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Abstract

Conventional tort law does not allow exposure victims to seek compensation until they develop symptoms of illness. Because this may bar recovery if the injurer is judgment proof, some have advocated allowing victims to sue at exposure. However, critics charge that such a tort for risk would create a ”race to file”. We show that a race may or may not occur in equilibrium, and that when it does occur, not all victims choose to file even if bankruptcy is an inevitable result. We examine the consequences of the possible equilibria on compensation of victims, litigation costs, and injurer care.

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1. Introduction

Many environmental accidents involve exposure to a hazardous substance that creates the possibility, but not the certainty, of a future illness. Examples include accidental chemical releases such as the one that occurred in Bhopal, India in 1984 (Fischer, 1996), and nuclear accidents such as Three Mile Island and Chernobyl.[1] Normally, victims of exposure are barred from suing for damages until an illness actually develops.[2] However, some scholars have argued that these individuals should have the option of suing for expected damages at the time of exposure. This approach essentially views the exposure itself as a tort (what we call a "tort for risk" or a "tort for exposure"), while under the conventional rule a tort is not deemed to have occurred unless the victim actually contracts the disease (Keeton, Dobbs, Keeton, and Owen, 1984).

Several previous authors have identified tradeoffs involved in allowing a tort for risk.[3] For example, some have argued that the number of suits, and hence litigation costs, would

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[1] Another related example is prolonged exposure to hazardous substances such as asbestos. Many such exposures occur in the workplace. This introduces two complications not considered in this paper: (1) the contractual relationship between the injurer and victim, and (2) the possibility of partial recovery under workers' compensation. We consider only "third party" accidents, where the victims have no contractual relationship with the injurer. (For a discussion of the impact of a contractual relationship on the assignment of liability, see Landes and Posner (1985).) Nonetheless, even in the case of asbestos, since workers' compensation is a system of partial liability, asbestos victims have sought recovery from asbestos manufacturers, with whom they have no direct contractual relationship. The model in this paper is relevant to this dimension of the asbestos problem.

[2] In some jurisdictions, even in the absence of a physical manifestation of exposure-related illness, victims are allowed to sue for emotional distress and/or medical monitoring expenses (Valk, 1995). In this paper, we abstract from issues regarding interim damages for emotional distress or medical monitoring and focus instead on the possibility that the exposure victim will ultimately contract an exposure-related illness. For a discussion of alternative liability rules in a tort-for-risk model with medical monitoring, see Bathgate (2001).

[3] Advocates of allowing a tort for risk include Chapin (1993), Landes and Posner (1984), Love (1996), Miller (1998), Note (1998), Rosen (1992), and Robinson (1995). Rose-Ackerman (1989) proposes a similar remedy, what she calls "ex ante suits", when the actions of one party increase the risk of direct monetary losses for another party, as for example, when one landowner builds a dam that increases the risk of flooding that would destroy the crops of downstream owners. For related discussions, see also Hamrick (1998), McDonnell (1997), and Rosenberg (1984).

increase if a tort for risk were allowed, possibly "by several orders of magnitude" (Robinson, 1985, p. 796). In this sense, allowing a tort for risk would increase social costs.[4] However, advocates suggest an offsetting deterrence benefit. In many toxic tort contexts, there is a long latency period between the time of exposure and the time a resulting disease is manifested. As a result, disallowing suits for exposure could actually bar victims from receiving any compensation if the injurer is insolvent or judgment-proof at the time the disease is contracted (Shavell, 1986; Beard, 1990; Larson, 1996), or if the victim cannot establish a causal connection between her illness and the injurer's actions (Shavell, 1985). This affects not only the extent of victim compensation but also the injurer's incentive to invest in care. Thus, the conventional wisdom is that allowing a tort for risk generates a benefit from increased deterrence that must be balanced against the cost of increased litigation.

The preceding conventional wisdom is based on an assumption that the risk of injurer insolvency is exogenous, i.e., driven by factors unrelated to liability. In many toxic tort contexts, however, the potential liability is sufficiently high that the liability itself could trigger bankruptcy (what we term "endogenous" bankruptcy). This second class of bankruptcy cases can arise when the expected damages plus litigation costs resulting from an exposure event exceed the injurer's assets. A well-known example is the bankruptcy of the Johns-Manville Sales Corporation, which was triggered by the costs associated with asbestos litigation (Note, 1983). If victims fear that the injurer will be bankrupted by liability, there is the potential for a race to file under which victims have an incentive to file early in an effort to secure some portion of the injurer's limited assets. The question then is whether allowing suits at the time of exposure would generate or exacerbate a race to file, and what implications it would have for total litigation costs and deterrence.

[4] In addition, some have argued that, if recovery is allowed for a tort for risk and then the individual never contracts the disease, the recovery constitutes a windfall for that individual. Conversely, since under a tort for risk recovery would be based on expected damages (rather than realized damages), individuals who eventually contract the disease would be undercompensated. Note, however, that victims who received payment at the time of exposure based on expected damages could presumably use their awards to purchase

In this paper, we present an economic model of a tort-for-risk rule in a context where litigation is costly and injurers have limited assets. We first use the model to examine the impact of allowing a tort for risk on the victims' incentives to file suit. This allows us to examine whether allowing a tort for risk would in fact lead to a "race to file." Previous models of the impact of injurer bankruptcy do not consider the potential "competition" among victims for the injurer's assets. Modeling this competition allows us not only to examine the potential for a race to file but also to determine how the injurer's limited assets are ultimately apportioned. Our results suggest that allowing a tort for risk would essentially establish a new priority rule for claims on the injurer's assets.

Second, we use our model to ask whether allowing a tort for risk could trigger bankruptcy even if, in the absence of a tort for risk, the liability associated with actual illnesses would not have done so. In this latter case, we show that, even if a tort for risk is allowed, an equilibrium under which all victims wait to sue, and bankruptcy does not occur, always exists. Thus, in such cases allowing a tort for risk will not necessarily trigger bankruptcy. However, we cannot rule out the possibility of other equilibria under which the tort for risk does trigger a race to file that leads to bankruptcy. Nonetheless, the equilibrium with no race is Pareto dominant in the sense that all victims are better off.

Finally, given the victims' incentives to sue, we use the model to examine whether the standard tradeoff between litigation costs and deterrence that arises in the context of exogenous bankruptcy exists when insolvency is triggered by liability. We show that such a tradeoff does not necessarily exist in this case.

