\lambda < 0$ (i.e., $\lambda > \frac{m' - c_p}{m'}$).

(i) There exist no semi-pooling equilibria.

(ii) If there exists a pooling equilibrium at $m^* = 0$ under slcn, then there exists a pooling equilibrium at $m^* = 0$ under sldcn; thus, the equilibrium $m^* = 0$ exists "more often" (in terms of a probability distribution over parameter values) under sldcn than under slcn.

(iii) If there exists a pooling equilibrium at $m^* = m'\ c_p$ under sldcn, then there exists a pooling equilibrium at $m^* = m' - c_p$ under slcn.

(iv) The only equilibria under n and ncn is at $m^* = 0$.

B. $m_\lambda \geq 0$.

(i) The pooling equilibrium offer $m^* = m' - c_p$ exists more often under sldcn than under slcn.

(ii) The pooling equilibrium offer $m^* = 0$ exists more often under slcn than under sldcn.

(iii) The pooling equilibrium offer $m^* = m_\lambda$ exists more often under n than under ncn.

(iv) The pooling equilibrium offer $m^* = 0$ exists more often under ncn than under n.

(v) The semi-pooling equilibria exist more often under n than under ncn; more over, the set of common offers is smaller under ncn than under n.

Thus we see that, given $m_\lambda \geq 0$, the pooling offers tend to be smaller going from n to ncn and slcn to sldcn, while with $m_\lambda < 0$ there is no difference between n and ncn, and the pooling offers are on average larger under sldcn than under slcn.

4. CONCLUSION

We have seen how the liability rule in force can influence the behavior of plaintiff and defendant in the pretrial bargaining of a civil suit. A generalization of the model would be to allow the plaintiff the ability to make the first offer, which the defendant can either accept or make a counteroffer, and the plaintiff either accepting this or rejecting and going to court. This would allow the defendant the opportunity to gain insight into the plaintiff's type prior to making his offer, an opportunity which does not exist in the model above. Note that, if the defendant rejected a pooled offer from the plaintiff, the subsequent behavior would fall directly under the model of this paper; given a pooled offer by the plaintiff, the defendant gains no information; given that he's rejected the offer, he proceeds to make his own offer.

In terms of analyzing behavior prior to an accident, notice that defendants prefer outcomes when $m_\lambda < 0$; i.e., $\lambda > \frac{m' - c_p}{m'}$, so that for a fixed damage size m', there is an incentive <u>as a group</u> to maintain a high prior probability of nonnegligence in the eyes of potential plaintiffs. Similarly, plaintiffs prefer outcomes when $\gamma c_d \geq m_\gamma$; i.e., $\gamma \geq \frac{m' - c_p}{m' + c_d}$ and $\tilde{m} < m_\lambda$; i.e., $\frac{m'}{c_d + c_p} < \frac{\gamma}{(1-\gamma)\lambda}$, so that there are incentives for (potential) plaintiffs to maintain a high probability of nonnegligence as a group. Analysis such as this is fairly ad hoc, however; a more complete development will be the topic of subsequent papers.

NOTES

* I would like to thank participants in the Caltech Theory Workshop for helpful comments and suggestions.

1. Epstein (1973) posits an alternative goal of liability law, that of "corrective justice."

2. Two other rules, no liability and strict liability, will be seen to be degenerate cases of strict liability with contributory negligence.

3. P'ng's (1984) analysis basically deals with this rule.

4. Of course, one could have initially defined perfect equilibrium and subsequently added divinity; however, divinity grew out of the methodology of the sequential equilibrium concept and as such is easier to characterize as a refinement of sequential equilibrium.

5. Since the payoffs are not a function of the plaintiff's type, the plaintiff's strategy can be a nontrivial function of type only if he is indifferent between a_1 and a_2. In this case, the (mixed) strategies of the plaintiff below can be interpreted as those which arise after taking expectations over p_1 and p_2.

6. Some mixing between a_1 and a_2 is allowed out of equilibrium, as shown below; this does not alter the set of nondivine sequential equilibria.

7. See note 6 above.

REFERENCES

Banks, J. and Sobel, J. 1985. "Equilibrium Selection in Signaling Games." Caltech Social Science Working Paper no. 565.

Bebchuk, L. 1984. "Litigation and Settlement under Imperfect Information." Rand Journal of Economics 15:404-415.

Brown, J. 1973. "Toward an Economic Theory of Liability." Journal of Legal Studies 2:323-349.

Diamond, P. 1974a. "Single Activity Accidents." Journal of Legal Studies 3:107-164.

__________. 1974b. "Accident Law and Resource Allocation." Bell Journal of Economics and Management Science 5:366-406.

Epstein, R. 1973. "A Theory of Strict Liability." Journal of Legal Studies 2:151-221.

