# Product Liability, Entry Incentives and Industry Structure

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**Abstract**

Numerous studies suggest that increasing producer liability in hazardous sectors stimulates small firm entry as incumbent firms divest risky activities. This paper considers the effect of increased producer liability in a fully-capitalized industry and shows that the effect on industry structure depends on the shape of the marginal injury relationship.

## I. Introduction

A great deal of debate has centered on the relationship between liability and industry structure. In an important paper, Ringleb and Wiggins (1990) examine a large number of hazardous product industries and find that increasing product liability is associated with the entry of small firms. The mechanism by which this occurs, they assert, is that liability rules create an incentive for large, incumbent firms to avoid paying damages by vertically divesting risky activities. Such divestiture is liability reducing when small firms conducting the risky task have insufficient assets to pay damages and declare bankruptcy when suits are filed or, in the case of latent harm, exit the industry before injury emerges.[1]

This paper considers entry incentives created in an industry by an increase in producer liability. The analysis concludes that while Ringleb and Wiggins' empirical observations may be sound, incomplete capitalization and vertical divestiture are not the only possible motivations for changes in market structure following increases in producer liability. Our results indicate that an incentive for divestiture is sufficient but is not necessary for liability to increase the market share of small firms. In this regard, the paper suggests that the effects of product liability on market structure are even more pervasive than previous analyses indicate.

We base our observations on an oligopoly model with asymmetric costs, endogenous entry and complete capitalization. The model employs a general specification of liability that incorporates several commonly used rules as special cases. Utilizing this framework, we explore the marginal effects of an increase in liability on several indicators of industry structure: output per firm (for various cost types), total industry output, small firm entry and small firm market share. In particular, we demonstrate that small firm entry is a likely result of increased producer liability when marginal injury is increasing in the level of industry output, even when divestiture incentives do not exist. The intuition is straightforward. If marginal harm is increasing in output, producer liability shifts the marginal benefit schedule of each incumbent firm downward, but also makes it more inelastic. Imposing producer liability in an industry with increasing marginal damages may thus increase the equilibrium price-cost margin and create an incentive for small firms to enter. The well-known empirical finding that an increase in producer liability precedes small firm entry can therefore be explained by more than simply divestiture incentives or incomplete capitalization in an industry.

The rest of the paper is organized as follows. Section II develops the basic liability model and discusses its relation to other models of oligopoly and to other models commonly used in the liability literature. Section III presents the marginal analysis and derives the impacts of an increase in liability on output levels and entry incentives. In Section IV, we highlight the importance of the damage function for the comparative statics results. In particular, we emphasize the heretofore unrecognized point that entry incentives depend on the sign of the marginal injury relationship. Section V contains concluding comments.

## II. The Model

We consider a Cournot oligopoly with endogenous entry as in Besley (1989), Konishi (1990), and Seade (1980a). The model distinguishes between small, high-cost firms and

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[1] Another analysis based on incomplete capitalization is Boyd and Ingberman (1994).

large, relatively cost-efficient firms on the basis of differences in marginal production costs as in Dierickx et al. (1988) and Kimmel (1992).

Denote the initial number of firms producing in equilibrium as $N = m + n$, where $m$ is the number of homogeneous low-cost firms, each with the cost function $c^l(y^l)$, and $n$ is the number of homogeneous high-cost firms, each with cost function $c^h(y^h)$. The output of a representative firm of each type is denoted $y^l$ and $y^h$, respectively, for the low- and high-cost firm. All firms maximize profit with respect to output; consumer and worker safety considerations are suppressed by limiting attention to unavoidable portions of liability exposure.

All firms in the industry are assumed to be fully capitalized. The expected liability from hazardous production is modeled as a function of total industry output, as in the case of common pool environmental health risks. The profit of each firm is

$$\pi^i = \left[P(Y) - g(Y)\right]y^i - c^i(y^i) - F^i ,\ i = (l,h) ,$$

where $Y = my^l + ny^h$, $P(Y)$ is the inverse demand function, and $g(Y)$ is marginal per-unit liability. This framework incorporates common liability rules and a special case of the model occurs when each firm's liability is determined solely by its own output.

