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PRODUCTS LIABILITY, CONSUMER MISPERCEPTIONS, AND MARKET POWER

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Abstract

This paper compares alternative liability rules for allocating losses from defective products when consumers underestimate these losses and producers may have some market power. If producers do not have any market power, the rule of strict liability leads to both the first-best accident probability and industry output. If producers do have some market power, strict liability still leads to the first-best accident probability, but there will now be too little output of the industry. It is shown that if market power is sufficiently large, a negligence rule is preferable. Under this rule, firms can still be induced to choose the first-best accident probability, but now the remaining damages are borne by consumers. Since consumers underestimate these damages, they buy more than under strict liability. However, there is a limit to how much the negligence rule can encourage extra consumption. It is shown that if market power is sufficiently large, the rule of no liability may then be preferred to the negligence rule. Without any liability imposed, producers will not choose the first-best accident probability. However, this may be more than compensated for by the increased output of the industry.

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1. Introduction

It is widely recognized that consumers often misperceive the risks from product failures and that, in many markets, producers have some market power. Examples of markets in which both misperceptions and market power occur might include those for pharmaceuticals and other patented products, automobiles, tires, farm machinery and aircraft.

The implications of consumer misperceptions for the optimal choice of a product liability rule in a competitive market are considered by Spence (1977) and Shavell (1980, pp. 14-16), among others. They show that the rule of strict liability--in which the producer is liable for all product failures regardless of his care--is preferable both to the rule of negligence--in which the producer pays damages only if he does not meet some standard of care--and to the rule of no liability. The implications of market power for the choice of a liability rule when consumers have perfect information are discussed by Hamada (1976) and Epple and Raviv (1978, pp. 83-87).[1/] They demonstrate that, in both competitive and monopolistic markets, strict liability, negligence, and no liability are all equally desirable. The results of these analyses might seem to suggest that when consumer misperceptions and market power occur simultaneously, strict liability is the preferred remedy--it does best when consumer misperceptions are the only problem and it does equally well when market power is the only problem. We will show that if consumers underestimate product risks, although strict liability is the best rule when market power is "low," negligence will be preferred when market power is higher, and no liability may be superior when market power is higher yet.

The central idea developed in this paper follows from the observation that shifting liability from producers to consumers causes the demand curve to shift down by consumers' perceived expected losses and producers' costs to fall by the actual expected losses. Therefore, if consumers underestimate the expected losses, costs will fall by more than demand, causing output to increase. Thus, when producers have market power, it may be desirable to take advantage of consumers' misperceptions by shifting liability to them in order to offset the producers' tendency to restrict output.[2/] Of course, this shift may have an undesirable effect on the producers' choice of the accident probability, which must also be taken into account.

This paper considers two ways of shifting liability from producers to consumers. Under the rule of negligence, assuming the standard of care corresponds to the first-best accident probability, producers will meet it and therefore they will not be liable for the accidents that still occur. Because of consumer misperceptions, this will lead to a larger output than under strict liability. Under the rule of no liability, producers will have an incentive to choose a higher accident probability than the first-best one because of consumer misperceptions and, for reasons to be explained, they will produce an even larger output than under negligence.

The circumstances under which each of the remedies may be preferred can now be described. Suppose consumers underestimate the accident probability and producers have no market power.

Then the rule of strict liability leads to the first-best outcome. By forcing producers to internalize all accident costs, this rule leads them to choose the correct accident probability; it also leads them to raise their prices to reflect the cost of achieving this probability and the cost of bearing the remaining damages, so that the appropriate output is demanded. The rule of negligence is less desirable because it leads to a larger output. And the rule of no liability is worse because it leads to an even larger output and it results in an excessive accident probability.

Now suppose market power increases, say due to an oligopoly situation. Strict liability will still lead to the first-best accident probability, but the positive degree of market power will now result in too little output of the industry. A negligence rule might be preferable because it increases industry output without distorting the accident probability. In fact, it will be shown that if market power is sufficiently large, the negligence rule will be preferable to the strict liability rule.

Finally, suppose market power increases even further, possibly to the level under monopoly. Then, in order to offset the greater effects of market power, it may be desirable to use the rule of no liability because it generates larger output even though it leads to an excessive accident probability. An example will be provided in which, if market power is sufficiently large, the no liability rule will be preferable to the others. However, in a different example, no liability will be shown to be inferior to the other remedies regardless of the degree of market power.

The preceding discussion has assumed that consumers underestimate product risks. Alternatively, they may overestimate these risks. The same kind of reasoning leads to the conclusion that strict liability is always preferred in this case. The only reason to consider negligence or no liability is to correct the problem of inadequate output due to market power. But if consumers overestimate product risks, this problem will be exacerbated to the extent that damages are borne by consumers. Strict liability is thus the preferred remedy regardless of the degree of market power.

Section 2 presents the model, which is then used in section 3 to derive the accident probabilities and industry outputs under the three rules. Section 4 focuses on the welfare comparison between strict liability and negligence, while section 5 focuses on the welfare effects of no liability. Section 6 presents a numerical example which suggests that the welfare loss from using the wrong remedy may be significant. Section 7 discusses the results when consumers overestimate the accident probability. Finally, section 8 considers several extensions and interpretations of the analysis.

2. The Model

Consumers are identical and risk neutral. Their aggregate inverse demand for a perfectly safe good is assumed to take the form:[3/]

(2.1) $p = \alpha - \beta q.$

If the good is not perfectly safe, let a be the true probability of a product accident (or product failure), and let $(1-\lambda)a$ be each consumer's perception of a, where $0 < \lambda \leqq 1$. Since $\lambda > 0$, consumers underestimate the true accident probability. Larger values of λ correspond to lower estimates. Thus, λ may be interpreted as a measure of the extent of the misperceptions. Notice also that consumers' perceptions are "unresponsive" in the sense that a change in the true accident probability induces a smaller change in the perceived accident probability.[4/]

Let ℓ be the dollar loss to the consumer in the event that one unit of the product fails. This loss includes the cost of repair and any damages resulting from the failure. Assuming that ℓ is the same for each unit of the good consumed,[5/] the aggregate inverse demand for the product when the perceived probability of failure is $(1-\lambda)a$ is:

(2.2) $p = \alpha - \beta q - (1-\lambda)a\ell.$

It is assumed that there are n identical firms, each with constant marginal costs c(a), where c is strictly decreasing and strictly convex, i.e., $c' < 0$ and $c'' > 0$. Let $m = 1/n$ be a measure of market power, ranging from 0 (the limiting competitive case as the number of firms goes to infinity) to 1 (the monopoly case).

