On liability and insurance

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The question considered in this article is how liability rules and insurance affect incentives to reduce accident risks and the allocation of such risks. This question is examined when liability is strict or based on the negligence rule; and, if first-party and liability insurance are available, when insurers have information about insured parties' behavior and when they do not have such information. The conclusions are in essence that although both of the forms of liability create incentives to take care, they differ in respect to the allocation of risk; that, of course, the presence of insurance markets mitigates this difference and alters incentives to take care; and that despite the latter effect, the sale of insurance is socially desirable.

1. Introduction

■ This article is concerned with identifying how liability rules and insurance affect incentives to reduce accident risks and the allocation of such risks.[1] Two principal forms of liability will be examined: *strict liability*, under which a party who has caused a loss must pay damages whether or not he was negligent; and the *negligence rule*, under which a party who has caused a loss is required to pay damages only if he was negligent. The two major types of insurance coverage will also be considered: *first-party insurance*, that is, coverage against direct loss; and *liability insurance*, coverage against having to pay damages.

It is clear that liability rules influence accident avoidance as well as the allocation of accident risks. It is evident too that insurance has both effects, for by its nature insurance spreads losses; and it also alters incentives—in a way that depends on the extent of coverage and on the connection, if any, between the terms of a policy and actions taken by an insured party to reduce risk.

Moreover, the effects of liability rules and of insurance are mutually dependent. The allocation of risk associated with the use of a liability rule depends on insurance coverage, and the latter depends on the liability rule since the rule determines in part the risks parties face. Likewise, the incentives to avoid accidents created by liability rules influence and are influenced by insurance coverage; and this raises a question of interest, namely, could liability insurance be socially disadvantageous on account of its dulling the incentive to reduce accident risks?[2]

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[1] The term "accident" is to be given the broadest interpretation. It will refer to instances of loss arising in most any type of situation in which the actions of a party (an individual or a firm) affect the probability distribution of loss suffered by others.

[2] This question was seriously discussed when liability insurance was first offered for sale in England and in the United States. As one commentator writes, "For a time . . . there was considerable uncertainty as to whether any contract by which an insured was to be protected against the consequences of his own negligence . . . was not void as contrary to public policy. . . . [But] when it became apparent that no dire consequences

In view of these remarks about the relationship between liability rules and insurance, the main features of the model and the analysis to be presented may be briefly indicated before proceeding.[3] In the model, accidents are assumed to involve two types of parties, "injurers" and "victims," only the former of which are assumed to be able to affect the likelihood of accidents, and only the latter of which are assumed to suffer direct losses in the event of accidents. Given this model, the following conclusions are reached.

(i) Strict liability and negligence both create incentives to reduce accident risk, but they differ with respect to the allocation of risk.[4] Under strict liability injurers bear risk and victims are protected against risk, whereas under the negligence rule injurers do not bear risk—if they are not negligent, they will not have to pay damages when involved in accidents—and victims do bear risk. In consequence, if insurance is unavailable, then strict liability will be attractive when injurers are risk neutral (or, more generally, are better able to bear risk than victims), and the negligence rule will be appealing in the reverse situation.[5]

(ii) The availability of insurance alters this conclusion and suggests that with respect to the bearing of risk, strict liability and negligence should be equally attractive; for victims can avoid the risk that they would bear under the negligence rule by purchasing first-party insurance, and injurers can shift the risk that they would bear under strict liability by purchasing liability insurance. However, matters are complicated if liability insurers cannot monitor injurer behavior, since problems of "moral hazard" would then result in injurers' purchasing only partial coverage.

(iii) The availability of liability insurance does not have an undesirable effect on the working of liability rules. Although the purchase of liability insurance changes the incentives created by liability rules, the terms of the insurance policies sold in a competitive setting would be such as to provide an appropriate substitute (but not necessarily

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in fact resulted, these objections passed out of the picture . . ." (Prosser, 1971, p. 543). However, it is worth noting that liability insurance is not sold in the Soviet Union, where the view is held that the insurance would interfere unduly with the role of liability as a deterrent (Tunc, 1973).

[3] The analysis builds in two important respects on Brown (1973), Diamond (1974), Green (1976), and Shavell (1980), which study accidents and liability when parties are risk neutral and thus when there are no insurance markets. The first respect in which the model of this article differs from those in the articles cited is in its portrayal of the functioning of liability rules. In the cited articles, a liable party pays any judgment rendered against him out of his own pocket, whereas in the model studied here—and as is usually the case in fact—a liable party pays little or none of a judgment against him; instead his liability insurer pays. This means that the way in which liability rules are envisioned here to create incentives to reduce accident risks is to a considerable degree indirect, being associated with the terms of liability insurance policies.

