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***MULTI-DEFENDANT SETTLEMENTS  
UNDER JOINT AND SEVERAL LIABILITY:  
THE PROBLEM OF INSOLVENCY***

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**Multi-Defendant Settlements Under Joint and Several Liability:  
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Abstract

This article studies the problem of multi-defendant settlements under joint and several liability when a defendant has insufficient solvency to satisfy the plaintiff's claim. It offers a simple model of settlement between a single plaintiff and multiple defendants. In the model, a plaintiff makes take-it-or-leave-it offers to two defendants. Each defendant then decides independently whether to accept the offer or to litigate. One of the defendants has sufficient solvency to satisfy the plaintiff's claim; the other does not. These two defendants face a rule of joint and several liability with contribution (proportional to their share of the liability). In the event that one defendant settles, the non-settling defendant loses its right to contribution, but its liability is set off by the amount of the settlement.

The article has three central conclusions about the impact of a defendant's limited solvency on the choice between settlement and litigation: (1) it induces settlements that otherwise would not occur when the plaintiff's probabilities of success are independent; (2) it also induces settlements that otherwise would not occur when the plaintiff's probabilities of success are perfectly correlated and the shares of liability of the two defendants are sufficiently different; and (3) it deters settlements that otherwise would occur when the plaintiff's probabilities of success are perfectly correlated and the shares of liability of the two defendants are sufficiently similar.

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**Multi-Defendant Settlements Under Joint and Several Liability:  
The Problem of Insolvency\***

**Lewis A. Kornhauser and Richard L. Revesz\*\***

This article studies the problem of multi-defendant settlements under joint and several liability when the defendants have insufficient solvency to satisfy the plaintiff's claim. Potentially insolvent defendants are, unfortunately, common in important areas of law such as toxic torts and Superfund, but the law and economics literature has not paid attention to this problem.<sup>1</sup>

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<sup>1</sup>In Lewis A. Kornhauser & Richard L. Revesz, *Apportioning Damages Among Potentially Insolvent Actors*, 19 J. Legal Stud. 617 (1990), we examined how the relative efficiency of rules for imposing liability and apportioning damages among joint tortfeasors is affected by the potential insolvency of some of the defendants. In that model, the plaintiff litigates against all the defendants; we did not consider the possibility of settlement. More recently, in Lewis A. Kornhauser & Richard L. Revesz, *Multi-Defendant Settlements: The Impact of Joint and Several Liability*, 23 J. Legal Stud. \_\_ (1994), we studied the impact of joint and several liability on the choice between settlement and litigation. The defendants in that model are fully solvent. This article is at the intersection of those two prior works.

The article considers four separate questions in the context of a model in which the plaintiff litigates against one defendant with full solvency and one with limited solvency: (1) the effects of insolvency on the choice between settlement and litigation under joint and several liability; (2) the comparison of the effects of insolvency under joint and several and non-joint (several only) liability; (3) the impact of the correlation of the plaintiff's probabilities of success in litigation against the defendants; and (4) the allocation between the plaintiff and solvent defendants of the shortfall caused by the limited solvency of other defendants.

In our prior article studying the effects of joint and several liability with contribution on the choice between settlement and litigation when two defendants are fully solvent, we concluded that, in the absence of litigation costs, when the plaintiff's probabilities of success are independent, the plaintiff litigates against both defendants; settlement never occurs. When its probabilities of success are perfectly correlated, the plaintiff settles with both defendants if their shares of the liability are relatively similar; otherwise, it settles with the defendant with the larger share and litigates against the other one. In contrast, when the plaintiff litigates against only one defendant or against two defendants under non-joint liability, it is indifferent between settling and litigating.<sup>2</sup>

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<sup>2</sup>See Kornhauser & Revesz, supra note 1.

We show here that, also in the absence of litigation costs, when the plaintiff litigates against only one defendant or against two defendants under non-joint liability, one defendant's limited solvency has no effect on the plaintiff's choice between settlement and litigation. In contrast, under joint and several liability, this choice is highly dependent on the defendant's solvency. When the plaintiff's probabilities of success in litigation are independent, a defendant's limited solvency induces settlements that otherwise would not occur. In contrast, when the probabilities are perfectly correlated a defendant's limited solvency can either induce settlements that otherwise would not occur, or deter settlements that otherwise would occur. Stating this conclusion somewhat differently, in the face of insolvency, joint and several liability can either promote or deter settlements; we define the conditions under which each of these results occurs.<sup>3</sup>

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<sup>3</sup>Courts and commentators appear to have different intuitions about this question, but have not gone beyond making conclusory statements. Compare *Hosley v. Armstrong Cork Co.*, 364 N.W.2d 813, 816 (Minn. Ct. App. 1985) (when some defendants are insolvent, joint and several liability promotes settlement), *aff'd* in relevant part, 383 N.W.2d 289 (Minn. 1986) and Matthew M. Durham, *Liability Under the Utah Hazardous Substances Mitigation Act*, 1991 Utah L. Rev. 445, 465-66 (student note) with Lori Jonas, *Dividing the Toxic Pie: Why Contingent Contribution Claims Should not Be Barred by the Bankruptcy Code*, 66 N.Y.U. L. Rev. 850, 862 (1991) (student note) (when some defendants are insolvent, joint and several liability deters settlements) and Anne D. Weber, *Misery Loves Company: Spreading the Costs of CERCLA Cleanup*, 42 Vand. L. Rev. 1469, 1507-08 (1989) (student note) ("an accurate, although oversimplified, observation is that as [a party's] disproportionate share of settlement costs increases, the advantages of settlement decrease").

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund), the

Our study of the allocation between the plaintiff and the solvent defendant of the shortfall caused by the limited solvency of the other defendant reveals that, over a broad range of solvencies, the plaintiff bears the full shortfall, and it is never the case that the full shortfall is borne by the solvent defendant. This conclusion challenges the accepted wisdom that, under joint and several liability, the burden of one defendant's insolvency falls exclusively on its co-defendants.<sup>4</sup>

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Environmental Protection Agency has the authority to enter into "mixed funding" settlements. 42 U.S.C. §9622(b)(1). In these settlements, EPA agrees not to seek from solvent defendants the shares attributable to the insolvent defendants. In essence, mixed funding settlements are equivalent to a case-by-case waiver of joint and several liability. One commentator believes that CERCLA's mixed funding provisions promote settlement. Peter F. Sexton, Superfund Settlements: The EPA's Role, 20 Conn. L. Rev. 923, 939 (1988). It follows from this belief that joint and several liability deters settlements.