Social welfare W is assumed to equal the benefit to consumers of industry output net of production costs:

$$\text{(2.3)} \qquad W(q,a) = \int_0^q (\alpha-\beta x-a\ell)dx - c(a)q$$

$$= [\alpha-\tfrac{1}{2}\beta q-a\ell-c(a)]q.$$

The first-best industry output and accident probability are determined by maximizing (2.3), which will be assumed to have a unique interior maximum, (q^*, a^*). The first-order conditions with respect to q and a are:

$$\text{(2.4)} \qquad \alpha-\beta q^*-a^*\ell = c(a^*),$$

$$\text{(2.5)} \qquad -c'(a^*) = \ell.$$

The first condition states that, given the optimal accident probability, industry output should be expanded until the marginal value to consumers of the last unit, $\alpha-\beta q-a\ell$, equals the cost of producing that unit, $c(a)$. The second condition states that the probability of a product accident should be reduced until the marginal benefit of the reduction in the form of lower expected accident losses, ℓ, equals the marginal cost of the reduction in the form of higher production costs, $-c'(a)$.

It will be useful to provide another interpretation of the optimal probability a^*. First note that the sum of production cost and expected accident loss, $c(a) + a\ell$, can be thought of as the full cost of the good. Thus, choosing an accident probability that maximizes social welfare is equivalent to choosing an accident probability that minimizes the full cost.

3. Accident Probabilities and Industry Outputs

The equilibrium accident probabilities and industry outputs under each of the liability rules will be calculated in the following way. The inverse demand curve and the marginal cost of each firm will first be described. These relationships will then be used to determine each firm's profit as a function of its and other firms' accident probabilities and output decisions. Equilibrium in the market is defined to be a set of output and accident probability choices for each firm such that each firm is maximizing its profits taking the other firms' choices as given.[6]

Strict liability. Under the rule of strict liability, whenever a product failure causes a loss of ℓ dollars to a consumer, the producer must pay that consumer ℓ dollars. Thus, since consumers are fully compensated for their losses, they treat the good as if it were perfectly safe, regardless of their misperceptions. Letting q_j be the quantity chosen by firm j, the aggregate inverse demand is then

$$(3.1) \qquad p = \alpha - \beta \sum_{j=1}^{n} q_j .$$

Each producer's marginal costs now include the expected liability payment:

$$(3.2) \qquad c(a) + a\ell .$$

Thus, firm i's profits are:

$$(3.3) \qquad \pi_i = [p - c(a_i) - a_i \ell] q_i .$$

Substituting (3.1) into (3.3) yields:

(3.4) $$\pi_i = [\alpha - \beta(q_i + \sum_{j \neq i} q_j) - c(a_i) - a_i \ell]q_i.$$

Then firm i, taking all other firms' choices as given, chooses its output, q_i, and its accident probability, a_i, to maximize its profits. This leads to the following first-order conditions:

(3.5) $$q_i = \frac{\alpha - \beta \sum_{j \neq i} q_j - c(a_i) - a_i \ell}{2\beta}$$

(3.6) $$- c'(a_i) = \ell.$$

An analogous set of first-order conditions applies to every other firm in the industry, resulting in 2n equations that must be satisfied in equilibrium. The conditions corresponding to (3.6) imply that each firm chooses its accident probability to minimize its marginal costs (3.2). Since, under strict liability, the firm's marginal costs are the "full costs" of the good, each firm chooses the first-best accident probability:

(3.7) $$a_S = a^*.$$

Now substituting a* for a_i into the conditions corresponding to (3.5) yields n equations in n unknowns. By straightforward manipulation, it can be shown that each firm chooses the same output:7/

(3.8) $$q_i = \frac{1}{(1+n)} \left[\frac{\alpha - c(a^*) - a^* \ell}{\beta} \right].$$

Since there are n firms, industry output under strict liability is:

(3.9) $$q_S = \frac{n}{(1+n)} \left[\frac{\alpha - c(a^*) - a^*\ell}{\beta}\right].$$

It will be useful to compare industry output under strict liability to the first-best level of output. Rewriting (2.4),

(3.10) $$q^* = \frac{\alpha - c(a^*) - a^*\ell}{\beta}.$$

Thus,

(3.11) $$q_S = \frac{n}{(1+n)} q^*.$$

At one extreme--the monopoly case--industry output is half of the first-best output. As the number of firms increases, industry output increases. In the limiting competitive case, industry output equals the first-best level.

Thus, the problem under strict liability is not with the safety levels chosen by firms, but with the restriction of output due to market power.

Negligence. Under the negligence rule, firms have to pay damages only if they do not meet some standard of care. This standard corresponds in the present context to a particular accident probability. A frequently cited legal principle for determining the standard of care is the "Learned Hand rule," which can be interpreted as requiring that the standard be set so as to minimize the sum of the cost of taking care and expected accident losses.[8] In accordance with this principle, it will be assumed that the standard of care is set equal to the accident probability that minimizes the full cost of the good--the first-best accident probability, a^*.