We describe the relative efficiency of a representative firm in each sub-group as follows: Firm $l$ is more efficient than firm $h$ whenever

$$\left.\frac{dc^l(y^l)}{dy^l}\right|_{y^{l*}} < \left.\frac{dc^h(y^h)}{dy^h}\right|_{y^{h*}} . \qquad \text{(C1)}$$

Condition (C1) states that the marginal cost of the representative low-cost producer is less than the marginal cost of a high-cost producer at the respective equilibrium output levels. Also, to derive the comparative statics effects of a change in liability structure, we define the efficiency of low- and high-cost firms with respect to marginal changes in output. Specifically, we wish to eliminate from consideration the somewhat unusual case in which a small, high-cost firm has a higher marginal cost of production that the representative low-cost firm, yet has a greater capacity to expand production. That is, while we do not wish to excessively restrict the model by expressing the difference in efficiency in a global sense, it is important maintain the identity of high- and low-cost firms by assuming that large, low-cost firms have greater scale economies than small, high-cost firms. The following condition represents the case in which low-cost firms have a cost advantage for a marginal expansion of output:

$$\left.\frac{\partial^2 c^l(y^l)}{\partial (y^l)^2}\right|_{y^{l*}} \leq \left.\frac{\partial^2 c^h(y^h)}{\partial (y^h)^2}\right|_{y^{h*}}. \tag{C2}$$

Condition (C2) states that a marginal expansion of output does not raise the marginal cost function of a low-cost firm by more than that of a high-cost firm. Restricting attention to this case eliminates ambiguity when we refer to low-cost firms by ruling out the situation in which high-cost firms switch identity with low-cost firms as output levels expand.[2]

Differentiating the profit expression of a representative firm in sub-group $i$ yields the first-order condition

$$\pi_{y^i}{}^i = P - g + (P' - g')y^i - c_{y^i}{}^i = 0 \tag{1}$$

and second-order condition

[2] Condition (C2) is sufficient, though not necessary, for the results that follow. The condition is likely to be met in practical applications, since low-cost firms may have higher marginal costs at low levels of output, yet be operating at a scale which is well beyond any crossing of marginal cost with that of high-cost firms. It is somewhat implausible to imagine high-cost firms sufficiently investing in the unused, excess capacity to make them more efficient than low-cost producers at high levels of output.

$$\pi_{y_i y_i}{}^{i} = 2(P' - g') + (P'' - g'')y^i - c_{y_i y_i}{}^{i} < 0. \tag{2}$$

where identical conditions can be written for the representative firm of type *j*.

The entry condition is described by treating the number of firms as a continuous variable following Besley (1989), Mankiw and Whinston (1986), and Seade (1980a). We assume that changes in liability structure are modest enough to not affect the number of low-cost firms (although liability may affect large firm output decisions), thereby restricting attention to small firm entry.[3] Entry occurs in the model until profit is driven to zero for firms in the high-cost industry sub-group. In equilibrium, the number of high-cost firms in the industry, $n^*$, is the solution to

$$\pi^h{}^* = \left[P(Y^*) - g(Y^*)\right]y^h{}^* - c^h(y^h{}^*) - F^h = 0, \tag{3}$$

where $Y^* = my^l{}^* + n^*y^h{}^*$ in a symmetric sub-group equilibrium. The equilibrium value of $n^*$ is determined simultaneously with $y^l{}^*$ and $y^h{}^*$ using first-order conditions (1) and the entry condition (3). It is assumed that $n^*$ is unique, as is the case when at least a portion of fixed costs are sunk (Vickers, 1989).

