# Market Share Liability and Economic Efficiency*

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## I. Introduction

In recent history, the trend in U.S. liability law has been to shift the burden of products liability from the consumer to the producer, with strict (producer) liability being the extreme case. One of the key economic rationales for the use of strict liability as opposed to the rules of no liability or negligence is that producers have knowledge of the riskiness of their products, while buyers do not have this knowledge. Given this information asymmetry, strict liability achieves economic efficiency, while the use of no liability or negligence will result in inefficiency. The crux of this well-known argument is that with strict liability producers are able to correctly internalize expected liability expenses to their costs, while buyers can not correctly internalize these costs to their willingness to pay.[1] Let us call this information problem the product evaluation problem.

Imagine now a second type of information problem where in addition to the lack of ability to evaluate the riskiness of a product, buyers (and sellers) are unable to identify ex post the particular producer of the product causing harm. There are a number of instances in which the producer identification problem is present. One example is provided by the case where a consumer uses a variety of generically similar drugs produced by many different producers. A similar example is provided by the case of a carcinogenic food additive entering many different foods produced by multiple producers. A third set of examples concerns products doing harm through exposure rather than ingestion. A single individual may come into contact with several different brands of asbestos, each brand containing the same fibers harmful to the lungs. Likewise, an individual may be exposed to several different brands of pesticides or herbicides each containing the same harmful chemical compound. In all of these cases, it is possible that the victim of harm would know the type of product doing damage but not the specific producer(s) of the product(s). In fact, for many of these cases, it is unreasonable to expect the consumer to be able to identify the producer causing harm. While strict liability provides a solution to the product evaluation problem, it can not similarly perform in the case of the producer identification problem.

A fairly recent California Supreme Court case, Sindel versus Abbott Laboratories [7], has used market shares to apportion the total damages among firms as a remedy for what we call

*The author thanks Y. Chan, S. Dasgupta, R. Eastin, R. Epstein, T. Gilligan, D. Joines, I. Png, J. Sicilian and M. Zupan for their helpful comments. Generous research support was provided by the School of Business, University of Southern California.

1. See Shavell's paper [3] for a clear presentation of this argument. See also the paper [2] by Landes and Posner for a more general discussion.

the producer identification problem.[2] This doctrine opens up the possibility that a group of firms producing a roughly homogeneous product can be held jointly strictly liable or jointly negligent, and each firm must pay the plaintiff their market share of the total damages. Within the legal literature, the market sharing rule has been called ". . . an equitable, legally and economically sound method of joint liability" [6, 975].

In this paper, we will examine the efficiency properties of strict market share liability, because we are interested in situations where the producer identification and the product evaluation problems are present. With both of these problems, the use of market shares to apportion damages under strict liability poses the most interesting economic issues. The reasoning is that earlier literature has shown that a rule of negligence (or a rule of no liability) is inefficient if the product evaluation problem is present (this would be true with or without the producer identification problem), and that a rule of no liability solves the producer identification problem if the product evaluation problem is not present. Our specific purpose is two-fold. First, we will evaluate the efficiency properties of strict market share liability in a Nash oligopoly model which assumes that strict market share liability is in place and that firms make decisions ex ante given this rule. Here it is shown that strict market share liability does not lead to efficiency, and that under this rule the second-best market structure type is oligopoly as opposed to the limiting cases of competition or monopoly. Second, we will conduct normative analysis by presenting other sharing rules which can improve upon aggregate welfare as compared to strict market share liability.

The analysis begins in section II where we present the model and the social optimality conditions. section III examines the efficiency of strict market share liability and studies properties of the second-best market structure under this rule. section IV provides three alternative sharing rules for use when the producer identification problem is present, and section V offers some concluding remarks.