The inverse demand curve under negligence can be determined as follows. If firm i chooses its accident probability a_i at or below a*, then consumers bear their own losses and the price they are willing to pay for firm i's product will reflect this. If a_i is above a*, firm i is liable for consumers' losses, so consumers will treat the good as if it were perfectly safe. Thus, the demand faced by firm i is:

$$(3.12)\qquad p_i = \begin{cases} \alpha - \beta \sum_{j=1}^{n} q_j - (1-\lambda)a_i\ell, & a_i \leqq a^*, \\ \alpha - \beta \sum_{j=1}^{n} q_j, & a_i > a^*. \end{cases}$$

Similarly, firm i's marginal costs, including possible liability payments, are:

$$(3.13)\qquad \begin{cases} c(a_i), & a_i \leqq a^*, \\ c(a_i) + a_i\ell, & a_i > a^*. \end{cases}$$

Thus, firm i's profits are:

$$(3.14)\qquad \pi_i = \begin{cases} [\alpha - \beta(q_i + \sum_{j\neq i} q_j) - c(a_i) - (1-\lambda)a_i\ell]q_i, & a_i \leqq a^* \\ [\alpha - \beta(q_i + \sum_{j\neq i} q_j) - c(a_i) - a_i\ell]q_i, & a_i > a^*. \end{cases}$$

It can be shown that all firms will choose to just meet the standard of care a*.[9/] After substituting a* for a_i in (3.14), equilibrium industry output can be derived as under strict liability. The end result is that:

(3.15) $a_N = a^*,$

and

(3.16) $$q_N = \frac{n}{(1+n)} \left[\frac{\alpha - c(a^*) - (1-\lambda)a^*\ell}{\beta} \right].$$

Under both negligence and strict liability, firms choose the first-best accident probability. Thus, the only effect of moving from strict liability to negligence is to shift the resulting expected accident losses from producers to consumers. The consequence of this can be seen by comparing (3.16) to (3.9), the corresponding condition for industry output under strict liability; the only difference is that under negligence consumers' perceived expected losses, $(1-\lambda)a^*\ell$, are substituted for the actual expected losses, $a^*\ell$. Since consumers underestimate accident losses, they buy more under negligence than under strict liability:

(3.17) $q_N > q_S.$

No liability. Under the rule of no liability, since consumers bear all product losses, the demand faced by firm i is:

(3.18) $$p_i = \alpha - \beta \sum_{j=1}^{n} q_j - (1-\lambda)a_i\ell,$$

and firm i's marginal costs are $c(a_i)$.

By a derivation similar to that under strict liability and negligence, it is straightforward to show that the accident probability chosen by each firm under no liability satisfies

$$-c'(a_0) = (1-\lambda)\ell. \tag{3.19}$$

In other words, firms provide safety until the marginal cost of increased safety equals the perceived marginal benefit of increased safety. Equivalently, firms choose the accident probability a_0 to minimize the perceived full cost, $c(a) + (1-\lambda)a\ell$. This is not surprising since, under no liability, consumers' demand for the good is based on their perceived accident losses.

Because the accident probability under no liability minimizes perceived full cost and the first-best accident probability minimizes actual full cost, the two probabilities are in general different. In fact, since $c'' > 0$, a comparison of (3.19) and (2.5) shows that:

$$a_0 > a^*. \tag{3.20}$$

This result can be explained as follows. Suppose under no liability firms chose the first-best accident probability. By definition, a small increase in the probability would lower production costs by an amount just equal to the increase in actual expected accident losses. However, since consumers' perceptions are assumed to be unresponsive to changes in the true accident probability, consumers perceive a smaller increase in expected accident losses. Thus, it is profitable for firms to raise the probability.

Industry output under no liability can be derived in a manner similar to the previous cases:

$$(3.21) \qquad q_0 = \frac{n}{(1+n)} \left[\frac{\alpha - c(a_0) - (1-\lambda)a_0\ell}{\beta} \right].$$

A comparison of (3.21) to (3.16), the corresponding result under negligence, shows that different industry outputs under no liability and negligence arise solely because different accident probabilities are chosen. Since a_0 minimizes $c(a) + (1-\lambda)a\ell$, industry output under no liability exceeds that under negligence:

$$(3.22) \qquad q_0 > q_N.$$

This can be explained in the following way. Under both negligence and no liability, consumers bear their own losses. Under no liability, firms have an incentive to choose the accident probability which minimizes the <u>perceived</u> full cost of the good--the production cost plus perceived expected accident losses. Under negligence, however, firms are induced by the standard of care to choose the first-best accident probability, which results in a higher <u>perceived</u> full cost. Thus, consumers buy less under the negligence rule.

The results of this section can be summarized as follows:

$$(3.23) \qquad a_0 > a^* = a_S = a_N ,$$

$$(3.24) \qquad q_0 > q_N > q_S ,$$

and

$$(3.25) \qquad q^* \geqq q_S ,$$

where the equality in (3.25) occurs only when market power is zero. Under strict liability, the accident probability is the first-best one despite consumer misperceptions because firms are forced to pay for all of their damages; industry output is below the first-best level when there is market power. Under negligence, firms meet the standard of care corresponding to the first-best accident probability, so consumers bear their own losses. Since consumers underestimate the expected losses, they view the full cost of the good as less than under strict liability and consequently buy more. Under no liability, firms have an incentive to increase the accident probability above the first-best level because consumers also underestimate the increase in expected losses. Since consumers then view the full cost of the good as less than under negligence, they buy even more.

4. Welfare Analysis I

As noted in the introduction, previous authors have analyzed product liability remedies when, alternatively, producers have no market power or consumers are perfectly informed. It will be useful to reproduce versions of their results within our model before considering the more general case when both market power and misperceptions occur.

Proposition 1: When there are consumer misperceptions but no market power, strict liability is the preferred remedy and leads to the first-best accident probability and industry output.

Proof: It is easy to see from section 3 that the limiting values of the accident probabilities and industry outputs as n goes to infinity have the following relationships:

(4.1) $$a_0 > a^* = a_S = a_N,$$

and

(4.2) $$q_0 > q_N > q_S = q^*.$$

Q.E.D.

To understand this result, recall from section 3 that the only possible problem with strict liability is that industry output might be too low because of market power. But when there is no market power, industry output equals the first-best output. However, under negligence and no liability, larger output levels are generated by consumer misperceptions, as is an excessive accident probability under no liability.

<u>Proposition</u> <u>2</u>: When there is market power but no consumer misperceptions, all three remedies are equally desirable and lead to the first-best accident probability but to too little industry output.

<u>Proof</u>: It is straightforward to show from section 3 that when $\lambda = 0$ the accident probabilities and industry outputs have the following relationships:

$$a_0 = a_N = a_S = a^*, \tag{4.3}$$

and

$$q^* \geqq q_0 = q_N = q_S, \tag{4.4}$$

where the first equality in (4.4) occurs only when market power is zero.

