The Role of Insurance in the Adjudication of Multiparty Accidents

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This paper considers the case where adequate negligence standards cannot be defined because actions of defendants before an accident are imperfectly observable. Negligence-based liability rules, which are often considered as the only efficient liability rule in the presence of multiple tortfeasors, are not feasible in this environment. We propose an insurance-based liability rule as a remedy: Damages are apportioned according to the insurance policies of the defendants. The adjudication is made dependent on the requirement that the injurers have taken out insurance coverage setting the right incentives. The liability rule is easy to characterize, efficient, and avoids the use of punitive damages. Insurance-based liability could also be helpful to mitigate the problem of unobservable avoidance costs. © 1999 by Elsevier Science Inc.

I. Introduction

Most of the research in law and economics concerning multiple defendants has been confined to situations where the court has all the necessary information about the circumstances of the accident. The present paper addresses the case where the fault of the defendants cannot be established accurately for lack of information about their actions before the accident.

The importance of accidents with multiple causation and imperfect information can be illustrated by some examples. In environmental liability problems, harm done to the
environment is often caused by many sources, the contributions of which cannot be monitored in a satisfactory way.\textsuperscript{1} The difficulty is obvious for nonpoint sources, for example in solid waste clean-ups or pollution of the sea. In the case of point sources of pollution, monitoring may often be technically feasible but, for example in the case of water pollution, perfect monitoring would be prohibitively expensive. Multiple causation is not limited to environmental liability. Another typical example is a highway mass collision. In this case, actions and measures of precaution before the accident may plainly be impossible to verify. A plane crash is a multiparty accident if the aircraft manufacturer and the airline are sued jointly. The causes of such an accident and the respective fault of the defendants may be buried deep beneath the sea. A final example are securities fraud law suits involving several defendants like managers, investment banks, and accounting firms.\textsuperscript{2} In all of these cases, unobservable actions seem to play an important role.

For accidents with multiple tortfeasors, finding an efficient liability rule can be a daunting task if the court is imperfectly informed about the action levels. More precisely, an efficient liability rule does not exist if the accident is jointly characterized by (1) the presence of multiple tortfeasors interacting in nonseparable ways, (2) imperfect information about the actions of the defendants before the accident, and (3) the exclusion of punitive damages.

The problem at hand is a variant of what is known as the team production problem.\textsuperscript{3} The intuition is the following. To choose her efficient action, each potential injurer would have to take into account the increase in the expected total damage as induced by her decision. If actions are unobservable, the court cannot identify deviating agents. Therefore, the only way of implementing the efficient action choice for all agents would be to saddle each agent with a contribution in the amount of the total loss. This proposal is known as the “double liability rule.”\textsuperscript{4}

Thus, the double liability rule might seem to be a possible solution to the problem. There are, however, two problems with this solution, linked to the fact that the double liability rule amounts to imposing punitive damages. The first one is institutional. In virtually all legal systems outside the United States, punitive damages are either excluded or play a very minor role. Even in the United States, punitive damages are normally restricted to cases of reckless conduct, e.g., drunken driving.\textsuperscript{5} The second


\textsuperscript{2}Moreover, several of the defendants may be organized as partnerships, which may create the potential of internal suits for retribution.


\textsuperscript{4}This rule has been explored in Jörg Finsinger and Mark Pauly, “The Double Liability Rule,” The Geneva Papers of Risk and Insurance Theory, 15, 1990, pp. 159–169.

\textsuperscript{5}See, e.g., Steven Shavell, “Economic Analysis of Accident Law,” p. 146, Cambridge MA: Harvard University Press,
problem is genuinely economic. By definition, punitive damages mean that injurers pay a multiple of the losses that the victims suffer. This discourages potential injurers from pursuing activities bearing accident risk, and more often than would efficient. As a result, risky, but socially desirable, investments will not be undertaken. For both reasons, it is worthwhile to investigate whether tort adjudication with multiple tortfeasors can be efficient without punitive damages.

As a creative solution to the problem, the present paper proposes an insurance-based liability rule. We show that our proposal of basing liability on insurance policies is sufficient to obtain an efficient adjudication in all cases, even in the most extreme case where the court has no information whatsoever about the actions of tortfeasors before the accident. Insurance coverage of liability risks should be exploited because insurance companies are better suited than for the courts for the task of providing desirable incentives for potential injurers. We propose that the court make the contributions of an injurer dependent on whether the party has, before the accident, been covered by an insurance contract that implements the socially desired care levels. Otherwise the party is liable to “punishment” via a discontinuous increase in its contribution. The present paper shows that the inefficiency dilemma can be completely overcome in this way. The reason is that the restriction of no punitive damages is not binding for insurance companies. In other words, though there are multiple defendants, insurers can address the problem of creating the right incentives as a purely bilateral task between the insurer and a single potential injurer.

Insurance-based liability implicitly delegates the task of designing incentives for care to insurance companies. This is not as new and daring as it might seem. The insurance industry has long recognized that setting the right incentives is a vital part of any insurance policy. It has developed expertise in defining and applying various incentive schemes like deductibles, coinsurance, and others. Witness that it is hard to find an example of an accident insurance policy granting full insurance even though this would be desirable from the point of view of optimal risk sharing. In practice, insurers assume a role in designing incentives as much as they do in providing optimal sharing of risks, and our liability rule directly proposes to exploit their expertise in this.

Our analysis focuses exclusively on the role of insurers in providing incentives. For that reason, risk-sharing motives are ignored and injurers are assumed to be risk neutral. In this respect, our article follows the tradition of previous literature that has analyzed motives behind the corporate demand for insurance other than risk aversion: Mayers and Smith refer to taxes, contracting costs, or the impact of financing policy on corporate investment decisions as possible explanations, and Skogh presents an explicit transactions cost theory of insurance demand. The insurance motive behind our liability rule is closer in relationship to an earlier proposal by Jost to delegate the design of incentive contracts to insurers. As in the present paper, Jost supposes that insurance

1987. Exceptions are rare. William S. Landes and Richard A. Posner, The Economic Structure of Tort Law, p. 304, Cambridge, MA: Harvard University Press, 1987, report that even in product liability lawsuits, punitive damages have been used in less than five percent of all successful suits. Also, there seems to be no correlation with multiple causation.