The analysis in this paper is related to other contexts in which a race to claim a firm's limited assets can result in bankruptcy. The classic example is a bank run, in which depositors

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insurance that would provide full compensation if the disease is eventually contracted, thereby eliminating both over- and under-compensation (Robinson, 1985).

rush to withdraw their assets because they expect other depositors to do the same.[5] In their model of bank runs, Diamond and Dybvig (1983) show that, even though runs are not inevitable, there always exists an equilibrium in which one occurs.[6] Their paper is similar to ours in that it establishes the existence of equilibria in which even "healthy" firms can fail as a result of agents who try to "jump the gun." However, their focus is quite different, emphasizing the liquidity service provided by banks and the impact of runs on risk sharing among risk averse depositors. In the "good" equilibrium, some depositors withdraw in the initial period while others wait, creating optimal risk sharing. When a bank run occurs, all depositors withdraw in the initial period and optimal risk sharing is ruined, resulting in an equilibrium that is worse for all agents. Here, we focus on the compensation of risk neutral victims and hence risk sharing plays no role in our results. In addition, in contrast to Diamond and Dybvig, in our model all victims wait to file suit in the "no race" or "good" equilibrium, whereas some victims file early in the equilibrium with a race.

Finally, in a litigation context similar to ours, Spier (2002) examines the settlement negotiations between a defendant and multiple plaintiffs when the defendant's assets are insufficient to cover the collective liability of plaintiffs if they all win at trial. Her focus, however, is on the decisions of plaintiffs about whether to settle or go to trial, given that they have already filed suit, whereas our interest is on how the availability of a tort for risk affects the timing of plaintiffs' filing decisions, given the defendant's limited assets.

The paper is organized as follows. Section 2 presents the general setup of the model. Section 3 then examines the decision of exposure victims of whether to file suit

[5] The issue arises more generally in the context of bankruptcy workouts when there are multiple creditors (Schwartz, 1993).

[6] Similarly, Deneckere and Peck (1998) examine a form of market failure that results when consumers enter a market inefficiently early for fear that a firm's fixed output will be exhausted if they wait. The authors show that an equilibrium in which all consumers enter early always exists, even though it is Pareto-dominated by one in which all consumers wait to enter.

at exposure or to wait until they actually develop an illness. The question is whether exposure suits, if allowed, would produce a race to file that bankrupts injurers and leaves some victims uncompensated. Finally, Section 4 considers the impact of exposure suits on the expected number of suits, litigation costs, and injurer care. Section 5 offers concluding comments. All proofs are in the Appendix.

2. The general model

In this section, we present the basic structure of the model. The model has three periods, a single injurer, and a large population of victims, all of whom are risk-neutral. Risk neutrality should hold for plaintiffs who file and recover fully at the time of exposure, provided they use their awards to purchase insurance against future illness. More generally, however, plaintiffs who do not receive full compensation will bear some risk, which would be costly if they are risk averse. With risk aversion, different liability rules could have different implications for risk sharing. Assuming risk neutrality allows us to abstract from these potential differences and focus solely on a comparison of the incentive effects of the different rules.

In the initial period (t=0), the injurer chooses a dollar investment in care, x, which determines the probability of exposure, $p(x)$, where $p'<0$ and $p''>0$. In the next period (t=1), an exposure occurs with probability $p(x)$. If an exposure occurs, in the final period (t=2) an exposure victim will become ill and incur damages of D dollars with probability q, and suffer no illness (and hence no damages) with probability $1-q$. For simplicity, we assume that neither D nor q depends on x.[7] For example, we suppose that x affects the probability that the victim is exposed to a carcinogen, but does not affect the extent of the exposure and hence the likelihood that she will contract the disease (given exposure), or the dollar loss that results if the disease is contracted.

We assume that all victims suffer the same loss in the event of illness. However, we allow q to vary across victims in a way that is observable to the court. More specifically, we let q be an index of exposure intensity, which varies across victims to reflect the fact that some victims were exposed for a longer period of time, or were in closer proximity to an accidental release of the hazardous substance, and hence have a greater chance of developing the illness. Indeed, we define q in such a way that for victims with an exposure index of q, a share q of them are expected to develop the illness in t=2.

We assume that each individual's exposure index (which also equals her probability of illness) is drawn from a differentiable density function, $f(q)$, that is positive on the support [0,1]. Victims observe their own exposure index, as does the court. While victims do not necessarily know the exposure of any other individual victim, we assume that the distribution, $f(q)$, is common knowledge and hence known by both the injurer and all victims.[8] Given the definition of q, we write the expected number of illnesses in t=2 as

$$N\int_0^1 qf(q)dq, \tag{1}$$

where N is the total volume or mass of exposures. Because we are interested in the context of mass torts, which involve a large number of victims, we assume that N is very large. In particular, we assume that N is sufficiently large to allow us to invoke the law of large numbers,

[7] We also ignore the possibility that between the time of exposure and illness a victim could invest in medical monitoring, which could affect either D or q.
[8] We assume that the distribution is known before any decisions are made, and that it is independent of any decisions made by either the injurer or victims. In particular, we assume that it is not affected by the injurer's care choice, and that victims have no opportunity to avoid or reduce their exposure once the care choice has been made. Any mitigation activities by the victims (e.g., moving away from a potentially hazardous facility) are assumed to occur before the injurer chooses care.

implying that the realized illness rate for victims with exposure q is equal to q.[9] Given this, the expected number of illnesses in (1) also equals the actual number of illnesses in t=2.[10] The assumption that the distribution of q is actually realized and that this distribution is known *a priori* implies that this is a game of complete information.

In the absence of bankruptcy, exposure victims who wait until they sustain actual damages before filing will get a net return equal to their losses, D, less the cost of filing suit, c_v.[11] We assume that $D>c_v$, so that filing suit if and when the illness arises would be profitable for all illness victims who expect to recover their full damages. In contrast, victims who file at exposure would receive the expected value of damages, qD, yielding a net return of $qD-c_v$.

Finally, we abstract from the specific length of time it takes for the loss to arise, and we ignore discounting. These assumptions keep the model simple without affecting the qualitative nature of the results. In addition, we assume throughout that the liability rule in place is strict liability.

The above model can be viewed as a two-stage game, where in the first stage the injurer chooses a level of precaution and, if an exposure occurs, then in the second stage victims simultaneously make a filing decision. That is, they decide whether to file a suit for damages, and more importantly, *when* to file, assuming existence of a tort for risk. If a tort for risk is

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[9] This is similar to the approach taken in risk assessments and calculations of the value of a statistical life, where, for example, exposure of a large population to an elevated level of air pollution is assumed to lead to a given number of additional deaths in the exposed population (Viscusi, 1993). While it is not possible to identify *a priori* which individual(s) will die as a result of the exposure, the total number of additional deaths within the population is assumed to be known.