Q.E.D.

The explanation of this result is as follows. Because there are no consumer misperceptions, the incentive for firms to choose too large an accident probability under no liability disappears. Thus, all three remedies lead to the first-best accident probability. Given the same accident probabilities and no misperceptions, the full cost of the good is viewed as the same under all three remedies. Thus, industry output is the same. When there is market power, this output is less than the first-best output.

For reasons mentioned in the introduction, it does not follow from the preceding propositions that strict liability is the preferred remedy when both market power and consumer misperceptions occur together. In general, any of the three remedies might be the preferred one. The combinations of market power and misperceptions for which each of the remedies is preferable are characterized in Propositions 3 and 4 below.

The results of these propositions are summarized in Figure 1. Recall that the measure of market power, m, is the reciprocal of the number of firms, 1/n. As drawn, the line separating the strict liability and negligence areas intersects the right-hand boundary. Therefore, for any degree of consumer misperceptions, negligence is preferable to strict liability if market power is high enough. However, depending on the parameters of the problem, the separation line may intersect the upper boundary. Then, of course, for some levels of consumer misperceptions, strict liability is preferred at all levels of market power. The line in Figure 1 labelled the "optimal negligence line"--defined below--also may intersect the right-hand boundary or the upper boundary.

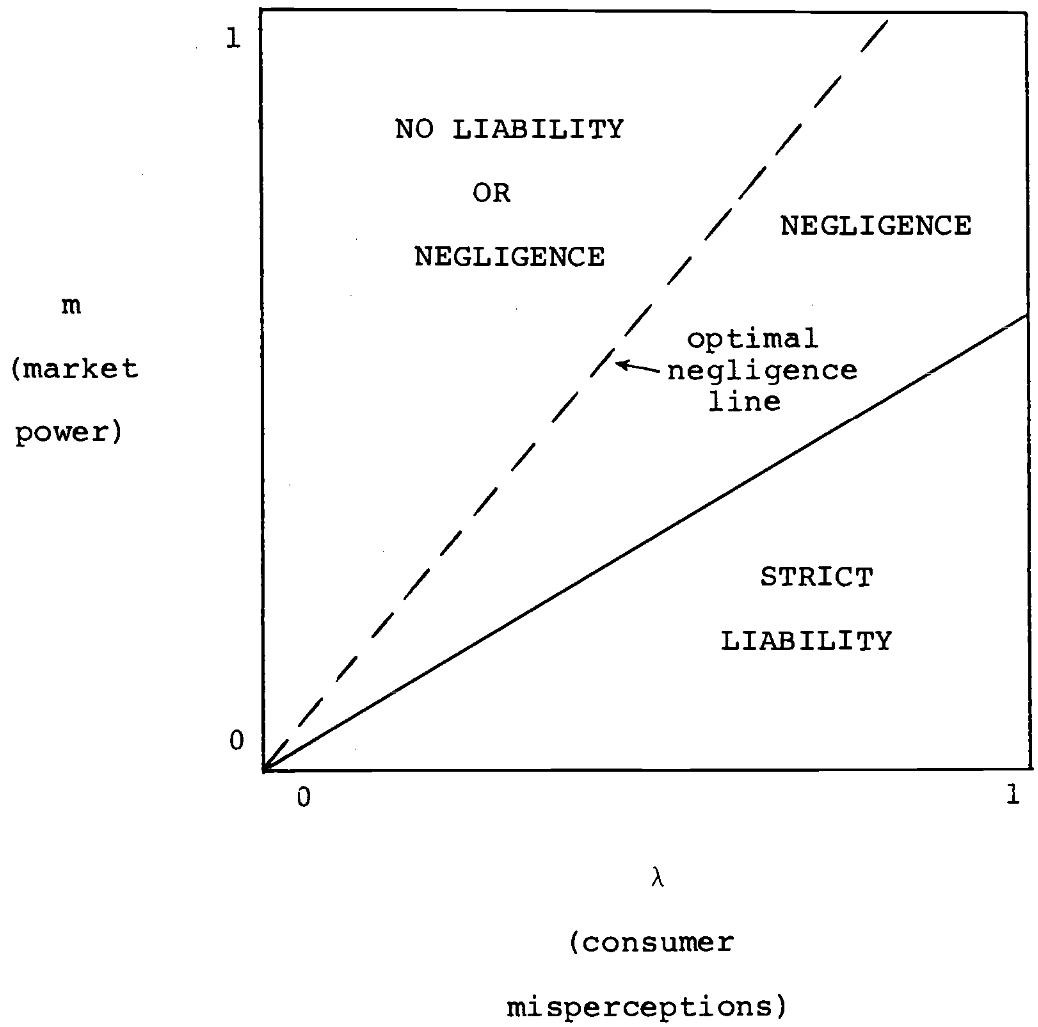
Proposition 3: Given positive consumer misperceptions, $\lambda > 0$, there exists a positive level of market power, $m > 0$, below which strict liability is preferred to negligence and above which negligence is preferred to strict liability. This level of market power increases linearly with misperceptions (unless it has reached the maximum value of one).

Proof: To determine social welfare under strict liability, W_S, substitute the accident probability (3.7) and industry output (3.9) under this remedy into the social welfare function (2.3). Social welfare under negligence, W_N, is determined similarly. It is then straightforward to show that:

(continued on p. 19)

FIGURE 1

WELFARE ANALYSIS I



Note: When $\lambda = 0$, all three remedies are equivalent regardless of the degree of market power; see section 4.

$$(4.5) \qquad W_N \gtreqless W_S \text{ as } m \gtreqless \left[\frac{a^*\ell}{2(\alpha - c(a^*) - a^*\ell)}\right]\lambda.$$

Q.E.D.

To understand this result, first recall that strict liability and negligence lead to the same accident probabilities. Therefore, the only basis for preferring one or the other is differences in industry output. Because of consumer misperceptions, output under negligence exceeds that under strict liability. When market power is zero, strict liability leads to the first-best output and thus negligence leads to excessive output. However, if market power is sufficiently high and output under strict liability therefore falls enough, the larger output under negligence will be desirable. Since greater misperceptions lead to a greater increase in output under negligence relative to strict liability, greater market power is then required before negligence is preferable.