7See Peter J. Jost, "Limited Liability and the Requirement to Purchase Insurance," International Review of Law and Economics, 16(2), 1996, pp. 253–276. In Jost’s model, decisions about approval or rejection of production processes are made contingent on proof of an efficient insurance policy. That is, regulation, not adjudication, is insurance based.
contracts are observable. The crucial difference is that insurance-based decision-making serves to get around the insolvency problems, not the problem of multiple injurers.

Under the insurance-based liability rule proposed here, insurance policies that set the desired incentives covering multiparty accidents must use high-powered incentive instruments, i.e., the payments of the injurers if harm occurs must be relatively high compared to the no-harm case. One may question, therefore, the realism of our construction; more concretely, one may question whether insurance contracts providing these incentives could plausibly emerge on today’s insurance markets. We argue that this concern can be dismissed, for three reasons. First, we show that optimal insurance contracts can do with standard incentive instruments. More precisely, an insurance contract consisting of a fixed premium, a constant coinsurance contribution of the insured and a bonus if there is no accident sets the desired incentives. Second, we show that the incentive schemes are strictly lower powered under our liability rule compared to any other efficient liability rule. Third, in practice, insurance contracts will use lower-powered incentives more often than our analysis would show. This is so because the size and the composition of the group of jointly liable defendants is frequently as random as the accident itself. Take the example of highway collisions. There could be two, three, or more defendants. In a majority of accidents, there is only a single injurer. Nobody can predict the precise nature of a future accident, but past data allow the formation of statistical expectations for the likelihood of the various possible constellations of possibilities. Incentive-compatible accident insurance must take expectations over accident risks with respect to single-injurer, bilateral, and multi-injurer accidents, and incentives must be based on a weighted expectation over all of these constellations. The smaller the probability that many injurers will be involved, the lower the necessary power of incentives.

The gain in efficiency if liability is based on insurance contracts is considerable. Moreover, the benefit of insurance-based liability may not be limited to the situation considered here, namely, unobservable action levels. A problem that has attracted a lot of attention in the literature is unobservable avoidance costs.8 We discuss briefly the possibility that insurance-based liability could also be a remedy in this case.

One side aspect of our proposal is that it is obviously all the more powerful, the more wide-spread liability insurance becomes. Thus, mandatory insurance, long adopted for car insurance and recently, in the United States as well as in Europe, introduced (though not yet implemented) for environmental liability, can be independently justified on the grounds of our findings.

The paper is organized as follows: In Section II, we demonstrate our results by means of an example. In Section III, the global efficiency of the insurance-based liability rule is demonstrated. In Section IV, the incentive instruments of optimal insurance contracts are presented. In Section V, we discuss briefly that our liability rule could also be useful in the case of unobservable avoidance costs. Section VI concludes.

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II. An Example

Inefficiency Without Insurance

In this section, the power of basing liability on insurance contracts is presented by means of an example. We start by showing that conventional liability rules cannot be efficient if they do not resort to punitive damages before turning to our liability rule.

In our example, there are only two injurers. We imagine two identical firms, A and B, which deposit hazardous waste on a single waste site. The individual quantities or the composition of their individual contributions are unknown. We denote by \( a_A \) (\( a_B \)) the deposited quantity of firm A (B). Each firm could have deposited a quantity of \( a_A \) (\( a_B \)) = 1, 2, 3 or 4. Two different types of accidents could occur: a small accident with a loss of \( x_L = $1,000 \), and a disastrous accident with a loss of \( x_H = $5,000 \). The quantity of waste deposited has an impact on the probability for each type of accident to occur. Both firms are risk neutral. We suppose that the socially optimal quantity for each firm is to deposit a quantity of \( a_A^* = a_B^* = 2 \).

Given that firm B adopts this optimal action of depositing \( a_B^* = 2 \), the probabilities depend on firm A’s action. This is shown in Table 1 (the asterisk indicates that this is the optimal activity level).

This means for example that, if firm A deposits \( a_A = 1 \) while firm B deposits the optimal quantity \( a_B^* = 2 \), the two types of accidents occur with a probability of 5% each. With 90% probability no accident occurs. A feature of the model that we will generalize in the next section is that the no-accident probability, \( p_0 \), decreases as \( a_A \) increases. It should be noted that in the situation depicted in Table 1, the avoidance costs of firm B are 60 as B takes action \( a_B^* = 2 \), and the model is completely symmetric.

Let \( a = (a_A, a_B) \) describe the total quantity on the site, and let \( Ex(a) \) denote the expected loss. The expected loss in this case is equal to:

\[
Ex(1, 2) = 0.90 \cdot 0 + 0.05 \cdot 1,000 + 0.05 \cdot 5,000 = 300. \tag{1}
\]

Similarly, if both adopt the optimal action of \( a_A^* = a_B^* = 2 \):

\[
Ex(2, 2) = 0.885 \cdot 0 + 0.055 \cdot 1,000 + 0.055 \cdot 5,000 = 335. \tag{2}
\]

<table>
<thead>
<tr>
<th>Quantity of firm A (given B deposits ( a_B^* = 2 ))</th>
<th>( a_A = 1 )</th>
<th>( a_A = 2 )</th>
<th>( a_A = 3 )</th>
<th>( a_A = 4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of ( x_L )</td>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
<td>0.12</td>
</tr>
<tr>
<td>Probability of ( x_H )</td>
<td>0.05</td>
<td>0.055</td>
<td>0.06</td>
<td>0.08</td>
</tr>
<tr>
<td>Probability of ( p_0 ) (no accident)</td>
<td>0.90</td>
<td>0.885</td>
<td>0.85</td>
<td>0.80</td>
</tr>
<tr>
<td>A’s avoidance costs</td>
<td>120</td>
<td>60</td>
<td>30</td>
<td>10</td>
</tr>
</tbody>
</table>