[10] For an analysis of a tort for risk in the small numbers case where the actual number of illnesses can differ from the expected number, see Miceli and Segerson (forthcoming).

[11] We assume throughout that all victims face identical filing costs, and that these costs are the same whether the victim files at exposure or at illness. This assumes that filing costs tend to be fixed rather than proportional to damages (as would be true, for example, of contingent fees). We make this assumption in order to isolate the impact of the bankruptcy threat on plaintiffs' filing decisions. We believe, however, that our qualitative results would be robust to different assumptions about legal costs. We also assume that

allowed, an exposure victim can file at the time of exposure (t=1) or wait to file if and when damages occur (t=2). We consider first the equilibrium of the filing subgame. We then turn in Section 4 to consideration of the full game.

3. Incentives to sue and the race to file

In deciding whether to file suit at the time of exposure or illness, each victim will compare the net return from filing at exposure to the net return she would expect to receive if she waited and filed at the time of illness (if it occurs). In making this comparison, a victim faces the following tradeoff. If she files at the time of exposure, she will incur litigation costs with certainty, whereas if she waits until illness, she will incur these costs only with probability q (the probability she will actually become ill and hence sue). Thus, if victims expect full recovery, all victims will prefer to wait, regardless of what other victims do, since waiting yields an expected return of $q(D-c_v)$, while filing at exposure yields a lower return of $qD-c_v$ for all q. The cost of waiting is the potential reduction in the damage award if the injurer's assets have been reduced or depleted by other (i.e., earlier) suits. Of course, this cost depends on the number of other victims who choose to file at exposure. We are thus interested in deriving a Nash Equilibrium of the filing subgame, in which each victim makes the filing decision that maximizes her expected return, given the expected filing decisions of all other victims.

Since the expected savings in litigation costs decreases with q, the advantages of waiting will be lower for victims with higher values of q. This suggests that victims with higher q's will

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victims always win suits that are filed, thus abstracting from the potentially difficult problem of proving causation (Shavell, 1985).

have a greater incentive to file at exposure. Given the large number of victims, it turns out that the equilibrium must of this "threshold type."[12]

Lemma 1: Consider a set of filing strategies Δ for victims, where the number of victims is large. If Δ is a Nash equilibrium of the filing subgame, then the strategies take the form of a threshold rule; that is

$$\Delta(q) = \begin{cases} \text{file at exposure} & \text{if } q > \tilde{q} \\ \text{wait to file} & \text{if } q < \tilde{q} \end{cases}$$

for some $0 \leq \tilde{q} \leq 1$, where $\Delta(q)$ is the strategy of a victim with an exposure index of q.[13]

Given that the equilibrium of the filing subgame must take the form of a threshold rule, the task is to determine the equilibrium threshold, $\tilde{q}$. Note that $\tilde{q} = 0$ would imply a complete race to file under which all exposure victims file at the time of exposure in an effort to secure some share of the injurer's limited assets. Conversely, $\tilde{q} = 1$ implies that there is no race, i.e., all victims wait to file.

We begin by defining the injurer's total liability-related costs (damages plus litigation costs) under the traditional rule that bars suits at the time of exposure:

$$\overline{L} \equiv (D + c_i)N\int_0^1 qf(q)dq\,, \qquad (2)$$

[12] We thank a referee for pointing out the necessity of the threshold feature of the equilibrium and how to prove it.

[13] Note that Lemma 1 is stated with strict inequalities because the optimal strategy at the point of indifference, i.e., for a victim with exposure intensity $\tilde{q}$, is arbitrary. For simplicity, we assume henceforth that, when indifferent, victims wait to file.

where c_i is the injurer's litigation cost per suit. We consider two cases. In the first, the injurer's assets, A,[14] are insufficient to cover $\overline{L}$ (i.e., $A < \overline{L}$). In this case, bankruptcy is inevitable in the sense that the injurer's liability costs exceed his assets, even if a tort for risk is not allowed. Later, we consider the case where $A \geq \overline{L}$; that is, the injurer has sufficient assets to cover his liability costs provided no victims file at exposure, so that bankruptcy is not inevitable. In that case, we ask whether allowing exposure suits could ever trigger a race to file that would not have occurred otherwise. In both cases, however, we assume that $A>N(c_v+c_i)$, which ensures that litigation costs alone would not bankrupt the injurer even in the most extreme race to file. Specifically, all victims would find suits profitable since $A/N-c_i>c_v$. This assumes that the injurer must pay his own litigation costs first, and then pays any damages out of his remaining assets (if any).

Bankruptcy inevitable: $A < \overline{L}$

To determine the existence and characteristics of the Nash equilibrium filing threshold, $\tilde{q}$, we must first determine the payoffs from filing at exposure, and from waiting, for each individual victim. Since these payoffs depend upon the magnitude of $\tilde{q}$, we need to consider three cases.

Case 1. In this case, the number of victims who file at exposure is sufficiently large that the injurer is bankrupted in t=1. This occurs when $\tilde{q}$ is sufficiently low, i.e., when $0 \leq \tilde{q} < q'$, where q' is the probability of illness such that, if all exposure victims with $q \geq q'$ file suit at

[14] A should be interpreted here as the injurer's assets at the beginning of t=1, i.e., after any monetary expenditure on care. Thus, if A_o is the asset level at the beginning of t=0, then $A=A_o-x$. See Section 4 below.

time of exposure, the injurer's assets will be just sufficient to cover both the liability payments, equal to qD, and the litigation costs associated with each of these suits. Formally, q' is defined by

$$A = N\int_{q'}^{1}(qD + c_i)f(q)dq \equiv TC_1(q'). \tag{3}$$

If $\tilde{q} < q'$, then, after paying his litigation costs, the injurer's assets are insufficient to cover the expected damages of each victim who files at exposure. We therefore assume that each victim receives an equal share, $\beta(\tilde{q})$, of her expected damages, where

$$\beta(\tilde{q}) = \frac{A - N\int_{\tilde{q}}^{1} c_i f(q)dq}{N\int_{\tilde{q}}^{1} qDf(q)dq}, \tag{4}$$

which is less than one for $\tilde{q} < q'$. This implies that the assets that remain after paying the injurer's litigation costs are divided equally among the victims who file at exposure. Note that $\partial\beta / \partial\tilde{q} > 0$, implying that a reduction in the number of victims filing at exposure increases the share of assets that each receives. Since the injurer's assets are fully exhausted by exposure suits, those victims who wait to file will receive nothing. Thus, a victim will file at exposure if and only if $\beta(\tilde{q})qD - c_v > 0$, or

$$q > \frac{c_v}{\beta(\tilde{q})D} \equiv J(\tilde{q}) \qquad (5)$$

Note that $J'(\tilde{q}) < 0$, reflecting that fact that as $\tilde{q}$ rises, fewer victims file at exposure, thus leaving more assets to be divided among those who do file and making filing at exposure more attractive. Also note that $J(q') = c_v / D$, and $J(0)<1$ (given the assumption that $A>N(c_v+c_i)$).