Green, J. 1976. "On the Optimal Structure of Liability Laws." Bell Journal of Economics 7:553-574.

Harsanyi, J. 1967-68. "Games with Incomplete Information Played by 'Bayesian Players.'" Management Science 14:159-182, 320-334, 486-502.

Kreps, D. 1985. "Signalling Games and Stable Equilibria." Mimeo, Stanford University.

Kreps, D. and Wilson, R. 1982. "Sequential Equilibria." Econometrica 50:863-894.

Posner, R. 1972. "A Theory of Negligence." Journal of Legal Studies 1:29-96.

P'ng, I. 1983. "Strategic Behavior in Suit, Settlement, and Trial." Bell Journal of Economics 14:539-550.

__________. 1984. "Liability, Litigation, and Incentives to take Care." Mimeo, Center for Economic Policy Research, Stanford University.

Reinganum, J. and Wilde, L. 1985. "Settlement, Litigation, and the Allocation of Litigation Costs." Caltech Social Science Working Paper no. 564.

Salant, S. 1984. "Litigation of Settlement Demands Questioned by Bayesian Defendants." Caltech Social Science Working Paper no. 516.

Samuelson, W. 1983. "Negotiation v. Litigation." Mimeo, Boston University.

Selten, R. 1975. "A Reexamination of the Perfectness Concept for Equilibrium Points in Extensive Games." International Journal of Game Theory 4:25-55.

Shavell, S. 1983. "Torts in which the Victim and Injurer Act Sequentially." Journal of Law and Economics 26:589-612.

Sobel, J. 1985. "An Analysis of Discovery Rules." Mimeo.

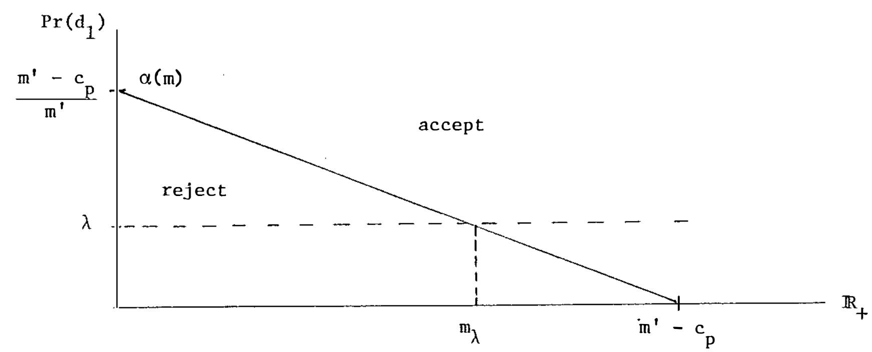
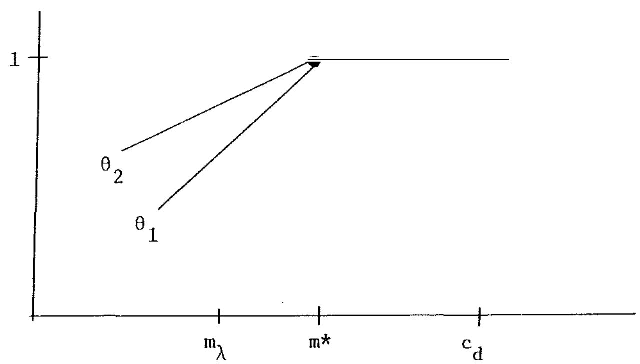


Figure 1



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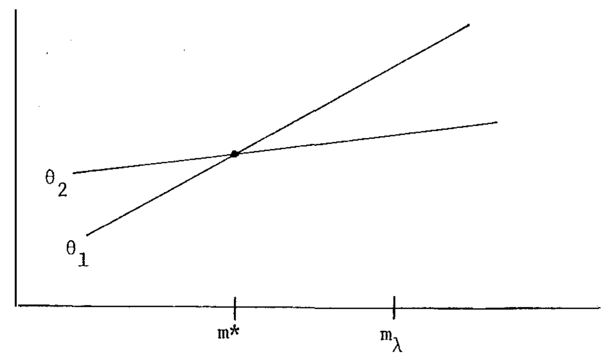

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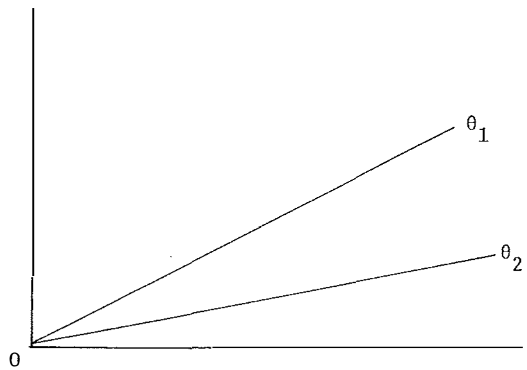

Figure 4