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Multi-Defendant Settlements: The Case of Superfund*

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This article extends the economic analysis of settlements to the analysis of problems involving multiple defendants. The law and economics literature on settlements has focused almost exclusively on the problem of a single plaintiff settling with a single defendant and has paid little attention to the game-theoretic issues that arise where there are multiple defendants.[1] The central conclusions of the single-defendant

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[1]The classic single-defendant works are John P. Gould, The Economics of Legal Conflicts, 2 J. Legal. Stud. 279 (1973); William M. Landes, An Economic Analysis of the Courts, 14 J. Law & Econ. 61 (1971); Richard A. Posner, An Economic Approach to Legal Procedure and Judicial Administration, 2 J. Legal Stud. 399 (1973).

For a recent work on settlements in litigation involving multiple, sequential plaintiffs, see Yeon Koo Che & Jong Goo Yi, Litigations with Multiple Plaintiffs: The Case of Effort Externality, Center for Economic Policy Research, Stanford University, Publication No. 200 (April 1990). This article focuses on the incentives to expend effort that would be useful to subsequent plaintiffs. Our article, instead, focuses on the non-cooperative game faced by multiple defendants in the face of a simultaneous offer of settlement.

In one chapter of his dissertation, Jong Goo Yi examines settlements in litigation with multiple defendants. Jong Goo Yi, literature do not apply where there are multiple defendants. Our analysis also reveals important differences between joint and several liability and non-joint (several only) liability. It shows, we believe contrary to prevailing wisdom, that, under broad sets of circumstances, joint and several liability discourages settlements.

We organize our analysis around the settlement process of the complex disputes that arise over the allocation of the costs of cleaning up releases of hazardous waste into the environment. This focus has two advantages and one disadvantage. First, it identifies an important, concrete context in which settlements arise. Disputes under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) involve large sums of money and multiple defendants. The average clean-up cost of a site on the National Priorities List (the list of most hazardous sites) is currently $25,000,000; some clean-ups cost

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Litigation with Multiple Defendants: How to Settle Under Different Apportionment Rules (unpublished Ph.D. dissertation, Stanford University, February 1991). He focuses only on the case in which the plaintiff's probability of success against each of the defendants is perfectly correlated, and thus deals with only a very narrow slice of the problem examined in this article. Yi also uses a different bargaining model than that employed here. As explained below, Yi's analysis overlooks an important dimension of the problem that he seeks to analyze. See infra note 40.

In a recent paper, Jeffrey Lange studies, in a multiple defendant context, possible contractual arrangements between a plaintiff and one or more defendants. Jeffrey Lange, Litigation Risk Exchange: An Economic Analysis of Sliding-Scale Settlements (manuscript). He appears to address only the case of perfectly correlated probabilities. See id. at 16.

more than $100,000,000.[2] It is not uncommon for hazardous waste sites to involve dozens, sometimes hundreds, of defendants; the transaction costs of litigating these disputes are extremely high. Second, the legislation and administrative process have placed additional structure on the settlement process; our model sometimes exploits this additional structure. Our argument, however, does not always depend on particular features of CERCLA. Our focus on hazardous waste, therefore, may obscure the generality of our major result: joint and several liability tends to reduce settlements relative to non-joint and several only liability.

CERCLA, as amended in 1986 by the Superfund Amendment and Reauthorization Act (SARA), has several provisions that are relevant to the analysis in this article. First, it imposes strict liability as well as joint and several liability on responsible parties, but parties held jointly and severally liable can bring actions for contribution against other responsible parties. Second, it confers broad powers on the United States Environmental Protection Agency (EPA) to design, compel, oversee and conduct clean-ups of hazardous waste sites. Third, CERCLA establishes a fund (the Superfund), financed primarily through a tax on petroleum and chemical feedstocks, to underwrite EPA's clean-up costs until it can obtain payment from solvent responsible parties, or, if no such parties can be found,

[2]See Lewis A. Kornhauser and Richard L. Revesz, Sequential Decisions by a Single Tortfeasor, 20 J. Legal Stud. 363, 364 (1991).

to bear the final cost. Fourth, under the statute, EPA may sue responsible parties either for the clean-up costs borne by the Government as well as for the Government's future clean-up costs, or for an injunction requiring the private parties to undertake a clean-up; in this article, we focus on situations in which the Government undertakes the cleanup and sues for the recovery of the resulting costs. Finally, the statute and regulations promulgated under it, give the EPA broad authority to promote settlements of various types.

The provisions of particular interest to us authorize de minimis and mixed settlements. In de minimis settlements, parties responsible for small amounts of the contamination are encouraged to settle in order to reduce the complexity of the Government's negotiation with larger parties and of any resulting litigation. In mixed settlements, work and costs are allocated between the United States and responsible parties.

The discussion proceeds as follows. Section I sets forth the model that underlies our analysis. Section II studies the defendants' settlement game. Section III analyzes EPA's strategy as the plaintiff seeking the recovery of clean-up costs. The results in section III (B) do not depend on features peculiar to CERCLA while the results in sections II, III(C) and (D) do exploit some of the structure imposed by the statute. Some mathematical derivations are listed in an appendix.

I. The Model

Our model contains several simplifying assumptions. First, as already indicated, at many sites there are many potentially responsible parties. Some of these parties generated the waste, others transported it, and some own or owned the contaminated site. Because the EPA and the courts appear to assign primary financial responsibility to generators, we focus on the allocation of costs among them.[3] Generators differ not only in the amount of waste generated but also in the nature of the generated waste. Different wastes present different risks and require different technologies of clean-up, therefore giving rise to different costs of cleanup. In what follows, we assume that there are two defendants--both generators--that have produced identical wastes.

Second, in typical Superfund cases, at the time of a settlement, many costs have not yet been incurred. EPA often files suit against responsible parties after having incurred only a small fraction of the total cleanup costs; in such suits, it seeks to recover its past cost as well as obtain declaratory judgment for future costs. There is, of course, great uncertainty as to the magnitude of future costs. EPA can often choose between settling (1) for the expected value of the future costs, retaining the right to seek an additional amount from the settling parties if the actual costs exceed their expected value, or (2) for the expected value of the future costs plus a premium, foregoing the right to reopen the settlement. A general model would give three options to responsible parties: (1) settling

[3]See Kornhauser & Revesz, supra note 2, at 363.

without a premium, (2) settling with a premium, or (3) not settling. In this article, we restrict our attention to the second and third options.

Third, we assume that the defendants are risk neutral. Hence, they make their decision whether to settle or litigate based on the expected value of future costs, rather than on the distribution of such costs. The only role played in our model by the uncertainty over costs is to enable EPA to charge a premium; in the absence of such uncertainty, EPA might be barred from doing so by a prohibition against supra-compensatory damages.

Fourth, while the potential insolvency of defendants is an important consideration in Superfund cases, we restrict our attention here to parties who are infinitely solvent.

As a result of these assumptions, we do not attempt in this article to examine EPA's policies with respect to de minimis and mixed funding settlements. We hope in the future to analyze three extensions of this study by allowing the presence of three or more defendants, giving defendants the option of settling without a premium (and facing a reopener), and relaxing the assumption of infinite solvency.[4] We will then be in a better position to make policy prescriptions.

The legal regime allocates to each generator a share of the total costs of clean-up proportional to the amount of wastes it

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[4]In a prior article, we studied the effects of different liability rules in situations in which the defendants are potentially insolvent. Lewis A. Kornhauser and Richard L. Revesz, Apportioning Damages Among Potentially Insolvent Actors, 19 J. Legal Stud. 617 (1990). We did not, however, examine the problem of settlement.

sent to the disposal site. In the event that one party settles and the other litigates, EPA's claim against the latter is reduced by the amount that EPA recovered from the settling party, rather than by the settling parties' proportional share of the liability (a pro tanto set-off rule).[5] Thus, to the extent that EPA settles with one party for less than this party's proportional share of liability, and then prevails in its litigation against the non-settling party, the latter will bear more than its proportional share of liability.

Moreover, when a party settles with EPA it obtains protection from contribution actions by non-settling parties.[6] This rule is modeled on the 1955 revisions to the Uniform Contribution Among Tortfeasors Act.[7] Thus, if a party settles for less than its proportional share of liability and EPA litigates against the other party and recovers more than that party's proportional share of the liability, the settling party will nonetheless not be subject to a contribution action.

In our model, the first generator, Row, produces a proportion $\underline{r}$ of the wastes, and the second generator, Column, produces a proportion $(1-\underline{r})$; we let $0 < r < 1$. The costs of the clean-up are $D(1+q)$, where D are the past costs incurred by EPA, and qD is the expected value of its future costs; $D > 0$; $q \geq 0$.

We model the settlement decisions as a two-stage game in

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[5]42 U.S.C. §9613(f)(2).

[6]42 U.S.C. §9613(f)(2).

[7]Section 4(b).

which EPA, acting first, selects a uniform premium rate, $\underline{i}$, where $\underline{i}$ is in the interval $[0,\infty]$. It then makes a take-it-or-leave-it offer of settlements to Row and Column for, respectively, $r(1+i)D$ and $(1-r)(1+i)D$.

We employ the assumption that EPA will offer the defendants a uniform premium because we believe that, as a practical matter, EPA is constrained to treat parties equally. This practice results in part from representations made by EPA in response to congressional concerns, expressed at the time of the passage of CERCLA, about the potential unfairness that results from joint and several liability.[8] We show, however, that our central insights would hold even if EPA were able to offer differential premia.[9]

Row and Column then simultaneously decide whether to settle or not to settle. We assume that costs of coordinating their actions are sufficiently high that they act non-cooperatively.[10] After Row and Column determine their actions, EPA litigates

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[8]In the Superfund hearings, industry groups complained about the potential unfairnesses of joint and several liability. See, e.g., Superfund Reauthorization: Judicial and Legal Issues, Oversight Hearings Before the Subcommittee on Administrative Law and Government Relations, Committee on the Judiciary, House of Representatives, 99th Cong., 1st Sess., July 17-18, 1985, at 953-54 (statement of Edmund Frost on behalf of the Chemical Manufacturers Ass'n). For the Administration's assurances, see, e.g., id. at 14-15 (statement of Lee Thomas, Administator of EPA), id. at 44-46 (statement of F. Henry Habicht, II, Assistant Attorney General, Land and Natural Resources Division).