<sup>4</sup>See, for example, *Coleman v. Frierson*, 607 F. Supp. 1578, 1582 n. 5 (N.D. Ill. 1985) (under joint and several liability, all risks of insolvency "are borne by the tortfeasors--the defendants--rather than by the innocent plaintiff"); *Fibreboard Corp. v. Fenton*, No. 91SC685 (Colo. 1993) (available on Lexis) (under joint and several liability "it is the non-settling tortfeasors who bear the risk of the insolvency of parties who are jointly and severally liable, and not the innocent plaintiff."); *Mountain Mobile Mix, Inc. v. Gifford*, 660 P.2d 883, 889 (Colo. 1983) ("In Colorado, therefore, a judgment proof tortfeasor causes his co-tortfeasors to suffer liability for his share of the judgment. A contrary result, however, would materially shift the risk of an impecunious tortfeasor from defendants back to plaintiffs."); *International Harvester Co. v. Superior Court*, 157 Cal. Rptr. 324, 328 (Cal. Ct. App. 1979) (joint and several liability produces "the shift of the risk of insolvency of a tortfeasor from the injured person to a concurrent tortfeasor."); Neil Doherty & Howard Kunreuther, An Evaluation of Joint and Several Liability for Managing Past and Present and Future Wastes (November 1992) (manuscript) ("Under JSL [joint and several liability] the shortfall in revenue due to insolvency is covered by the surviving firm(s)"); Stephen D. Sugarman, A Restatement of Torts, 44 Stan. L. Rev. 1163, 1188 (1992) (absent plaintiff's fault, or if its fault is disregarded,

The reason for the entrenchment of this erroneous view may be that judges and commentators implicitly consider only the situation in which the plaintiff's probabilities of success are perfectly correlated and the plaintiff litigates against both defendants. Then, any shortfall caused by one defendant's limited solvency is borne by the other defendant. If, however, the correlation of the probabilities is less than perfect, the plaintiff's expected recovery is reduced because it might prevail only against the defendant with limited solvency. Moreover, the focus on litigation overlooks two important facts: the plaintiff often is better off settling and the amount that it can recover in settlement is a function of the solvency of the defendants.

Section I discusses the effects of insolvency on the choice between settlement and litigation in situations involving a single defendant or multiple defendants under non-joint liability. Section II presents the model that forms the basis for our analysis of joint and several liability. Section III discusses the intuitions underlying our results. Section IV

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"the risk of insolvency ... would fall fully on the defendant(s)); Kevin J. Grehan, *Comparative Negligence*, 81 Colum. L. Rev. 1668, 1696 (1981) (student note) ("Under traditional joint and several liability rules, the solvent defendant would bear the entire burden of insolvency.").

A corollary to the prevailing view is that, provided that there is at least one solvent defendant, the plaintiff will be indifferent as to how much it can extract from defendants with partial solvency. See Robert Funsten & Alejandro Hernandez, *The Toxic Waste Generator in Bankruptcy: Should Environmental Cleanup Costs Be Given a Priority?*, 6 Stan. Env'tl. L.J. 108, 134 (1986-87) ("Since under CERCLA, the EPA can always go after another potentially responsible party linked to the site, it may be inclined to settle for whatever the insolvent operator/generator will give it."). We show that this view is incorrect.

provides a detailed analysis of the problem of settlement under insolvency.

**I. Settlements with a Single Defendant or Multiple Defendants Under Non-Joint Liability**

The simplest model of the choice between settlement and litigation considers a plaintiff and a single defendant with complete information of their respective strategic situations. Specifically, each party knows both its own and the other party's belief about the plaintiff's probability of success at trial and the value of the litigation, as well as the litigation costs faced by each.

In this model, if both parties are risk-neutral, have common beliefs about the prospect and value of success at trial, and face zero litigation costs, each is indifferent between litigation and settlement for the expected value of the litigation.<sup>5</sup> If the defendant is fully solvent, this expected value is the probability that the plaintiff will succeed times the plaintiff's damages. In contrast, if the defendant has only limited solvency, the expected value of the litigation is the probability that the plaintiff will succeed times the defendant's solvency. Thus, limited solvency reduces the plaintiff's expected recovery but does not affect the choice between settlement and litigation.

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<sup>5</sup>Positive litigation costs, risk aversion, or pessimistic beliefs about the prospects or value of success at trial make settlement preferable. For definitions of pessimism and optimism, see note 9 *infra*.



The results of the one-defendant problem extend directly to settlement with multiple defendants under non-joint (several only) liability. Under non-joint liability, the plaintiff's claim against each of the defendants is equal to that defendant's apportioned share of the liability. This claim is not affected by whether the plaintiff litigates or settles with the other defendants, or, in the latter case, by the amount of the settlement. So, the plaintiff faces the one-defendant problem against each of the defendants.

As in the single-actor problem, if the plaintiff and a defendant are risk neutral, share common beliefs about the plaintiff's probability of settlement, and litigation costs are zero, the two parties will be indifferent between litigating or settling for the expected value of the litigation.

Here, too, a defendant's limited solvency does not affect the plaintiff's decision whether to settle with or litigate against that defendant. It affects only the plaintiff's expected recovery. Moreover, one defendant's limited solvency does not affect the plaintiff's decision whether to settle with or litigate against the other defendants (or the plaintiff's expected recovery against that defendant).

It also follows from this analysis that the choice between settlement and litigation is independent of (1) the plaintiff's probabilities of success; (2) the correlation of these

probabilities;<sup>6</sup> (3) the share of liability of the defendants; and (4) the defendants' solvency. Our analysis in Section IV reveals that, under joint and several liability, this choice is affected by each of the four factors.

## II. The Model

In this section, we adapt to the case of limited solvency the model developed for our analysis of settlement under joint and several liability when the defendants are fully solvent.<sup>7</sup> We therefore discuss the features of the model only briefly. While our analysis focuses on the specifications set forth below, we briefly discuss some alternatives.

We consider a regime of joint and several liability with pro rata contribution (contribution according to the defendants' relative shares of the liability) in which a single plaintiff has a claim against two defendants, Row and Column. Row's share of the liability is  $r$  and Column's is  $(1-r)$ . Without any loss of generality, we normalize the value of the plaintiff's claim to 1. Row's solvency,  $u_R$ , is not sufficient to satisfy the plaintiff's full claim; thus,  $u_R < 1$ . In contrast, Column is fully solvent.

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<sup>6</sup>We showed in our previous article, for full solvency, that the plaintiff's expected recovery from litigation under non-joint liability is independent of the correlation of probabilities. See Kornhauser & Revesz, *Multi-Defendant Settlements*, supra note 1. The same result holds for limited solvency.

<sup>7</sup>See Kornhauser & Revesz, *Multi-Defendant Settlements*, supra note 1.

We assume that the litigation costs are zero.<sup>8</sup>

The probability that the plaintiff will prevail against each defendant is  $p$ , where  $0 < p < 1$ ; all the parties know the value of  $p$ . We analyze the problem both when the probabilities that the plaintiff will succeed against the defendants are independent and when they are perfectly correlated.

The parties may either litigate ( $\neg s$ ) or settle ( $s$ ) the claim. We adopt the convention that, if a defendant is indifferent between settlement and litigation, it settles.