We assume the usual conditions for stability of a Cournot equilibrium. Following Dixit (1986), and Seade (1980b), expected marginal benefit is a decreasing function of firm output and declines faster than the marginal cost curve of either type of firm, or

$$B' = P' - g' < 0, \tag{C3}$$

and

[3] This modeling assumption is based in part on the desire to isolate the marginal effects of entry. Low cost firms not currently producing (i.e., potential entrants with superior technology), have incentives to enter unrelated to industry liability. Thus, we restrict attention to industries that are in long run equilibria and identify conditions in which an increase in liability induces high-cost entry that would otherwise be unprofitable.

$$V^i = B' - c^i_{y_i y_i} < 0\,. \tag{C4}$$

In the context of the asymmetric-cost equilibrium it is possible to show that the output of low-cost firms is greater than that of high-cost firms using expressions (1). Manipulating the first-order conditions for low- and high-cost types yields

$$B'(y^l - y^h) = c^l_{y_l} - c^h_{y_h}\,,$$

whence $y^l > y^h$ follows from conditions (C1) and (C3).

## III. Marginal Effects of Changing Product Liability

The effect of modifying the product liability rule can be expressed as a shift in the expected liability function. Following Dixit (1986), let $\theta$ be a shift parameter in the expected liability function $g = g(Y;\ \theta)$.[4] The expected liability function is expressed as

$$g = g(y^l + (m-1)\delta + y^h + (n-1)\gamma; \theta)\,, \tag{4}$$

where $\delta$ and $\gamma$ are introduced purely for notational convenience and denote the output levels of low- and high-cost rival firms.

The effect of a change in expected liability is computed by totally differentiating equation (1) for both low- and high-cost types and expression (3), making use of equation (4), the envelope theorem, and the identities $\delta = y^l$ and $\gamma = y^h$. Combining equations,

$$\begin{bmatrix} \pi^l_{y_l y_l} + \pi^l_{y_l \delta} & \pi^l_{y_l y_h} + \pi^l_{y_l \gamma} & \pi^l_{y_l n} \\ \pi^h_{y_h y_l} + \pi^h_{y_h \delta} & \pi^h_{y_h y_h} + \pi^h_{y_h \gamma} & \pi^h_{y_h n} \\ \pi^h_{y_l} + \pi^h_{\delta} & \pi^h_{\gamma} & \pi^h_{n} \end{bmatrix} \begin{bmatrix} dy^l \\ dy^h \\ dn \end{bmatrix} = - \begin{bmatrix} \pi^l_{y_l \theta} \\ \pi^h_{y_h \theta} \\ \pi^h_{\theta} \end{bmatrix} d\theta\,. \tag{5}$$

Evaluating the determinant of coefficient matrix (5) yields $D = (y^h)^2 B'\left[V^l \pi^h_{y_h y_h}\right] < 0$,

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[4] If liability rules are newly imposed in an industry, such as occurred in the late 1960s in the U.S., we can think of initial expected liability, g(Y), as being infinitesimally small so as to avoid complications arising from a discontinuous expected liability function.

where the inequality holds by stability conditions (C3) and (C4).

The effect of the change in expected liability on the output of the representative high- and low-cost firm is

$$\frac{dy^h}{d\theta} = \frac{y^h \Omega}{B' \pi^h_{y_h y_h}} \ , \tag{6}$$

and

$$\frac{dy^l}{d\theta} = \frac{\left[V^h y^l + B'(y^l - y^h)\right]\Omega}{B' V^l \pi^h_{y_h y_h}}, \tag{7}$$

respectively, where $\Omega = [g_{Y\theta}B' - g_\theta B'']$. Note that the sign of expressions (6) and (7) are the same as the sign of $\Omega$.

Changing liability has the following effect on the number of high-cost firms:

$$\frac{dn}{d\theta} = \frac{y^h}{D}\left\{g_\theta V^l \pi^h_{y_h y_h} - \Omega\left[(n-1)y^h V^l + my^l V^h + mB'(y^l - y^h)\right]\right\}, \tag{8}$$

where the expression in square brackets is negative. Expression (8) provides a condition that defines the entry and exit of high-cost firms in a hazardous sector following a change in expected liability. The sign of expression (8) depends on the value of two parameters, the change in expected liability per unit of output, $g_\theta$, and the value of the cross-elasticity parameter, $\Omega$.