[9]In a more general model, EPA would select a pair of premia (i_R, i_C), and offer Row and Column settlements for $r(1+i_R)D$ and $(1-r)(1+i_C)D$, respectively.

[10]See infra note 16 (discussing non-cooperative games).

against all non-settling parties. We assume that EPA faces an independent probability $\underline{p}$ of prevailing against each of the defendants, where $0 < p < 1$.[11] Although CERCLA makes it relatively easy for EPA to prevail, it does leave defendants some avenues for litigation over their liability. They can argue, for example, that they did not send wastes to the site, that the wastes were not hazardous, or they may attempt to assert one of the statutory defenses of section 107(b)(3).[12]

Litigation, of course, imposes costs on the parties. We assume that each defendant faces a litigation cost of tD, where $t \geq 0$; this cost is independent of the other defendant's decision whether or not to settle. EPA's litigation cost is a function of the number of non-settling parties: it is tD if only one defendant declines the offer of settlement, and utD if both defendants decline the offer, where $1 \leq u$. This assumption excludes the possibility that the total cost of litigation against two parties is less than the cost of litigation against one. When $u < 2$, EPA faces economies of scale in litigation; its total cost of litigation against both parties is less than the cost of litigating against each separately. When $u > 2$, EPA faces diseconomies of scale--on its face, perhaps a less

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[11]Because the parties know this probability, the results would be no different if EPA made sequential, rather than simultaneous, offers. Moreover, the results in this article do not depend on the assumption that the plaintiff faces the same probability of prevailing against both defendants. In section III.B.2, we relax the assumption of independent probabilities and discuss the situation in which the probabilities are correlated.

[12]42 U.S.C. §9607(b)(3).

plausible condition.[13]

Courts have allowed EPA to recover its cost of litigation as part of the cost of clean-up.[14] Thus, these decisions have established a modified British rule, in which a prevailing plaintiff recovers its cost of litigation, but a prevailing defendant does not.

Because we believe that our analysis has applications outside of the Superfund context, we first analyze the American rule, under which each party is liable for its own cost of litigation. Then, turning to the modified British rule, we assume: (1) if EPA litigates against only one defendant and prevails it recovers its cost tD; (2) if EPA litigates against both defendants and prevails against both, it recovers its cost

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[13]The notation tD does not imply that litigation costs are a function of EPA's already incurred costs. It simply reflects that fact that only the relative sizes of litigation costs, incurred costs, and future costs matter.

We also note two other inessential assumptions. First, we assume that each defendant's cost of litigation is independent of the number of defendants in the litigation. The analysis may be easily adapted to a different assumption. If costs rise with the number of defendants, the strategic situation shifts favorably to EPA in a manner analagous to that caused by the modified British rule. If costs fall with the number of defendants, the strategic situation shifts unfavorably to EPA; again our analysis of the British rule will suggest the appropriate modifications in the analysis.

Second, we assume that, when EPA litigates against only one party, its litigation costs equal those of the defendant. A different assumption merely complicates the algebra.

[14]See, e.g., United States v. South Carolina Recycling & Disposal, Inc., 653 F. Supp. 984 1009 (D.S.C. 1984), aff'd in relevant part, United States v. Monsanto Co., 858 F.2d 160, 176 (4th Cir. 1988), cert. denied, 490 U.S. 1106 (1989); United States v. Northeastern Pharmaceutical & Chemical Co., 579 F. Supp. 823, 851-52 (W.D. Mo. 1984), aff'd in relevant part, 810 F.2d 726, 747-48 (8th Cir. 1986), cert. denied, 484 U.S. 848 (1987). The statutory basis is 42 U.S.C. 9604(b).

tuD, and Row and Colum pay the shares rtuD and (1-r)tuD, respectively; and (3) if EPA litigates against two parties and prevails against only one, it recovers only tD and is not compensated for the remaining (u-1)tD.[15]

In Sections II and III, we proceed by backwards induction. That is, we first solve the second stage settlement game among the defendants, deriving the set of equilibria that result from an offer of premium i. In Section III, we turn to the question of what choice of i is optimal from EPA's perspective.

II. The Defendant's Settlement Game

As discussed above, we model the interaction between the defendants after EPA has chosen i as a non-cooperative game. Game theory considers situations of strategic interaction in which how well each party does depends not only on her own strategic choices but also on the strategic choices of the other players. Non-cooperative games are ones in which the parties are not able to coordinate their strategies through binding agree-

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[15]When u differs from 2, there are other plausible allocations of litigation costs in the event that EPA litigates against both defendants but prevails against only one. If $u < 2$, then the fact that EPA litigated against both parties reduced its average costs of litigation against each party. In this event, requiring the losing party to pay tD might be seen as overcharging; when $u > 2$, it might be seen as undercharging.

Note that we also assume that the parties do not contract around the rule governing the allocation of litigation costs. See John J. Donohue III, Opting for the British Rule, or If Posner and Shavell Can't Remember the Coase Theorem, Who Will?, 104 Harv. L. Rev. 1093 (1991).

ments.[16] The analysis of a non-cooperative game requires that one state the strategies available to each player and, for every possible combination of chosen strategies, the payoff to each player. The solution to the game embodies a conception of rational action for the players--how each party best protects or promotes her interests given the strategic structure of the interaction. We shall identify the Nash equilibria of the settlement game, the standard solution concept in non-cooperative game theory.

Once EPA chooses i, the defendants face a simple non-cooperative game in which each party has two strategies: settle (s), or not settle (¬s). We sometimes label these strategies with the subscripts 1 and 2, respectively.

We may write the game matrix as follows:

		Column: s	Column: ¬s
Row	s	$(\alpha_{11}, \beta_{11})$	$(\alpha_{12}, \beta_{12})$
	¬s	$(\alpha_{21}, \beta_{21})$	$(\alpha_{22}, \beta_{22})$

[16]Non-cooperative game theory can also be used to analyze contracts between non-cooperating parties. Such games, however, model contracts as a sequence of individual moves: at time t, one act available to party A is to make an offer; at time t+1, if party A has made an offer, one act available to party B is to accept the offer; at time t + 2, if party B has accepted an offer, one act available to party A is to perform her contract (and another act is not to perform); at time t + 3, in the event of non-performance, one act available to party B is to file a complaint; etc. This game will remain non-cooperative if the parties cannot make binding agreements to coordinate their strategies. A strategy is a complete plan of action for a player; i.e., a strategy plans an action for every contingency that the player may face.

The pair $(\alpha_{jk}, \beta_{jk})$ in each cell of the matrix represent the payoffs to Row and Column respectively when Row adopts strategy j and Column adopts strategy k. In the text, we define the payoffs under the American rule. The corresponding expressions under the modified British rule are presented in the appendix.

If a party accepts EPA's settlement offer, its payoff is independent of the other party's decision; it merely pays the amount requested by EPA and does not expend any transaction costs. Thus,

$$\alpha_{11} = \alpha_{12} = -Dr(1+i)$$

$$\beta_{11} = \beta_{21} = -D(1-r)(1+i)$$

If a party rejects EPA's settlement offer and the other party accepts the offer, the non-settling party faces, with probability p, the full liability D(1+q) reduced by the amount of the settlement. Regardless of the outcome of the litigation, the non-settling party expends transaction costs of Dt. Thus,

$$\alpha_{21} = -D\{p[(1+q) - (1-r)(1+i)] + t\}$$

$$\beta_{12} = -D\{p[(1+q) - r(1+i)] + t\}$$

If a party rejects EPA's settlement offer and the other party also rejects the offer, it faces liability for its apportioned share (rD(1+q) and (1-r)D(1+q) for Row and Column, respectively) with probability p^2--if it loses the litigation and the other party does so as well--and for the whole loss D(1+q) with probability p(1-p)--if it loses the litigation but the other party prevails. Regardless of the outcome of the litigation, each party expends transaction costs of Dt. Thus,

$$\alpha_{22} = -D\{p(1+q)[pr + (1-p)] + t\}$$

$= -D\{p(1+q)[r + (1-p)(1-r)] + t\}$

$\beta_{22} = -D\{p(1+q)[p(1-r) + (1-p)] + t\}$

$= -D\{p(1+q)[(1-r) + (1-p)r] + t\}$

In a Nash equilibrium, neither party can unilaterally improve its payoff. For example, if Column settles Row will settle only if its payoff from settling in the face of Column's settlement (α_{11}) is greater than or equal to its payoff from not settling in the face of Column's settlement (α_{21}). (We employ the convention that if a party is indifferent between settlement and litigation, it will settle.)

The game matrix defines the settlement game faced by the two defendants for any non-negative premium rate chosen by EPA. We wish to identify the equilibrium pair of pure strategies that the defendants will adopt as a function of $\underline{i}$. A simple graph, displayed in Figure 1, permits us to analyze all these games.

We define the indifference curves R_j and C_k, where j,k = {1,2}. Along R_j, Row is indifferent between settling and not settling, conditional on Column adopting strategy j. Thus, R_j is the curve defined by $\alpha_{1j} = \alpha_{2j}$. Along C_k, Column is indifferent between settling and not settling, conditional on Row adopting strategy k. Thus, C_k is the curve on which $\beta_{k1} = \beta_{k2}$.