Before continuing, it will be useful to define what is referred to in Figure 1 as the optimal negligence line. This line determines, for each level of consumer misperceptions, the level of market power at which social welfare under the negligence rule is highest. When market power is zero, recall that output under negligence exceeds the first-best level. As market power increases, output under negligence decreases. At some level of market power, it may equal the first-best output. If so, this level of market power is on the optimal negligence line. If output under negligence has not yet fallen to the first-best level when market power is one, then this level of market power is on the optimal negligence line.

It is straightforward to show that the optimal negligence line is above the line separating the strict liability and negligence areas--in fact, it has twice the slope.[10/] The reason why it is above the line separating strict liability and negligence is as follows. When market power is zero, strict liability output equals the first-best output and negligence output exceeds the first-best output. As market power increases, output levels under both remedies decrease and the advantage of strict liability over negligence therefore decreases. When the level of market power reaches the level defined by the optimal negligence line, negligence output is first-best and strict liability output is too small. Thus, the switch from strict liability to negligence must have occurred at a lower level of market power.

<u>Proposition 4</u>: Given positive consumer misperceptions, there exists a positive level of market power at and below which negligence is preferred to no liability and above which either no liability or negligence may be preferred. This level of market power is defined by the optimal negligence line.

<u>Proof</u>: For a given $\lambda > 0$, suppose m is less than or equal to the level of market power defined by the optimal negligence line. Therefore, $q_N \geq q^*$. It is always true that $q_0 > q_N$. Thus, since $\partial^2 W/\partial q^2 = -\beta < 0$,

(4.6) $$W(q_N, a_N) > W(q_0, a_N).$$

Recall that $a_0 > a_N = a^*$. Note that a^* maximizes $W(q,a)$ for any q. Thus, since $\partial^2 W/\partial a^2 = -c''(a)q < 0$,

(4.7) $$W(q_0, a_N) > W(q_0, a_0).$$

It follows from (4.6) and (4.7) that $W_N > W_0$. Since this holds on the optimal negligence line, by continuity it also holds for values of m just above the line. An example in which $W_0 > W_N$ for some values of m above the optimal negligence line is provided in section 5 below.

Q.E.D.

This result should not be surprising. When market power is below the level corresponding to the optimal negligence line, negligence output exceeds the first-best output. Under no liability, output is even larger. Since the accident probability under no liability exceeds the probability under negligence--which equals the first-best probability--no liability is worse than negligence on both accounts. When market power is above the optimal negligence line, negligence output is below the first-best output, so that the increased output under no liability may make it the preferred remedy.

The results of Propositions 3 and 4 together provide a more complete ranking of the remedies for various combinations of consumer misperceptions and market power. Below the line separating strict liability and negligence defined by Proposition 3, strict liability dominates both other remedies--it dominates negligence by Proposition 3, and negligence dominates no liability by Proposition 4. Above this line but below the optimal negligence line, negligence is the preferred remedy--it dominates strict liability by Proposition 3 and it dominates no liability by Proposition 4. Above the optimal negligence line, either negligence or no liability may be the preferred remedy--strict liability is inferior to negligence by Proposition 3.

5. Welfare Analysis II

Without more specific assumptions, nothing further can be stated about the choice between negligence and no liability above the optimal negligence line. By providing two examples, this section first shows that there may be a region in which no liability is the preferred remedy, and then shows that no liability may never be the preferred remedy.

The intuition that motivates these examples is as follows. Both remedies determine social welfare through their effects on the accident probability and industry output. With respect to the accident probability, negligence is preferable since it leads to the first-best outcome. With respect to output, no liability may be preferable since, above the optimal negligence line, output under negligence is less than the first-best level and output under no liability is greater than under negligence. In the two examples considered in this section only industry output or only the accident probability affects social welfare. When only industry output matters, no liability may be preferred; when only the accident probability matters, negligence is preferred.

In the first example, it will be assumed that the accident probability does not directly affect social welfare. This means that the full cost of the good is constant, i.e., it does not vary with the accident probability:

$$(5.1) \qquad c(a) + a\ell = k,$$

where k is some positive constant. Obviously, in this example, all accident probabilities are equally desirable.

Under the negligence rule, let $\bar{a} < 1$ be an arbitrarily chosen accident probability used as the standard of care. It is easily shown that firms will choose to just meet this standard:11/

(5.2) $\quad a_N = \bar{a}.$

Thus, industry output under negligence is:

(5.3) $$q_N = \frac{n}{1+n}\left[\frac{\alpha - c(\bar{a}) - (1-\lambda)\bar{a}\ell}{\beta}\right] = \frac{n}{1+n}\left[\frac{\alpha - k + \lambda\bar{a}\ell}{\beta}\right].$$

Under the no liability rule, the accident probability selected by firms minimizes perceived full costs:

(5.4) $\quad c(a) + (1-\lambda)a\ell = k - \lambda a\ell.$

Since perceived full costs decline with a,

(5.5) $\quad a_0 = 1.$

Thus, industry output under no liability is:

(5.6) $$q_0 = \frac{n}{1+n}\left[\frac{\alpha - c(a_0) - (1-\lambda)a_0\ell}{\beta}\right] = \frac{n}{1+n}\left[\frac{\alpha - k + \lambda\ell}{\beta}\right].$$

Given the accident probabilities and industry outputs under negligence and no liability, social welfare for each remedy can be determined by (2.3). A comparison of these values leads to the conclusion that:

(5.7) $$W_0 \gtreqless W_N \text{ as } m \gtreqless \left[\frac{(1+\bar{a})\ell}{2(\alpha-k)}\right]\lambda,$$

where, recall, $m = 1/n$. Note in particular that if consumer misperceptions are sufficiently small, there are levels of market power such that no liability is the preferred remedy.