Using (6), (7), and (8), the effect of producer liability rules on industry output is

$\frac{dY}{d\theta} = y^h\left(\frac{dn}{d\theta}\right) + n\left(\frac{dy^h}{d\theta}\right) + m\left(\frac{dy^l}{d\theta}\right)$, which is written as

$$\frac{dY}{d\theta} = \frac{g_\theta \pi^h_{y_h y_h} - \Omega y^h}{B' \pi^h_{y_h y_h}} \, . \tag{9}$$

Expression (9) shows that an increase in producer exposure to liability reduces the total output of the hazardous product whenever $\Omega \geq 0$. An increase in expected marginal liability increases output in (9) iff $g_{\theta}\left[2(B'+B''y^h) - c^h_{y^h y^h}\right] - g_{Y\theta}B'y^h > 0$. Increased liability leads to greater industry output when the level effect of the shift in expected liability is small relative to the slope effect. If the expected marginal liability is an increasing function of industry output ($g_{Y\theta} > 0$), for example, a perverse output effect can occur as the expected marginal benefit schedule becomes more inelastic following the liability rule. The key component here is the entry condition. In an oligopoly without entry, a decrease in the elasticity of expected marginal benefit tends to increase the residual price-cost margin, compounding the downward level effect by causing an output contraction. In the present model, however, industry output can expand when demand becomes more inelastic due to the entry of high-cost firms. The ability of incumbent firms to increase residual price premiums in response to greater exposure to liability is thus constrained by the possibility of entry.

We now examine the central question of interest: the effect of a change in liability structure on the market shares of high- and low-cost firms. The change in market share for firms in each respective sub-group is

$$\frac{ds^i}{d\theta} = \frac{Y(dx^i/d\theta) - x^i(dX/d\theta)}{X^2}.$$

Substituting terms from the analysis above, it follows that changes in the market shares of high- and low-cost firms are given as follows:

$$\frac{ds^h}{d\theta} = \frac{-s^h\left[g_\theta \pi^h_{y_h y_h} - \Omega(Y - y^h)\right]}{XB'\pi^h_{y_h y_h}} \tag{10}$$

and

$$\frac{ds^l}{d\theta} = \frac{-\left\{g_\theta y^l V^l \pi^h_{y_h y_h} - \Omega\left[B'Y(y^l - y^h) + y^l\left(YV^h - y^h V^l\right)\right]\right\}}{X^2 B'V^l \pi^h_{y_h y_h}}. \tag{11}$$

The first term in each expression represents an increase in the market share for each type of firm as the downward shift in expected marginal benefit through the level effect precipitates the exit of high-cost firms. Note that the term in square brackets in expression (11) is positive by the definition of low-cost producers in condition (C2). Thus, for either type of firm, market share unambiguously increases when $\Omega \geq 0$. The market share of each type of firm can decrease when $\Omega < 0$, however, as the entry of high-cost firms is possible in this region.

We next describe the effect of a change in liability structure on the entry of small, high-cost firms. As we shall see, the shape of the expected liability function has a profound effect on market structure in the hazardous product sector.

**IV. Liability and Industry Structure**

When producer liability rules are imposed in an industry with latent hazards, the effect can be represented by an outwards shift in expected production risk, $g_\theta > 0$, or alternately, by an inward shift of the expected marginal benefit schedule, *B*. If production risk in the hazardous sector is associated with constant expected marginal liability, the effect is the parallel inward shift of expected net benefits represented by $g_\theta > 0$ and $g_{Y\theta} = 0$. Similarly, the case of increasing marginal liability can be expressed by the conditions $g_\theta > 0$ and

$g_{Y\theta} > 0$, while decreasing marginal liability can be expressed by $g_{\theta} > 0$ and $g_{Y\theta} < 0$.