TABLE 2. Social costs

<table>
<thead>
<tr>
<th>Quantity of firm A (given B deposits ( a_B^* = 2 ))</th>
<th>( a_A = 1 )</th>
<th>( a_A = 2 )</th>
<th>( a_A = 3 )</th>
<th>( a_A = 4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) total expected accident loss ( Ex(a_A, a_B) )</td>
<td>300</td>
<td>335</td>
<td>390</td>
<td>520</td>
</tr>
<tr>
<td>(2) total costs of care (both firms)</td>
<td>180</td>
<td>120</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>(1) + (2) total social costs ( C(a_A, a_B) )</td>
<td>480</td>
<td>455</td>
<td>480</td>
<td>590</td>
</tr>
</tbody>
</table>
In the same fashion, we can calculate $Ex(3, 2)$ and $Ex(4, 2)$. To these expected losses, the total costs of care have to be added to get a result on the total social costs of any pair of disposed quantities.

Table 2 shows the total social costs as a function of the actions of both firms. For example, if firm A chooses $a_A = 3$ while firm B chooses $a_B = 2$, then A has avoidance costs of 60 and B of 30. Add the expected accident loss of 390 to get the social costs of 480. From Table 2, it is transparent that social costs are indeed minimized at $a_A^* = 2$, given that the other firm’s choice is also $a_B^* = 2$.

It is well known from the literature that all kinds of negligence rules implement the first best as long as the court is fully informed. We begin the discussion with a brief review of the solution in case where the individual actions (quantity and composition of waste deposits) can be perfectly observed. The distinctive feature of negligence-based rules is that the expected contribution of each potential injurer increases steeply (typically characterized by a discontinuous jump) when the due care standards are violated. It is precisely this feature that serves well in the present context because the jump around the required level of care makes a potential injurer think twice before relaxing her level of care below the required mark. If the court is fully informed, then the due care standards can be defined in a socially optimal way. For our example with only two potential injurers, the following kind of strict liability with contributory negligence has been proposed:

$$l_i^n(x_k) = \begin{cases} \frac{x_k}{2} & \text{if } a_i, a_j \leq 2 \text{ or } a_i, a_j > 2 \\ x_k & \text{if } a_i > 2 \text{ and } a_j \leq 2 \\ 0 & \text{otherwise} \end{cases}$$

(3)

where $x_k \in [x_L, x_H]$. Subscripts $i$ and $j$ denote any order of the injurers A and B. The liability rule in (3) is the simplest rule of strict liability with contributory negligence, which is efficient. The first term $x_k/2$ means that every agent has to pay half of the damage if both firms act efficiently (because, given the proposed liability rule, there is no reason to choose $a_i < 2$). If agent A violates the due care standard and agent B acts efficiently, agent A has to pay the whole damage and vice versa. This leads to a damage payment of 0 for agent B, which is expressed in the third row of (3).

It is clear that the proposed liability rule leads to the desired allocation. Consider for example agent A who chooses an activity level $a_A^* = 2$. If this is also true for agent B, then the expected loss is 335 and A’s expected contribution toward damages is 167.5, because the damage is equally divided between both agents. If agent A increases her action level (i.e., her quantity of hazardous waste), say by one unit, the expected damage raises from 335 to 390. The expected liability payments raise from 167.5 to 390. Next, we denote by $c_A(a_i)$ the avoidance costs of agent A when choosing the action level of $a_A$. Moreover, let $v_A$ denote the total expected costs of agent A, or, in other words, $c_A(a_A) +$ the expected damages to be borne by her. We consider three action levels:

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9Note that there are also probabilities if neither of the firms dumps a quantity of 2. We ignore all these cases and concentrate solely on the efficient situation and possible deviations from it; this is the usual logic of determining a Nash equilibrium.

$a_A^* = 2$ which we have stipulated to be socially efficient as well as the levels $a_A = 3$ and $a_A = 1$. Then $v_A$ is:

$$v_A(2) = 167.5 + 60 = 227.5.$$  \hfill (4)

if agent $A$ chooses the first-best action level. In (4), 167.5 is one half of the expected accident loss of 335, and 60 is $A$’s avoidance cost. On the other hand, if she chooses $a_A = 1$ (given $a_B^* = 2$), then her total costs would attain:

$$v_A(1) = 150 + 120 = 270.$$  \hfill (5)

Finally, if she chooses $a_A = 3$, then her total costs would attain:

$$v_A(3) = 390 + 30 = 420.$$  \hfill (6)

Thus, the expected costs, $v_A$, increase in both cases. This should be quite intuitive: We have made the agent fully responsible for all the social consequences of her precaution if she chooses a level higher than the first-best level. This leads her to fully take into account the total harm that she is inflicting. Then the choice $a_A^* = 2$, which minimizes the social cost, must coincide with the minimization of her individual total costs $v_A$.

The trouble starts when action levels are unobservable. This implies that the court cannot employ a negligence-based rule to implement the first best. To see this, recall that negligence-based rules require that the level of care be observable because all negligence-based rules rely on a sharp increase of liability payments when the due care standards are violated. Thus, we must investigate liability rules that are constant in unobservable action levels and that depend on the actual damage alone.