## II. The Model and Social Optimality

There are $M$ identical consumers purchasing a risk free numeraire good $y$ and a risky product. A consumer's consumption of the risky product is denoted by $q_c$. Each consumer has a utility function of the form $U(q_c) + y$, when the producer is totally liable for damages. That is, the riskiness of the product is irrelevant to the consumer's utility if strict liability is used. We assume throughout that $U' > 0$ and $U'' < 0$. The typical consumer has a fixed income and faces a parametric price $p$ for the risky product. Utility maximization then implies an inverse market demand of the form

$$p = U'(Q/M), \tag{1}$$

where $Q$ is market output and $q_c = Q/M$. The dollar magnitude of loss to the consumer per unit of the product that fails is assumed to equal a fixed sum $L$. While each consumer is assumed

2. In this case, the drug DES was used by pregnant mothers for preventing miscarriage. The daughters of these individuals developed a rare form of cancer almost twenty years after being exposed to DES in utero. DES was produced by a group of firms, and it was clearly unreasonable to expect the victims of harm to identify the particular producer of the product inflicting damage. For a detailed account of the legal issues surrounding this case, see Sheiner's paper [6]. Also see [7].

to take exogenous care in consuming the product, producers are assumed to directly choose the probability of the product causing harm.

We assume that there are $n$ identical firms each choosing an output $q_i$ and an accident probability $a_i$. Thus, market structure, $n$, is exogenous to our analysis. Each firm faces a constant marginal production cost $c(a_i)$, with $c' < 0$ and $c'' > 0$. We have that $\Sigma q_i = Q$.

Social welfare (expected total surplus) can be written as

$$W(Q, a) = MU'(Q/M) - c(a)Q - aLQ, \quad (2)$$

where $a$ is the accident probability of a typical firm. The first-best solution maximizes (2) over a choice of $Q$ and $a$, and the first-order conditions are

$$U'(Q^*/M) = c(a^*) + a^*L, \quad (3)$$

and

$$- c'(a^*) = L. \quad (4)$$

Under our assumptions, the second-order conditions are globally met, so that $(Q^*, a^*)$ is unique if it exists.

The expression $(cQ + aLQ)$ can be called the full or the social cost of the risky product. Condition (3) says that price should equal the full marginal cost, consisting of the sum of marginal production cost and expected marginal accident costs. Condition (4) states that the accident probability should be chosen so as to minimize the full cost of the risky product.

## III. Efficiency and Market Share Liability

The market is described by a symmetric Nash oligopoly model with each identical firm making a choice of $q_i$ and $a_i$, under the expectation that they will be held strictly liable for their market share of the total damages caused by their market. The $i$th firm's profit maximization problem under market share liability and Nash behavior is

$$\operatorname*{Max}_{\{q_i, a_i\}} \pi_i(q_1, \ldots, q_n, a_1, \ldots, a_n), \quad (5)$$

where

$$\pi_i = U'(\textstyle\sum q_i/M)q_i - c(a_i)q_i - (q_i/\sum q_i)\sum a_i L q_i. \quad (6)$$

Solving (5) and assuming that the industry is in a symmetric Nash equilibrium with $q_i = q^s$ and $a_i = a^s$, for all $i$, we obtain the following first-order equilibrium conditions:

$$U'(nq^s/M) + U''(nq^s/M)q^s/M = c(a^s) + La^s, \quad (7)$$

and

$$- c'(a^s) = L(1/n). \quad (8)$$

We assume throughout that each firm is making a nonnegative profit, given the market sharing rule for total liability expenses. This assumption is in keeping with our assumption that market structure, $n$, is exogenous.[3]

The right side of condition (7) shows that each firm will internalize the full marginal cost associated with output. With identical firms, the only distortion contained in (7) is the usual output distortion caused by the existence of market power.[4] An oligopolist marginally values output at marginal revenue rather than price, so that an output restriction relative to the socially optimal $Q$ will result. To see this note that $a^*$ uniquely minimizes $(c(a) + aL)$, so that by comparing (3) and (7)

$$U'(nq^*/M) < U'(nq^s/M) + U''(nq^s/M)q^s/M.$$

Given $U' > 0$, $U'' < 0$,

$$U'(nq^*/M) < U'(nq^s/M),$$

so that $Q^s < Q^*$.