Figure 2 illustrates this result, as well as the results of section 4 in the context of this example.[12/]

The simplifying assumption in the preceding example was that full costs were constant. This was inessential; by continuity, a region in which no liability is preferred will still exist if there is a unique minimum to full costs as long as full costs are "close" to being constant. The negligence standard $\bar{a}$ would then be assumed to be the accident probability that minimizes full costs.[13/]

In the second example--which will show that no liability may never be the preferred remedy--it will be assumed that the demand curve is perfectly inelastic and given by:

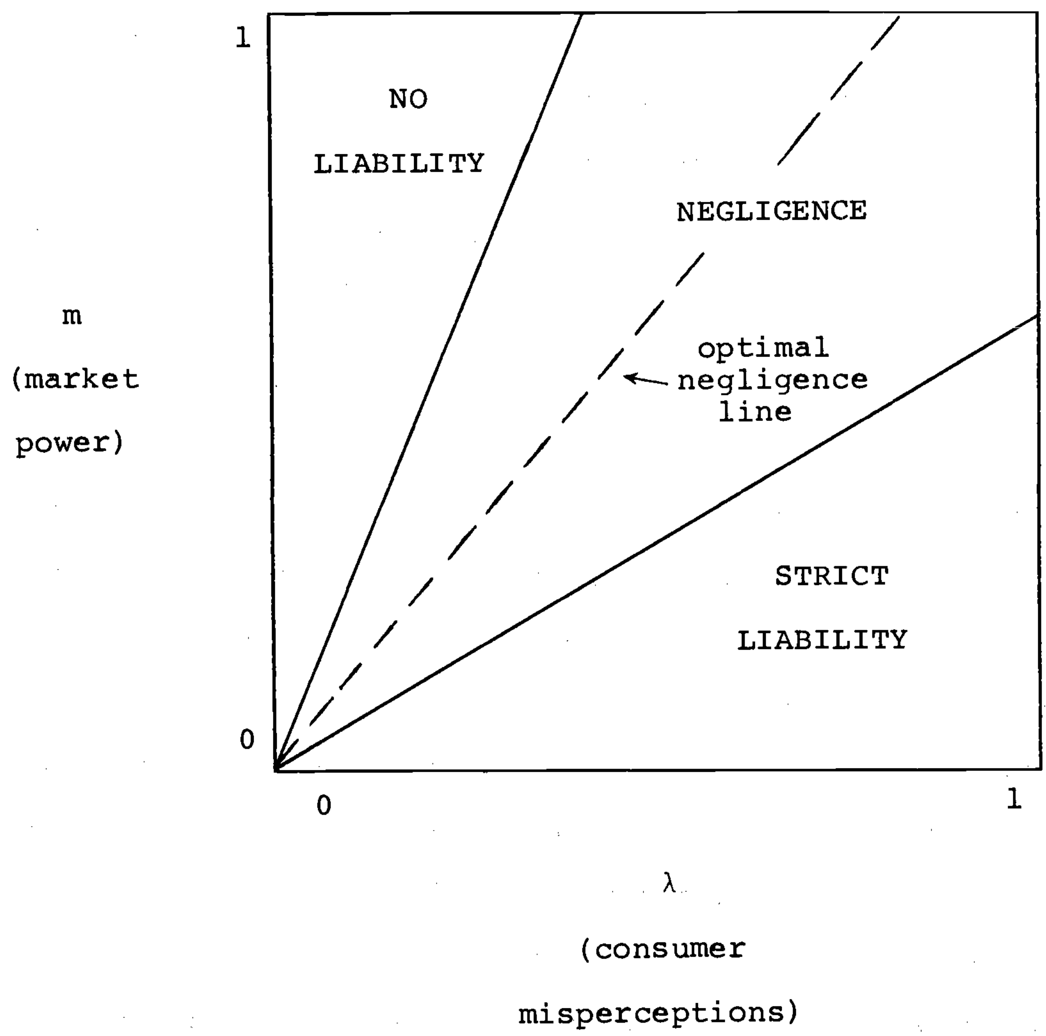
$$(5.8) \qquad p = \begin{cases} \bar{p}, & q \leq \bar{q}, \\ 0, & q > \bar{q}, \end{cases}$$

where $\bar{q}$ is some positive output and $\bar{p}$ is some positive price exceeding full cost at the first-best accident probability.

Under the negligence rule with the standard of care corresponding to the first-best accident probability, firms will choose this probability, a*, and industry output will be $\bar{q}$ for any level of market power.[14/] Under no liability, firms will choose an accident probability, a_0, greater than a* because of consumer misperceptions, and industry output will be $\bar{q}$ regardless of market power.[15/] Since industry output is the same under both remedies but the accident probability is first-best only under negligence, negligence is preferred to no liability for all positive levels of consumer misperceptions and any level of market power.

FIGURE 2

WELFARE ANALYSIS II



Note: When $\lambda = 0$, all three remedies are equivalent regardless of the degree of market power; see section 4.

6. A Numerical Example

This section presents a numerical example which illustrates the results of the previous two sections and shows that the various product liability remedies may result in substantially different levels of social welfare. For this example, let the demand for a perfectly safe good be

$$p = 250 - .001q, \tag{6.1}$$

let the loss from a product accident be

$$\ell = 500, \tag{6.2}$$

and let the cost of production be

$$c(a) = 10 - 50\log(a). \tag{6.3}$$

The first-best accident probability and industry output are then .1 and 124,850. This leads to a production cost of 125.15, an expected accident cost of 50, and therefore a full cost of 175.15. At the first-best output, the elasticity of demand is -2.34.

Table 1 summarizes the welfare results for this example. For combinations of consumer misperceptions and market power below the heavy line, strict liability is the preferred remedy. For combinations above it, negligence is preferred. In this example, no liability is never the preferred remedy. Each box in the table presents the percentage loss in welfare from using the next most preferred remedy and the least preferred remedy, where S, N, and 0 stand for strict liability, negligence, and no liability.