Settlement negotiations have the following structure. The plaintiff makes settlement offers to the two defendants. Row and Column decide simultaneously whether to accept these offers. We assume that costs of coordinating their actions are sufficiently high that they act non-cooperatively.

The plaintiff then litigates against the non-settling defendants, if any. If the plaintiff is successful in its litigation against both defendants, the damages are apportioned between Row and Column according to their relative shares of the liability.

We define the following legal regime governing settlements under joint and several liability.<sup>9</sup> First, if only one

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<sup>8</sup>Positive litigation costs merely make settlement more likely. If the plaintiff settles with both defendants in the absence of litigation costs, it will do so also for positive litigation costs. In contrast, if the plaintiff litigates with one or both defendants in the absence of litigation costs, it will, instead, settle if litigation costs are sufficiently high.

<sup>9</sup>We study alternative regimes in Kornhauser & Revesz, Multi-Defendant Settlements, supra note 1.

defendant accepts the plaintiff's offer, the value of its claim against the other defendant is reduced by the amount of the settlement (a pro tanto set-off rule). Second, a settling defendant cannot be sued for contribution by the other defendants. Third, a settling defendant cannot obtain contribution from another defendant. Fourth, there are no constraints on the types of settlement offers that the plaintiff can make to each of the defendants.

### **III. Intuitions Underlying Our Results**

This section seeks to explain the intuitions underlying our three central conclusions regarding the impact of a defendant's limited solvency on the choice between settlement and litigation: (1) it induces settlements that otherwise would not occur when the plaintiff's probabilities of success are independent; (2) it also induces settlements that otherwise would not occur when the plaintiff's probabilities of success are perfectly correlated and the shares of liability of the two defendants are sufficiently different; and (3) it deters settlements that otherwise would occur when the plaintiff's probabilities of success are perfectly correlated and the shares of liability of the two defendants are sufficiently similar.

For the purposes of this section, we define the plaintiff's surplus to be the difference between its expected recovery from its preferred option and its expected recovery from its next-preferred option when the parties are risk neutral and share

common beliefs about the plaintiff's probabilities of success in litigation. For risk neutrality and common beliefs, the size of the surplus plays no role in determining the choice between settlement and litigation: the plaintiff simply picks the option that maximizes its expected recovery.

The size of the surplus affects the outcome, however, if these conditions do not hold. For example, the plaintiff will settle with both defendants when the parties are risk preferring or have optimistic beliefs only if settlement with both defendants is the preferred option in the model involving risk neutrality and common beliefs, and the corresponding surplus is of sufficient size. Conversely, the plaintiff will litigate with both defendants when the parties are risk averse or have pessimistic beliefs only if litigation with both defendants is the preferred option in the model involving risk neutrality and common beliefs, and the surplus is sufficiently large.<sup>10</sup>

We derive our intuitions by thinking about how the results of our prior article concerning the choice between settlement and litigation involving fully solvent defendants are likely to change when one of the defendants has only limited solvency. In section IV, we solve the problem formally and confirm that these

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<sup>10</sup>The beliefs of the parties are pessimistic when a plaintiff believes that her probability of success is lower than the defendant's belief of the plaintiff's probability of success. Conversely, the beliefs of the parties are optimistic when a plaintiff believes that her probability of success is higher than the defendant's belief of the plaintiff's probability of success. See Kornhauser & Revesz, Multi-Defendant Settlements, supra note 1.

intuitions are, in fact, correct.

In the case of independent probabilities, when the defendants are fully solvent, the plaintiff's expected recovery is greatest when it litigates against both defendants. Litigation is advantageous because the plaintiff can recover its full damages regardless of whether the plaintiff prevails against both defendants, only against Row, or only against Column. To match this recovery through settlement, a defendant's payment must be sufficiently large that it reduces the expected loss of the other defendant through the operation of the set-off rule. Because of this externality, settlement does not occur.<sup>11</sup>

In turn, when the plaintiff litigates against both defendants (and its probabilities of success are independent), each of the defendants faces a larger expected loss than under one of the alternative outcomes. As a result, the shortfall in solvency necessary to reduce the plaintiff's expected recovery under this outcome is smaller than under the other outcomes, and for a given shortfall in solvency, the reduction in the plaintiff's expected recovery is greater when the plaintiff litigates against both defendants.<sup>12</sup> Most clearly, any level

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<sup>11</sup>See Kornhauser & Revesz, Multi-Defendant Settlements, supra note 1.

<sup>12</sup>This intuition suggests that the result is not specific to the pro tanto set-off rule. Consider the leading alternative set-off rule--the apportioned set-off rule, which reduces a plaintiff's claim against a non-settling defendant by the apportioned share of the settling defendant. We showed in our prior article, for full solvency, that, in the absence of litigation costs, the plaintiff litigates against both defendants if its probabilities of success are independent. See Kornhauser

of Row's solvency less than 1 reduces the plaintiff's expected recovery from litigating against both defendants because, with probability  $p(1-p)$ , the plaintiff prevails only against Row. In contrast, for example, if Column settles, the plaintiff's expected recovery is affected by Row's limited solvency only if this solvency is insufficient to cover the portion of the plaintiff's damages that remains unpaid after Column's settlement. Thus, the defendants' limited solvency reduces the surplus that the plaintiff obtains from litigating against both defendants and, consequently, has the effect of pushing the parties toward settlement.<sup>13</sup>

The situation is different in the case of perfectly correlated probabilities. Here, the plaintiff never chooses to litigate against both defendants because settlement with one does not reduce the probability that it will recover damages through litigation: the probability of prevailing against one is no different than the probability of prevailing against both. In

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& Revesz, supra note 1. Once again, the shortfall in solvency necessary to reduce the plaintiff's expected recovery under this outcome is smaller than under the other outcomes, and for any given shortfall in solvency, the reduction in the plaintiff's expected recovery is greater when the plaintiff litigates against both defendants. Insolvency therefore induces settlements that otherwise would not occur.

<sup>13</sup>We showed in Kornhauser & Revesz, Multi-Defendant Settlements, supra note 1, that for full solvency and zero litigation costs, the specifications of the legal regime in our model (such as whether settling defendants can sue or be sued for contribution) did not affect the conclusion that the plaintiff would choose to litigate against fully solvent defendants. Our intuition suggests that a defendant's limited solvency pushes the parties toward settlement under these alternative rules.

the case of fully solvent defendants, the plaintiff settles with both defendants if their shares of the liability are sufficiently similar. Otherwise it settles with the defendant with the larger share of liability and litigates against the other. In the latter case, the plaintiff does not settle with both defendants because an offer sufficiently attractive to induce the defendant with the smaller share of the liability to settle would cause the other defendant to litigate, making the plaintiff worse off.<sup>14</sup>

As in the case of independent probabilities, each defendant faces a larger expected loss under the outcome preferred by the plaintiff. It follows that the shortfall in solvency necessary to reduce the plaintiff's expected recovery under this preferred outcome is smaller than under the other outcomes. Thus, when the defendants' shares of the liability are sufficiently similar, limited solvency reduces the surplus that the plaintiff obtains from settling with both defendants, therefore having an anti-settlement effect. When the defendants' shares of the liability are sufficiently different, limited solvency reduces the surplus that the plaintiff obtains from litigating against the defendant with the smaller share of the liability, pushing the parties toward settlement.