The second respect in which the present model differs from the others is simply that because account is taken of attitudes toward risk, the normative comparison of liability rules involves considerations of the allocation of risk as well as of reduction of accident losses. Indeed, this means that liability rules are sometimes not equivalent here when they would have been had parties been assumed risk neutral. Similarly, because this article considers the possibility of risk aversion and, therefore, the presence of insurance markets, the social desirability of liability insurance can be examined.

In addition to the articles cited above, the reader may wish to refer to Spence (1977) and to Epple and Raviv (1978), which study strict product liability but not the negligence rule and which, in any event, focus on different issues (Spence on warranties; Epple and Raviv on market structure). Finally, the reader should refer to Calabresi (1970) and to Posner (1977), which contain interesting and suggestive, informal analysis of accidents and liability.

[4] The model abstracts from considerations other than those of incentives and the allocation of risk. In particular, there is no account taken of administrative costs (but see the concluding comments).

[5] Moreover, it will be shown that were strict liability the form of liability in this situation, it would be best for the level of liability to be less than losses caused, as if to insure partially the risk averse injurers. In other words, when the generator of an externality is risk averse, "fully internalizing" the externality is not desirable.

equivalent) set of incentives to reduce accident risks. In other words, it is not socially beneficial for the government to intervene in the operation of competitive liability insurance markets (thus answering the question posed above).[6]

2. The model

■ It is assumed in the model that injurers are identical and act so as to maximize the expected utility of wealth, and the same is presumed about victims. Under one interpretation to be made, injurers are taken to be sellers of a product for which each victim has an inelastic demand for a single unit;[7] under the other interpretation, injurers are assumed to be engaged in a private, nonmarket activity.[8] Now define the following notation:

U = utility function of injurers—who are risk neutral or risk averse;
u = initial wealth of injurers; $0 < u$;
V = utility function of victims—who are risk neutral or risk averse;
v = initial wealth of victims; $0 < v$;
x = level of injurers' expenditures on accident prevention activity;
$p(x)$ = probability of an accident, given x; $0 < p < 1$ and p is decreasing and strictly convex in x;
l = loss[9] sustained by a victim if there is an accident; $0 < l < u$[10];
r = under the first interpretation of the model, the price paid by victims for the product sold by injurers; under the other interpretation, a "lump sum" amount paid (before an accident might occur) by victims and received, as a lump sum, by injurers.

The problem to be solved using this model and notation is to choose "policy variables" in a Pareto efficient way, that is, in a way such that no alternative choice would raise the expected utility of both injurers and victims.[11] It is assumed that given the choice of policy variables, injurers select a level of prevention activity and a liability insurance policy (if available) to maximize their expected utility EU, while taking as fixed the behavior of victims and the value of r;[12] and victims select a first-party insurance policy (if available) to maximize their expected utility EV, while taking as fixed injurers' behavior and the value of r. Formally, then, the problem is:

to choose policy variables to maximize EV subject to the constraints: (1)

victims maximize EV (taking injurers' behavior and r as given); (2)

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[6] It will be seen that this fact cannot be interpreted as an application of the theorem of welfare economics stating that a competitive equilibrium with complete markets is Pareto efficient.

[7] Under this interpretation, victims may either be imagined to suffer a loss due to a production-related accident (oil spill ruins beach front property), or else to suffer a loss due to failure of the product purchased (explosion of purchased boiler causes damage to plant).

[8] We do not ask whether (or to what extent) the injurer would engage in his activity. That question is among those considered in Shavell (1980).

[9] The possibility of nonmonetary losses is not considered.

[10] In other words, it is assumed that injurers are able to pay for the losses they might cause.

[11] In the various versions of the problem that will be considered, the relevant policy variables will be obvious from context. They may include parameters of a liability rule, a choice among alternative liability rules, or, possibly, a decision about intervention in insurance markets.

[12] For the assumption that injurers take r as fixed to make sense under the interpretation that r is the price of the product they sell and that loss is caused by product failure, it must be assumed that victim/consumers of the product cannot determine the accident probabilities of sellers on an individual basis. (Otherwise, the level of prevention activity would affect the price r through its influence on the accident probability.)

injurers maximize EU (taking victims' behavior and r as given); (3)

r satisfies $EU = \bar{U}$; (4)

and, sometimes, subject also to the constraint that

competitive first party and liability insurance markets operate. (5)

Under the interpretation whereby injurers are sellers of a product, the price r may be viewed as market determined: Suppose that there is free entry into the product market and that $\bar{U}$ is the injurers' "opportunity level" of utility (injurers may engage in an alternative activity that yields $\bar{U}$). Then, in equilibrium, r must be such that their expected utility is $\bar{U}$. Under the other interpretation, when injurers are not sellers of a product, the reference level of expected utility $\bar{U}$, and thus the amount r, may be regarded as reflecting a social decision about their welfare.