TABLE 1

NUMERICAL EXAMPLE

Percentage Welfare Loss from Using Less Preferred Remedies

(S = strict liability, N = negligence, O = no liability)

market power

m \ λ	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
1.0	0<1 S=4	0=2 S=8	0=5 S=11	0=13 S=13	S=16 0=29	S=18 0=63	S=19 0>99	S=21 0>99	S=22 0>99	S=23 0>99
.9	0<1 S=4	0=2 S=7	0=6 S=10	S=13 0=14	S=15 0=31	S=17 0=66	S=18 0>99	S=19 0>99	S=20 0>99	S=21 0>99
.8	0<1 S=4	0=2 S=7	0=6 S=10	S=12 0=15	S=14 0=32	S=16 0=69	S=17 0>99	S=18 0>99	S=19 0>99	S=19 0>99
.7	0<1 S=4	0=2 S=7	0=6 S=9	S=11 0=15	S=13 0=34	S=14 0=73	S=15 0>99	S=16 0>99	S=17 0>99	S=17 0>99
.6	0<1 S=3	0=2 S=6	0=7 S=8	S=10 0=16	S=12 0=36	S=13 0=78	S=13 0>99	S=14 0>99	S=14 0>99	S=14 0>99
.5	0<1 S=3	0=2 S=5	0=7 S=7	S=9 0=18	S=10 0=39	S=11 0=84	S=11 0>99	S=11 0>99	S=11 0>99	S=10 0>99
.4	0<1 S=3	0=3 S=5	S=6 0=8	S=7 0=19	S=8 0=43	S=8 0=92	S=8 0>99	S=7 0>99	S=6 0>99	S=5 0>99
.3	0=1 S=2	0=3 S=4	S=5 0=9	S=5 0=22	S=5 0=48	S=5 0>99	S=4 0>99	S=2 0>99	N<1 0>99	N=3 0>99
.2	0=1 S=2	S=2 0=3	S=3 0=10	S=2 0=24	S=2 0=54	N<1 0>99	N=2 0>99	N=5 0>99	N=9 0>99	N=13 0>99
.1	0=1 S=1	S=1 0=4	N<1 0=12	N=1 0=30	N=4 0=65	N=7 0>99	N=10 0>99	N=15 0>99	N=20 0>99	N=26 0>99
.0	N<1 0=1	N=2 0=6	N=4 0=18	N=7 0=40	N=11 0=81	N=16 0>99	N=22 0>99	N=29 0>99	N=36 0>99	N=45 0>99

consumer misperceptions

Note: Below the dark line, strict liability is the preferred remedy; above it, negligence is preferred.

When there are no consumer misperceptions, recall from Proposition 2 that the three remedies are equally desirable. It is therefore not surprising to see in Table 1 that when misperceptions are low, the welfare loss from using the wrong remedy is small. For example, when $\lambda = .1$, the loss never exceeds 4 percent. When misperceptions are large, the welfare loss from using the wrong remedy is substantial. For example, when $\lambda = 1.0$, the loss from using even the next-best remedy may be as high as 45 percent. Over a broad range of intermediate levels of misperceptions, the welfare loss from using the second-most preferred remedy ranges from 5 to 15 percent. For example, when $\lambda = .5$ and $m = .5$, there is a 10 percent loss from using strict liability rather than negligence.

7. Overestimates of the Accident Probability

The model of this paper can easily be used to analyze product liability rules when consumers overestimate the probability of an accident. In this case,[16/]

$$(7.1) \qquad a_0 > a^* = a_S = a_N,$$

and

$$(7.2) \qquad q^* \geqq q_S > q_0 > q_N,$$

where the equality in (7.2) occurs only when market power is zero.

Under strict liability, the accident probability is first-best and industry output is too low to the extent that there is market power for reasons already discussed. Under negligence, the accident probability is also the first-best one for reasons already discussed. However, because consumers now overestimate the expected losses that remain, the output of the industry is less than under strict liability. Under no liability, the accident probability exceeds the first-best level for reasons already discussed.[17/] Output is less than under strict liability for essentially the same reason as under negligence--consumers view the full cost of the good as higher than it actually is and therefore buy less. Output is greater under no liability than under negligence because only under the former rule do firms minimize the perceived full cost of the good.

Thus, when consumers overestimate the accident probability, strict liability is the preferred rule regardless of the degree of consumer misperceptions and market power. Strict liability leads to the first-best accident probability, but to too little output whenever there is any market power. Both negligence and no liability worsen the problem of restricted output, and no liability also leads to an excessive accident probability.

Note, however, that when consumers overestimate the accident probability, it may not be necessary to impose strict liability on producers. Presumably producers would voluntarily assume full liability through product warranties since consumers would be willing to pay more than the actual cost of providing the warranty.[18/]

8. Concluding Remarks

This section discusses several extensions and interpretations of the analysis:

(1) If consumers are risk averse and do not have insurance for product accidents, the effects of product liability rules on risk bearing must also be taken into account. Assuming that firms are risk neutral (or less risk averse than consumers), then strict liability is preferable to both negligence and no liability in this regard. Thus, strict liability will be the preferred remedy for a wider range of consumer misperceptions and market power than in the risk neutral case.

(2) It was implicitly assumed in the model that the consumer could not affect the probability of a product accident. Allowing for this possibility does not change the comparison between strict liability and negligence provided that a defense of contributory negligence is included with both rules and consumers meet the corresponding standard of care in order to avoid being contributorily negligent. In other words, if consumers choose the same level of care under strict liability and negligence, the comparison of these rules is unaffected. It is not clear whether the rule of no liability will become more or less desirable relative to the other rules when consumers can affect the accident probability.

(3) The results of the paper can be applied directly to situations in which the victim of the product accident is a third party rather than a consumer of the product. It is

easy to see that this situation is equivalent to the case in which the consumer is the victim and completely underestimates the accident probability.

Recall that, as consumer misperceptions increase, strict liability becomes the preferred remedy over a wider range of market power (see Figure 1). Thus, strict liability is more likely to be the preferred remedy in situations in which the victim is a third party.

(4) The analysis of this paper also can be applied to situations in which employees are exposed to workplace accidents and the supply of labor is competitive. Under this interpretation, employees are substituted for consumers and the employees' wage rate is substituted for the price paid by consumers. Lower wages correspond to higher prices.

If firms have market power in the labor market, then the results of the paper apply immediately. For example, if firms are strictly liable to employees for workplace accidents, then firms will choose the first-best level of workplace safety but will purchase less than the first-best amount of labor. However, if firms are liable only if negligent and employees underestimate the accident probability, firms will still choose the correct level of safety but will now purchase more labor, which could be welfare-improving.