These intuitions generalize as follows. The plaintiff's expected recovery under the outcome that it prefers when the defendants are fully solvent is more affected by limited solvency than the alternative outcomes. Thus, limited solvency

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<sup>14</sup>See *id.*



has the effect of pushing the plaintiff away from the outcome it would choose if the defendants were fully solvent.

#### IV. The Results

In this section, we analyze, initially for independent probabilities and then for perfectly correlated probabilities, the effects of Row's limited solvency. First, we define the expected losses of the defendants and the expected recovery of the plaintiff under the four outcomes defined by whether Row and Column settle or litigate. Second, we determine which outcome maximizes the plaintiff's expected recovery for every value of Row's solvency. Third, we discuss the impact of Row's limited solvency on the choice between settlement and litigation. Fourth, we study the impact of Row's limited solvency on the plaintiff's expected recovery and on the defendants' expected losses. Fifth, we consider whether our central conclusions would differ if both defendants had limited solvency. Sixth, we compare the effects of limited solvency under joint and several, and non-joint liability.

##### A. Independent Probabilities

###### 1. The Various Outcomes

If the plaintiff litigates against both defendants, Row's expected loss,  $L_R$ , is given by

$$(1) \quad L_R = p^2 \text{Min}(r, u_R) + p(1-p)u_R$$

First, with probability  $p^2$ , the plaintiff prevails against both

defendants. If Row were fully solvent, it would have to pay its share  $\underline{r}$ . Not being fully solvent, it pays the lesser of  $\underline{r}$  or its full solvency. Second, with probability  $p(1-p)$ , the plaintiff prevails against Row but not against Column. If Row were fully solvent, it would have to pay the full damage of 1; instead, it pays its full solvency.

Equation (1) illustrates that the plaintiff's recovery from Row is reduced by Row's limited solvency in two distinct ways. The second term is proportional to Row's solvency over the whole range of relevant solvencies. Thus, anything less than full solvency reduces this term and, consequently, the plaintiff's recovery. The first term is independent of Row's solvency for any solvency greater or equal to  $\underline{r}$ ; thus, over this range, Row's lack of full solvency does not affect the term. For smaller solvencies, this term is also proportional to Row's solvency. Equation (1) reveals that for  $u_R < r$ , Row's expected liability is simply  $pu_R$ . This amount is equal to its expected liability under non-joint liability. Thus, for this range of solvency, the plaintiff does not capture any litigation surplus from Row.

Similarly, we write the expression for Column's expected loss  $L_C$  as

$$(2) \quad L_C = p^2[1 - \text{Min}(r, u_R)] + p(1-p)$$

First, with probability  $p^2$ , the plaintiff prevails against both defendants, and Column pays the plaintiff's full damage of 1 minus whatever Row paid. If Row's solvency is  $\underline{r}$  or greater, Column merely pays its share of  $(1-r)$ , as it would had Row been

fully solvent; otherwise, Column pays more than its share. Second, with probability  $p(1-p)$ , the plaintiff prevails against Column but not against Row, and Column must pay the full damage of 1. Row's limited solvency does not affect Column's expected loss when  $u_R \geq r$ . For smaller values, however, Column's expected loss rises as Row's solvency falls.

The plaintiff's expected recovery from litigating against both defendants,  $V(-s, -s)$ , is simply the sum of  $L_R$  and  $L_C$ . Thus,

$$(3) \quad V(-s, -s) = p[1 + u_R(1-p)]$$

If  $u_R \geq r$ , the plaintiff bears the full burden of the shortfall. Every decrease of one unit in Row's solvency produces a decrease of  $p(1-p)$  units (an amount smaller than one) in the plaintiff's recovery.<sup>15</sup> For lower solvencies, the shortfall is shared between the plaintiff and Column. The plaintiff continues to lose  $p(1-p)$  units for every unit of decrease in Row's solvency. In addition, in this range, Column's expected liability increases  $p^2$  units for every unit of decrease in Row's solvency.

We now consider the situation in which the plaintiff settles with both defendants. The maximum settlement that Row will accept conditional on Column settling,  $G_R$ , is Row's expected cost of litigation. With probability  $p$ , the plaintiff prevails. If Row were fully solvent, it would pay the plaintiff's damages of 1 minus Column's settlement. Instead, it pays the lesser of this amount and the amount of its solvency. Thus,

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<sup>15</sup>Recall that  $u_R < 1$ . In making claims about the effect of a decrease of unit in Row's solvency, by "unit" we do not mean the full range of  $u_R$ , but, rather, a small decrease.

$$(4) \quad G_R = p \text{Min}[(1-G_C), u_R]$$

The corresponding expression for the maximum settlement,  $G_C$ , that Column would accept is simply

$$(5) \quad G_C = p(1-G_R)$$

Adding equations (4) and (5) reveals that if Row were fully solvent,  $G_R = G_C = p/(1+p)$ .<sup>16</sup> It follows from equation (4) that Row will pay this amount rather than litigate if and only if  $u_R \geq 1/(1+p)$ . For smaller values of Row's solvency, the maximum amount for which Row will settle is  $pu_R$ . In this case, Column will be willing to settle for up to  $p(1-pu_R)$ . The plaintiff's recovery is given by

$$(6) \quad V(s,s) = \begin{cases} 2p/(1+p) & u_R > 1/(1+p) \\ p[1 + u_R(1-p)] & u_R \leq 1/(1+p) \end{cases}$$

When it settles with both defendants, the plaintiff's expected recovery is affected only over a partial range of Row's solvency: for solvencies between  $1/(1+p)$  and 1, the plaintiff's recovery is unaffected. Similarly, in this range, Column pays no more as a result of Row's lack of full solvency. For lower solvencies, the shortfall is shared between the plaintiff and Column in the same manner as for the  $(-s,-s)$  outcome. The plaintiff begins to lose  $p(1-p)$  units for every unit of decrease in Row's solvency and Column's expected liability begins to increase  $p^2$  units for every unit of decrease in Row's solvency.

To analyze the  $(s,-s)$  outcome, we define  $S_R$  as the maximum

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<sup>16</sup>It is easy to see that if the plaintiff accepted a smaller settlement from one of the defendants, it could only recover a fraction  $p$  of the resulting shortfall from the other.

settlement that Row will accept conditional on Column litigating and  $\theta_C$  as Column's expected value of litigation given that Row settles for  $S_R$ .

$$(7) \quad S_R = p^2 \text{Min}(r, u_R) + p(1-p)u_R$$

$$(8) \quad \theta_C = p(1-S_R)$$

The maximum settlement that Row will accept conditional on Column litigating is simply the expected cost to Row of litigation conditional on Column litigating; thus, as the comparison of equations (1) and (7) reveals,  $S_R = L_R$ . In turn, conditional on Row settling, when Column litigates it pays, with probability  $p$ , the plaintiff's damages minus Row's settlement.