Case 2: In this case, $\tilde{q}$ is in an intermediate range such that the number of exposure suits is not large enough to exhaust the injurer's assets in t=1, but his remaining assets are insufficient to cover the litigation costs of all victims who did not file at exposure and become ill in t=2. Thus, illness victims file up to the point where the injurer's assets are exhausted, resulting in a zero return for the marginal filer. As a result, the best response of an exposure victim is to file at exposure if and only if $qD-c_v>0$, or $q>c_v/D$. This case occurs when $q' \leq \tilde{q} < \hat{q}$, where we define $\hat{q}$ below. Note that the number of exposure suits is constant in this range because the anticipated competition by illness victims in period two drives the return from waiting to zero.

Case 3. In this case, $\tilde{q}$ is sufficiently high, i.e., the number of exposure suits is sufficiently low, that they do not bankrupt the injurer in t=1, and his remaining assets are sufficient to induce all victims to file in t=2 if they become ill. This occurs when $\hat{q} \leq \tilde{q} \leq 1$. The expected number of suits in t=2 is therefore

$$S_2(\tilde{q}) \equiv N\int_0^{\tilde{q}} qf(q)dq\ . \qquad (6)$$

Note that

$$R(\tilde{q}) \equiv A - TC_1(\tilde{q}) - c_i S_2(\tilde{q}) \tag{7}$$

represents the assets the injurer has available to pay damages in t=2 after paying his total period-one costs plus his period-two litigation costs. We can now define $\hat{q}$ as the solution to

$$r(\hat{q}) = c_v, \tag{8}$$

where $r(q) \equiv R(q)/S_2(q)$ Thus, $\hat{q}$ is the level of $\tilde{q}$ such that return per victim in period 2 is just sufficient to cover that victim's litigation costs.

In Case 3 (i.e., $\tilde{q} \geq \hat{q}$), the injurer is not driven into bankruptcy by the exposure suits, and all victims who file at exposure receive their full expected damages (qD) rather than a pro-rated share. Furthermore, those who wait expect to receive $r(\tilde{q}) - c_v$. It follows that in this case, a victim's best response is to choose to file at exposure rather than waiting if and only if $qD - c_v > q[r(\tilde{q}) - c_v]$, or

$$q > \frac{c_v}{c_v + D - r(\tilde{q})} \equiv H(\tilde{q}), \tag{9}$$

Note that $\partial H/\partial \tilde{q} > 0$, reflecting the fact that as $\tilde{q}$ rises, fewer victims file at exposure, thereby leaving the injurer greater assets in t=2. This makes it more attractive to wait to file. Note also that $H(\hat{q}) = c_v / D$ and $H(1) < 1$ given that $A < \overline{L}$.

We can now combine the preceding cases to characterize the general strategy of victims as follows:

Lemma 2: In the case where $A<\overline{L}$, if all other victims follow the strategy "file at exposure if and only if $q > \tilde{q}$," the best response of a victim with an exposure index of q is the strategy "file at exposure if and only if $q>G(\tilde{q})$," where $G(q)$ is a piecewise continuous function defined by:

$$G(\tilde{q}) \equiv \begin{cases} J(\tilde{q}) & if \quad 0 \le \tilde{q} < q' \\ c_v / D & if \quad q' \le \tilde{q} < \hat{q} \\ H(\tilde{q}) & if \quad \hat{q} \le \tilde{q} \le 1 \end{cases} \tag{10}$$

The equilibrium of the filing subgame occurs at the fixed point $\tilde{q} = G(\tilde{q})$. The characteristics of $G(\cdot)$ therefore allow us to prove:

Proposition 1: An equilibrium $\tilde{q}$ always exists, and in equilibrium $c_v / D \le \tilde{q} < 1$.

Graphically, the equilibrium level of $\tilde{q}$ occurs where $G(q)$ intersects the 45^{o} line. It should be clear that an equilibrium could occur on any segment of the $G(\cdot)$ function. Figure 1 shows an equilibrium corresponding to Case 1 in which the injurer is bankrupted in t=1 (an intersection point along $J(q)$). Generally, the type of equilibrium will depend on the magnitude of A.

Note that both $\partial q'/\partial A$ and $\partial \hat{q}/\partial A$ are negative. Thus, as A increases, the horizontal segment of G in Figure 1 shifts leftward, with corresponding shifts in J and H. As this occurs, the intersection with the 45^{o} line will first shift from $J(q)$ (the Case 1 equilibrium) to the horizontal segment, producing a Case 2 equilibrium in which the injurer is not bankrupted by exposure suits, but illness victims compete away the injurer's remaining assets. Further increases in A eventually yield an intersection point to the right of $\hat{q}$, i.e., a point along $H(q)$, producing a Case 3 equilibrium in which bankruptcy again does not occur until t=2, but illness victims receive compensation that more than covers their litigation costs.

Because the nature of the equilibrium varies with A, firms with different asset levels can be expected to face different filing patterns. However, the preceding analysis implies that the equilibrium $\tilde{q}$ is non-monotonic in A. Starting from a low A, as A increases, the equilibrium $\tilde{q}$ initially decreases through Case 1, then remains constant in Case 2, and finally increases in Case 3.[15] Correspondingly, the number of exposure suits initially increases, then remains constant, and finally decreases with increases in A. Thus, contrary to what might be expected, it is possible that a firm with low assets will face e number of exposure suits as a wealthier firm.

Of course, litigation costs are determined not just by the number of exposure suits but by the number of total suits. However, as with exposure suits, the number of total suits is non-monotonic in A. When A is sufficiently low to yield a Case 1 equilibrium, the firm is bankrupted in period 1. As a result, the total number of suits simply equals the number of exposure suits, which increases with A throughout this range in the manner just described. In Case 2, an increase in A has no effect on exposure suits, but it now takes more illness suits to "compete away" the firm's assets. Thus, in this range the total number of suits also increases with A. However, in Case 3, an increase in A will decrease the number of exposure suits (as described above) but increase the number of illness suits since some victims who previously filed at exposure will be

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[15] This assumes a single intersection between the H function and the 45^{o} line in Case 3 (and also relies on the fact that $H(1)<1$). Because $H(\tilde{q})$ is not necessarily convex, however, we cannot rule out the possibility of multiple equilibria in this range.

induced to wait by the increase in A. The total number of suits will nevertheless decrease since a suit that formerly occurred with certainty is replaced by one that only occurs with probability q.