Because both agents are completely identical in their impact on the damage function, it seems natural to split the total damage equally between them.\footnote{In fact, one can show that this is the best possible rule at hand. The formal proof would proceed as our more general proof in the next section.} We inquire about the consequences of such an equal splitting rule for agent $A$. If both firms choose the optimal action level, $a_A^* = a_B^* = 2$, the expected contribution of agent $A$ is 167.5. If agent $A$ chooses a level $a_A = 3$, corresponding to less care, the expected damage increases from 335 to 390, but the expected contribution increases only from 167.5 to 195, because agent $B$ has to pay the rest of the damage increase (recall that it is not possible to increase the percentage contribution of $A$, as given under the negligence rule, because actions are unobservable). So, although the damage increases by 55 units, the expected contribution of agent $A$ would increase only by 27.5 units. The other 27.5 units are borne by agent $B$. In the example, by choosing $a_A^* = 2$, she expects under the equal splitting rule:

$$v_A(2) = 167.5 + 60 = 227.5.$$  \hfill (7)

On the other hand, by loosening precaution to a level of $a_A = 3$ she expects:

$$v_A(3) = 195 + 30 = 225.$$  \hfill (8)

Thus, agent $A$ would prefer the level $a_A = 3$. This is socially inefficient: The total costs of agent $A$ decrease by 2.5 units, whereas the expected social costs increase by 25 units. The inefficient choice of $a_A = 3$ occurs because agent $A$ is not held liable for the full marginal impact of her lack of care.
To understand the difference in a more general fashion, note that with the equal splitting rule, by loosening her level of precaution, agent A fully enjoys the benefit of $c_A(3) - c_A(2) < 0$, but she bears only half of the social accident loss. Thus, the equal splitting rule will obviously not lead to the efficient action levels. Each of the two agents will choose a higher action level than desired because one agent knows that she can externalize parts of the accident loss on the other agent.

Thus, one concludes that a liability rule can only be efficient if the increase of the expected contribution equals the increase of the expected total damage, and equally so for all injurers. This is nothing but the “double liability rule,” which is the most straightforward proposal adopting this approach. The double liability rule has the following simple form for agent A:

$$t^A_L(x_k) = x_k \quad x_k \in \{ x_L, x_H \}$$

and likewise for agent B. This means that each participant is held liable for the total harm. However, the trouble with the double liability rule is that expected total damages necessarily exceed the accident loss. The economic problem is that this may give the wrong incentives to engage in risky activities. This explains why the use of punitive damages in areas sensitive to business activity (like product liability and environmental liability) has come under so much pressure lately.

Thus, the solutions considered so far are all deficient: Sharing rules lead to too little care, whereas the double liability rule gives the desired incentives for care but in turn hurts investment incentives.

The Insurance-Based Liability Rule

In this section, we introduce the insurance-based liability rule. The rest of the model is unchanged, including the assumption that agents are risk neutral. We do so to keep the argument as simple as possible. This is convenient for our analysis as we consider a role of insurers unrelated to risk sharing and introduce a motive for taking out insurance that is independent of attitudes toward risk. All of the arguments in the present paper carry over to a set-up with risk-averse agents.

The central idea is that liability contributions will increase steeply if the injurer has not signed an insurance policy giving her the desired incentives. As a consequence, the insurer must design the insurance contract in a way that gives the right incentives to the insured for care, given the liability rule in place. Something very similar is happening in practice: Insurers care about incentives, which, in turn, depend on expected liability. Insurance contracts provide many features that enhance incentives for care. Deductibles, coinsurance, insurance caps (policy limits), and bonus-malus systems are among the most frequently used. We demonstrate that the obligation to sign insurance contracts with the right incentives can be fulfilled by a contract using only these standard instruments. The innovation is that liability is now explicitly based on incentives. Also, efficiency may require that the incentives become more accentuated than is the current practice.

For the moment, we suppose simply that such an insurance contract giving the desired incentives exists. We denote this contract by $e^i$. $e^i$ will be described below, after the presentation of the liability rule. The liability rule can be made dependent on the

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12See Jörg Finsinger and Mark Pauly, supra note 4.
harm $x_k$ as well as on the insurance contracts of both agents. We capture this by denoting the liability rule as $l(x_k, e_A, e_B)$. The liability rule we propose coincides with the equal splitting rule considered above, but only if the court verifies that both agents are covered by the desired insurance contracts $e_A^*$ and $e_B^*$. In this case, $l(x_k, e_A^*, e_B^*) = x_k/2$. If agent $A$ is not insured, or is found to be covered by a different insurance contract, she is made fully liable for the total damage and agent $B$ is fully exonerated. Hence, $l(x_k, e_A, e_B^*) = x_k$ and $l(x_k, e_A^*, e_B) = 0$. If both agents are not covered by an adequate insurance contract, then the equal splitting rule is again invoked. Thus, $l(x_k, e_A, e_B) = x_k/2$. To summarize, the liability rule for our example can be characterized by:

$$l(x_k, e_A, e_B) = \begin{cases} 
  x_k & \text{if } e_i = e_i^* \text{ and } e_j = e_j^* \\
  \frac{x_k}{2} & \text{if } e_i \neq e_i^* \text{ and } e_j \neq e_j^* \text{ or } e_i = e_i^* \text{ and } e_j = e_j^* \\
  0 & \text{otherwise.}
\end{cases}$$

We analyze how agent $A$ behaves if agent $B$ takes her equilibrium actions. That is, agent $B$ is covered by contract $e_B^*$ and chooses action as $a_B^* = 2$. We restrict attention in the example to the action levels $a_A^* = 2$ and $a_A = 3$ because only higher action levels (less care) are critical. Again, this is completely sufficient to make our point.

Next we describe the optimal insurance contract, $e^*$. We introduce a contract, $e^*$, that uses only “incentive instruments,” as they are widely known and are used daily all over the world. In particular, we invoke the following three components or incentive instruments:

- **Coinsurance payments as a constant fraction of damages.** Let $g < 1$ denote the fraction of damages paid by the insured.
- **A bonus refund** $b$ that the insured receives if no accident occurs.
- **A fixed premium** $f$.