The comparison of equation (2), which gives Column's expected loss conditional on Row litigating, to equation (8) shows that  $\theta_C \leq L_C$ ; that the relationship holds as an inequality for  $u_R > r$ ; and that, for this range, the difference between  $L_C$  and  $\theta_C$  decreases with decreasing values of  $u_R$ . Thus, for sufficiently high levels of Row's solvency, Row confers an external benefit on Column, but the magnitude of this externality decreases as Row's solvency falls.

For the (s,-s) outcome, anything less than full solvency reduces the maximum settlement that Row will accept. In turn, Row's limited solvency increases Column's expected liability. The plaintiff's expected recovery is also reduced over the full range of Row's solvency because a decrease of one unit in the maximum settlement that Row will accept is compensated by an increase in only  $p$  units of Column's expected liability. Adding

$S_R$  and  $\theta_C$ , we have

$$(9) \quad V(s, -s) = \begin{cases} p\{1 + (1-p)[pr + (1-p)u_R]\} & u_R > r \\ p\{1 + u_R(1-p)\} & u_R \leq r \end{cases}$$

Finally, to analyze the  $(-s, s)$  outcome, we define  $S_C$  as the maximum settlement that Column will accept conditional on Row litigating and  $\theta_R$  as Row's expected value of litigation given that Column settles for  $S_C$ . Then,

$$(10) \quad S_C = p^2[1 - \text{Min}(r, u_R)] + p(1-p) = p[1 - p\text{Min}(r, u_R)]$$

$$(11) \quad \theta_R = p\text{Min}[(1 - S_C), u_R]$$

The maximum settlement that Column will accept conditional on Row litigating is simply the expected cost to Column of litigation conditional on Row litigating; thus, as the comparison of equations (2) and (10) reveals,  $S_C = L_C$ . In turn, the plaintiff has a probability  $p$  of prevailing against Row. If Row were fully solvent it would pay the plaintiff's damages of 1 minus Column's settlement. Instead, it pays the lesser of this amount and the amount of its solvency.

The comparison of equation (1), which gives Row's expected loss conditional on Column litigating, to equation (11) shows that, here too, for sufficiently high levels of Row's solvency, Row confers an external benefit on Column, but the magnitude of this externality decreases as Row's solvency falls.<sup>17</sup>

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<sup>17</sup>Consider first the case of  $r < 1/(1+p)$ . Then,  $\theta_R < L_R$  for  $u_R > 1-p(1-pr)$  and  $\theta_R = L_R$  for  $u_R \leq r$ . Interestingly,  $\theta_R < L_R$  for  $r < u_R \leq 1-p(1-pr)$ ; in this range, as a result of the shortfall in Row's solvency, the surplus that the plaintiff obtains from litigating against both defendants under joint and several liability is sufficiently small that it is willing to accept from Column a settlement that confers an external benefit on Row.

The plaintiff's expected recovery under this outcome (the sum of  $S_C$  and  $\theta_R$ ), can take one of four different values depending on the comparison of  $u_R$  to both  $r$  and  $(1-S_C)$ , which is itself a function of  $u_R$ . The expressions 12(a) and 12(b) present the values of  $V(-s,s)$  for  $r < 1/(1+p)$  and for  $r \geq 1/(1+p)$ , respectively.

$$(12) (a) \quad V(-s,s) = \begin{cases} p[1 + (1-p)(1-pr)] & u_R > 1-p(1-pr) \\ p(1 + u_R - pr) & r < u_R \leq 1-p(1-pr) \\ p[1 + u_R(1-p)] & u_R \leq r \end{cases}$$

where  $r < 1/(1+p)$ .

$$(12) (b) \quad V(-s,s) = \begin{cases} p[1 + (1-p)(1-pr)] & u_R > r \\ p[1 + (1-p)(1-pu_R)] & 1/(1+p) < u_R \leq r \\ p[1 + u_R(1-p)] & u_R \leq 1/(1+p) \end{cases}$$

where  $r \geq 1/(1+p)$ .

Equation (12) shows that as long as Row's solvency is no less than the greater of  $\underline{r}$  and  $(1-S_C)$ , the plaintiff is unaffected by Row's limited solvency. Moreover, equation (10) shows that as long as Row solvency is no less than  $\underline{r}$ , Column is unaffected by Row's limited solvency. For smaller solvencies, the shortfall caused by Row's limited solvency is shared between the plaintiff and Column.

Despite the complicated expressions for the plaintiff's expected recovery under the various outcomes, the central conclusions that emerge from the preceding analysis are relatively straightforward.

## 2. The Plaintiff's Choice Among the Outcomes

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Second, consider  $r \geq 1/(1+p)$ . Then,  $\theta_R \leq L_R$ ; the relationship holds as an inequality for  $u_R > 1/(1+p)$ .

First, the comparison of equations (3), (6), (9), and (12) reveals that for sufficiently small values of  $u_R$ , all four outcomes give the plaintiff the same expected recovery. As indicated above, for sufficiently low levels of Row's solvency, the externality that precludes settlement is not present. Thus, under our convention, the plaintiff settles with both defendants. This result occurs when Row's solvency is no greater than the smaller of  $\underline{r}$  and  $1/(1+p)$ . The range of Row's solvencies for which the plaintiff settles with both defendants is largest when  $\underline{r}$  is large and  $p$  is small.

Second, when  $u_R$  is sufficiently large, the plaintiff litigates against both defendants. Recall that this is the outcome in the case of full solvency. Because the plaintiff's expected recovery from litigating against both defendants is a continuous function of  $u_R$ , and the plaintiff's expected recovery from the other three outcomes never increases when  $u_R$  decreases, it follows that the  $(-s, -s)$  maximizes the plaintiff's expected recovery even when Row is not fully solvent.<sup>18</sup>

Third, the plaintiff never chooses the  $(s, -s)$  outcome. When the plaintiff settles with one defendant and litigates against the other, it seeks to maximize the amount of the settlement because each additional unit that it obtains in settlement decreases by at most only  $p$  units its expected claim against the

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<sup>18</sup>We know that this is the case when the defendants are solvent. It follows from the continuity of the functions that this result holds as well for somewhat lower solvencies.



litigating defendant.<sup>19</sup> Thus, when both defendants are fully solvent, the plaintiff chooses to settle with the defendant that has the larger share of the liability (Column for  $r < 1/2$  and Row for  $r > 1/2$ ).