If firms have market power in the product market, then results analogous to those in the paper occur. For example, it may be preferable to use negligence rather than strict liability to control workplace accidents in order to reduce the price of labor and thus increase output in the product market.

(5) The social welfare function used in this paper did not take into account the distribution of total welfare between producers and consumers. It is straightforward to show that when consumers underestimate the accident probability, producers' profits rise as the product liability rule is changed from strict liability to negligence, and from negligence to no liability, and that consumers' surpluses fall with these changes. Thus, if distributional considerations are thought to be important, the conclusions of this paper might have to be modified.

Footnotes

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1) The results of Epple and Raviv (1978, pp. 83-87) that are relevant to the present discussion are the ones when consumers can purchase actuarially fair insurance (or are risk neutral). Although Hamada (1976) and Epple and Raviv (1978) also consider consumer misperceptions, they do not analyze the effects of misperceptions and market power simultaneously.

2) To our knowledge, the general idea that it might be desirable not to place the full costs of accidents on monopolized industries was first suggested by Calabresi (1961, pp. 507-14). For a related discussion, see Shapiro (1982).

3) The qualitative results of the model remain true for any downward-sloping demand curve.

4) The basic results of the paper--those in sections 3 and 4--hold for any perception function $\gamma(a)$ characterized by underestimation, $\gamma(a) < a$, and unresponsiveness, $0 \leqq \gamma'(a) < 1$.

(For the propositions in section 4, the measure of misperceptions would then be $\lambda = (a^* - \gamma(a^*))/a^*$, where a^* is defined by (2.5) below.) It is only when analytical examples are constructed in section 5 and when the numerical example is computed in section 6 that the assumption that $\gamma(a) = (1-\lambda)a$ is useful. For consistency, this form is maintained throughout the paper.

5) This assumption implies that, given a level of consumer misperceptions, the level of market power does not affect the firm's choice of the accident probability; see section 3. In general, market power might affect the choice of the probability for reasons discussed, for example, by Spence (1975, pp. 417-22).

6) It will be seen below that under this definition of equilibrium, industry output increases from the monopoly level to the competitive level as the number of firms increases. Any equilibrium concept with this property would generate the results of this paper.

7) The n equations in n unknowns $(q_1, \ldots, q_n)$ can be rewritten as

$$q_i = \frac{\alpha - \beta \sum_{j=1}^{n} q_j - c(a^*) - a^*\ell}{\beta}, \quad i = 1,\ldots,n.$$

Since the right-hand-sides of each equation are identical, q_i must be the same for all i in any solution. Let q_i be this common value. Substituting q_i for each firm's quantity in the n equations above yields (3.8).

8) See, for example, Brown (1973, pp. 331-35).

9) From (3.14), firm i maximizes its profits for any $(q_1, \ldots, q_n)$ by choosing a_i to minimize

$$\begin{cases} c(a_i) + (1-\lambda)a_i\ell, & a_i \leqq a^*, \\ c(a_i) + a_i\ell, & a_i > a^*. \end{cases}$$

In other words, firm i minimizes the sum of production costs and "relevant" expected accident losses, where the relevant losses are the consumers' perceived losses when they bear their own losses and the actual losses when firm i bears the losses. This sum has its minimum at a* for the following reasons. It is decreasing up to and including a* because, as shown in the discussion of no liability later in this section, the minimum of $c(a) + (1-\lambda)a\ell$ occurs at a higher probability than a*. It is rising beyond a* because the minimum of $c(a) + a\ell$ occurs at a*. Since $c(a^*) + (1-\lambda)a^*\ell < c(a^*) + a^*\ell$, the result follows.

10) Industry output under negligence, q_N, is given by (3.16) as a function of consumer misperceptions, λ, and market power, m (by substituting 1/m for n). The optimal negligence line is determined by setting q_N equal to q* and solving for m as a function of λ:

$$m = \left[\frac{a^*\ell}{(\alpha - c(a^*) - a^*\ell)}\right]\lambda.$$

11) The argument is virtually identical to that discussed in note 9 above.

12) In this example, the optimal negligence line is:

$$m = \left[\frac{\bar{a}\ell}{\alpha - k} \right] \lambda.$$

Since $\bar{a} < 1$, this line is flatter than the line separating the no liability and negligence regions defined in (5.7). The line separating the negligence and strict liability regions has half the slope of the optimal negligence line.

13) For example, let $\bar{a}$ be any accident probability between zero and one. Assume that full cost at $\bar{a}$ is $k - \varepsilon$ for some $\varepsilon > 0$, that full cost at probabilities of zero and one is k, and that full cost at other probabilities is determined by joining these three points with two straight lines. Then for any combination of λ and m such that $W_0 > W_N$ in the example in the text, it is easy to see that this welfare ranking is preserved for sufficiently small ε.

14) Industry output will be $\bar{q}$ in equilibrium for the following reasons. Consider the output decision of an arbitrarily selected firm. It views the aggregate output of the other firms, $\hat{q}$, as fixed. If $\hat{q} < \bar{q}$, this firm can increase its profits by expanding its output until industry output equals $\bar{q}$. If $\hat{q} \geqq \bar{q}$, this firm will produce nothing since the price would be zero if it produced any positive quantity. Other firms will make the same decision until industry output falls to $\bar{q}$.

15) Industry output will be $\bar{q}$ for the reasons discussed in the previous footnote.

16) These results follow from the analysis in section 3 with a perception function $\gamma(a)$, substituted for $(1-\lambda)a$, having the properties of overestimation, $\gamma(a) > a$, and unresponsiveness, $0 \leqq \gamma'(a) < 1$.

17) Recall that this follows from the unresponsiveness of perceptions.

18) For a discussion of voluntary product warranties which complements the present analysis, see Courville and Hausman (1979). In their model, when consumers overestimate the accident probability, warranty coverage is complete and producers provide the optimal level of reliability. When consumers underestimate the accident probability, warranty coverage is incomplete and the level of reliability is not optimal. They show that these results do not depend on whether the product market is competitive or monopolistic.