3. The first-best solution to the accident problem

■ Before considering liability rules and insurance, it will be of interest to know what an omniscient and benevolent dictator would do to solve the accident problem. The dictator would choose in a Pareto efficient way the level of injurers' prevention activity and the levels of wealth for both injurers and victims, contingent on accident involvement and subject to a resource constraint. More precisely, denoting by v_n the wealth of a victim if he is not involved in an accident, v_a his wealth if he is, and similarly for u_n and u_a, the dictator would

$$\underset{x, v_n, v_a, u_n, u_a}{\text{maximize}}\ EV = (1 - p(x))V(v_n) + p(x)V(v_a) \tag{6}$$

subject to:

$$EU = (1 - p(x))U(u_n) + p(x)U(u_a) = \bar{U}; \tag{7}$$

$$[(1 - p(x))v_n + p(x)v_a] + [(1 - p(x))u_n + p(x)u_a] + [p(x)l + x] = u + v. \tag{8}$$

Note that equation (8) states that expected resource use equals the available resources.[13] We then have

Proposition 1. A first-best solution to the accident problem is achieved if and only if (a) the level of prevention activity minimizes expected accident losses plus the costs of prevention activity (i.e., $p(x)l + x$); and (b) risk averse parties (injurers or victims) are left with the same level of wealth regardless of whether an accident actually occurs.

Note: The explanation for this is, of course, that the dictator can fully insure risk averse parties and, thus, it becomes desirable to maximize total expected resources, which means minimizing expected accident losses plus prevention costs.

Proof: Note first that given any x, a necessary and sufficient condition for optimality of v_n, v_a, u_n, and u_a is that they satisfy (7) and (8), that $v_n = v_a$ if the victim is risk averse, and that $u_n = u_a$ if the injurer is risk averse.[14]

Consequently, we may set $\gamma = v_n = v_a$ and $\mu = u_n = u_a$. (If the victim is risk neutral, we may always take $v_n = v_a$; and similarly if the injurer is risk neutral, we may always take $u_n = u_a$.) Thus the problem (6)–(8) is equivalent to

$$\underset{\gamma, \mu, x}{\text{maximize}}\ V(\gamma) \tag{9}$$

[13] The justification for writing the resource constraint in terms of expected values is the conventional one, that accident risks are small and independent. Note that the constraint makes sense only if the number of injurers equals the number of victims, an assumption which would be easy to modify.

[14] This is a standard result in the theory of Pareto-efficient sharing of risk (see for example Borch (1962)) and can easily be verified from the Kuhn-Tucker conditions for the problem (6)–(8).

subject to:

$$U(\mu) = \bar{U}, \tag{10}$$

$$\gamma + \mu + p(x)l + x = u + v. \tag{11}$$

But (10) determines a value, say $\bar{\mu}$, of μ, so that the two constraints reduce to

$$\gamma = (u + v - \bar{\mu}) - (p(x)l + x). \tag{12}$$

Hence, the problem is simply to maximize over x the quantity $V(u + v - \bar{\mu} - (p(x)l + x))$, which is equivalent to minimizing $p(x)l + x$. *Q.E.D.*

Note that the first-best level of prevention activity, to be denoted x^*, must be unique (by strict convexity of $p(x)$). Since the situation of interest is where $x^* > 0$, this will be assumed to be true below.

4. The achievable solution to the accident problem

■ To determine the solution to the accident problem when liability rules are used—that is, to determine Pareto efficient solutions to the problem (1)–(5)—the rules must first be formally defined. Under strict liability, whenever an injurer is involved in an accident, he must pay the victim an amount in damages. Denote damages by d, and observe that in principle damages need not equal the victim's loss. Under the negligence rule, an injurer must pay damages to the victim only if the court determines that the injurer's prevention activity fell short of a *standard of due care*. Denote the standard of due care by $\bar{x}$. It will be assumed that the courts' information about the injurer's behavior is accurate, so that an injurer will be found negligent if and only if he was in fact negligent.[15]

The operation of liability rules will now be studied both when insurance is assumed to be available and when it is not. The latter case is of interest both because it will allow us to see more easily the difference that insurance makes and also because in reality insurance might be unavailable.

□ **Functioning of liability rules when insurance is not available.** Let us first show

Proposition 2. Under strict liability, suppose that injurers are risk neutral. Then, according to a Pareto efficient solution, (a) damages paid by an injurer equal a victim's losses (i.e., $d = l$) and (b) a first-best outcome is achieved. On the other hand, if injurers are risk averse, then under an efficient solution (c) damages paid are less than a victim's losses (i.e., $d < l$) and (d) a first-best outcome is not achieved.