Row's lack of full solvency complicates this analysis. If both defendants had an equal share of the liability, the more solvent defendant--in our case Column--would accept the higher settlement, and, contingent on settling with one defendant and litigating against the other, the plaintiff would choose to settle with Column. It follows, a fortiori, that this result also holds when Row has the smaller share of the liability. In contrast, if Row, the defendant with the limited solvency, has the larger share of liability, there is a tradeoff: its higher share increases the maximum settlement that it would accept but its limited solvency decreases it. For sufficiently high  $r$  and  $u_R$ , the plaintiff obtains a higher recovery under the  $(s, -s)$  outcome than under the  $(-s, s)$  outcome.

Nonetheless, when this holds, Row's solvency is sufficiently high that the plaintiff's expected recovery is even higher under the  $(-s, -s)$  outcome. Indeed, the comparison of equations (3) and (9) shows that there is no range of solvencies for which the plaintiff prefers the  $(s, -s)$  to the  $(-s, -s)$  outcome.

Fourth, for  $r < 1/(1+p)$ , there is an intermediate range of

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<sup>19</sup>This decrease is  $p$  units if the non-settling defendant is sufficiently solvent to satisfy the plaintiff's claim; otherwise, the decrease in the plaintiff's expected claim against the non-settling defendant is less than  $p$  times the amount of the settlement.

Row's solvency for which the plaintiff chooses the  $(-s, s)$  outcome. For larger values of  $\underline{r}$ , the plaintiff never chooses the  $(-s, s)$  outcome.

Tables I and II show the plaintiff's choice of outcome under different values of  $u_R$  for  $r < 1/(1+p)$  and  $r \geq 1/(1+p)$ , respectively.<sup>20</sup>

**Table I: Plaintiff's Choice of Outcome for  $r < 1/(1+p)$**

Range of Solvency	Outcome
$u_R > 1 - pr$	$(-s, -s)$
$r < u_R \leq 1 - pr$	$(-s, s)$
$u_R \leq r$	$(s, s)$

**Table II: Plaintiff's Choice of Outcome for  $r \geq 1/(1+p)$**

Range of Solvency	Outcome
$u_R > 1/(1+p)$	$(-s, -s)$
$u_R \leq 1/(1+p)$	$(s, s)$

### 3. Impact of Row's Limited Solvency on the Choice Between Settlement and Litigation

Tables I and II show that Row's limited solvency creates incentives for settlement. Whereas the plaintiff would litigate against both defendants if Row were fully solvent, it settles with both if Row's solvency is sufficiently low. More precisely,

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<sup>20</sup>A comparison of the relevant expressions reveals that the plaintiff's expected recovery as well as Row's and Column's expected payoffs are continuous functions of  $u_R$  (piecewise smooth though not differentiable).

for sufficiently high solvency, the plaintiff obtains a surplus from litigating rather than settling. Thus, litigation will occur not only when the parties share common beliefs and are risk neutral, but also when they are somewhat risk-averse or their beliefs are slightly pessimistic.

In contrast, if Row's solvency is sufficiently low, the plaintiff is indifferent between settling with both defendants and pursuing one of the alternative outcomes. Any degree of risk aversion or pessimism will make settlement with both defendants more desirable than the alternatives.

#### 4. Impact of Row's Limited Solvency on the Parties

We now focus on the impact on the plaintiff as well as on both defendants of Row's limited solvency. Tables III and IV show, for each of the two scenarios, the impact of a decrease in one unit of Row's solvency on the plaintiff's expected recovery as well as on Column's and Row's expected payments. The various entries are obtained from the equations defining the plaintiff's expected recovery and the defendants' expected losses for each of the outcomes.

These functions are also plotted in Figure I as functions of  $u_R$ . The top line shows the plaintiff's expected recovery. The bottom line shows Column's expected loss. The difference between the lines is Row's expected loss.<sup>21</sup>

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<sup>21</sup>The figure is drawn to scale for  $p = .5$ . In case 1 ( $r < 1/(1+p)$ ),  $r = .5$ . In case 2 ( $r \geq 1/(1+p)$ ),  $r = .7$ .

**Table III: Effects of Row's Limited Solvency if  $r < 1/(1+p)$**

Range of Solvency	Plaintiff	Column	Row
$u_R > 1 - pr$	$-p(1-p)$	0	$-p(1-p)$
$1 - p(1-pr) < u_R \leq 1 - pr$	0	0	0
$r < u_R \leq 1 - p(1-pr)$	$-p$	0	$-p$
$u_R \leq r$	$-p(1-p)$	$p^2$	$-p$

**Table IV: Effects of Row's Limited Solvency if  $r \geq 1/(1+p)$**

Range of Solvency	Plaintiff	Column	Row
$u_R > r$	$-p(1-p)$	0	$-p(1-p)$
$u_R \leq r$	$-p(1-p)$	$p^2$	$-p$

Several important conclusions emerge from these tables. First, for  $r \geq 1/(1+p)$ , over all the ranges of Row's solvency, the plaintiff's expected recovery decreases  $p(1-p)$  units for every unit of decrease in Row's solvency. For  $r < 1/(1+p)$ , the relationship is not quite as simple. In two of the ranges, Row's limited solvency has a similar effect. There is one range for which a decrease of one unit in Row's solvency has a larger effect on the plaintiff's expected recovery: it reduces it by  $p$  units. There is also one range of solvency for which, somewhat counterintuitively, a decrease in Row's solvency has no effect on the plaintiff's expected recovery (or on the expected losses of the defendants).<sup>22</sup>

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<sup>22</sup>In this range, the plaintiff chooses the  $(-s, s)$  outcome; equation (10) and the first line of equations (12) (a) and (12) (b) show, respectively, that Column's expected loss and the plaintiff's recovery is not affected by a decrease in  $u_R$ .

Second, for  $u_R > r$ , Column's expected loss is unaffected by Row's limited solvency. As long as a defendant's solvency is sufficient to cover its share of the liability, its solvent co-defendant does not bear any additional burden.

Third, for  $u_R \leq r$ , the plaintiff's expected recovery decreases  $p(1-p)$  units for each unit of decrease in Row's solvency. At the same time, Column's expected loss increases  $p^2$  units for every unit of decrease in Row's solvency. The ratio of the plaintiff's burden to Column's burden is therefore  $(1-p)/p$ . Thus, for high values of  $p$ , Column bears most of the additional burden that results when Row's solvency falls below  $r$ . In contrast, for low values of  $p$ , the plaintiff bears most of this additional burden.

##### 5. Two Potentially Insolvent Defendants

So far, we have analyzed the problem when only one defendant has limited solvency. The central conclusions of our discussion hold also when both defendants have limited solvency--that is, where  $u_C$  as well as  $u_R$  is smaller than one. First, for sufficiently high solvencies, the plaintiff chooses to litigate against both defendants.<sup>23</sup> Second, for sufficiently low solvencies, the plaintiff is indifferent among the four outcomes, and, under our convention, chooses to settle with both

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<sup>23</sup>We know that this is the case when the defendants are fully solvent. It follows from the continuity of the functions that this result holds as well for somewhat lower solvencies.

defendants.<sup>24</sup>

## 6. Comparison with Non-Joint Liability

As indicated in section I, under non-joint liability, the limited solvency of the defendants does not affect the plaintiff's choice between settlement and litigation. In contrast, under joint and several liability, insolvency creates incentives for settlement. In our simple model of common beliefs and risk neutrality, the plaintiff, under non-joint liability, is indifferent between settling with or litigating against each of the defendants. Under joint and several liability, the plaintiff gains from litigating against both defendants when the defendants' solvencies are sufficiently high but is indifferent between settling and litigating with each of the defendants when they are sufficiently low.