Note that this is not an exhaustive list of incentive instruments, as our discussion in Section IV shows. Neither deductibles nor insurance caps, although also universally known and used, are needed for our demonstration, which can be performed with a coinsurance payment, a bonus refund, and an insurance premium. Many other possible and efficient insurance contracts exist, for example, contracts with a deductible instead of constant coinsurance.

Our efficient contract, $e^*$, consists of a fixed premium $f^*$, a coinsurance share $g^*$ (as a fraction of the contribution toward damages), and a bonus, $b^*$. We specify $f^*$ = 508.55, $g^*$ = 0.5, and $b^*$ = 480. This implies that the effective insurance payment if there is no accident is $f^* - b^* = 28.55$. Let $p_0(a_A, a_B)$ denote the probability that no accident occurs.

In a Nash equilibrium, agent $B$ will choose her equilibrium strategy, viz. sign contract $e_B^*$ and act accordingly. We suppose that $B$ chooses to do so and look at $A$’s incentives. Suppose first that agent $A$ has also signed the desired insurance contract $e_A^*$. Then the equal splitting rule will apply. If she chooses $a_A^* = 2$, then her expected costs will be:

$$v_A(2) = c_A(2) + f^* + g^* \frac{1}{2} \text{Ex} - p_0(2, 2) \cdot b^*$$

$$= 60 + 508.55 + 0.5 \cdot 167.5 - 0.885 \cdot 480$$

$$= 227.5.$$
Note that in (10), \( g^* \frac{1}{2} Ex \) denotes injurer A’s expected coinsurance payments where expectations are taken with respect to all possible accident outcomes \( x_k \):

\[
g^* \frac{1}{2} Ex = g^* p_H(a_A, a_B^* \frac{x_H}{2}) + g^* p_L(a_A, a_B^* \frac{x_L}{2}).
\]

So equation (10) says that she pays expected costs of 227.5 — the same costs she would pay in a world of perfect information where strict liability with contributory negligence applies.

On the other hand, if she chooses \( a_A = 3 \), then her total costs would be:

\[
v_A(3) = c_A(3) + f^* + g^* \cdot \frac{1}{2} Ex - p_0(3, 2) \cdot b^*
\]

\[
= 30 + 508.55 + 0.5 \cdot 195 - 0.85 \cdot 480
\]

\[
= 228.05,
\]

which is more than under the optimal action, \( a_A^* = 2 \). By analogy, firm B has clearly the right incentives for care as well, given that A chooses her equilibrium action \( a_A^* \).

Suppose that both agents are insured. If there is a competitive market for insurance, then insurance will be fair. That is, in equilibrium the insurer just expects to break even. Let \( \pi_A \) denote the profit of the insurance company insuring firm A. We verify that the insurance company offers a fair insurance policy:

\[
\pi_A(e^*, \ell^*) = f^* - p_0(2, 2) \cdot b^* - (1 - g^*) \frac{1}{2} Ex
\]

\[
= 508.55 - (1 - 0.055 - 0.06) \cdot 480 - 0.5 \cdot \frac{1}{2} \cdot 335 = 0.
\]

This demonstrates that the sum of insurance premium and coinsurance contributions of the insured add up to the expected damages.

Next, we analyze the case where agent A is caught with a deviant insurance contract, i.e., with any sort of insurance contract other than \( \ell^*_A \). Because agent B has the correct contract, that means that agent A will have to pay for the total damage. Call this deviant contract \( \ell'_A \), which also (for simplicity) consists of a fixed premium, \( f'_A \), a fixed bonus, \( b'_A \), and a fixed coinsurance share of \( g'_A \). We can naturally assume that no insurance company would provide such a coverage without at least breaking even. Thus, we must have:

\[
f' + g'_A Ex - p_0 b'_A = Ex.
\]

Then, if agent A chooses an action level of \( a_A^* = 2 \), she expects total costs of:

\[
v_A(2) = c_A(2) + f'_A + g'_A Ex - p_0(2, 2) b'_A = c_A(2) + Ex(2, 2) = 60 + 335 = 395.
\]

If, on the other hand, she chooses \( a_A = 3 \), she expects:

\[
v_A(3) = c_A(3) + f'_A + g'_A Ex - p_0(3, 2) b'_A = c_A(3) + Ex(3, 2) = 30 + 390 = 420.
\]

Comparing these four alternatives, clearly the socially desired choice is also the individually optimal one, i.e., to sign first the desired insurance contract, \( \ell^*_A \), which provides the optimal incentives, and then to carry out the action level \( a_A^* = 2 \).
It is now easy to explain how our mechanism works. The desired insurance contracts are precisely those that give the right incentives. That is, the incentive structure of the insurance contracts are internally mimicking a single-injurer strict liability rule, but with a bonus that redistributes the expected revenues to the insured. Any evidence of an insurance contract with different incentives is punished heavily by inflicting the full damage on the deviant. Thus, with respect to the sort of insurance coverage that the agents take out, our liability rule resembles a strict liability rule with contributory negligence. This is sufficient to enforce that the desired insurance contracts will be chosen. But then the rest is obvious: The insured will carry out the action levels according to the incentives implied by their insurance coverage and because the insurance contract imposes the desired incentives, they prefer the socially optimal action.

III. The General Case

In this section, we demonstrate that insurance-based liability will provide an effective remedy under very general conditions.