This description of the equilibria of the filing subgame implies that, with inevitable bankruptcy triggered by liability, allowing a tort for risk will always induce some victims to "race to file" in order to receive as much compensation as possible. However, as long as litigation costs are positive, the race is not complete in the sense that not all victims file at exposure (i.e., $\tilde{q}$ is bounded below by c_v/D). The existence of positive litigation costs for victims prevents a total race.[16] As a result, even though the injurer always faces eventual bankruptcy if an accident occurs (by assumption), allowing a tort for risk will not necessarily drive the injurer into immediate bankruptcy by inducing all (or even most) victims to file at exposure.

Allowing a tort for risk, however, will change the distribution of the injurer's limited assets in favor of high q victims. Note that without a tort for risk, all victims who ultimately suffer damages receive the same compensation amount (regardless of how likely it was in an ex ante sense that they would contract the disease), while those who do not contract the disease receive nothing. Under the tort for risk with endogenous bankruptcy, however, high exposure victims, i.e., victims with high values of q, effectively have the first claim on the injurer's limited assets.[17] It is only after the expected damages for these victims (those most likely to contract the disease) are covered that victims who were less likely to contract the disease, but who ultimately do, receive any compensation. Thus, allowing a tort for risk effectively treats exposure as the primary tortious act, providing compensation for victims with high exposure first, and then allowing any remaining assets to be used for compensation of illness victims who did not file at t=1. In other words, a tort for risk effectively creates two classes of victims: a primary class

[16] Recall, however, that in the absence of a tort for risk, even with positive litigation costs all illness victims would file at the time of illness, given our assumption that $D>c_v$.

[17] In addition, when recovery for emotional distress is not allowed, a tort for risk serves to at least partially compensate high probability victims for their presumably higher emotional distress.

comprised of high exposure victims who have first claim on the injurer's limited assets, and a secondary class comprised of low exposure victims who ultimately contract the disease and who can then make a claim on any remaining assets. In contrast, with suits only allowed at the time of illness, there is a single class of victims (all those who contract the disease) who are given equal priority regardless of their exposure index.

Bankruptcy not inevitable: $A \geq \overline{L}$

Having characterized the Nash equilibria for the case where bankruptcy is inevitable, we now ask whether allowing a tort for risk could trigger bankruptcy in a situation where the injurer would not go bankrupt if the tort for risk were not allowed.

In the absence of a tort for risk, the injurer's liability-related costs continue to be given by $\overline{L}$. Thus, as long as the injurer's assets are at least equal to $\overline{L}$, he will be able to cover his costs if a tort for risk is barred. However, if a tort for risk is allowed, then for an arbitrary value of $\tilde{q}$, the injurer's total liability could be higher. Compare, for example, total expected liability if a tort for risk is not allowed ($\overline{L}$) to the total first-period costs when a tort for risk is allowed but the injurer is not bankrupt in the initial period. Depending on the value of $\tilde{q}$, it is possible to have an asset level A such that

$$N\int_{\tilde{q}}^{1}(qD+c_i)f(q)dq > A > N\int_{0}^{1}q(D+c_i)f(q)dq \equiv \overline{L}\,. \tag{11}$$

Because the injurer incurs the litigation costs associated with exposure suits with certainty when a tort for risk is allowed, the total first-period costs associated with a tort for risk could actually exceed the costs the injurer would incur if such suits were barred, and this additional cost (due to potentially higher litigation costs) could be sufficiently large to induce bankruptcy. The question, then, is whether this potential outcome (for an arbitrary $\tilde{q}$) emerges as an equilibrium outcome. We begin by stating the following result:

Proposition 2: If $A \geq \overline{L}$, then $\tilde{q} = 1$ is an equilibrium of the filing subgame.

Proposition 2 implies that allowing a tort for risk will not necessarily induce a race to file in the case where bankruptcy is not inevitable. If the injurer has sufficient assets to cover all suits at illness, then even though victims have the option to sue for exposure, in this equilibrium they choose not to do so. Intuitively, if all but one victim chooses to wait, then it is the best response for the remaining victim to wait as well, given that waiting is a dominant strategy if the victim expects full recovery.

The question, then, is whether there exist other equilibria under which a race to file and bankruptcy result. It is certainly possible that the equilibrium under which all victims wait is a unique equilibrium; such a case is depicted in Figure 2. This outcome, however, is not guaranteed. In general, we cannot rule out the possibility of other equilibria under which a race to file occurs even though the injurer would otherwise have sufficient assets to cover all suits at illness. Figure 3 depicts such a case.

To compare the possible equilibria, we first note the following:

Proposition 3: In any equilibrium with $\tilde{q} < 1$, the injurer is bankrupted by liability.

In other words, it is not possible to have an equilibrium race-to-file that does not end in bankruptcy. Thus, in Figure 3, while the injurer would not be bankrupted by liability in equilibrium C (where $\tilde{q} = 1$), he would be bankrupted at either of the other two equilibria (A or B). (In both cases depicted, the injurer is not bankrupted by exposure suits but has insufficient remaining assets to cover the potential liability he faces from illness suits.) Thus, when there are multiple equilibria, allowing a tort for risk can trigger bankruptcy when it would not otherwise have occurred.[18]

Why in equilibrium might there be a race to file that triggers bankruptcy if bankruptcy is not inevitable? As we argued above, if one victim expects all others to file at illness, then that victim will be better off waiting to file as well rather than filing at exposure. However, if a victim expects enough other victims to file at exposure to trigger bankruptcy, provided her value of q exceeds $\tilde{q}$, she will be better off filing at exposure as well. Thus, equilibria with $\tilde{q} < 1$ (and hence injurer bankruptcy) can emerge, even though bankruptcy is not inevitable.

Note, however, that the no-bankruptcy equilibrium is Pareto dominant in the sense that all victims are better off with $\tilde{q} = 1$ than they would be with $\tilde{q} < 1$. If $\tilde{q} = 1$, each victim has an expected payoff of $q(D-c_v)$, whereas if $\tilde{q} < 1$, each victim has a lower expected payoff. Those who file at exposure have an expected payoff of at most $qD-c_v$, those who file at illness have an expected payoff less than $q(D-c_v)$, and those who never file have an expected payoff of zero.[19] Thus, as in the bank run literature, victims always prefer the no-bankruptcy equilibrium.