Condition (8) points out that firms will under provide care or choose an accident probability which is greater than the socially optimal accident probability. Furthermore, the lesser is the market power of each firm (that is, the greater is the total number of firms) the greater does $a^s$ exceed $a^*$. There is a direct relationship between the equilibrium accident probability and the number of firms, with the socially optimal $a^*$ being a lower bound for $a^s$. The reasoning behind this result is analogous to the logic underlying the free rider problem.[5] Each firm sees the marginal cost of their accident probability as being their market share of the damage loss per unit of output, $L/n$, rather than the entire amount of the damage loss per unit of output, $L$. It is of interest to note that if market share were 1 or if we had a monopoly, $a^s$ would equal the socially optimal $a$. This is just the result that a monopolist provides socially optimal care under a regime of individual strict liability. On the other hand, if we let the number of firms become infinite, then it is optimal for each firm to choose the highest possible accident probability or take the lowest possible care in making their product safe to consume.

Market structure, which we take as the number of firms, $n$, parameterizes the market share liability optimum, so that we can write

$$Q^s = Q(n) \quad \text{and} \quad a^s = a(n). \tag{9}$$

3. Our interpretation of strict market share liability then imposes all liability on existing firms, as was decided in the Sindell decision. Some have argued that the rule should use market shares determined at the time the product was sold to the harmed consumer. If at the time of the liability suit some firms are insolvent, then the remaining firms would only be responsible for their original shares and no portion of the shares of now insolvent firms. See Epstein's paper [1] for a discussion of this point.

4. Note that this implication (and the right side of (7)) is dependent on the assumption that firms are identical. With heterogeneous firms, each firm internalizes a marginal cost given by $c_i(\cdot)$ plus a convex combination of their personal expected liability expenses and the market average expected liability expenses, $(q_i/Q)a_iL + (1 - q_i/Q)\sum a_iLq_i/Q$. This sum represents the generalization of the right side of (7). The additional distortion under this generalization would make firms with lower than average expected liability expenses per unit internalize a marginal cost term which is too great, other things equal.

5. While our paper is concerned with products liability, Shavell [5, 164–65, 177–78] points out that the same free rider problem is present in accident liability with multiple injurers.

From (7) and (8), we can show that

$$a'(n) = L^2/n^2c'' > 0, \tag{10}$$

and

$$Q'(n) = [U''Q^s/Mn^2 + L^2(n-1)/n^3c'']/[U''/M + U'''Q^s/M^2n + U''/Mn]. \tag{11}$$

The observation that market structure parameterizes the market share liability optimum suggests that there is a second-best number of firms $n^o$ which lies between the extremes of monopoly and perfect competition. If this is the case, such an optimal $n^o > 1$ solves

$$\operatorname*{Max}_{\{n\}} W(Q(n), a(n))$$

and is characterized by the first-order condition

$$dW(n)/dn = (U' - c - a^sL)Q'(n) - [L(n-1)/n]Q^sa'(n), \tag{12}$$

where we have used $L(n-1)/n = (c' + L)$ from (8). Such a maximum exists, if it can be shown that $dW(1)/dn > 0$ and that, for sufficiently large $n$ $dW(n)/dn < 0$. First consider the case of monopoly or $n = 1$. From (10)–(12),

$$dW(1)/dn = (U' - c - a^sL)[(U''Q^s/M)]/[U''/M + U''/Mn + U'''Q^s/M^2] > 0. \tag{13}$$

From (7), $(U' - c - a^sL) = -U''Q^s/M > 0$. Thus, (13) holds so long as $U''/M + U''/Mn + U'''Q^s/M^2 < 0$. The latter condition is true if the second-order conditions to the monopolist's profit maximization problem are met. We assume that this is the case. Next, allow $n$ to become sufficiently large so as to implement the competitive solution wherein price is equal to full marginal (and full average) cost:

$$U' - c - a^sL = 0. \tag{14}$$

Thus, from (10)–(12) and (14), we have at such an $n$

$$dW(n)/dn = -[L(n-1)/n]Q^sL^2/nc'' < 0.$$

It then follows that an interior maximizer, $n^o > 1$, exists.

The fact that the second-best market structure under strict market share liability is neither monopoly nor perfect competition is of some policy interest. In comparing monopoly with the second-best, this result says that although monopoly yields gains in welfare due to efficient accident probability choice, the loss in welfare due to output distortion is too great to make monopoly the dominant market form under strict market share liability. Moreover in comparing perfect competition with the second-best, although perfect competition yields gains in welfare due to greater market output, the loss in welfare due to the free rider problem is too great to warrant extreme antitrust measures or other moves to perfect competition.