When expected marginal liability is constant, the imposition of producer liability rules lowers profitability in the sector by a parallel inward shift of expected marginal benefit. Inspecting expressions (6) and (7), a parallel shift in expected marginal liability does not perturb the output level of representative low- and high-cost firms in the case of a linear demand function, but decreases (increases) the output of each firm in each sub-group when industry demand is convex (concave).

The exit of high-cost firms unambiguously occurs in an industry with constant marginal liability when demand is concave, although entry can occur when demand is sufficiently convex. Industry output decreases in all cases except when demand is highly convex. The market share of incumbent firms increases when demand is concave, but can decrease when demand is strongly convex under the same conditions that stimulate the entry of high-cost firms. Similarly, the net producer price and industry profitability increase when demand is concave and decrease when demand is convex.[5]

When the expected marginal liability function is decreasing, $\Omega$ is likely to be positive; it is unambiguously positive, in fact, when the liability function is weakly concave and can only be negative when industry liability is highly convex. Hence, the likely effect of a producer liability rule in the case of decreasing expected marginal liability is to create an output expansion by incumbents and an increase in the market share of representative firms in each sub-group. Declining marginal liability is also likely to

[5] The influence of demand convexity on the comparative statics of an asymmetric-cost oligopoly is described in Dierickx et al., 1988.

stimulate the exit of high-cost firms, reduce total industry output of the hazardous product, and lead to higher expected marginal benefit and to greater industry profit.

The case of increasing expected marginal liability is the most likely scenario when the liability arises from environmental health risk, such as in the case of consumer health risk associated with radiation exposure, DES, cigarette smoking, dioxin, vinyl chloride, PCB, coke-oven emissions, and other latent hazards. Increasing expected marginal liability is likely to occur for such carcinogenic substances, as the health risk associated with exposure generally increases with exposure level (Lichtenberg and Zilberman, 1989). For industries that rely on hazardous productive inputs, the expected marginal liability function, in most cases, is an increasing function of industry output.

When the expected marginal liability is increasing in industry output, $\Omega$ is negative in all but the most unlikely case in which the expected marginal benefit function is highly concave. When the expected marginal benefit function is at least weakly convex, it follows that $\Omega < 0$ in the case of increasing marginal liability, whence the production level of each incumbent firm contracts, expected marginal benefit decreases and industry profitability declines. All other effects are ambiguous and depend on the magnitude of the level effect of the change in expected liability.

Of all the possible scenarios, the case of increasing marginal injury is most likely to stimulate the entry of high-cost firms. The possibility of high-cost firm entry is greater when the level effect of the liability rule is small relative to the slope of the expected marginal liability function. That is, when marginal liability is small and increasing with industry output, entry of high-cost firms is likely to occur.

## V. Conclusion

In an important paper, Ringleb and Wiggins (1990) find that an increase in liability frequently precedes the entry of small firms and leads to increases in small firm market share in hazardous sectors of the economy. They hypothesize that such entry results from the desire of large, incumbent firms to shield themselves from liability by divesting risky activities. This paper shows that while Ringleb and Wiggins' empirical observations may be sound, incomplete capitalization and latent injury are not the only possible motivations for changes in market structure following an increase in product liability. In particular, we show that small firm entry can occur even in a fully capitalized environment without divestiture incentives.

Our paper points out that entry incentives are fundamentally related to the shape of the damage function. In particular, an increase in liability is likely to result in small firm entry when marginal damage is increasing in the level of industry output. In this case, increased liability shifts the marginal benefit schedule downward for each incumbent firm and makes it more inelastic. Imposing liability may thus increase the industry price-cost margin and create incentives for small firm entry. The well-known empirical finding that an increase in liability precedes small firm entry in industries with latent hazards can therefore be explained by factors other than divestiture incentives or incomplete capitalization. The implication is that the relationship between liability and market structure may be considerably richer than previously recognized.

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