For ease of future reference, we write out the definitions of each of the curves (recall that settling is strategy 1 and not settling is strategy 2):

R_1: Row is indifferent between settling and not settling, given that Column chooses to settle;

R_2: Row is indifferent between settling and not settling, given that Column chooses not to settle;

C_1: Column is indifferent between settling and not settling, given that Row chooses to settle;

C_2: Column is indifferent between settling and not settling, given that Row chooses not to settle.

We have:

$$R_1(r) \equiv i = -1 + \frac{p(1+q)+t}{r+p(1-r)}$$

$$R_2(r) \equiv i = -1 + \frac{p(1+q)\,[r+(1-p)\,(1-r)\,]+t}{r}$$

$$C_1(r) \equiv i = -1 + \frac{p(1+q)+t}{(1-r)+pr}$$

$$C_2(r) \equiv i = -1 + \frac{p(1+q)\,[\,(1-r)+(1-p)\,r]+t}{1-r}$$

These curves define the five regions in Figure 1:

(1) For $\underline{i}$ lower than both C_1 and R_1, both parties settle. This region is striped vertically.

(2) For $\underline{i}$ higher than both R_2 and C_2, neither party settles. This region is striped horizontally.

(3) For $\underline{i}$ in the diamond-shaped region bounded by the four

curves, either Row or Column settles, but the other party does not. This region is striped with lines sloping down both to the right and to the left.

(4) For r less than 1/2, and i between C_1 and R_2 (except in the diamond shaped region), Row settles and Column litigates. This region is striped with lines sloping down to the left.

(5) For r greater than 1/2 and i between R_1 and C_2 (except in the diamond shaped region), Column settles and Row litigates. This region is striped with lines sloping down to the right.

Figure 1 shows, not surprisingly, that where EPA offers a sufficiently low premium, both parties will settle. For such cases, for each of the defendants, the premium is low compared to the expected costs of litigation. Conversely, where EPA offers a sufficiently high premium, both parties will litigate.[17]

For a premium in an intermediate range, with the exception of the diamond-shaped region, the smaller party will settle and the larger will litigate. At first glance it might appear that this result is driven by our assumption on the structure of transaction costs. Because, in our model, each party faces litigation costs of tD, for the smaller defendant the transaction costs are a larger proportion of its expected liability. A settlement therefore appears to it more attractive than to the larger defendant.

[17]Figure 1 presents the relation of the premium i to the size r of Row for fixed transaction costs t, probability p of (EPA) success in litigation, and expected future costs qD. As t decreases the curves shift down (and change shape slightly) Specifically, for a fixed value of r, as t decreases, R_1 shifts down less than R_2.

This intuition, however, is faulty. Even in the absence of transaction costs, a substantial region in which only the smaller defendant settles will exist. Consider the curves R_j and C_k. These curves would define the same regions under transaction costs of zero. The transaction costs merely shift each of the curves up, although they do so by different amounts.[18]

The reason, then, for this result stems from the major difference between settlements involving multiple defendants under joint and several liability and settlements involving a single defendant. In single-defendant problems, settlement is a function of the probability of not prevailing at litigation and of the transaction costs of litigation. Multiple defendants under joint and several liability face another consideration: the probability that, while they might lose the litigation, some (or all) of their co-defendants will prevail.

This effect is seen most clearly in our two-person model. Consider the case in which Row is the smaller defendant and in which both defendants choose to litigate. The component of expected liability attributable to Row's apportioned share is $r(1+q)Dp$, the expected costs of clean-up times Row's share of those costs; it must expend this component of costs whenever it loses in litigation, regardless of the outcome of EPA's litigation with Column. The component of expected liability

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[18]In the absence of transaction costs, there is a range of premia for which the smaller defendant would settle and the larger defendant would litigate. We show in Section III.B, however, that the plaintiff would not offer such premia because it would maximize its recovery by litigating with both defendants.

attributable to being held responsible for Column's share as well is (1-r)(1+q)Dp(1-p) which reflects those instances when Row loses and Column prevails. The ratio of the second component to the first is

$$\frac{(1-r)(1-p)}{r}$$

For any given p, this ratio decreases as r increases. Thus, the smaller party is more likely to settle because the component attributable to being held liable for the whole amount is a larger proportion of its total expected liability than for the larger defendant.

This effect is peculiar to joint and several liability. Under non-joint (several only) liability, a defendant never has to worry about being held liable for portion of the loss attributable to other defendants. Thus, from the perspective of settlements, the problem of multiple defendants under a rule of non-joint liability is functionally equivalent to the problem of a single defendant. It is easy to see that under non-joint liability Row will settle if and only if $i \leq -1 + p(1+q) + t/r$; Column will settle if and only if $i \leq -1 + p(1+q) + t/(1-r)$; and that the decision of each defendant will be independent of the decision of the other defendant. Thus, for sufficiently low i both parties will settle, for sufficiently high i both parties will litigate, and for i in an intermediate range, the smaller party will settle and the larger will litigate. Under this rule, unlike under joint and several liability, the latter effect is driven exclusively by the structure of transaction costs.[19]

We return to the diamond-shaped region. Because the defendants are relatively close in size, each has concerns about the possibility of being held liable for the full costs of the clean-up if they both litigate and the other defendant prevails. Thus, there is a range where, given that one party chooses to litigate, the other will choose to settle. That outcome is an equilibrium solution because in this range, the premium paid by the settling defendant is sufficiently high that, in light of the settlement, the other defendant prefers to litigate. The settlement eliminates for the non-settling party the concern about being held liable for the full clean-up cost, as its liability in the event that it loses the litigation is reduced by the amount of the settlement.[20]

Tables 1 and 2 summarize the preceding discussion. The tables exploit the symmetry of the problem. Because Figure 1 is symmetrical about r = 1/2, it is only necessary to analyze the problem for r between zero and one-half. For the remainder of the article, where the parties are not equal in size, Row will be the smaller party. It should be clear, however, that the results

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[19]We analyze the comparative properties of joint and several liability and non-joint liability in Lewis A. Kornhauser & Richard L. Revesz, Sharing Damages Among Multiple Tortfeasors, 98 Yale L.J. 831 (1989). While from the perspective of settlement, multiple defendants under non-joint liability behave as single defendants, from the perspective of adopting the socially desirable level of care they do not; as a general matter, non-joint liability underdeters. See id. at 849-50.

[20]For the reasons discussed in the preceding paragraph, this concern does not arise under non-joint liability.

would be exactly the same if Column were the smaller party.

Table 1: Equilibria Under Different Premium Ranges

	Equilibrium	
Premium Range	Row Small	Row Large
$[0, i_1]$	[s,s]	[s,s]
$[i_1, i_2]$	[s,¬s]	[s,s]
$[i_2, i_3]$	[s,¬s]	[s,¬s] or [¬s,s]
$[i_3, \infty]$	[s,¬s]	[¬s,¬s]

Table 1 shows that there are four relevant ranges for the premium i. When i is between zero and i_1, both defendants will settle regardless of Row's size. In the range between i_1 and i_2, Row will settle and Column will litigate if Row is small, but both defendants will settle if Row is large (closer to, though still smaller than, 1/2). In the range between i_2 and i_3, Row will settle and Column will litigate if Row is small; if Row is large, either one of the defendants, but only one, will settle. Finally, when i is larger than i_3, Row will settle and Column will litigate if Row is small, and both defendants will litigate if Row is large.

Table 2 shows that there are two relevant ranges for the size of Row. When Row is between zero and r_1, both defendants will settle if the premium is sufficiently small, only Row will settle if the premium is in an intermediate range, and neither will settle if the premium is sufficently large. The results are similar when Row is between r_1 and one-half, except that, if the premium is in the intermediate range, there is a subregion in which either one of the defendants, but only one, will settle.

Table 2: Equilibria Under Different Row Sizes

		Equilibrium	
Row Size	Small Premium	Intermediate Premium	Large Premium
$[0,r_1]$	[s,s]	[s,¬s]	[¬s,¬s]
$[r_1,1/2]$	[s,s]	[s,¬s]*	[¬s,¬s]

*There is a subregion in which the equilibria are [s,¬s] and [¬s,s].

The full analysis of the optimal strategy for EPA must await further mathematical derivations in the following section. Figure 1, however, permits several relevant observations. First, when it is optimal for EPA to induce both defendants to settle, it will maximize its payoff be setting a premium along C_1. (Recall that we are analyzing only the case in which the size of Row is no greater than one-half.[21]) This premium increases as the size of Row increases. Along C_1, Row unambiguosly prefers to settle, but Column is indifferent between settling and litigating. As the share for which Column must pay the premium decreases, the premium that it is willing pay in a settlement increases.

Second, when it is optimal for EPA to induce only Row to settle, it will maximize its payoff by setting a premium along

[21]Of course, if the size of Row were greater than one-half, EPA would set a premium along R_1 if it wanted both defendants to settle.

R_2. This premium decreases as the size of Row increases. When i is set along R_2, Column does not settle and Row is indifferent between settling and not settling. As the size of Row increases, the component of its liability attributable to being held liable for the whole amount (as a result of losing the litigation and having Column prevail) becomes a smaller proportion of its total expected liability. Therefore, litigation becomes relatively more attractive and EPA must reduce the premium offered in order to induce a settlement.

Third, when it is optimal for EPA to induce either party, but not both to settle, it will maximize its payoff by setting a premium along the portion of C_2 in which the size of Row is between r_1 and one-half). Once again, as the share for which Column must pay a premium decreases, the premium that it is willing to pay in a settlement increases.

Thus, provided that EPA's objective is to maximize its payoff, we can restrict the domain of optimal choice of i to the three curves discussed in the preceding paragraphs, and eliminate all other choices of i. The purpose of the next section is to determine the conditions under which it is desirable for EPA to induce both parties, one party, or neither party to settle.