Note: Parts (a) and (b) are true for familiar reasons: When $d = l$, the "externality" of accident losses is "fully internalized," so that the injurers choose an appropriate level of prevention activity. Also, since injurers are risk neutral, it does not matter that they bear risk. Finally, victims, who might be risk averse, bear no risk since they are compensated for accident losses.

With regard to (c), it is not surprising that when injurers are risk averse, the externality they generate should not be fully internalized. (Under the first interpretation of the model, this means that buyers of a risky product are better off if risk averse sellers are subject to less than full liability for harm done.) Were d set equal to l, injurers would be exposed to "excessive" risk, with the consequence that they would have to be compensated excessively for bearing the risk or for engaging in excessive accident prevention activity. (The actual magnitude of the efficient d would depend on the victims' attitude toward risk as well; presumably, the more risk averse the victims, the higher would be

[15] The importance of this assumption is noted in the concluding comments.

this d.) Part (d) is true because if the efficient d is positive (as one would expect), then injurers bear risk; and if the efficient d is 0,[16] then injurers will choose x equal to 0, which is not first-best (as $x^* > 0$).

Proof: Assume first that injurers are risk neutral. Then if a first-best outcome is achieved when $d = l$, certainly $d = l$ must be a Pareto efficient solution to the problem of concern. We shall therefore assume that $d = l$ and shall show that a first-best outcome would result. If $d = l$, injurers will select x to maximize[17]

$$EU = (1 - p(x))(u + r - x) + p(x)(u + r - x - l) = u + r - (x + p(x)l). \quad (13)$$

Therefore, they will select x to minimize $x + p(x)l$. Moreover, since victims (who might be risk averse) will receive l whenever there is an accident, their income will be constant. Thus, if r is such that $EU = \bar{U}$, the "if" part of Proposition 1 implies that the first-best solution (corresponding to $\bar{U}$) is achieved. This proves parts (a) and (b).

Assume now that injurers are risk averse, so that

$$EU = (1 - p(x))U(u + r - x) + p(x)U(u + r - x - d). \quad (14)$$

Victims' expected utility is then

$$EV = (1 - p(x))V(v - r) + p(x)V(v - r - l + d), \quad (15)$$

and the problem (1)–(5) reduces to

$$\underset{d,r,x}{\text{maximize}}\ EV \quad (16)$$

subject to:[18]

$$EU_x = 0 \quad (17)$$

$$EU = \bar{U}. \quad (18)$$

Since the constraints (17) and (18) determine (and, let us assume, uniquely) r and x as functions of d, the problem may be written as

$$\text{maximize } EV(d) = (1 - p(x(d)))V(v - r(d)) + p(x(d))V(v - r(d) - l + d). \quad (19)$$

Now observe that[19]

$$EV'(d) = -p'x'[V(v - r) - V(v - r - l + d)] \\ - r'(1 - p)V'(v - r) + p(1 - r')V'(v - r - l + d). \quad (20)$$

To show that $d < l$, we shall verify that $EV'(l) < 0$. (A similar series of steps will verify that $EV'(d) < 0$ for $d > l$.) From (20), we have that $EV'(l) = (p - r')V'(v - r)$, so that we need to verify that $r' > p$. To do this, differentiate (18) to get

$$EU_x x'(d) + EU_r r'(d) + EU_d = 0, \quad (21)$$

and using (17), solve for r',

$$r'(d) = \frac{-EU_d}{EU_r} = \frac{p(x)U'(u + r - x - d)}{(1 - p(x))U'(u + r - x) + p(x)U'(u + r - x - d)} \\ = p(x)/[(1 - p(x))\frac{U'(u + r - x)}{U'(u + r - x - d)} + p(x)]. \quad (22)$$

[16] Examples can be constructed in which the efficient d is 0.

[17] Since the injurer is risk neutral, we may assume that the utility function is just $U(w) = w$ for any wealth w.

[18] It will be assumed that the first-order condition (17) determines the injurer's choice of x for the values of r and d to be considered.

[19] In the next expression and several later ones, certain functions will for convenience be written without their arguments (e.g., p' rather than $p'(x(d))$).

It is clear from (22) that $r' > p$ for any $d > 0$ (and thus for $d = l$). This establishes part (c), and part (d) is clear from the Note. *Q.E.D.*

The next result is

Proposition 3. Under the negligence rule, suppose that victims are risk neutral. Then, according to a Pareto efficient solution, (a) the standard of due care equals the first-best level (i.e., $\bar{x} = x^*$), and (b) a first-best outcome is achieved. However, if victims are risk averse, then under a Pareto efficient solution (c) the standard of due care is generally different from the first-best level, and (d) a first-best outcome is not achieved.