We begin by presenting the elements of the model. There are \( n \) potential injurers that are completely identical. Injurer \( i \) chooses action level \( a_i \), and so forth. \( a = (a_1, a_2, \ldots, a_n) \) denotes the joint profile of action levels of all \( n \) injurers. The variable \( x_k \) denotes the monetary level of the accident loss, where loss levels are ranked as \( x_1 < x_2 < x_3 \ldots \). The most desirable of all outcomes is, of course, that no accident occurs that happens with probability \( p_0(a) \). In other words, \( 1 - p_0(a) \) is the total accident probability. \( p_k(a) \) expresses the prior probability that accident \( x_k \) will occur, given that \( a \) is the joint action profile. The probability density function over accident outcomes is denoted by \( p(a) = (p_0(a), p_1(a), p_2(a), \ldots, p_k(a), \ldots) \), which is said to be induced by the action profile \( a \). Let \( \text{Ex}(a) = \sum_k p_k(a) x_k \) be the expected damage if \( a \) is chosen. \( l_i(x_k) \) denotes the contribution owed by injurer \( i \) if damage \( x_k \) is realized. A liability rule is a complete system of contributions, \( l_i(x_k) \), for each injurer \( i \) and each possible accident \( x_k \).

All agents have the expected cost functions as they are commonly used in the literature:

\[
v_i(a) = c_i(a) + \sum_k p_k(a) l_i(x_k).
\]

We invoke the following standard assumptions on the functional forms: The avoidance costs, \( c_i(a) \), are decreasing as the action level, \( a_i \) (for instance, the disposal of waste), increases, and so for all \( n \) potential injurers. We assume that \( \text{Ex}(a) \) is twice continuously differentiable in each component of \( a \), increasing and strictly convex. As in our example, all injurers are assumed to be risk neutral.

The objective of the present article is to find a liability rule, \( l(x) \), that minimizes total social cost. The total social costs, \( C(a) \), are defined in the usual manner, that is to say, by summing over the expected costs of the potential injurers and adding the expected harm done to the victims. Thus, \( C(a) = \sum_i c_i(a) + \text{Ex}(a) \). \( a \) is called efficient if it leads to the lowest possible value of the social costs \( C(a) \) among all feasible action profiles.

As motivated in the Introduction, we require that victims are compensated exactly in the amount of their losses (strict liability without punitive damages). In terms of the model, this means that \( \sum_i l_i(x_k) = x_k \) for all possible accidents \( x_k \).

We want to briefly explain that this description includes multilateral and bilateral accidents as special cases. If victims of the accident are also contributing to the accident risk, then they will be included as injurers, with an appropriate adjustment of their cost.
functions so as to include fully the damages they receive, in the amount \( x_k \). If the liability rule is fully compensating, the victims will suffer no losses after being compensated. Thus, in the utility function of a victim who is also an injurer, harm and damages will cancel, and her net cost function is identical to an injurer who is not also a victim.

Before turning to insurance companies, we want to briefly state the dilemma of finding an efficient liability rule in this general model. To yield efficiency, a liability rule must impose a contribution on each injurer which increases with the same slope as the expected damage does. Formally, it is required that:

\[
\frac{\partial E x(a)}{\partial a_i} = \frac{\partial E [l(x(a))]}{\partial a_i} \quad \forall i.
\]  

(16)

On the other hand, for the rule to be nonpunitive, the sum of all individual contributions can only increase at the same pace as the expected damage does. In formal terms:

\[
\frac{\partial E x(a)}{\partial a_i} = \sum_i \frac{\partial E [l(x(a))]}{\partial a_i}.
\]  

(17)

But the two conditions (16) and (17) are obviously incompatible, as \( E x(a) \) is strictly increasing.

As an application of the economic theory of team production, it is possible to show that an efficient liability rule satisfying no punitive damages does not exist. Without going into details, we want to emphasize that three assumptions of the model are crucial in this respect: (a) multiple causation; (b) unobservable action levels; and (c) the desirable objective of no punitive damages. If these three conditions occur jointly, then the dilemma exists. If any of these three conditions is absent, then it is possible to find an efficient liability rule without resorting to insurers as intermediaries.13

Next, we introduce insurance companies and show how they can be used to overcome

- **Stage 1**: a social planner proposes a liability rule \( l(x_k, \{e_i\}) \) so as to minimize total social cost.
- **Stage 2**: insurance companies propose contracts \( e_i \) to the injurers.
- **Stage 3**: injurers choose their contracts.
- **Stage 4**: action levels are chosen simultaneously by the injurers.
- **Stage 5**: accident \( x_k \) occurs.
- **Stage 6**: the liability rule \( l(\cdot) \) is carried out and payments are made according to the liability rule and the insurance contracts.

---

**Fig. 1. Timing of actions.**
the dilemma. There are several insurance companies, \( m = 1, 2, \ldots \). Insurance companies are risk neutral, and they are operating in an insurance market with perfect competition. This implies that insurance will be fair, i.e., profits are zero in equilibrium. Actions are unobservable for insurance companies as they are for the court, so there is no informational gain.

The timing of the model is assumed to be as follows:

Because our basic idea is to make the division of damages dependent on insurance contracts, we assume that insurance contracts are observable in court. This is a crucial assumption, which will be discussed in the fourth part of Section V.

We say that an insurance contract is incentive compatible if it induces the insured to choose her efficient action level, \( a_i^* \), given that she expects all other injurers to choose their efficient action levels. We assume for the moment that such an incentive-compatible insurance contract exists and denote this contract by \( e_i^* \). The insurance contract, \( e_i^* \), will be characterized and discussed in the next section.

Before doing so, we state and prove that insurance-based adjudication will satisfy all desirable objectives. The insurance-based liability rule is contained in Proposition 1.