III. The Strategy of EPA

We divide this discussion into four parts. First, we consider what objective function is appropriate for EPA. In the remainder of the section, we take EPA's objective function to be the maximization of its payoff. We consider, in turn, the situation in which transaction costs are zero, and, for non-zero transaction costs, the effects of the American and modified British rules.

A. The Choice of Objective Function

In our prior, Superfund-related work, we took the objective function of governmental actors to be the maximization of social welfare.[22] That function is not appropriate for the model used in this article because, here, we are looking at the problem ex post, after there has been a release and EPA has incurred clean-up costs. It is therefore too late for EPA to affect the generators' incentives when they determine how much to dump at a site.

A more general model could have EPA pre-commit to a level of the premium i before the generators decide how much to dump. EPA's decision would then be to choose the i that maximizes social welfare. An appropriate social welfare function would be defined by the benefits that generators receive from the economic activity that results in the production of hazardous wastes minus the social cost that this by-product imposes, and minus the transaction costs of possible litigation. One would then study, for different levels of i, not only whether generators choose to settle or litigate, but the level of hazardous wastes that they decide to generate.

In this article, we employ a simpler objective function: EPA

[22]See Kornhauser & Revesz, supra note 2; Kornhauser & Revesz, supra note 4; Kornhauser & Revesz, supra note 19.

seeks to maximize the recovery that it obtains from the defendants minus the transaction costs that it must expend in litigation. Thus, in designing its settlement policy, EPA does not attempt to affect the ex ante behavior of generators with respect to their decision of how much waste to dump.[23] The function that we use is a "public choice" objective function because it makes EPA indifferent to the transaction costs that it makes the defendants expend. We assume that EPA, in its capacity as a litigator, behaves like private litigators, and attempts to maximize its recovery net of litigation costs. Overall considerations of social welfare can more appropriately be made by Congress when it sets the ground-rules under which EPA must operate, such as the liability rules, settlement rules, and rules determining the apportionment of litigation costs.

B. Zero Transaction Costs

1. Uncorrelated Probabilities

The simplest model of the choice between settlement and litigation considers a plaintiff and a single defendant with

[23]In any event, given this constraint, it is not clear what an attractive objective function would be. An objective function that simply sought to minimize the aggregate transaction costs would be indifferent to whether the defendants paid EPA for the cleanup. It would instruct EPA always to settle with both defendants and would not even tell EPA to maximize the premium that it can obtain consistent with a global settlement. On the other hand, an objective function that sought to maximize EPA's recovery less its transaction costs and the transaction costs of the defendants would not be indifferent to whether the defendants paid EPA for the clean-up but it would compromise the Congressional goal that the United States only bear the costs of clean-up when no solvent, responsible parties could be found.

complete information of their strategic situation. Specifically, each party knows both her own and the other party's belief about her success at trial and the belief about the value of the litigation as well as the transaction costs faced by each.[24] In this model, if both parties are risk-neutral, have common beliefs about the prospect and value of success at trial, and face zero transaction costs, then each is indifferent between litigation and settlement for the expected value of the litigation. This model leads to the following conclusions: (1) parties that face positive transaction costs (but are risk-neutral and have common beliefs) will settle and divide the "surplus" of avoided costs of litigation; (2) parties that are risk averse (but face no transaction costs and share common beliefs) will settle to avoid the risk of litigation; and (3) risk-neutral parties that face zero transaction costs will settle when at least one has pessimistic beliefs about the prospects or value of success at trial and none has optimistic beliefs.[25]

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[24]This describes the models of Gould, Landes, and Posner cited in note 2 supra. In fact, none of the authors explicitly frames his analysis in game theoretic terms. Subsequent analyses of the settlement game between a single plaintiff and a single defendant have been framed explicitly in game-theoretic terms but consider much more complex strategic situations in which there is either asymmetric information or symmetric but incomplete (or imperfect) information. See, e.g., Lucian Bebchuck, Litigation and Settlement Under Imperfect Information, 15 Rand J. Econ. 404 (1984); Barry Nalebuff, Credible Pre-trial Negotiation, 18 Rand J. Econ. 198 (1987).

[25]A plaintiff has pessimistic beliefs when it believes that its own prospects of success are less than its true prospects of success while a defendant has pessimistic beliefs when it believes that the plaintiff's prospects of success are greater than plaintiff's true prospects of success.

In this section, we demonstrate that, when a plaintiff faces multiple defendants subject to a rule of joint and several liability, and the probability of prevailing against each defendant is independent of the probability of prevailing against the other (uncorrelated probabilities), the structure of choice between settlement and litigation differs in important ways from the simple one-defendant model. Our discussion focuses on the case of zero transaction costs, risk-neutrality of all parties, and common beliefs in the prospects and value of success at trial. Under these circumstances, we show that settlement will never occur. EPA will strictly prefer to litigate against both defendants rather than offer terms acceptable to one or both defendants. Because this preference is strict and smooth, there will be no settlement either when transaction costs are small or beliefs slightly pessimistic or parties marginally risk-averse.

Joint and several liability improves the plaintiff's prospects of recovery; EPA needs to prevail against only one of the defendants to recover fully. If EPA faces only one defendant, its expected recovery from litigation is simply the probability of prevailing times the recovery in the event that it prevails. Using the notation of our model, EPA's expected

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There is an alternative definition of pessimism and optimism, which does not depend on a comparison to the objective probabilities of success, but instead relies on the relative assessments of the parties. 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.

recovery in the one-defendant problem is p(1+q)D. Similarly, if liability were non-joint and only several, EPA's expected recovery from Row would be rp(1+q)D and from Column (1-r)p(1+q)D for the identical total expected recovery of p(1+q)D.

Under joint and several liability, in contrast, if EPA litigates against both defendants, it recovers the full amount of the expected clean-up costs, (1+q)D, under three different scenarios: with probability p^2 if it prevails against both defendants; with probability p(1-p) if it prevails only against Row; and, similarly, with probability p(1-p) if it prevails only against Column. Let V be the expected value of the litigation; then

$$V = [p^2 + 2p(1-p)](1+q)D = p(1+q)(2-p)D$$

This expected value is higher than the expected value of litigation in the one-actor problem for any p, such that $0 < p < 1$. The surplus that EPA obtains in the two-actor problem as a result of the operation of joint and several liability is given by

$$p(1+q)(2-p)D - p(1+q)D = p(1+q)(1-p)D$$

Any settlement must be acceptable to EPA and to any other settling party. A settlement will be acceptable to EPA if and only if the expected return to EPA from the settlement and any attendant litigation at least equals EPA's expected return V from litigation against both defendants. We must show that there is no settlement with both defendants of the form (S,V-S), in which Row pays S and Column pays (V-S), and no settlement with one defendant and litigation with the other that is acceptable to EPA and the settling defendants.

In equilibrium, there is no settlement with both defendants of the form (S,V-S), in which Row pays S and Column pays (V-S). Suppose one party, say Row, settles for the amount S. There are two possibilities: $S < p(1+q)D$ and $S \geq p(1+q)D$. We consider these in turn.

Suppose first that $S < p(1+q)D$. Column would then have to choose between litigation and settlement for the amount (V-S). But Column would always prefer to litigate than to accept this offer because, conditional on Row's having settled, Column has an expected loss of only $p[(1+q)D-S]$ which is always less than the settlement offer $(V-S) = p(1+q)(2-p)D - S$. Put differently, EPA would never make a pair of offers (S,V-S) where $S < p(1+q)D$ because EPA knows that at most one party would accept the settlement and EPA's expected recovery from the settlement with one party and the litigation with the other would be less than V, its expected recovery from litigation against both parties.

Now suppose that $S \geq p(1+q)D$. Column now prefers to settle rather than litigate conditional on Row's settling. For (S,V-S) to be an equilibrium, however, requires that, conditional on Column deciding to settle, Row must also prefer to settle. By an argument analagous to that about Column we see that Row will prefer to litigate (conditional on Column settling for (V-S)) rather than settle for the amount S if and only if Row's expected cost from litigation $p[(1+q)D - (V-S)] < S$, its cost of settlement. But this condition holds whenever $S > p(1-p)(1+q)D$, which is true by assumption. Consequently, EPA knows that any pair of offers (S,V-S) will induce only one party to settle and that EPA's own expected recovery from the settling party and the litigating party will be less than $\underline{V}$, the amount it can expect to recover if it litigates against both.[26]

The above argument, moreover, indicates why EPA will not settle with one party and litigate with the other. We now know that EPA must litigate against at least one party. From the litigating party, EPA expects a recovery of $p[(1+q)D - S]$, where $\underline{S}$ is the settlement received from the settling party. Now this settlement $\underline{S}$ must be acceptable both to EPA and to the settling party. To be acceptable to the settling party, say Row, $\underline{S}$ must be less than or equal to the expected value of Row litigating (conditional on Column litigating) or

$$S \leq p(1+q)[r + (1-p)(1-r)]D = S_R$$

while for $\underline{S}$ to be acceptable to EPA it must be the case that

$$S + p[(1+q)D - S] \geq p(2-p)(1+q)D$$

Thus,

$$S \geq p(1+q)D = S_E$$

But, because $S_R < S_E$, there is no settlement amount $\underline{S}$ that will be mutually acceptable to EPA and to Row.

The situation is no different if EPA seeks to induce Row to litigate and Column to settle. In this case Column will accept an offer S only if

$$S \leq p(1+q)[(1-r)+(1-p)r]D = S_C.$$

Again, $S_C < S_E$. Thus, in this case, there is no settlement

[26]This argument is independent of the size of $\underline{r}$.

amount S that is mutually acceptable to EPA and to Column.