Note: Parts (a) and (b) are true because if $\bar{x} = x^*$, injurers will find it in their interest to choose $x = \bar{x}$, that is, to act in a nonnegligent way. Thus, the injurers, who might be risk averse, bear no risk. As victims are risk neutral, the fact that they bear risk does not matter. But, of course, when victims are risk averse, that they bear risk does matter, so that, as stated in (d), a first-best outcome would not be achieved. Moreover, in this case it will be seen that it would often be desirable that $\bar{x} > x^*$, so as to further reduce the likelihood of accidents.

Proof: To establish (a) and (b), let us show that when victims are risk neutral, a first-best outcome will result if $\bar{x} = x^*$ and $d = l$. To see this, consider first the possibility that injurers choose an $x \geqq x^*$. Then, clearly, it must be that they choose $x = x^*$. On the other hand, if the injurers choose an $x < x^*$, then, since they would be found negligent if involved in accidents,

$$EU = (1 - p(x))U(u + r - x) + p(x)U(u + r - x - l)$$
$$\leqq U(u + r - x - p(x)l) < U(u + r - x^* - p(x^*)l) < U(u + r - x^*). \quad (23)$$

(Use was made here of the fact that x^* minimizes $x + p(x)l$.) Thus injurers would choose x^*, would not be found negligent if involved in accidents, and would bear no risk. As victims are risk neutral, Proposition 1 then implies that a first-best outcome would be achieved.

Now assume that victims are risk averse and consider only $\bar{x}$ such that injurers would choose $x = \bar{x}$.[20] (Even if we restrict attention to the case when $d = l$, the set of such $\bar{x}$ properly includes $[0, x^*]$ since (23) is a strict inequality.) For such $\bar{x}$, $EV = (1 - p(\bar{x}))V(v - r) + p(\bar{x})V(v - r - l)$ and $EU = U(u + r - \bar{x})$. The problem of concern is therefore to maximize EV over r and $\bar{x}$ subject to $EU = \bar{U}$. But from the latter constraint, it follows that r and $\bar{x}$ are determined by $r = \bar{x} + k$, where k is an appropriate constant, so that the problem reduces to

$$\underset{\bar{x}}{\text{maximize}}\ (1 - p(\bar{x}))V(v - k - \bar{x}) + p(\bar{x})V(v - k - \bar{x} - l). \quad (24)$$

If V were linear, the solution to (24) would be $\bar{x} = x^*$, but since V is concave we would, as remarked, expect the solution to exceed x^*. It is possible, however, that the solution to (24) would be less than x^*.[21] In any event, since victims are risk averse and bear risk, Proposition 1 implies that a first-best outcome is not achieved. *Q.E.D.*

□ **Functioning of liability rules when insurance is available.** It will be assumed here that parties can purchase insurance at actuarially fair rates from a competitive insurance industry. Thus, if victims are risk averse, they will choose to buy full coverage against any risk they bear.

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[20] Otherwise, the liability rule reduces to strict liability.

[21] The intuition is that even though a risk averse injurer has a greater motive to reduce the probability of a loss than does a risk neutral injurer, spending to reduce the probability exposes him to a larger risk (for if he loses l, his final income will be lower by l *plus* his expenditure).

In contrast, whether risk averse injurers will purchase full coverage depends on whether liability insurers can "observe" the levels of prevention activity of individual injurers. If liability insurers cannot do this, then, clearly, they cannot link the premium or terms of the policy to the level of prevention activity. Consequently, were injurers to purchase complete coverage, there would be a problem of moral hazard: Injurers would have no reason to avoid accidents, would therefore be involved in accidents with high probability, and would find themselves paying a high premium per dollar of coverage. But if injurers purchased policies with incomplete coverage, they would be exposed to some risk, would thus have some inducement to avoid accidents, would be involved in accidents with a lower probability than before, and would therefore pay a lower premium per dollar of coverage (though still an actuarially fair premium—given their altered behavior). Hence, it should seem plausible and can be shown under quite general assumptions that injurers would in fact purchase policies with incomplete coverage.[22]

On the other hand, if liability insurers can observe prevention activity, then they can make the premium or other policy terms depend on such activity, thereby giving injurers an incentive to avoid accidents even if they purchase full coverage. Hence, it should seem plausible in this case that risk averse injurers would purchase complete coverage and would be motivated to act so as to minimize expected damages plus prevention costs (i.e., $p(x)d + x$).[23]

The next result can now be stated and proved.

Proposition 4. Under strict liability, according to a Pareto efficient solution, (a) damages paid by an injurer equal a victim's losses (i.e., $d = l$), (b) government intervention in the liability insurance market is not desirable, and (c) a first-best outcome is achieved unless injurers are risk averse and liability insurers cannot observe their level of prevention activity.