## IV. Normative Analysis

The model of market share liability presented above does not attain optimality for two reasons. First, the existence of market power causes a distortion in output from the first best. Second, at the chosen output, each firm chooses an accident probability which is too high due to the free rider problem. The market power problem is not generated by the liability rule, and it can not be avoided unless the government implements price or quantity controls. The second problem is directly caused by strict market share liability, and it can perhaps be alleviated by altering the rule dictating how liability expenses are allocated among firms. Given the separability of the social optimality conditions (3) and (4), if we could redesign the sharing rule so as to move $a_i$ closer to $a^*$ without affecting the output allocation at a Nash equilibrium, then this process would increase welfare. Our strategy will be to examine this possibility.

In formulating a mechanism for the sharing of market liability expenses among firms under strict liability, two key goals should be considered. An implicit assumption with both goals is that the Nash output allocation is not affected by the proposed sharing rule. The first goal is that the shares should add to unity, so that if individuals are harmed their damages can be covered. Second, the sharing arrangement should allow Nash choice of $a_i$ to generate the socially optimal accident probability in equilibrium. In general, we will consider sharing functions, which depend on the vectors of outputs and accident probabilities across all firms. We can then write firm $i$'s share of market liability expenses as

$$s_i(q_1, \ldots, q_n, a_1, \ldots, a_n). \tag{15}$$

The $i$th firm's profit function becomes

$$\pi_i = U'(\sum q_i/M)q_i - c(a_i)q_i - s_i(\cdot)\sum a_i L q_i. \tag{16}$$

The adding-up goal is expressed as

$$\sum s_i(\cdot) = 1, \tag{P1}$$

and the efficiency goal for the accident probability is given by

$$-c'(a_i) = L, \quad \text{for all } i. \tag{P2}$$

If it were theoretically possible to devise a rule satisfying (P1) or (P2), the ability to implement that rule would depend on the information gathering capability of the courts. In general, sharing rules capable of attaining both (P1) and (P2) are more likely to make greater information demands on the courts than would rules capable of attaining just one of these goals. That is, there is a trade-off between goal attainment and the feasibility of information gathering.

Let us begin with the market share liability rule. This is a special case of (15) in which $s_i(\cdot)$ depends only on outputs. That is,

$$s_i(q_1, \ldots, q_n, a_1, \ldots, a_n) = s_i(q_1, \ldots, q_n) \equiv q_i/\sum q_i. \tag{17}$$

This rule satisfies the adding-up goal (P1), but, as pointed out above, it does not meet the efficiency goal (P2). With respect to information requirements, the implementation of (17) requires that the courts be able to compute each firm's output at the time that the damage is done.

An alternative possibility is to devise a liability sharing rule which makes each firm's share depend only on that firm's accident probability (and on how that probability deviates from the social optimum). That is, we could consider

$$s_i(q_1, \ldots, q_n, a_1, \ldots a_n) \equiv s(a_i), \quad \text{for all } i. \tag{18}$$

In the Appendix we show that the class of all $s(a_i)$ satisfying both (P1) and (P2) in a Nash equilibrium is given by

$$s(a_i) \equiv 1 - [(n-1)/n](a^*)^{1/n}(a_i)^{-1/n}, \quad \text{for all } i. \tag{19}$$

Sharing rule (19) generates $a^*$ at a Nash equilibrium, it meets the adding-up goal in equilibrium, and it generates the Nash equilibrium output allocation defined by (7). Rule (19) works by penalizing firms for deviating from the socially optimal accident probability. In particular, it makes

$$s \leq (\geq) 1/n \quad \text{as} \quad a_i \leq (\geq) a^*.$$

The implementation of (19) requires a different information gathering capability than what was the case for the market share rule (17). The courts must be able to compute $a^*$ and to ex post verify each firm's accident probability. No information on output need be gathered. This set of information demands would seem to be equivalent to those of a negligence standard except that the standard is applied to each firm in the industry. While the "accident probability" rule (19) does add up in equilibrium, it does not add up out of equilibrium. This is a drawback, because it is only guaranteed on average that actual market liability expenses will be covered exactly by the sum of the payments made by all firms.