4. Litigation costs and injurer care

To this point, we have characterized the impact of allowing a tort for risk on the filing equilibrium. To examine the question of whether allowing a tort for risk is more efficient (in the

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[18] It is easy to show that as A increases, eventually the only equilibrium is the one at $\tilde{q} = 1$ (the case illustrated in Figure 2), in which case bankruptcy cannot occur.

sense of yielding lower total social costs) than the conventional rule, we must consider litigation and damage costs. Total litigation costs depend on the total number of suits filed, which depends directly on the filing behavior described above. Total damage costs depend on the care choice of the injurer, which is determined by the equilibrium of the full game. We consider each of these in turn.

Impact on litigation costs

As noted previously, the conventional wisdom is that allowing a tort for risk would increase the number of suits and hence increase overall litigation costs. We have shown above that the tort for risk could induce a race to file, even in a context where bankruptcy is not inevitable. However, we show here that such a race does not necessarily imply higher litigation costs (relative to an outcome where exposure suits are not allowed). Our main result is the following.

Proposition 4: If the tort-for-risk equilibrium corresponds to Cases 1 or 2, then the total number of suits may be higher or lower under a tort for risk. However, if it corresponds to Case 3, then there are more suits under a tort for risk.

Proposition 4 implies that, in contrast to the conventional wisdom, allowing a tort for risk does not necessarily increase the number of suits, and hence overall litigation costs.[20] While this conventional wisdom holds for Case 3 equilibria, it does not hold more generally. Intuitively, even though exposure suits occur with certainty in t=1 (while these same victims would only file

[19] In the $\tilde{q} = 1$ equilibrium, it is profitable for all victims to file suit at illness, given $D>c_v$.

[20] As an example, in a Case 1 equilibrium, if q is uniformly distributed on [0,1], then there will be fewer suits under a tort for risk if $\tilde{q} > 1/2$ in equilibrium.

at t=2 with probability q if the tort for risk were barred), the population of victims who sue at some point (either t=1 or t=2) is potentially smaller when a tort for risk is allowed. Suits in t=1 may so reduce the injurer's assets that some or all illness victims in t=2 find suits unprofitable. However, when all illness victims find suits profitable in t=2 (as in Case 3), then a tort for risk does increase the total number of suits (and hence litigation costs).

Incentives for care

The above results suggest that alternative values of $\tilde{q}$ cannot be ranked on the basis of litigation costs. We turn next to the question of how they compare in terms of incentives for injurer care. For this, we need to consider the subgame perfect equilibria of the full game, which involves deriving the optimal choice of care for the injurer, given the possible equilibria in the filing subgame.

It should be clear from the discussion above that in the case where $A < \overline{L}$, if an accident occurs, the injurer expects to pay out his entire assets in the form of compensation and/or litigation costs in any of the three types of possible equilibria in the filing subgame. Thus, the total cost of an accident to the injurer is independent of $\tilde{q}$. However, as noted by Beard (1990), when care involves a dollar expenditure, the injurer's asset level at the time an accident occurs depends on his prior expenditure on care, i.e., $A=A_o-x$, where A_o is the injurer's initial asset level. Thus, bankruptcy is inevitable if the injurer chooses a level of care greater than $A_o - \overline{L}$. In addition, even when bankruptcy is not inevitable, the injurer may still choose a level of care that creates the possibility of a filing equilibrium in which there is a race to file that results in bankruptcy. Both of these possibilities must be considered when examining the incentive effects of allowing a tort for risk. Our main result regarding the impact of allowing a tort for risk on the injurer's choice of care is given in Proposition 5:[21]

Proposition 5: (i) If the optimal choice of care when a tort for risk is not allowed leads to inevitable bankruptcy if an accident occurs, i.e., if the optimal x exceeds $A_o - \overline{L}$, then allowing a tort for risk does not affect the injurer's choice of care. (ii) If the optimal choice of care when a tort for risk is not allowed does not lead to inevitable bankruptcy, i.e., if the optimal x is less than $A_o - \overline{L}$, then allowing a tort for risk will either leave the injurer's choice of care unchanged or increase it, depending upon the type of equilibrium that is expected to emerge. If a $\widetilde{q} = 1$ equilibrium is expected to emerge when bankruptcy is not inevitable, then allowing a tort for risk will not affect the injurer's choice of care.

Intuitively, allowing a tort for risk will affect the injurer's care choice only if it affects the total amount he expects to pay out in exposure-related costs.[22] This occurs only when the injurer would not be bankrupt in the absence of a tort for risk but expects to be bankrupted if a tort for risk is allowed. In this case, allowing a tort for risk increases the injurer's total expected pay out, and hence increases his level of care.

Proposition 5 implies that the effect of a tort for risk on care choices stems from the possibility that allowing a tort for risk will lead to a race-to-file that ends in bankruptcy even when bankruptcy is not inevitable. However, as noted above, whenever such an equilibrium exists, there is also a no-bankruptcy equilibrium under which a race to file does not occur, and

[21] The proof of Proposition 5 is omitted but is available from the authors on request.

[22] Note that Proposition 5 does not imply that the potential for bankruptcy has no effect on the choice of care. As shown by Beard (1990), the potential for bankruptcy can lead to either under- or over-deterrence.

this equilibrium Pareto dominates in the sense that all victims are at least as well off as they are under a race-to-file equilibrium. If Pareto dominance makes this equilibrium more likely to occur, then Proposition 5 suggests that, in contrast to the result with exogenous bankruptcy, allowing a tort for risk would not be expected to lead to greater deterrence. Thus, neither the increased litigation costs nor the greater deterrence that arose under a tort for risk with exogenous bankruptcy necessarily arise when bankruptcy is endogenous.

5. Conclusion

Conventional tort law does not permit victims of exposure to a toxic substance to seek compensation until they actually develop symptoms of illness. However, this rule often has the practical effect of barring recovery because, by the time the illness arises, the injurer may be judgment-proof. A possible solution is to allow victims to sue for expected damages at the time of exposure—that is, to create a tort for risk. Critics of this idea, however, warn that it could induce a "race to file" that would lead to increased litigation costs. Supporters argue that there would be an offsetting benefit in the form of increased deterrence. This paper has evaluated the impact of a tort for risk on the filing decisions of victims, as well as the resulting effect on litigation costs and injurer care. We show that, when the filing decisions of victims and the potential for bankruptcy are endogenized, the conventional arguments both for and against a tort for risk do not necessarily hold.