Note: In the case when injurers are risk neutral and liability insurers cannot observe prevention activity, injurers would decide against purchase of liability insurance. The reason is that because of moral hazard, the cost of insurance coverage would exceed an injurer's expected cost were he not to purchase coverage; and since protection against risk is of no consequence to him, he would not buy coverage. Hence, the situation will be essentially that in the first part of Proposition 2, and a first-best outcome will be achieved. Note also that the issue of intervention in insurance markets is moot since no one buys insurance.

If injurers are risk neutral and liability insurers can observe prevention activity, then injurers will be indifferent as to whether and in what amount to purchase liability coverage and will, if $d = l$, be induced to choose x^* by their exposure to liability or by the terms of their insurance policy, should they have one. Also, since victims will bear no risk (although they could always purchase insurance if they needed it), Proposition 1 implies that a first-best outcome will be achieved and, thus, that government intervention in insurance markets could not be desirable.

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[22] The formal problem that yields this result is

$$\max_{\pi,q} EU = (1 - p(x))U(u + r - \pi - x) + p(x)U(u + r - \pi - x + q - d)$$

subject to (i) EU is maximized over x and (ii) $\pi = p(x)q$, where π is the insurance premium and q is the level of coverage. Constraint (i) says that the insured chooses x in a personally optimal way, given his insurance policy, and constraint (ii) is the condition of actuarial fairness. Shavell (1979b) discusses conditions under which the solution has $q < d$, which we shall assume to be true; Arrow (1971) and Pauly (1974) also analyze the general problem of moral hazard.

[23] The formal problem that yields this result is $\max_{q,x} EU = (1 - p(x))U(u + r - p(x)q - x) + p(x)U(u + r - p(x)q - x + q - d)$. Note that in this problem the individual takes into account that his choice of x affects the premium he pays, whereas in the problem described in note 22 that was not true. It is well known and easy to verify that the solution to this problem is $q = d$ and the x that minimizes $p(x)d + x$.

If injurers are risk averse and liability insurers can observe prevention activity, injurers will purchase full coverage against damages, will therefore not bear risk and, if $d = l$, will be induced by the terms of their policy to choose x^*. Thus, Proposition 1 again implies our result.

In the last case (which is complex), when liability insurers cannot observe the prevention activity of risk averse injurers, the injurers will purchase incomplete coverage against damages (as explained in the paragraph preceding the Proposition). If we let q denote their level of coverage, this means that the injurers will bear a positive residual risk of $d - q$, so that a first-best outcome will not be achieved. Moreover, it becomes obvious that the argument that liability insurance eliminates the incentive to avoid accidents is mistaken. Because injurers will still bear a risk after purchase of liability coverage, they will make some effort to avoid accidents. But, of course, what is asserted in the Proposition is a stronger claim than that liability insurance does not eliminate incentives. What is asserted is that if $d = l$ and injurers purchase liability coverage, there are no measures the government can take to improve welfare. Why this should be so may be put informally as follows. One supposes that there would be scope for beneficial government intervention in the liability insurance market only if the sale of liability coverage were to worsen the welfare of victims. But if $d = l$, the welfare of victims is unaffected by the occurrence of accidents because the victims are fully compensated for losses. Thus there is no apparent opportunity for beneficial intervention in the insurance market.[24]

At the same time, it is important to point out (and will be shown at the end of the proof) that in this last case under discussion an efficient solution could also be achieved by the government's banning liability insurance and reducing liability from l to $l - q$, leaving risk averse victims to purchase first-party coverage of q.[25] (Note that this does not contradict the Proposition, for the banning of liability insurance and reduction of liability do not raise welfare; they leave it unchanged.)

Proof: If injurers are risk neutral and liability insurers cannot observe x, suppose that injurers were to purchase coverage $q > 0$. Then they would select x to maximize $u + r - \pi - x - p(x)(d - q)$, where π is the actuarially fair premium. If we denote the solution to this problem by x_1, then π must equal $p(x_1)q$, so that the expected wealth of injurers would be

$$u + r - p(x_1)q - x_1 - p(x_1)(d - q) = u + r - x_1 - p(x_1)d. \qquad (25)$$

On the other hand, if injurers do not purchase any coverage, they will select x to maximize $u + r - x - p(x)d$, so that denoting the solution to this by x_2, their expected wealth would be

$$u + r - x_2 - p(x_2)d. \qquad (26)$$

Since, as is easily verified, $x_1 < x_2$, and since x_2 maximizes $u + r - x - p(x)d$ and is unique (for $p(x)$ is strictly convex), the expression in (26) is larger than that in (25). Hence, the injurers will not purchase liability insurance coverage, and we may appeal to the argument proving Proposition 2 (a) and (b) to establish Proposition 4 in the present case.