A third possibility is to formulate a sharing rule which would mimic individual strict liability. Such a rule is given by

$$s_i(q_1, \ldots, q_n, a_1, \ldots a_n) \equiv a_i q_i / \sum a_i q_i, \quad \text{for all } i. \tag{20}$$

Rule (20) might be called a weighted market share liability rule, where the weights on outputs are the individual accident probabilities.[6] It satisfies (P1), (P2), and adds up both in and out of equilibrium, without affecting the Nash output allocation defined by (7). However, as compared to (17) and (19), it demands the most information. Courts must be able to compute individual firm outputs and be able to ex post verify individual accident probabilities. Thus, it has the informational requirements of a negligence standard along with the requirement that outputs be computed, but it is the most successful in terms of our goals.

A final alternative is a rule which requires no information on accident probabilities or outputs for its implementation. We might call this the "monopoly rule," because each firm faces

$$s_i(\cdot) \equiv 1, \quad \text{for all } i. \tag{21}$$

Rule (21) generates the efficiency goal (P2) and does not affect the Nash output allocation as defined by (7). It obviously does not meet the adding-up goal. In fact, the monopoly rule penal-

6. Shavell [5, 607] points out in a footnote that such weighted market shares should be used in determining the likelihood that a failed unit of a product was made by a particular firm.

izes the market in the amount of $(n - 1)$ times actual damages should they occur. It generates efficiency, because it gives each firm the same incentive as faced by a monopolist under strict liability. While rule (14) has very small information demands, it may be impractical due to obvious equity considerations.

## V. Concluding Remarks

In this paper we have analyzed market share liability within the context of a Nash oligopoly model. We find that this rule generates a free rider problem with respect to each firm's choice of an accident probability. Each firm internalizes a marginal cost of the accident probability which is equal to their market share of the true marginal social cost. The more atomistic is the market, the more severe is this problem, and the free rider problem is eliminated in the case of monopoly. Under strict market share liability, the second-best market structure type is an intermediate market structure between monopoly and perfect competition. Thus, strict market share liability yields greatest welfare when applied to oligopolistic market form, so that moves to monopoly under strict liability or perfect competition under market share liability generate strictly less welfare.

We presented alternatives to the market share method of allocating damages among firms, and we noted that the use of these rules is conditional on the ability of the courts to verify information on outputs and accident probabilities of individual firms. We presented three sharing rules which generated our efficiency goal without affecting the Nash equilibrium output allocation. Thus, all three rules increased welfare relative to market share liability. Our accident probability rule required the courts to verify information on accident probabilities alone. While this rule satisfied our adding-up goal in equilibrium, its drawback was that it did not add up out of equilibrium. Our monopoly rule required that no information be verified by the courts. However, this rule did not add up in or out of equilibrium. Our weighted market share rule required the courts to verify information on outputs and accident probabilities, and it satisfied the adding-up goal both in and out of equilibrium. If it is feasible for the courts to gather output information along with the information necessary to implement a negligence standard (i.e., information on the accident probabilities), then the weighted market share rule dominates all of the other rules.

## Appendix

Consider the class of sharing functions in which each identical firm faces $s(a)$, where $a$ refers to the typical firm's accident probability. We want to show that $s(a)$ as given by (19) is the only rule which meets both (P1) and (P2) in a Nash equilibrium. First, it is easy to verify that (19) implies (P1) and (P2) in a Nash equilibrium. To see the converse, note that under (P1) and (P2) we have

$$ns(a) = 1, \tag{A1}$$

$$-c'(a)/L = 1, \quad \text{and} \tag{A2}$$

$$(ds/da)nqaL + s(a)Lq = -c'(a)q, \tag{A3}$$

in a Nash equilibrium. (A2) and (A3) together imply

$$ds/da + s(a)/na = 1/na. \tag{A4}$$

The differential equation (A4) has a general solution given by

$$s(a) = (\alpha + \beta a^{-1/n}). \tag{A5}$$

Optimality in the variable $a$ at a Nash equilibrium implies that $\alpha = 1$. (A1) implies that $\beta = [(1 - n)/n](a^*)^{1/n}$. Thus, from (A5), $s(a)$ is of the form (19).

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