The argument for why EPA will not settle with either defendant also explains that, if EPA offers settlements to the defendants, the offers will be of the form (S_1, S_2), where $S_1 > S_R$, and $S_2 > S_C$. If EPA were to make a lower settlement offer to one of the defendants, that defendant would accept the offer and EPA's total recovery (the settlement plus the expected value of the litigation against the other defendant) would be less than V, the value of litigating against both defendants. This result would follow even if the two settlement offers added to more than V.[27] As shown above, when EPA makes settlement offers of the form (S_1, S_2), the defendants will reject them. Thus, there is little reason for EPA even to make settlement offers, because any settlements that would be advantageous to EPA will be rejected by both defendants, and any settlements that would be accepted by at least one of the defendants would be less desirable for EPA than litigating against both defendants.

The intuition behind the result that EPA will not settle with either defendant is relatively straightforward. It stems both from the surplus generated by joint and several liability, and from the set-off that a non-settling party receives when EPA settles with the other party. As a result of the surplus, EPA will not accept from one party a settlement that is too low, even if it chooses to litigate against the other party. In the

[27]Note, moreover, that $S_1 + S_2 > S_R + S_C = V$. Thus, the total amount of the settlement offers that EPA would make is larger than V.

extreme case in which EPA settled with one party for zero (or an infinitesimally small amount), it would lose the full benefit that it derives from litigating with two parties under a rule of joint and several liability, and would face the same expected payoff as in the one-defendant problem.

Any settlement with, for example, Row that is sufficiently attractive for EPA to accept confers two types of benefits on Column. First, it reduces the amount that Column has at risk in the litigation because EPA's potential recovery will be set off by the settlement amount. As a consequence, litigation becomes a less forbidding option. Concomitantly, Column will be willing to pay less in any settlement because the threat of bearing the entire liability has been eliminated. As a result of this externality, each defendant will be willing to settle only for amounts that sum to less than EPA can expect through litigation against both.[28] A defendant cannot capture the full benefit of a settlement offer that is acceptable to EPA, because part of that benefit will accrue to the other defendant.

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[28]The benefit that accrues to the non-settling party can be defined more formally. Column's expected payoff of litigation given that Row litigates is $Dp(1+q)[(1-r) + (1-p)r]$. Column's expected payoff of litigation given that Row settles is $p[(1+q)D - S]$. Column will get a benefit from Row's decision to settle if

$$p[(1+q)D - S] < Dp(1+q)[(1-r) + (1-p)r]$$

This relationship will hold for

$$S > D(1+q)pr = S_N$$

But S_N is the amount that EPA would recover in a settlement with Row under non-joint liability, and not, surprisingly, is less than the minimum settlement S_E that EPA would be willing to accept under joint and several liability. For any settlement by Row for an amount higher than S_N, Column receives an external benefit from the settlement.

The externality explains not only why both defendants do not settle but also why one defendant does not settle. Given, for example, that Column litigates, Row would have to pay in settlement an amount that is greater than Row's expected value of litigation. The additional amount is the benefit conferred on Column as a result of the settlement.

It is important to stress the generality of our result. The argument presented above does not rely on the equal treatment condition our model imposes on EPA. Any pair of offers that, if accepted, would be advantageous to EPA, will be rejected by the defendants.

Similarly, the result does not depend on the pro tanto setoff rule used to reduce the claim against the non-settling party in the event of a settlement with the other party. The structure of our argument is identical under an apportioned setoff rule, under which the claim against the non-settling party is reduced not by the amount of the settlement, but by the settling party's apportioned share of the liability.[29] In fact, from EPA's perspective, settlements are relatively less desirable under an apportioned rule because the plaintiff does not always recover the full value of its claim when it settles with one party and prevails in litigation with the other; it is not fully compensated when it settles with one party for less than that

[29]The result does not extend, however, to a legal regime under which there is no set off whatsoever. Under such conditions, EPA can induce both parties to settle. In fact EPA would be able to extract in settlement, from each defendant $p(1+q)D$. Its total recovery is $2p(1+q)D$.

party's apportioned share.[30]

The result is also independent of our assumption that EPA moves first and makes a take-it-or-leave-it offer--an assumption that plays a more prominent role in the subsquent sections. If the defendants made take-it-or-leave offers, EPA would simply reject them, because its expected payoff from litigating is higher than what it could obtain in settlement.

The argument also extends to situations with more than two defendants because the surplus produced by joint and several liability increases with increasing numbers of defendants.[31] Thus, the settlement of one party provides an analagous (though diminishing) external benefit on all non-settling parties.[32]

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[30]We assume that, under the apportioned set-off rule, if Row's settlement exceeds Row's share then the actual settlement (rather than Row's share) is set-off against any recovery from Column.

[31]This occurs because the probability of prevailing against at least one defendant when there are three defendants is larger than the probability of prevailing against at least one defendant when there are two defendants.Formally $[1 - (1-p)^3] - [1 - (1-p)^2] = p(1-p)^2 > 0$ for $0 < p < 1$. In general, $[1 - (1-p)^n] - [1 - (1-p)^{n-1}] = p(1-p)^{n-1} > 0$ for $0 < p < 1$.

[32]The results derived in this section do depend critically on two assumptions. First, the defendants must act non-cooperatively, that is, they must be unable to negotiate as a single unit with EPA. If they acted cooperatively, even in the absence of transaction costs, they could agree to offer EPA an aggregate amount equal to $\underline{V}$, the expected value for EPA of litigation with both parties. We have assumed throughout that the costs of coordinating their actions are sufficiently high that the defendants act non-cooperatively. In Superfund cases, defendants often fail to agree on the allocation of their joint liability, even in the face of staggering transaction costs.

Second, we have assumed that EPA faces an independent probability of prevailing against each defendant. We deal in the next section with the situation in which the probabilities are correlated.

As we noted at the outset, these results differ from those of the simple one-defendant model, where, in the absence of transaction costs, if the plaintiff and defendant are risk-neutral and have the same estimate of the probability that the plaintiff will prevail, the parties will be indifferent between settling and litigating. The same is true for multiple parties under a rule of non-joint liability, because, as we have already discussed, the parties face the single-defendant problem. In contrast, multiple defendants acting non-cooperatively under joint and several liability will not settle in the absence of transaction costs, even if they are risk neutral and they, as well as the plaintiff, have the same estimate of the probability that the plaintiff will prevail.

The result that joint and several liability discourages settlements is not peculiar to the situation of zero transaction costs. For positive transaction costs, the traditional model of settlement predicts that a single defendant, or multiple defendants under non-joint liability, will always settle, provided that the parties are not risk-preferring and that they have the same estimate of the probability that the plaintiff will prevail.[33] As we show in the next section and as is illustrated in Figure 2, there is a range of transaction costs for which such parties will not settle.

In the congressional debates surrounding the enactment of

[33]More sophisitcated models explain that, even under these conditions, settlements might not take place because of strategic behavior of the parties, as they each try to capture the bulk of the surplus that results from settlement.

Superfund, the supporters of joint and several liability argued, contrary to the conclusion that we reach here, that this rule would promote settlements because of its tough treatment of defendants who choose to litigate.[34] We believe that this perception is commonly shared in the legal literature.[35]

The view that joint and several liability promotes settlements stems from a fallacy similar to, though analytically distinct from that discussed by Professor Geoffrey Miller in his article on Federal Rule of Civil Procedure 68.[36] Rule 68 provides that a plaintiff who refuses a defendant's settlement offer and then obtains a judgment not more favorable than the offer must pay the defendant's post-offer costs.

The belief with respect to Rule 68 was that it encouraged settlements by penalizing plaintiffs who reject reasonable offers. It is obvious that there is a range of offers that a plaintiff will accept as a result of Rule 68 that it would not accept in the absence of this rule. Professor Miller showed,

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[34]The Admistration argued vigorously that joint and several liability would promote settlements. See, e.g., Superfund Reauthorization: Judicial and Legal Issues, Oversight Hearings Before the Subcommittee on Administrative Law and Government Relations, Committee on the Judiciary, House of Representatives, 99th Cong., 1st Sess., July 17-18, 1985, at 5-6 (statement of Lee Thomas, Administator of EPA), id. at 45 (statement of F. Henry Habicht, II, Assistant Attorney General, Land and Natural Resources Division); Superfund Improvement Act of 1985, Hearings Before the Committee on the Judiciary on S. 51, United States Senate, 99th Cong., 1st Sess., June 7, 10, 1985, at 18, 22 (statement of Lee Thomas)

[35][Add footnote].

[36]Geoffrey P. Miller, An Economic Analysis of Rule 68, 15 J. Legal Stud. 93 (1986).

however, that the rule affects not only the behavior of plaintiffs but also that of defendants: it reduces the amount that a defendant will offer. Thus, the primary effect of Rule 68 is to shift downward the relevant settlement range. Its effect on settlements, however, is ambiguous.

Here, joint and several liability has the effect of shifting upward the settlement range by creating a surplus for plaintiffs. As in the case of Rule 68, it appears that the legal literature mistakenly believes that a legal rule that is unfavorable to one party will make that party more willing to accept a settlement, not realizing that such a rule also has the effect of inducing the other party to demand more.

Our discussion of joint and several liability also illustrates an independent effect, not present in the Rule 68 context. As a result of the positive externality that result when one party settles with EPA, joint and several liability has the unambiguous consequence of making settlements less likely.

2. Correlated Probabilities

The conclusion that joint and several liability precludes settlements does not hold if the plaintiff's probabilities of success against each of the defendants are sufficiently correlated. Consider, first, the case of perfectly correlated probabilities, that is, where the plaintiff either prevails against both defendants or loses against both defendants.

The plaintiff's expected value of litigation against both defendants is now only $p(1+q)D$, the same as when the plaintiff litigates against only one defendant, or when the plaintiff litigates against two plaintiffs under non-joint liability. Thus, where the probabilities are perfectly correlated, joint and several liability does not create a surplus from litigation.