If injurers are risk neutral, $d = l$, and liability insurers can observe x, then whatever level of coverage injurers select (they are in fact indifferent among all levels of coverage,

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[24] But if there were a nonmonetary component to the loss suffered by victims for which compensation could not possibly be made (perhaps blindness or paralysis), then the victims' welfare would be affected by the occurrence of accidents. Thus, limiting the purchase of liability insurance might in principle be desirable.

[25] This describes a solution which resembles the situation in the Soviet Union. As mentioned in note 2, liability insurance is not available there.

including none), they will be induced to choose x^*. This follows because their premium for coverage $q \geqq 0$ will depend on x and equal $p(x)q$, so that they will choose x to maximize

$$u + r - p(x)q - x - p(x)(l - q) = u + r - x - p(x)l. \tag{27}$$

Since if $d = l$, x^* will be chosen, and since victims will bear no risk, Proposition 1 implies our result.

If injurers are risk averse and liability insurers can observe x, the remark in the Note following the proposition supplies the argument for the result.

We shall use a two-part argument to establish (a) and (b) for the case in which injurers are risk averse and liability insurers cannot observe x. First, we shall consider what would be done by a benevolent dictator whose powers are limited only by inability to observe x and, therefore, by inability to set x directly. Then we shall show in a series of steps that under strict liability, with $d = l$, the operation of the liability insurance market leads to the same result that the dictator would have chosen. This will complete the argument establishing (a) and (b).

The problem of the benevolent dictator who cannot observe x is

$$\underset{v_n, v_a, u_n, u_a}{\text{maximize}}\; EV = (1 - p(x))V(v_n) + p(x)V(v_a) \tag{28}$$

subject to

$$EU = (1 - p(x))U(u_n - x) + p(x)U(u_a - x) = \bar{U} \tag{29}$$

$$EU \text{ is maximized over } x \tag{30}$$

$$[(1 - p(x))v_n + p(x)v_a] + [(1 - p(x))u_n + p(x)u_a] + p(x)l = u + v. \tag{31}$$

Here the variables are defined as in Section 3, except that now u_n and u_a are gross of the costs of prevention activity. Constraint (30) is introduced because injurers are free to select x. As in the proof of Proposition 1, it is easy to show that we may take $v_n = v_a$. Thus, setting $\gamma = v_n = v_a$, the dictator's problem becomes

$$\underset{\gamma, u_n, u_a}{\text{maximize}}\; EV = V(\gamma) \tag{32}$$

subject to (29), (30), and to

$$\gamma + (1 - p(x))u_n + p(x)u_a + p(x)l = u + v. \tag{33}$$

Now let us show that the above problem is equivalent to the following one: liability is strict, with $d = l$; liability insurance is sold at an actuarially fair price; but the government, rather than the competitive insurance market, determines the extent of coverage q. This latter problem is (where π, recall, is the premium for insurance)

$$\underset{q, \pi, r}{\text{maximize}}\; V(v - r) \tag{34}$$

subject to

$$EU = (1 - p(x))U(u + r - \pi - x) + p(x)U(u + r - \pi - x + q - l) = \bar{U} \tag{35}$$

$$EU \text{ is maximized over } x, \tag{36}$$

$$\pi = p(x)q. \tag{37}$$

Under the change of variables $\gamma = v - r$, $u_n = u + r - \pi$, $u_a = u + r - \pi + q - l$, direct substitution shows that the problem (34)–(37) is, as claimed, the same as the problem (32), (29), (30), (33).

Now write (34)–(37) in the equivalent form

$$\underset{q, \pi, r}{\text{maximize}}\; EU = (1 - p(x))U(u + r - \pi - x) + p(x)U(u + r - \pi - x + q - l) \tag{38}$$

subject to

$$EU \text{ is maximized over } x, \tag{39}$$

$$\pi = p(x)q, \tag{40}$$

$$EV = V(v - r) = \bar{V}, \tag{41}$$

where $\bar{V}$ is the optimal value of V in (34)–(37). Observe that (41) alone determines r. Thus, (38)–(41) reduce to

$$\underset{q,\pi}{\text{maximize}}\ EU \tag{42}$$

subject to (39) and (40). But (see note 22) this is exactly the problem that is solved by the liability insurance market. Hence, we have completed our proof of (a) and (b) for the case in which injurers are risk averse and liability insurers cannot observe x. Part (c) also follows since liability coverage will be partial.

With regard to the claim made in the Note about the banning of liability insurance, suppose that such insurance cannot be purchased and let $\hat{d} = l - q$, and $\hat{r} = r - \pi$, where r, q, and π are the values from the efficient solution when liability insurance can be purchased. The reader may easily verify that the injurer would then select the same level of prevention activity and enjoy the same expected utility as in the efficient solution with the purchase of liability insurance allowed; the same is true of the victim, who, if risk averse, buys first party insurance, paying π for coverage of q. *Q.E.D.*

The last result is

Proposition 5. Under the negligence rule, a Pareto-efficient solution is such that: (a) the standard of due care equals the first-best level (i.e., $\bar{x} = x^*$); (b) a first-best outcome is achieved; and (c) government intervention in the liability insurance market is not desirable.