To examine the impact of a tort for risk on victims' filing decisions, we considered two scenarios: one in which the injurer's assets were less than his expected damages plus litigation costs in the absence of a tort for risk, and one in which his assets exceeded those costs. In the first case, where bankruptcy is inevitable, the effect of a tort for risk is to induce some, but not all,

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Proposition 5 simply states that, regardless of the optimal level of x, allowing a tort for risk can never lead to less deterrence than would have existed under the conventional rule where only illness suits are allowed.

victims to file suit at exposure. This suggests that, when the firm's assets are sufficiently low, allowing a tort for risk would trigger a race to file, but it would be a partial race, and the resulting exposure suits would not necessarily bankrupt the firm (although the firm would ultimately be bankrupted by assumption in this case). In equilibrium, victims with the higher probabilities of developing the illness choose to file early while those with lower probabilities either wait or do not file at all. Thus, a tort for risk effectively creates a priority rule that gives high exposure victims first claim on the injurer's limited assets. In contrast, the traditional tort rule gives priority to victims who actually develop the illness, regardless of their ex ante risk.

In the case where the injurer is not expected to be bankrupted by illness suits, we showed that there always exists an equilibirum in which all victims wait to file at illness. Thus, a race to file does not necessarily occur even though a tort for risk is allowed. Nevertheless, there also exist other equilibria in which a race does occur and results in bankruptcy even though bankruptcy was not inevitable. Not surprisingly, the equilibrium in which all victims wait to file is Pareto dominant in that all victims expect to receive a higher return.

We also evaluated the impact of a tort for risk on the expected number of suits and injurer care. We first showed that, although a tort for risk induces some victims to file at the time of exposure, it does not necessarily increase the overall number of suits. The reason is that the initial race to file may foreclose additional suits by bankrupting the injurer or leaving him with insufficient assets to make such suits profitable. Thus, while the conventional wisdom that allowing a tort for risk will increase litigation costs holds for some types of equilibria, it does not hold for other types. In particular, it is less likely to hold (*ceteris paribus*) when the injurer has low assets. As for injurer care, we showed that a tort for risk will affect the injurer's optimal choice of care only if it affects the total amount that he expects to pay in liability-related costs. In particular, if the injurer would not have been bankrupted under the traditional rule but is bankrupted under a tort for risk, then he will take greater care under the latter rule. However, the conventional wisdom does not hold when bankruptcy is inevitable. Thus, as with litigation costs, it is less likely to hold (*ceteris paribus*) when the injurer has low assets.

Our results suggest that it is difficult to evaluate the desirability of a tort for risk on welfare grounds. In the case where bankruptcy is not inevitable, denying such claims, which in our model amounts to ensuring an equilibrium where there is no race to file, makes all victims better off, induces injurers to take at least as much care as under a tort-for-risk, and has an ambiguous effect on litigation costs. When bankruptcy is inevitable, a tort for risk makes some victims better off by changing the priority rule for allocating the injurer's assets, but it has no effect on injurer care and an ambiguous effect on litigation costs.

Appendix

This appendix contains the proofs of Lemmas 1 and 2, and Propositions 1-4.

Proof of Lemma 1: First note that any set of strategies Δ induces a partitioning of victims into two mutually exclusive and exhaustive subsets: $E(\Delta)$={set of all victims who file at exposure} and $W(\Delta)$={set of all victims who wait to file}. This partitioning implies a share $\tilde{\beta}$ of expected damages that each member of $E(\Delta)$ receives, and an award $\tilde{r}$ that each member of $W(\Delta)$ who becomes ill and files suit receives, where $0<\tilde{\beta}\leq 1$, $0\leq\tilde{r}\leq D$, and $\tilde{r}=0$ if $\tilde{\beta}<1$. Thus, each member of $E(\Delta)$ expects a return of $\tilde{\beta}qD - c_v$, while each member of $W(\Delta)$ expects $\max\{0, q(\tilde{r}-c_v)\}$. Define $\tilde{r}_{+i}$ to be the corresponding award implied by a partitioning that is identical to $\{E(\Delta), W(\Delta)\}$ except that one victim $i\in E(\Delta)$ waits to file rather than filing at exposure. Likewise, define $\tilde{\beta}_{+i}$ to be the corresponding share implied by the partitioning that is identical to $\{E(\Delta), W(\Delta)\}$ except that one victim $i\in W(\Delta)$ files at exposure rather than waiting. Assume N is large enough that each victim in $E(\Delta)$ acts as if $\tilde{r}_{+i}=\tilde{r}$ and each victim in $W(\Delta)$ acts as if $\tilde{\beta}_{+i}=\tilde{\beta}$.

If Δ is a Nash equilibrium, then because each victim chooses her best response

$$\tilde{\beta}qD - c_v \geq \max\{0, q(\tilde{r}_{+i}-c_v)\} = \max\{0, q(\tilde{r}-c_v)\} \qquad \forall i\in E(\Delta) \qquad \text{(A1)}$$

and

$$\max\{0, q(\tilde{r} - c_v)\} \geq \tilde{\beta}_{+i}\, qD - c_v = \tilde{\beta}\, qD - c_v \qquad \forall i \in W(\Delta). \qquad \text{(A2)}$$

Now define

$$\tilde{q} = \min\left\{1, \frac{c_v}{\tilde{\beta}D - \max\{0, \tilde{r} - c_v\}}\right\}. \qquad \text{(A3)}$$

The conditions on $\tilde{\beta}$ and $\tilde{r}$ imply that $0 \leq \tilde{q} \leq 1$. Furthermore, for all $q > \tilde{q}$, (A2) does not hold, implying that any such victim does not belong to $W(\Delta)$ and therefore must belong to $E(\Delta)$. Likewise, for all $q < \tilde{q}$, (A1) does not hold, implying that any such victim does not belong to $E(\Delta)$ and therefore must belong to $W(\Delta)$. *Q.E.D.*

Proof of Lemma 2: The lemma follows from the description of the three cases in the text. For case 2 to be non-degenerate, it must be true that $\hat{q} > q'$. To prove this, note from (3) that $A - TC_1(q') = 0$, while from (7) and (8) $A - TC_1(\hat{q}) = S_2(\hat{q})(c_i + c_v)$. Since $\partial TC_1/\partial\hat{q} < 0$, it follows that $\hat{q} > q'$. *Q.E.D.*

Proof of Proposition 1: Note first that $G(0) \equiv J(0) < 1$ (given $A > N(c_i + c_v)$) and $G(1) \equiv H(1) < 1$ (given $A < \bar{L}$). Also, $J(q') = H(\hat{q}) = c_v / D \geq 0$. Finally, J is monotonically decreasing and H is monotonically increasing. Thus, G is a continuous function that maps from $[0,1] \rightarrow [0,1]$. By Brouwer's Fixed Point Theorem, there exists a $\tilde{q}$ such that $G(\tilde{q}) = \tilde{q}$. Further, since $c_v / D \leq G(\tilde{q}) < 1$ for all $\tilde{q}$, at the fixed point $c_v / D \leq \tilde{q} < 1$. *Q.E.D.*