### B. Perfectly Correlated Probabilities

#### 1. The Various Outcomes

Equations (4)-(6) show that if the plaintiff settles with both defendants, its recovery and the defendants' payments are independent of the correlation of the probabilities of the

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<sup>24</sup>It is easy to show that, for sufficiently low solvencies, the plaintiff's expected recovery under all four outcomes is  $p(u_R + u_C)$ . In this range, a decrease of one unit in a defendant's solvency decreases its expected loss and the plaintiff's expected recovery by  $p$  units but does not affect the other defendant.

plaintiff's success in litigation.<sup>25</sup> For the other three outcomes, however, the analysis differs.

If the plaintiff litigates against both defendants, Row's expected loss is given by

$$(13) \quad L_R = p \text{Min}(r, u_R)$$

With probability  $p$ , the plaintiff prevails against both defendants. If Row were fully solvent, it would have to pay its share  $r$ . Not being fully solvent, it pays the lesser of  $r$  or its full solvency.

In turn, Column's expected loss is

$$(14) \quad L_C = p[1 - \text{Min}(r, u_R)]$$

With probability  $p$ , the plaintiff prevails against both defendants, and Column pays the plaintiff's full damage of 1 minus whatever Row paid. If Row's solvency is  $r$  or greater, Column merely pays its share of  $(1-r)$ , as it would had Row been fully solvent; otherwise, Column pays more than its share.

Adding the expressions for  $L_R$  and  $L_C$ ,

$$(15) \quad V(-s, -s) = p$$

Equation (15) shows that the plaintiff's expected recovery is independent of Row's solvency. The full shortfall attributable to Row's limited solvency is borne by Column.

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<sup>25</sup>We are making one simplification. We showed in Kornhauser & Revesz, Multi-Defendant Settlements, supra note 1, that in the case of perfectly correlated probabilities, an offer of  $(L_R, L_C)$  can induce either the  $(s, s)$  or  $(-s, -s)$  outcomes, and that the plaintiff prefers the former. In order to be sure that both defendants will settle, the plaintiff needs to modify its offers in a manner that reduces its recovery but does not affect the choice among outcomes. Thus, for our current purposes, we can disregard this issue.

For the (s,¬s) outcome, the maximum settlement that Row will accept conditional on Column litigating is

$$(16) \quad S_R = p\text{Min}(r, u_R)$$

Column's expected value of litigation given that Row settles for  $S_R$  is

$$(17) \quad \theta_C = p(1-S_R) = p[1 - p\text{Min}(r, u_R)]$$

For this outcome, Row's settlement and Column's expected loss are affected only for  $u_R < r$ . For smaller solvencies, Column's expected loss increases  $p^2$  units for every unit of decrease in Row's solvency.

The plaintiff's expected recovery is

$$(18) \quad V(s, \neg s) = \begin{cases} p[1 + (1-p)r] & u_R > r \\ p[1 + u_R(1-p)] & u_R \leq r \end{cases}$$

For  $u_R < r$ , the plaintiff's expected recovery decreases  $p(1-p)$  units for each unit of decrease in Row's solvency.

For the (¬s,s) outcome, the maximum settlement that Column will accept conditional on Row litigating is

$$(19) \quad S_C = p[1 - \text{Min}(r, u_R)]$$

Row's expected value of litigation given that Column settles for  $S_C$  is

$$(20) \quad \theta_R = p\text{Min}[(1-S_C), u_R]$$

The plaintiff's expected recovery is given by

$$(21) \quad V(\neg s, s) = \begin{cases} p[1 + (1-p)(1-r)] & u_R > 1 - p(1-r) \\ p(1 + u_R - r) & r < u_R \leq 1 - p(1-r) \\ p & u_R \leq r \end{cases}$$

Equation (21) shows that as long as Row's solvency is no less than  $1 - p(1-r)$ , the plaintiff is unaffected by Row's



limited solvency. Moreover, equation (19) shows that as long as Row's solvency is no less than  $\underline{r}$ , Column is unaffected by Row's limited solvency. In contrast, the additional shortfall caused when Row's solvency falls below  $\underline{r}$  is borne exclusively by Column.

2. The Plaintiff's Choice Among the Outcomes

We now compare equations (6), (15), (18), and (21), which give the plaintiff's expected recoveries under the three outcomes. Tables V, VI, and VII show the plaintiff's choice for different values of  $u_R$ .<sup>26</sup> There are three relevant scenarios: (i)  $r < p/(1+p)$ , (ii)  $p/(1+p) \leq r < 1/(1+p)$ , and (iii)  $r \geq 1/(1+p)$

**Table V: Plaintiff's Choice of Outcome for  $r < p/(1+p)$**

Range of Solvency	Outcome
$u_R > r/p$	$(-s, s)$
$u_R \leq r/p$	$(s, s)$

**Table VI: Plaintiff's Choice of Outcome for  $p/(1+p) \leq r < 1/(1+p)$**

Range of Solvency	Outcome
$u_R \geq 0$	$(s, s)$

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<sup>26</sup>A comparison of the relevant expressions reveals that the plaintiff's expected recovery as well as Row's and Column's expected payoffs are continuous functions of  $u_R$  (piecewise smooth though not differentiable).

**Table VII: Plaintiff's Choice of Outcome for  $r \geq 1/(1+p)$**

Range of Solvency	Outcome
$u_R > 1/(1+p)$	(s, -s)
$u_R \leq 1/(1+p)$	(s, s)

The comparison of the various expressions reveals, first, that the plaintiff never litigates against both defendants. Indeed, except when Row is completely insolvent, the plaintiff can always do better by extracting some settlement from Row, however small, and litigating against Column.<sup>27</sup>

Second, for sufficiently small values of  $u_R$ , the (s,s) and (s,-s) outcomes give the plaintiff the same expected recovery (for positive solvencies, the other two give the plaintiff a lower recovery). Thus, under our convention, when Row's solvency is low, the plaintiff settles with both defendants. Moreover, for  $u_R = 0$ , all four outcomes give the plaintiff the same expected recovery.

Third, when  $u_R$  is sufficiently large, the plaintiff behaves just as it does when the defendants are fully solvent: it chooses (-s,s) for  $r < p/(1+p)$ , (s,s) for  $p/(1+p) \leq r < 1/(1+p)$ , and (s,-s) for  $r \geq 1/(1+p)$ .<sup>28</sup>

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<sup>27</sup>See Frank H. Easterbrook, William M. Landes & Richard A. Posner, Contribution Among Antitrust Defendants: A Legal and Economic Analysis, 23 J.L. & Econ. 331, 356 (1980); Kornhauser & Revesz, Multi-Defendant Settlements, supra note 1.