However, joint and several liability does create a surplus even under perfectly correlated probabilities because of the availability of settlements. A settlement with one party for any amount whatsoever increases the plaintiff's expected payoff. If the plaintiff prevails in the litigation, it will be in the same position as if it had not settled--it will recover a total of (1+q)D--but if it loses its payoff will have been increased by the amount of the settlement. In this situation, the plaintiff does not need to worry that if it settles with one party, say Row, it will forfeit the option of recovering in litigation from Row if it loses against Column. Indeed, when the probabilities are perfectly correlated a loss against Column implies also a loss against Row.

If EPA were to settle with only one defendant, it would choose to settle with Column, the larger party, for Column's expected cost of litigation given that Row litigates. This amount is given by $(1-r)p(1+q)D$. Row then faces the following expected cost of litigation:

$$p[(1+q)D - (1-r)p(1+q)D] = p(1+q)D[1 - (1-r)p]$$

There is an equilibrium in which Row settles for this expected value (and thus both defendants settle) for $r \geq p/(1+p)$.[37]

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[37]If Row pays $p(1+q)D[1 - (1-r)p]$ in settlement, Column will litigate rather than settle for $(1-r)p(1+q)D$ if and only if

There are, in addition, two other equilibria in which both defendants settle. If, instead, Row settles for its expected cost of litigation given that Column litigates, namely, $rp(1+q)D$, Column faces the following expected cost of litigation:

$$p[(1+q)D - rp(1+q)D] = p(1+q)D[1 - rp]$$

There is an equilibrium in which Column settles for this amount (and thus both defendants settle) for all $r \leq 1/2$.[38]

The final equilibrium is symmetric: each defendant settles for $p(1+q)D/(1+p)$.[39] It is easy to show that this equilibrium maximizes EPA's recovery.[40] Therefore, EPA will make these

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$$p\{(1+q)D - p(1+q)D[1 - (1-r)p]\} < (1-r)p(1+q)D$$
$$r < p[1 - (1-r)p]$$
$$r < p/(1+p)$$

Thus, for $r \geq p/(1+p)$, there is an equilibrium in which both parties settle.

[38]If Column pays $p(1+q)D[1 - rp]$ in settlement, Row will litigate rather than settle for $rp(1+q)D$ if and only if

$$p\{(1+q)D - p(1+q)D[1 - rp]\} < rp(1+q)D$$
$$[1 - p(1 - rp) < r$$
$$r > 1/(1+p)$$

Thus, for $r \leq 1/(1+p)$, there is an equilibrium in which both parties settle. This condition holds for all $r \leq 1/2$.

[39]If Column settles for $p(1+q)D/(1+p)$, Row will litigate rather than also settle for $p(1+q)D/(1+p)$ if and only if

$$p[(1+q)D - p(1+q)D/(1+p)] < p(1+q)D/(1+p)$$

But the right hand side is equal to the left-hand side, so the relationship never holds. Likewise, if Row settles for $p(1+q)D/(1+p)$, Column will also settle for this amount rather than litigate.

[40]Note also that, under the first asymmetric equilibrium, which exists only for $r \geq p/(1+p)$, Column pays less than under the symmetric equilibrium and Row pays more--except at $r = p/(1+p)$, where the equilibria have the same consequences. It is also interesting that in this case, Row, the smaller party, settles for more than Column. In the case of the second asymmetric equilibrium, Column pays more than under the symmetric equilibrium and Row pays less. In his dissertation, Jong Goo Yi did not consider these asymmetric equilibria. This omission is particularly significant for his model because his defendants

symmetric offers and will recover a total of $2p(1+q)D/(1+p)$, which, as in the case of all three settlement equilibria, is greater than the expected value of litigating with both defendants under correlated probabilities for $0 < p < 1$. Note, however, that for $0 < p < 1$, the recovery from the symmetric settlement offers is less than EPA's expected recovery $\underline{V}$ from litigating against both defendants when the probabilities are uncorrelated. In summary, when the probabilities are perfectly correlated, EPA will settle with both defendants.

Finally, we deal with the situation in which EPA's probabilities of success against the defendants are positively, though not perfectly, correlated. Suppose that the probability that EPA will prevail in a litigation against a single party is $\underline{p}$ (regardless of which party is the defendant). Let δp^2 be the probability that EPA prevails against both parties where δ is in the closed interval $[0,1/p]$. The complete joint probability distribution is then:

$$\Pr[\text{R loses and C loses}] = \delta p^2$$
$$\Pr[\text{R wins and C loses}] = p(1-\delta p)$$
$$\Pr[\text{R loses and C wins}] = p(1-\delta p)$$
$$\Pr[\text{R wins and C wins}] = 1 - 2p + \delta p^2$$

Given these assumptions $\delta = 1/p$ implies perfect (positive) correlation of the outcome of litigation, $\delta = 1$ implies no

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make take-it-or-leave-it offers to the plaintiff for the minimum amount that the plaintiff would accept, and thus settlements in which the defendants pay a smaller aggregate amount are particularly attractive. See Yi, supra note 1, at 76-79.

correlation, and $\delta = 0$ implies perfect negative correlation.[41] Stated differently, in the range [0,1], the correlation in negative, whereas in the range [1,1/p], the correlation is positive.

We show in the margin that EPA will settle with both defendants only if the correlation is sufficiently high.[42]

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[41]Note that $\delta = 0$ and the symmetry (with respect to litigation prospects) of Row and Column implies that p = 1/2.

[42]To determine settlement behavior under zero transaction costs we calculate EPA's expected return $V(\delta)$ from litigation against <u>both</u> Row and Column:

$$V(\delta) = (1+q)D[p(2-\delta p)]$$

Of course $V(1/p) = p(1+q)D$, $V(0) = (1+q)D$ (because p = 1/2) and $V(1) = p(2-p)(1+q)D$.

Again, we consider settlements of the form $(S,V(\delta)-S)$. Suppose one party, say Row, settles for the amount S. We first look for conditions in which $(S,V(\delta)-S)$ is an equilibrium for Row and Column.

Without loss of generality, we may write $S = \mu(1+q)D$ and normalize $(1+q)D = 1$. The pair $(S,V(\delta)-S)$ may then be written as the pair $(\mu,p(2-\delta p)-\mu)$,

$(S,V(\delta)-S)$ is a Nash equilibrium if and only if settling is Row's best response to Column's decision to settle <u>and</u> if settling is Column's best response to Row's decision to settle. Now, conditional on Row's settling, Column will settle if and only if

$$V(\delta) - S \leq p[1 - S)]$$

which we may rewrite as

$$p(1-\delta p) \leq \mu(1-p). \quad (1)$$

We derive a second necessary condition by considering the incentives on Row. Row will settle conditional on Column settling if and only if

$$S \leq p[1 - (V(\delta)-S))]$$

which we may rewrite as

Otherwise, it will litigate with both defendants.[43] Thus, the negative impact of joint and several liability on settlements

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$$\mu(1-p) \leq p[1-p(2-\delta p)] \qquad (2)$$

Note that (1) and (2) are jointly necessary and sufficient for (S,V(δ)-S) to be a Nash equilibrium. Combining (1) and (2) we see that

$$p[1-p(2-\delta p)] \geq \mu \geq p(1-\delta p)$$

which implies that a necessary condition for both Row and Column to accept the offer (S,V(δ)-S) is

$$\delta(1+p) \geq 2 \qquad (3)$$

This condition implies that if $\delta < 1$ (i.e., there is some negative correlation between litigation outcomes), (S, V(δ)-S) is not an equilibrium. Moreover, the smaller p, the greater the positive correlation must be between litigation outcomes before (S,V(δ)-S) will be acceptable to both parties. E.g., if $p = 1/2$, settlement occurs for $4/3 \leq \delta \leq 2$ and if $p = 3/4$, settlement occurs for $8/7 \leq \delta \leq 4/3$. From the discussion in the text, we know that, when $\delta = 1/p$ (perfect positive correlation), both Row and Column accept the offers (S, V(δ)-S) and for $\delta = 1$ (no correlation), the equilibrium in which both parties settle will not exist for $0 < p < 1$. Obviously for $0 \leq \delta < 1$, no settlement occurs.

[43]Following the logic of the argument in the text, we may also determine when an equilibrium in which one party settles but the other litigates may be acceptable to EPA. Suppose Row is the party that settles. Then for (s,¬s) to be an equilibrium acceptable to EPA, three conditions must be satisfied. First, equation (1) in the previous footnote must not be satisfied, i.e., $p(1-\delta p) > \mu(1-p)$. Second, the settlement must be acceptable to Row (conditional on Column's litigating) or we must have:

$$\mu \leq rp^2\delta + p(1-\delta p) = \mu_R \qquad (4)$$

Third, (s,¬s) must be acceptable to EPA, i.e.

$$\mu + p[1-\mu] > p(2-\delta p)$$

which we may rewrite as

$$\mu(1-p) > p(1-\delta p) = \mu_E \qquad (5)$$

But (1) cannot be violated and (5) satisfied at the same time. So, (s,¬s) will not be an equilibrium. A similar argument shows why (¬s,s) will not be an equilibrium.

extends beyond the situation, discussed in the previous section, in which the plaintiff's probabilities of success are wholly independent.

C. The American Rule

We now return to the model analyzed in Parts I and II, where EPA offers equal premia to the two defendants. We can easily write down EPA's expected payoff, N, for three of the four outcomes depicted in Figure 1: (s,s), where both defendants settle; (¬s,¬s), where neither defendant settles, and (s,¬s), where Row settles and Column litigates. Recall that, because of the symmetry of the problem, we consider only values of r, the size of Row, between zero and one-half. Because D changes only the scale of the axes in Figure 1, the past costs incurred by EPA, without the loss of generality, we can set D equal to 1.