**Proposition 1:** Suppose insurance contracts are observable in court. Then the following liability rule is efficient and satisfies no punitive damages:

\[
l^*_i(x, \epsilon_1, \epsilon_2, \ldots, \epsilon_m) =
\begin{cases}
  \frac{x_k}{m} & \text{if } i, \text{ together with } m-1 \text{ other injurers, has not} \\
  \text{signed an incentive-compatible insurance contract } e_i^* \\
  \frac{x_k}{n} & \text{if either no injurer or all injurers have signed} \\
  \text{an incentive-compatible insurance contract } e_i^* \\
  0 & \text{otherwise.}
\end{cases}
\]  

(18)

**Proof:** Let \( a^* \) denote the efficient action profile. Clearly, the proposed rule \( l^*(x) \) is nonpunitive. It remains to show that \( l^*(x) \) implements the efficient action profile as an equilibrium. For that, it suffices to show that the surplus of the insured, given a zero profit for the insurer, cannot increase. Suppose it could. Then there exists \( a_i \in A_i \) such that

\[
c_i(a_i) + \sum_k p_k(a_{-i}, a_{-i}^*) x_k < c_i(a_i^*) + \sum_k p_k(a^*) \frac{x_k}{n}
\]

or

\[
c_i(a_i^*) - c_i(a_i) > \frac{1}{n} [Ex(a_i^*) - Ex(a_i, a_{-i}^*)] > Ex(a_i, a_{-i}^*) - Ex(a_i).
\]  

(19)

We refer the interested reader to a more technical companion paper where these and more general results are derived and explained. See Eberhard Feess and Ulrich Hege, “Efficient Liability Rules for Multi-Party Accidents with Moral Hazard,” *Journal of Institutional and Theoretical Economics*, 154(2), 1998, pp. 422–450.
where the second inequality is from \( n \geq 1 \). From the fact that total liability payments are equal to the total loss and from (19) we get:

\[
C(a_i, a^*_{-i}) = c_i(a_i) + \sum_{j \neq i} c_j(a^*_j) + \text{Ex}(a_i, a^*_{-i}) < \sum_i c_i(a^*_i) + \text{Ex}(a^*) = C(a^*),
\]

which contradicts the assumption that \( a^* \) is efficient. \( \square \)

This liability rule is a straightforward generalization of our example stated in the second part of Section II. In fact, the insurance-based liability rule is closely related to strict liability with contributory negligence as introduced in the second part of Section II. It is based on the same construction principle but uses observable insurance contracts instead of unobservable actions as the variable where the discontinuity of the rule hinges on.

Note that the stated liability rule does always exist as long as \( e^*_i \) exists, which will be established in the next section. The basic idea can be expressed as follows: Courts will punish an agent harshly if the agent has not signed an insurance contract that provides incentives to adhere to the desired allocation. The comparison to the strict liability rule with contributory negligence offers a good intuition for the mechanism that makes this rule work. Strict liability with contributory negligence is a “high-powered” incentive scheme: Any deviation to a higher action level will be punished by imposing the full brunt of damages on the deviating injurer. Similarly for insurance-based adjudication: Any deviation to an insurance contract giving other incentives than \( e^* \) will be punished by imposing the full charge of damages on the injurer found deviating with respect to her insurance coverage. This offers high-powered incentives for injurers to look for insurance coverage, giving them in turn the desired incentives for their care levels.

IV. Efficient Insurance Policies

The incentive-compatible insurance contract, \( e^* \), was still left open. In this section, this contract will be characterized and its realism will be discussed. The following two questions will be investigated: First, do incentive-compatible insurance contracts on a competitive insurance market exist? Second, does the insurance contract exhibit characteristics as they are known and used? Questions concerning the practicability and desirability of these insurance policies will be discussed in the next section.

For the purposes of this section, we consider insurance contracts that consist exclusively of

- a premium, \( f \);
- a bonus, \( b \), if no accident occurs; and
- a constant coinsurance, \( g \).

Thus, we consider the same well-known instruments as in the example in Section II. As indicated in the example, we introduce the assumption that an increase in \( a_i \) leads to a monotonic decrease of \( p_0 \). This means, for instance, that the overall probability of environmental harm increases if the total waste disposal increases, and seems to be quite realistic. Actually, the assumption is not necessary to prove the existence of efficient insurance contracts, but it simplifies the understanding because otherwise the contracts would be of a different form. Proposition 2 characterizes the optimal insurance policies.

**Proposition 2:** Suppose the insurance-based liability rule \( l^*(x_k) \) applies. Then there exists an incentive compatible and fair insurance contract, \( e^*_r \), using only the following elements:
• a premium;
• a bonus if no accident occurs; and
• constant coinsurance.

Proof: See the Appendix.

In fact, the incentive-compatible and fair insurance contract cited in Proposition 2 is only one of many possible contracts. For example, it is also possible to use a cap instead of using coinsurance or using nondecreasing instead of constant coinsurance. Also, there exist incentive-compatible and fair insurance contracts using a deductible. Finally, it is possible to construct an incentive-compatible insurance contract without a coinsurance contribution of the injurer. To see the latter proposition, note that in this case, it suffices to choose a high bonus. The higher the bonus, the higher the expected loss to the injurer if she increases the action level, because she must expect to get the refund with smaller probability. Thus, there must be a bonus, \( b^*_p \), high enough so as to satisfy the condition that action level \( a^*_i \) minimizes the injurer’s total cost. This freedom of choice is not so important in the present setting of risk-neutral injurers. If injurers are risk averse, then they would choose the one insurance contract among the many incentive-compatible ones that offers the least exposure to risk.

V. Extension to Unobservable Avoidance Costs

In this section, we show that the benefits of insurance-based liability rules are not confined to unobservable actions but could also extend to unobservable avoidance costs. Unobservable avoidance costs play an eminent role in the law and economics literature. One reason is that they are the main practical obstacle to the efficiency of negligence-based liability. For example, the standard argument for why liability rules can only condition on negligence, but not on excessive action levels, is that the avoidance costs of reducing action levels are unobservable.\(^{14}\)

Applying results from economic theory, one finds that in the case of unobservable avoidance costs, objectives will conflict much in the same way as under unobservable actions: A liability rule offering efficiency and avoiding punitive damages will very often not exist.\(^{15}\) The problem of distortions of investment incentives, which is the economic rationale against punitive damages may still exist in this case: Although it is always possible to find a balanced liability rule (that is, damages of all injurers will add up to the total loss), it is not always possible that each individual injurer has expected damages below the expected social loss.\(^{16}\)

In addition, insurance-based liability could be helpful for the following two reasons. First, we have noted that economic incentives are not the only reason to avoid punitive damages; there are also institutional factors. Second, the liability rules proposed in this case are prohibitively complex because they must give incentives to the injurers to voluntarily reveal their true avoidance costs. As a result, the court need not only to collect a lot of information, but also show quite sophisticated competencies in mechanism design.