Note: As in Proposition 3, if $\bar{x} = x^*$, injurers will decide to be nonnegligent and will choose $x = x^*$, but now this is true despite their opportunity to act negligently and to protect themselves by purchase of liability insurance. And although this also means that victims will bear risk, they can purchase full coverage from first-party insurers. Thus a first-best solution will be achieved and, therefore, government intervention in insurance markets could not be desirable.

Proof: It will suffice to show that liability insurance would not be purchased, for then an argument virtually identical to that of parts (a) and (b) of Proposition 3 may be employed to show (a) and (b) here; and (c) follows from (b). Let us therefore assume that when $\bar{x} = x^*$, injurers purchase coverage, and show that this leads to a contradiction. If they purchase coverage, it must be that $x < x^*$ (for otherwise injurers would never be found negligent if involved in accidents and would have no reason to insure). Thus, the injurers' premium must be $p(x)q$, so that

$$\begin{aligned} EU &= (1 - p(x))U(u + r - p(x)q - x) + p(x)U(u + r - p(x)q - x + q - l)) \\ &\leqq U((1 - p(x))(u + r - p(x)q - x) + p(x)(u + r - p(x)q - x + q - l)) \\ &= U(u + r - x - p(x)l) < U(u + r - x^* - p(x^*)l) \\ &< U(u + r - x^*). \end{aligned} \tag{43}$$

But this is a contradiction, since it means that injurers would prefer to choose x^* and to be nonnegligent. *Q.E.D.*

4. Concluding comments

■ Because the object here was to isolate the roles of liability rules and of insurance in providing incentives and in allocating risk, it was of course necessary to exclude much from the analysis. Hence, we shall close with brief comments on several of the more important omissions, pointing out how, if at all, they affect our results.

Perhaps the most noticeable simplification of the model was the assumption that victims could not alter accident risks. Were that assumption relaxed, however, appropriate analogues to our results would remain true.[26] Consider, for instance, the situation under strict liability with a defense of contributory negligence (allowing the injurer to escape liability if the victim was shown to have acted negligently), when insurers can observe the level of prevention activity of risk averse insureds, be they injurers or victims. In this situation it can be demonstrated that a first-best outcome can be achieved (in Nash equilibrium). Victims are induced to act in a nonnegligent way despite their opportunity to purchase first-party insurance, and injurers, realizing that victims will not be found contributorily negligent, are induced under the terms of their liability policies to choose the socially optimal level of prevention activity. The arguments applied with respect to victims to show these and other results in the more general case are essentially those we presented with respect to injurers, for not only may victims alter accident risks, but also first-party coverage (like liability coverage) involves potential elements of moral hazard.

Another simplifying assumption of the model was that there were no "administrative" costs connected with the supply of insurance or with the operation of the legal system. Consideration of administrative costs would have made a difference to our study, especially with regard to the closely related issues of the type of insurance coverage offered by the market and the comparison of liability rules. Suppose, for example, that it would be very expensive to determine injurers' prevention activity. Then liability insurers would not do so, and therefore, as explained, the policies they sell would involve incomplete coverage. Consequently, as stated in Proposition 4, under strict liability risk averse injurers would be left bearing a risk, which is socially undesirable. On the other hand, according to Proposition 5, under the negligence rule the socially undesirable bearing of risk would be avoided, for the injurers would act in a nonnegligent way. Yet it should not be concluded from this that the negligence rule would be superior to strict liability, for the application of the negligence rule requires the courts to ascertain injurers' prevention activity—an undertaking that was assumed in the first place to have been sufficiently costly to make it less than worthwhile for liability insurers. This should illustrate both the complexities that would be involved in an analysis of our subject incorporating administrative costs and the need for caution in interpretation of results.

A third simplifying assumption of the model was that there were no errors or uncertainty as to legal outcomes. Thus, under strict liability, an injurer who caused a loss was always found liable, and under the negligence rule, an injurer's fault or lack of fault was always correctly determined. Were these assumptions altered, certain unnatural features of equilibrium in our model would disappear: under strict liability, victims would no longer be completely protected against risk, and, if risk averse, they would purchase first-party coverage; and under the negligence rule, nonnegligent injurers would no longer be sure that they would be found free of fault, and, if risk averse, they would purchase liability coverage. These new elements of uncertainty under the liability rules would generally mean that our results would hold only in an approximate sense.

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[26] In Shavell (1979a), an earlier version of this article, the possibility that victims can alter accident risks is taken into account.

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