When EPA settles with both defendants, it gets r(1+i) and (1-r)(1+i) from Row and Column, respectively. Thus,

$$N(s,s) = \mathrm{Max}_i(1+i) \qquad i \le C_1$$

Figure 1 shows that, when EPA enters into settlements with both parties, it maximizes its recovery when it chooses $i = C_1$. As a result,

$$N(s,s) = \frac{p(1+q)+t}{(1-r)+pr}$$

When EPA does not settle with either defendant, its expected payoff is the expected payoff of the litigation, which we discussed in the preceding section, minus the transaction costs, ut, that result from litigating with two parties:

$$N(\neg s,\neg s) = p(1+q)(2-p) - ut \qquad i > R_2$$

When EPA settles with Row and litigates with Column, it obtains $r(1+i)$ from Row. If it prevails in its litigation with Column, an event that carries a probability p, it obtains the remainder of its expected costs, for a total recovery of $p(1+q)$. If it loses the litigation, an event that carries a probability $(1-p)$, its total recovery will simply be the settlement with Row. EPA will expend transaction costs of t in its litigation with Column. Thus,

$$N(s,\neg s) = \text{Max}_i[p(1+q) + (1-p)r(1+i) - t] \quad \text{for } i \in (R_2,C_1)$$

Figure 1 shows that that, when EPA enters into a settlement only with Row, it maximizes its recovery when it chooses $i = R_2$. It follows that

$$N(s,\neg s) = p(1+q) + (1-p)\{p(1+q)[r + (1-p)(1-r)] + t\} - t$$
$$= p(1+q)\{1 + (1-p)[r + (1-p)(1-r)]\} - pt$$

The fourth equilibrium, where EPA can settle with either Row or Column, requires additional discussion. As we discussed above, this outcome is available when r lies in the range between r_1 and one-half, and in this region EPA offers a premium along C_2. If EPA knew that, when it offered such a premium, the settling party would always be Row, it would never avail itself of this option. EPA is better off inducing such a settlement by offering a premium along R_2.

To determine whether this equilibrium is dominated by the $(s,\neg s)$ equilibrium, we need first to compute EPA's expected payoff when it is certain that it will settle with Column and litigate with Row. Then,

$$N(\neg s,s) = p(1+q) + (1-p)(1-r)(1+i) - t \quad \text{for } i \in (R_1,C_2)$$

As we already stated, when EPA enters into a settlement only with Column, it maximizes its recovery when it chooses $i = C_2$.

Thus,

$$N(\neg s,s) = p(1+q) + (1-p)\{p(1+q)[(1-r) + (1-p)r] + t\} - t$$
$$= p(1+q)\{1 + (1-p)[(1-r) + (1-p)r]\} - pt$$

For $r < 1/2$, $N(\neg s,s) > N(s,\neg s)$. EPA extracts a lower premium (C_2 instead of R_2), but does so for a larger share ($(1-r)$ instead of r).

While EPA prefers to settle with the larger party rather than the smaller party, it cannot guarantee that this result will occur, because when EPA offers a settlement with a premium of C_2, either the smaller or the larger party (but not both) will settle.[44] If the smaller party settles, EPA will be worse off than if it had sought a settlement with the larger premium R_2. Thus, the relative desirability of these two strategies will depend on the probability $\underline{\theta}$ that, in the face of a premium of C_2, the smaller party will be the one to settle; we will refer to the strategy in which EPA can settle with either Row or Column as $N(\theta)$. As indicated, where $\underline{\theta}$ is sufficiently high, EPA is better off with the certainty of settling with the smaller party.

To summarize, for $\underline{r}$ in the interval $[0,r_1]$, the $N(\theta)$

[44]We might treat the region where multiple pure strategy equilibria exist somewhat differently. We might suppose that Row and Column play an equilibrium mixture of their strategies (settle and non-settle); in this event, there would be four possible outcomes depending on the realization of each party's random choice of strategy.

strategy is not available. For $\underline{r}$ in the interval $[r_1, 1/2]$, the N(θ) strategy is dominated by the N(s,¬s) strategy where θ is sufficiently high. In the remainder of the section, we analyze the case in which the N(θ) strategy is either not available, or is dominated by the N(s,¬s) strategy. The analysis is similar for the case in which EPA's expected payoff under N(θ) strategy is higher than under the N(s,¬s) strategy.

In light of this simplification, we wish to determine the optimal strategy of EPA when it chooses among the equilibria (s,s), (¬s,¬s) and (s,¬s). Recall that EPA's choice of premium rate determines which equilibrium will be selected by the defendants. We wish to know how EPA's optimal strategy varies both with the size r of the smaller defendant and with the size t of litigation costs.

We begin with an analysis of EPA's strategy as a function of transaction costs. We can write the payoff to EPA for each equilibrium as a linear function of the transaction costs $\underline{t}$. We arrive at the following expressions which are displayed in Figure 2, with all other parameters fixed:

$$N(s,s) = a + et = \frac{p(1+q)}{(1-r)+pr} + \frac{t}{(1-r)+pr}$$

$$N(s,\neg s) = b - ft = p(1+q)\{1 + (1-p)[r + (1-p)(1-r)]\} - pt.$$

$$N(\neg s,\neg s) = c - gt = p(1+q)(2-p) - ut.$$

where a,b,c,e,f,g > 0.

The analysis of EPA's optimal strategy reduces to identification of the piece-wise linear boundary of Figure 2. It follows from expressions defining the curves that a < b < c, and that f < g. Thus, for small t, EPA's maximizes its expected payoff by litigating with both parties, whereas where t is large, EPA maximizes its expected payoff by settling with both parties.

The first result is a more general version of the result in the preceding section, where we showed that, in the absence of transaction costs, EPA will litigate with both defendants. The second result stems from the feature of the model that allows EPA to make a take-it-or-leave it offer. EPA can then capture the defendants' savings that results from the avoidance of litigation.[45]

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[45] If, in contrast, the defendants could make such an offer to EPA, they would be able to capture the surplus from settling, and EPA may then prefer to litigate. In a model under which the parties are allowed to bargain over the terms of the settlement, the optimal strategy for EPA will depend on its success at capturing a sufficient portion of this surplus.

Two features of our model merit discussion in light of the economic literature on bargaining. In this literature, the parties must divide a surplus. In models of the choice between settlement and litigation, transaction costs (and, when the parties are risk-averse, the risk of litigation) are the surplus to be divided.

To those familiar with the bargaining literature, our results may appear somewhat surprising. In most analyses, there are multiple Nash equilibria (although often a unique subgame perfect Nash equilibrium, see Ariel Rubinstein, Perfect Equilibrium in a Bargaining Model, 50 Econometrica 97 (1982)) whereas, except in a limited range, our model has a unique equilibrium. Uniqueness in our model derives from the specific rules of bargaining: EPA makes an offer that the other two parties must take or leave.

The specific rules also explain why EPA can receive all the surplus "available" should both parties settle. To induce the parties' to settle, EPA need only offer each party their allotted share plus a bit less than the transaction costs of litigation. Of course, if one of the defendants could move first and present

The remaining question is whether, for intermediate values of t, EPA will maximize its payoff by settling with the smaller party and litigating with the larger one. Let t_1 be the intersection of the N(¬s,¬s) and N(s,s) curves. Let t_2 be the intersection of the N(¬s,¬s) and N(s,¬s) curves. EPA will choose the equilibrium in which one party settles if and only if $t_2 < t_1$.[46]

The expressions in the margin show that the existence of a range of transaction costs for which EPA settles with one party

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its co-defendant and EPA with take-it-or-leave-it offers, that defendant would extract all the possible surplus. In a more plausible alternative studied by Yi, supra note 1, EPA will retain most of the surplus. Suppose that each defendant independently submits an offer to settle its share and that EPA may accept (or reject) each offer. Then the defendants essentially compete away the surplus.

[46] We have the following expressions:

$$t_1 = \frac{c-a}{g+e} = \frac{p(1+q)(1-p)[1-r(2-p)]}{1+u[(1-r)+pr]}$$

$$t_2 = \frac{c-b}{g-f} = \frac{p^2(1+q)(1-p)(1-r)}{u-p}$$

To determine the relationship between t_1 and t_2, we first define the ratio t_2/t_1.

$$\frac{t_2}{t_1} = \frac{1+u[1-r(1-p)]}{(u-p)} \frac{p(1-r)}{[1-r(2-p)]}$$

It follows that $t_2/t_1 < 1$ if and only if

$$p[2(1-r)-r(1-p)] < u(1-p)[(1-r)(1+rp) - r]$$

or if and only if

$$p[2(\frac{1-r}{1-p})-r] < u[(1-r)(1+rp)-r]$$

is more likely when u is large--that is, when EPA faces diseconomies of scale in litigation. In this case, if EPA litigates against both parties, it takes the risk that it will prevail only against one, expending litigation costs ut, recover only t, and bearing (u-1)t. This penalty creates an incentive for EPA to settle with one party, so that it does not have to face these diseconomies of scale.

Conversely, the existence of a range of transaction costs for which EPA settles with only one party is less likely when p is large. The intuition behind this result is that in the face of a settlement with the smaller party, the larger party is more likely to settle as well, for a given level of transaction costs, when the probability that it will lose the litigation is higher.

EPA's expected payoff under the three strategies is shown in Figure 2. In the case of low transaction costs, it decreases as t increases, because EPA chooses to litigate and must bear its own transaction costs. In the case of high transaction costs, EPA's expected payoff increases as t increases, because EPA chooses to settle and can capture the surplus that results from settlement. This result holds true even though EPA is bearing its own litigation costs.

It is also possible to draw some conclusions on how EPA's expected payoff depends on the relative sizes of Row and Column. When EPA litigates with both defendants, its expected payoff N(¬s,¬s) is independent of r, because, if it loses against both, it either receives no payment at all, and if it prevails against at least one, it receives the expected value of the cleanup costs.