Proof of Proposition 2: Lemma 2 holds when $A \geq \overline{L}$ if we replace $H(\widetilde{q})$ with

$$h(\widetilde{q}) \equiv \min\{1, H(\widetilde{q})\} \equiv \min\{1, \frac{c_v}{c_v + D - r(\widetilde{q})}\}. \qquad \text{(A4)}$$

When $A \geq \overline{L}$, $\frac{c_v}{c_v + D - r(1)} \geq 1$, which implies $h(1)=1$. Thus, $\widetilde{q} = 1$ is a Nash equilibrium of the filing subgame. *Q.E.D.*

Proof of Proposition 3: Clearly, in a Case 1 or Case 2 equilibrium, the firm would be bankrupted. In a Case 3 equilibrium with $\widetilde{q} < 1$, it follows that $H(\widetilde{q}) < 1$, which implies that $D > r(\widetilde{q})$. Using (7), it follows directly that the firm is bankrupted by the liability. *Q.E.D.*

Proof of Proposition 4: When a tort for risk is not allowed, the expected number of suits (all in t=2) is $S_2 = N\int_0^1 qf(q)dq$. is $N\int_{\widetilde{q}}^1 f(q)dq$, which may be larger or smaller than S_2, Now suppose a tort for risk is allowed. In a Case 1 equilibrium, the number of suits (all in t=1) depending on the value of the equilibrium $\widetilde{q}$. In a Case 2 equilibrium, the total number of suits is $N[\int_{\widetilde{q}}^1 f(q)dq + \alpha\int_0^{\widetilde{q}} qf(q)dq]$, where $\alpha<1$ is the fraction of illness victims who file suit in t=2 before the injurer's assets are exhausted.[23] Again, this number may be larger or smaller than S_2.

[23] All illness victims appear identical in t=2. We therefore assume that a randomly chosen subset of these victims file suit in Case 2.

Finally, in a Case 3 equilibrium the number of suits is $N[\int_{\tilde{q}}^{1} f(q)dq + \int_{0}^{\tilde{q}} qf(q)dq]$, which is clearly larger than S_2. *Q.E.D.*

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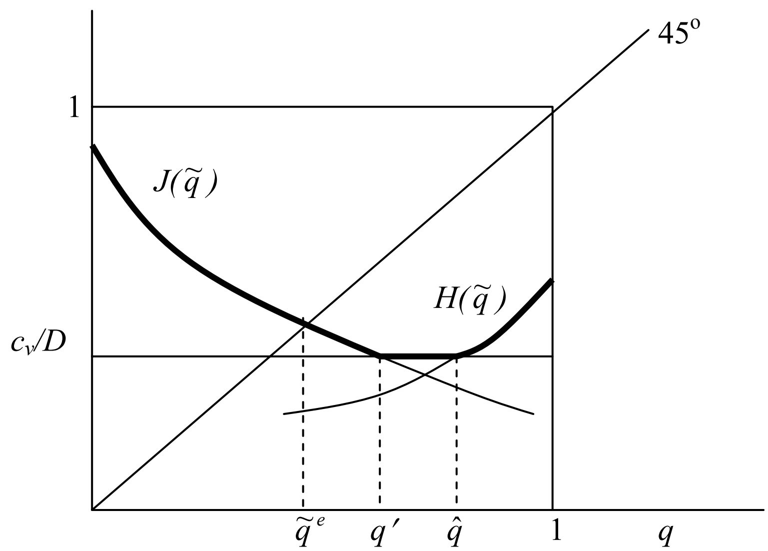

Figure 1. One type of equilibrium when bankruptcy is inevitable.

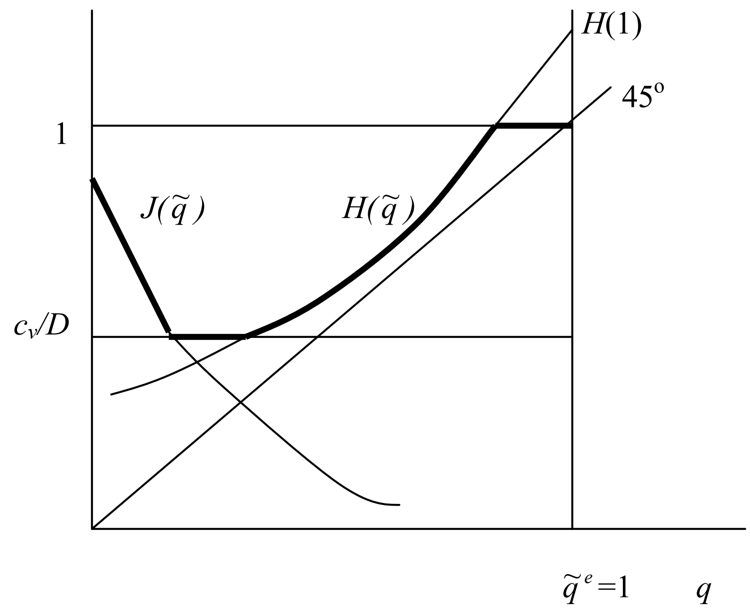

Figure 2. Unique equilibrium in which all victims wait to file.

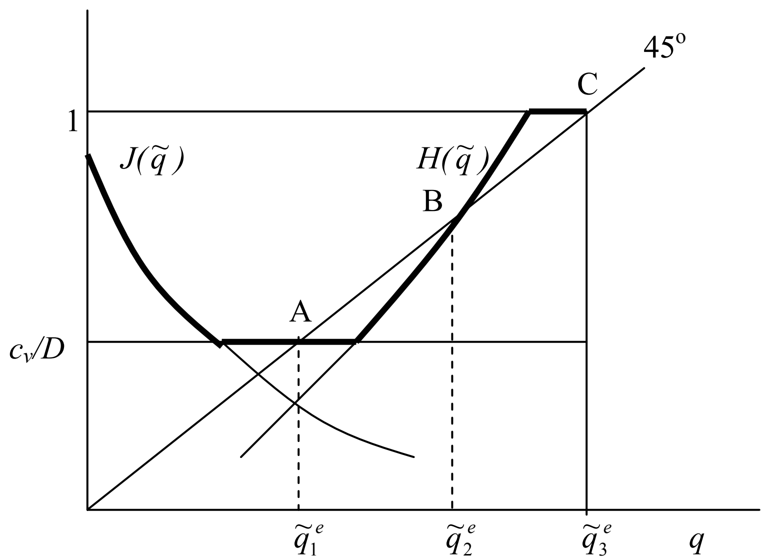

Figure 3. Multiple equilibria when bankruptcy is not inevitable.