<sup>28</sup>See Kornhauser & Revesz, Multi-Defendant Settlements, supra note 1.

### 3. Impact of Row's Limited Solvency on the Choice Between Settlement and Litigation

Row's limited solvency has a complex effect on the choice between settlement and litigation. Most simply, one can state that, for sufficiently low solvencies the plaintiff always settles with both defendant but for higher solvencies it does so only sometimes (when the defendants' shares of the liability are relatively even). So, one could conclude from this observation that Row's limited solvency creates incentives for settlement.

In fact, however, the full picture is not quite as simple. Consider the situation in which  $p/(1+p) \leq r < 1/(1+p)$ , in which, as Table VI shows, the plaintiff settles with both defendants over the full range of Row's solvencies. The next best outcome to  $(s,s)$  from the plaintiff's perspective is  $(s,-s)$ . For  $r < u_R \leq 1/(1+p)$ , the plaintiff's expected recovery decreases with falling values of Row's solvency for the  $(s,s)$  outcome but remains constant for the  $(s,-s)$  outcome. Thus, the surplus from settling with both defendants falls, and becomes zero at  $u_R = r$ . While the plaintiff nonetheless settles with both defendants when the parties are risk neutral and share common beliefs, the falling surplus means that, when the parties are somewhat optimistic or somewhat risk preferring, Row's limited solvency will lead the plaintiff to litigate with one defendant rather than to settle with both.<sup>29</sup> In this way, Row's limited solvency discourages settlements.

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<sup>29</sup>Similar arguments apply to other values of  $r$ .

#### 4. Impact of Row's Limited Solvency on the Parties

We now focus on the impact on the plaintiff as well as on both defendants of Row's limited solvency. Tables VIII, IX, and X show, for each of the three scenarios, the impact of a decrease in one unit of Row's solvency on the plaintiff's expected recovery as well as on Column's and Row's expected payments. The various entries are obtained from the equations defining the plaintiff's expected recovery and the defendants' expected losses for each of the outcomes.

These functions are also plotted in Figure II as functions of  $u_R$ . The top line shows the plaintiff's expected recovery. The bottom line shows Column's expected payoff. The difference between the lines is Row's expected payoff.<sup>30</sup>

**Table VIII: Effects of Row's Limited Solvency if  $r < p/(1+p)$**

Range of Solvency	Plaintiff	Column	Row
$u_R > 1 - p(1-r)$	0	0	0
$r/p < u_R \leq 1 - p(1-r)$	-p	0	-p
$u_R \leq r/p$	-p(1-p)	$p^2$	-p

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<sup>30</sup>The figure is drawn to scale for  $p = .5$ . In case 1 ( $r < p/(1+p)$ ),  $r = .3$ . In case 2 ( $p/(1+p) \leq r < 1/(1+p)$ ),  $r = .5$ . In case 3 ( $r > 1/(1+p)$ ),  $r = .7$ .

**Table IX: Effects of Row's Limited Solvency  
if  $p/(1+p) \leq r < 1/(1+p)$**

Range of Solvency	Plaintiff	Column	Row
$u_R > 1/(1+p)$	0	0	0
$u_R \leq 1/(1+p)$	$-p(1-p)$	$p^2$	$-p$

**Table X: Effects of Row's Limited Solvency if  $r \geq 1/(1+p)$**

Range of Solvency	Plaintiff	Column	Row
$u_R > r$	0	0	0
$0 < u_R \leq r$	$-p(1-p)$	$p^2$	$-p$

Tables VIII, IX, and X show, first, that, unlike the case of independent probabilities, for sufficiently high solvencies Row's limited solvency has no effect on the plaintiff's expected recovery or on the defendants' expected loss. Second, like in the case of independent probabilities, for sufficiently low solvencies, a unit of decrease in Row's solvency produces a decrease in the plaintiff's expected recovery decreases of  $p(1-p)$  units and an increase in Column's expected loss of  $p^2$  units. Third, Table VIII show a range in which the plaintiff's expected recovery decreases  $p$  units for every unit of decrease in Row's solvency, but where Column is unaffected by Row's limited solvency.<sup>31</sup>

#### 5. Two Potentially Insolvent Defendants

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<sup>31</sup>Equation (19) shows that, because  $u_R \geq r$ , Column is unaffected. Equation (20) shows that, because  $u_R < 1-S_C$ , Row's expected loss decreases  $p$  units for each unit of decrease in its solvency.

Here, too, the central conclusions of our discussion hold also when both defendants have limited solvency. First, when both defendants have sufficiently high solvencies, the plaintiff chooses the same outcomes as when they are fully solvent. Second, for sufficiently low solvencies, the plaintiff is indifferent among the four outcomes, and, under our convention, chooses to settle with both defendants.<sup>32</sup>

#### 6. Comparison with Non-Joint Liability

As we have already stated, under non-joint liability, the limited solvency of the defendants does not affect the plaintiff's choice between settlement and litigation. In our simple model of common beliefs and risk neutrality, the plaintiff, under non-joint liability, is indifferent between settling with or litigating against each of the defendants. In contrast, under joint and several liability, insolvency creates incentives for settlement in this simple model. As we show in section III.B.3, for optimistic beliefs or risk-preferring defendants, the lack of full solvency can deter settlements.

#### Conclusion

Our findings concerning the allocation of the shortfall caused by a defendant's limited solvency between the plaintiff

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<sup>32</sup>As in the case of independent probabilities, it is easy to show that, for sufficiently low solvencies, the plaintiff's expected recovery under all four outcomes is  $p(u_R + u_C)$ . See note 24 supra.

and the solvent co-defendant have important implications. This article deals only with the choice between settlement and litigation after the underlying activity causing the harm has occurred. But, of course, this choice affects the expected loss of the defendants. Thus, it affects the choices of activity levels and levels of care.

In a prior article, we investigated the impact of potential insolvency on ex ante conduct, but restricted our attention to legal disputes resolved through litigation.<sup>33</sup> We showed that, under strict liability, though not under negligence, one defendant's insolvency can lead its co-defendant to choose activity levels or levels of care that render it insolvent as well: the insolvency of one defendant can be the but-for cause for the other's insolvency.<sup>34</sup>

While we have not worked out the details, the combination of the results of both articles suggests that this domino effect is more likely if, as courts and commentators appear to believe, the solvent defendant, rather than the plaintiff, bears the bulk of the shortfall caused by the limited solvency of the other defendant. It is therefore encouraging that our results show that over certain ranges of solvency, the plaintiff bears the full shortfall and that, elsewhere, the shortfall is shared.

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<sup>33</sup>Kornhauser & Revesz, *Apportioning Damages*, supra note 1.

<sup>34</sup>*Id.* at 642-56.