When EPA settles with both parties, its expected payoff N(s,s) increases as r increases. As discussed in the preceding section, along the curve C_1 in Figure 1, Row unambiguously prefers to settle, but Column is indifferent between settling and litigating. As the share for which Column must pay the premium decreases, the premium that it is willing to pay in a settlement increases.

Similarly, when EPA settles only with Row, its expected payoff N(s,¬s) also increases a r increases. Even though the curve R_2 falls as r increases, the total amount paid by Row, r(1+i) increases.

The expressions N(s,s), N(s,¬s) and N(¬s,¬s) derived earlier show that if transaction costs are sufficiently high, EPA will select the equilibrium (s,s) and settle with both parties regardless of their relative sizes. Conversely, if the transaction costs that are sufficiently low, EPA will select the equilibrium (¬s,¬s) in which it litigates against both parties regardless of the relative sizes of the parties. For an intermediate range of transaction costs, however, EPA's optimal strategy will depend on the size r of the smaller party.

Where EPA pursues only two strategies--(¬s,¬s) and (s,s)--, because there are no instances in which it maximizes its payoff by settling with the smaller party and litigating with the larger party, there is a range of transaction costs for which EPA litigates with both parties when r is small, but settles with both parties when r is large. Where EPA also pursues the (s,¬s) strategy, there is a range of transaction costs for which it litigates with both parties when r is small, settles only with the smaller party for intermediate values of r, and settles with both parties when r is large.

So far, we have studied the situation in which EPA offers equal premia to both parties if they both settle. The central conclusions of the section--(1) that, for low transaction costs EPA will prefer to litigate against both parties and (2) that, for high transaction costs, it will prefer to settle with both parties--are not dependent upon this assumption. We showed in the preceding section that for zero transaction costs, and by extension for low transaction costs, EPA will prefer to litigate with both parties even if it faces no constraints on the type of settlements it can offer.

As for the second conclusion, the ability to offer differential premia will make settlement with both parties more favorable to EPA. The elimination of the equal premium constraint will allow EPA to extract a larger premium from the smaller party.

Moreover, under the equal premium constraint, there are instances (where $t_2 < t_1$) in which EPA settles with only one party because, to induce the larger party to settle EPA would have to offer the smaller party a premium that is too low, but where, absent this constraint, EPA would settle with both parties because it could offer the larger party a more attractive premium without compromising its recovery from the smaller party. Thus, for large transaction costs, EPA will continue to choose to settle with both parties. This discussion illustrates that the elimination of the constraint increases both EPA's payoff and the range of transaction costs for which EPA settles with both parties.

D. The British Rule

The relevant expressions for the modified British rule are set forth in the appendix. We discuss in this section the ways in which this rule produces results different from the American rule. Of course, in the absence of transaction costs, both rules produce identical results.

The shapes of the curves in Figure 1 are the same as under the American rule. The curves do get shifted upwards, as the parties are willing to pay more in settlements given that the expected cost of litigation are higher, but the intersections of the curves define the same regions.

With one exception, the shapes of the curves in Figure 2 are the same as under the American rule. Not surprisingly, regardless of the equilibrium, EPA is better off under the British rule.

First, when EPA litigates with both parties, its expected payoff $N_B(\neg s,\neg s)$ is higher than $N(\neg s,\neg s)$, its expected payoff under the American rule. Like $N(\neg s,\neg s)$, the curve $N_B(\neg s,\neg s)$ decreases as t increases, but it does so by a smaller amount.

Second, when EPA litigates with both parties, its expected payoff $N_B(s,s)$ is higher than $N(s,s)$, its expected payoff under the American rule. Like $N(s,s)$, the curve $N_B(s,s)$ increases as t increases, but it does so by a larger amount.

Third, when EPA settles with Row and litigates with Column, its expected payoff $N_B(s,\neg s)$ is higher than $N(s,\neg s)$, its expected payoff under the American rule. Unlike its American rule counterpart, the curve $N_B(s,\neg s)$ increases as $\underline{t}$ increases, because EPA is able to extract a larger settlement from Row as transaction costs rise.

The relevant curves are shown in Figure 3 (for a value of u $\leq$ 2). The pattern of EPA's optimal strategy is parallel to its optimal strategy under the American rule. Here, too, when $\underline{t}$ is low, EPA litigates against both defendants. When $\underline{t}$ is sufficiently large, EPA settles with both parties. As with the American rule, there is sometimes an intermediate range in which EPA settles with the smaller party and litigates with the larger party.[47]

In the single-defendant problem, where the plaintiff and defendant are risk-neutral and have the same estimate of the probability of plaintiff's success at trial, both the American and modified British rules predict that the parties will be

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[47]Under some circumstances, however, the situation for high transaction costs may differ from that observed under the American rule. If the diseconomies of scale of litigating against two defendants are sufficiently great (that is, $\underline{u}$ is sufficiently larger than 2), EPA will never choose to settle with both parties; instead when transaction costs are large, it will settle with the smaller party and litigate with the larger. The intuition is that, when $\underline{u}$ is sufficiently large, the threat of litigation is particularly unattractive to the smaller party, which is therefore willing to settle for a relatively large amount. In light of this generous settlement (and with the elimination of the possibility of having to bear the diseconomies of scale) the larger party prefers to litigate. The relevant condition is derived in the appendix.

indifferent between settling and litigating when the transaction costs are zero, and that they will prefer to settle for all positive transaction costs.[48]

We have attempted to determine the relative effects of the American and modified British rules on settlements in the two-defendant problem. We have concluded, after cumbersome arithmetic manipulations, that these effects depend on the values of the various parameters. Therefore, it is not possible to make an unambiguous prediction as to which rule would be preferable from the standpoint of encouraging settlements.

Conclusion

The analysis in this article extends our prior work on the relative differences of joint and several liability and non-joint (several only) liability. Our work on infinitely solvent tortfeasors concluded that negligence rules are efficient under joint and several liability as long as the standards of care for each of the actors are set at the socially optimal level but that negligence rules are not generally efficient in the absence of joint and several liability. We also determined that strict liability rules are not efficient regardless of whether there is joint and several liability.[49]

In our article on potential insolvency among joint

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[48]See Donohue, supra note 15, at 1096-97, for the comparison involving the traditional British rule. The result is the same under the modified British rule.

[49]Kornhauser & Revesz, supra note 19.

tortfeasors, we determined that it is not possible to draw any general conclusion about whether, on efficiency grounds, joint and several liability is preferable to non-joint liability. This conclusion is applicable both to negligence and strict liability.[50]

Here, we show that joint and several liability has the effect of discouraging settlements. When settlements do occur, however, it increase the amount that the plaintiff can recover.

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[50]Kornhauser & Revesz, supra note 4.

Appendix

The relevant expressions for the British rule are set forth in this appendix. It is easy to see from the expressions for the payoff matrix that the expressions under the British rule are simple transformations of the expressions under the American rule. When litigation occurs, the British rule simply increases the expected cost of losing by the expected value of the litigation costs it will have to pay. We have first the payoffs for the defendants' settlement game under the British rule:

$$\alpha_{11B} = \alpha_{12B} = -Dr(1+i) = \alpha_{11} = \alpha_{12}$$

$$\beta_{11B} = \beta_{21B} = -D(1-r)(1+i) = \beta_{11} = \beta_{21}$$

$$\alpha_{21B} = -D\{p[(1+q+t) - (1-r)(1+i)] + t\} = \alpha_{21} - Dpt$$

$$\beta_{12B} = -D\{p[(1+q+t) - r(1+i)] + t\} = \beta_{12} - Dpt$$

$$\alpha_{22B} = \alpha_{22} - Dpt[pru + (1-p)]$$

$$\beta_{22B} = \beta_{22} - Dpt[p(1-r)u + (1-p)]$$

Next we define the indifference curves for Row and Column from which we can determine the set of equilibria as a function of Row's size r:

$$R_{1B}(r) \equiv i = R_1(r) + \frac{pt}{r+p(1-r)}$$

$$R_{2B}(r) \equiv i = R_2(r) + \frac{pt[pru+(1-p)]}{r}$$

$$C_{1B}(r) \equiv i = C_1(r) + \frac{pt}{(1-r)+pr}$$

$$C_{2B}(r) \equiv i = C_2(r) + \frac{pt[p(1-r)u+(1-p)]}{(1-r)}$$

Similarly, we may calculate the value to the government of each potential equilibrium:

$$N_B(s,s) = \frac{p(1+q)+(1+p)t}{(1-r)+pr} = N(s,s) + \frac{pt}{(1-r)+pr}$$

$$N_B(\neg s,\neg s) = p(1+q)(2-p) - (1-p)t[2p(u-1) + (1-p)u]$$
$$= N(\neg s,\neg s) + t[p^2u + 2p(1-p)]$$
$$N_B(s,\neg s) = p(1+q)\{1 + (1-p)[r + (1-p)(1-r)]\} + pt[pru + (1-p)]$$
$$= N(s,\neg s) + pt[pru + (2-p)]$$

We can write:

$N_B(s,s) = a + e_Bt$

$N_B(s,\neg s) = b + f_Bt$

$N_B(\neg s,\neg s) = c - g_Bt$

where a, b, c, e_B, f_B, $g_B > 0$. By comparison to the expressions under the American rule we note that $e_B > e$; $g_B < g$; $f_B > 0$.

If the diseconomies to scale u of litigation against both parties are sufficiently high, then EPA may choose never to settle against both parties. We can see this by comparing e_B and f_B. Because $N_B(s,\neg s) > N_B(s,s)$ at $t = 0$, a necessary condition for EPA to induce the equilibrium (s,s) is $e_B > f_B$, which occurs if and only if

$$u < \frac{1+p^2+rp(1-p)^2}{p^2 r[1-r(1-p)]}$$

Note that at p = 1, u must be less than 2/r and that the bound on u increases as p decreases.