\(^{14}\)See Steven Shavell, supra note 5, p. 25.
\(^{15}\)It will not exist if the interval of possible avoidance costs is relatively large; it will exist if this interval is relatively small. For details, see Eberhard Feess and Ulrich Hege, “Liability Rules as Ex Post Mechanisms,” mimeo, Frankfurt, 1998.
Insurance-based liability could help in that it delegates information collection and incentive design to the insurance industry. Not only do insurance companies act as professionals in incentive design, they are probably more competent at doing this than a court of law. In a multiparty accident, there will be legal competition among insurers trying to impose all of the damages on the other parties. This should assure that the evidence concerning what constitutes a good incentive contract and what does not will automatically come to the fore.

VI. Concluding Remarks

In the economic analysis of accident law, it has long been known that an efficient liability rule must be based on the (relative) contribution of the defendants if there are multiple tortfeasors. The problem is that frequently the avoidance costs of the defendants are unknown or their levels of preventive care cannot be determined. The double liability rule has been proposed in the literature as an alternative. Although this proposal implies efficient care levels, it is problematic for economic reasons because agents expect too high penalties in court if they consider taking socially desirable risks. Moreover, the double liability rule amounts to punitive damages, which neither in the United States nor elsewhere are applied to solve incentive problems in torts with multiple defendants.

The present article proposes a liability rule that does not appeal to punitive damages and is nonetheless efficient. The trick is that liability is made conditional on the right form of insurance coverage. The task of setting incentives for due care is delegated to insurers. Under this proposal, insurers assume an additional role beyond their traditional role of providing optimal risk sharing. The theoretical analysis shows that the scope of insurance-based liability is striking. We demonstrate that it emerges as an efficient liability rule in every single multiparty accident with unobservable levels of care.

The operation of insurance markets will be altered by our proposal because insurers are now directly penalized for not providing the right incentives. As a consequence, insurance policies may be required to contain high-powered incentive schemes. This could imply that insurance policies contain elements that are not standard in current insurance contracts. Insurance markets have proven to be flexible and creative many times in the past. There are good reasons to believe that the challenge posed by the insurance-based liability rule would be minor. The gain in efficiency for society as a whole could be handsome.

Appendix

Proof of Proposition 2

With an insurance contract consisting of a fixed premium, $f_i$, a constant coinsurance, $g_i$, and a bonus, $b_i$, the expected total costs of the injurer add up to

$$v_i(a) = c_i(a) + f_i + g_i \cdot \left[ p_1(a) l(x_1) + \ldots + p_k(a) l(x_k) \right] - p_0(a) b_i. \quad (A1)$$

This can be written as

$$v_i(a) = c_i(a) + f_i + g_i \cdot \left( \sum_k p_k(a) l(x_k) \right) - p_0(a) b_i. \quad (A2)$$
As was explained in Section III, the marginal increase of the costs of the injurer must be identical to the marginal increase of the expected harm for reaching efficiency. Therefore, \(\gamma^*_i\) and \(b^*_i\) must be chosen such that:

\[
\frac{\frac{\partial p_k(a)l_k(x_k)}{\partial a_i} - \partial p_0(a) b^*_i}{\partial a_i} = \frac{\partial E(x)\gamma}{\partial a_i}.
\]

(A3)

In other words, the slope of the insurance contract (the increase of the expected contribution if \(a_i\) is increased), on the one hand, and the slope of the expected damage, on the other hand, must be the same. Next, we show that an incentive-compatible insurance contract, \(e^*_i\), exists. To see this, just keep \(g_i\) constant and increase the benefit from a higher nonaccident probability \(p_0(a)\) as much as is needed for incentive compatibility. Note that this benefit is the product \(\frac{\partial p_0(a)}{\partial a_i} b^*_i\). Recall also that \(\frac{\partial p_0(a)}{\partial a_i}\) is negative. Thus, the only instrument needed to assure incentive compatibility is an adjustment in \(b_i\). In other words, incentive compatibility can be achieved by raising \(b_i\) to the level at which condition (A3) is satisfied. Such a solution must exist: To see this, note that the slope of the expected contribution is

\[
\frac{\frac{\partial p_k(a)l_k(x_k)}{\partial a_i} - \partial p_0(a) b^*_i}{\partial a_i} = \frac{\partial p_0(a)}{\partial a_i} b^*_i.
\]

This expression is linear in \(b_i\) (when fixing \(b^*_i\), \(\frac{\partial p_0(a)}{\partial a_i}\) is a constant with positive value), so that it can be arbitrarily increased by raising \(b_i\).

It remains to be shown that contracts of the suggested form are compatible with the zero-profit condition for insurance companies. With a constant coinsurance, \(g_i\), the bonus payment, \(b^*_i\), and the fixed premium, \(f_r\), the profits of an insurance company can be written as

\[
\pi_i = f_r^* - p_0(a) b^*_i - (1 - g^*_i) \sum_k p_k(a) l_k(x_k) = 0.
\]

(A4)

Note that the last term in (A4) is the difference between the expected payment given by the liability rule and the expected coinsurance of the insured. It is clear that insurance contracts that satisfy the zero-profit condition do always exist because so far no restriction on \(f_r\) was introduced (because \(f_r\) is independent of \(x_k\) and therefore independent of the behavior of the insured, variations of \(f_r\) do not affect the incentive compatibility). Hence \(f_r\) can be chosen so as to satisfy the zero-profit condition. \(\square\)