Taxation, Fines, and Producer Liability Rules: Efficiency and Market Structure Implications

By

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Abstract: This paper addresses the comparative efficiency of liability rules and regulatory policy in competitive equilibria with endogenous product safety. Pigouvian taxation fails to achieve long-run social optimality. A policy involving accident fines and safety subsidization can achieve efficiency, although the optimal policy may involve taxation, not subsidization, of product safety.

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1. Introduction

The control of external diseconomies created by worker, consumer, and environmental exposure to hazardous substances is a pervasive problem. In many industries, consumers and workers are routinely exposed to health risks associated with radiation, DES, cigarette smoking, saccharin, asbestos, dioxin, vinyl chloride, PCB, beta-napthylamine, benzidine, coke-oven emissions, and various occupational carcinogens arising from the use of basic materials such as pesticides, petroleum, coal, paraffin, iron ore, nickel, and chromium. Other industries involved with petroleum production, nuclear power generation, metal mining and smelting, pulp milling, and solid waste disposal pose the threat of contamination through accidental "spills" into the environmental medium. The unifying feature of these problems is that the extent of external damages is determined jointly through the choice of output and safety provision by producers.

Two important forms of externality control in hazardous sectors of the economy are producer liability rules and direct regulatory control through the use of output (i.e., Pigouvian) taxation and fines on injuries. This paper provides a comparative analysis of the relative efficiency properties of producer liability rules and regulatory policy in both short-run and long-run competitive equilibria. The essential feature of the model is that the provision of product safety in the hazardous sector is endogenized as a choice variable of the firm. The extent or magnitude of external damages can be limited, for example, by removing carcinogens from consumer products, by following re-entry guidelines after the application of pesticides, by requiring safety gear for construction workers, or by implementing better containment measures for solid and liquid waste.

Given the conceptual unity of worker, consumer, and environmental safety issues, producer liability rules and regulatory controls are nested in a general model that allows their comparative properties to be examined.

The theoretical framework, which views producer care as a choice variable of the firm, falls within a family of papers in the liability literature [see, for example, Hamada (1976), Shavell (1980), Landes and Posner (1985), and Marino (1988)]. In each of these papers, producer (or strict) liability achieves social optimality in a long-run competitive equilibrium, provided that the extent or likelihood of damage is not correlated across firms (i.e., no externalities exist in the liability functions). The present analysis supports this finding that tort liability achieves a first-best resource allocation in the long run, but finds the choice of regulatory controls to be more problematic.

In an important contribution, two papers by Carlton and Loury (1980, 1986) discuss the limitations of Pigouvian taxes in long-run equilibria. For the case of unavoidable damages, they demonstrate that a Pigouvian tax is inefficient when the damage function does not depend multiplicatively on the item that is taxed. This finding, though certainly important, is limited by the fact that firms typically exert some control over the extent of external damages through their choice of safety provision. In the following section, we revisit the limitations of Pigouvian taxation in a model that allows competitive firms to invest in product safety measures that reduce the probability of accidental injury to workers, consumers, and the environment. It is shown that Pigouvian taxation fails to achieve a socially optimal outcome in a long-run competitive equilibrium in which both output and safety provision are taxed (subsidized) according to their marginal contributions to social damage. A joint policy involving fines on accidents and subsidies on safety provision can achieve a first-best resource allocation; however, the optimal policy may involve the taxation, not the subsidization, of product safety.

The paper also addresses the effect of increased exposure to tort liability on market structure. The existing literature regarding the effects of producer liability on market structure has focused on the issue of solvency [e.g., Ringleb and Wiggins (1990), Boyd and Ingberman (1994) and Watts (1998)]. In a recent paper, Ringleb and Wiggins (1990) examine a wide range of hazardous industries and find that increased exposure to tort liability tends to stimulate small firm entry. Their intuition for this effect is that the entry of firms results through incomplete capitalization and/or through latent risks that allow small firms to cease production before claims are made. It is shown here that, regardless of firm solvency, *de novo* entry can occur purely through market forces following an increase in producer liability exposure. The finding that increased tort liability induces entry in hazardous sectors, therefore, is not sufficient evidence to support the hypothesis that firms respond to greater liability exposure through divestiture.

2. The Model

Consider a simple partial-equilibrium model with n identical competitive firms. Each firm produces a homogeneous product with inverse demand given by $P(Y)$, where $Y=ny$ is total industry output. Production by each firm in the industry also imposes additional damages to society, $g(y)$, in the event of an accident. The expected damage, D, created by a firm's production decision is given by $D = ag(y)$, where $a \in [0,1]$, is the probability in which an accident occurs. In cases where damages arise through worker exposure to toxic substances or through environmental "spills", a may be interpreted as the probability of product failure, as in Marino (1991). In cases where external damages arise through health risk, *a* may be interpreted as an inverse measure of product safety, for example the level of product carcinogenity or the degree of worker exposure to toxic substances. To produce *y* units of output at safety level *a*, the representative firm incurs production costs of $c(a, y)$, where $dc(a, y)/dy > 0$ and $dc(a, y)/da < 0$.

In a short-run equilibrium the number of firms is fixed and we can completely characterize the socially optimal *a, y* as the solution to

$$\max_{\substack{a \geq 0 \\ y \geq 0}} \int_0^{ny} P(z)dz - nc(a, y) - nag(y).$$

Using the definition of the inverse demand curve, *a*, *y* satisfy the first-order conditions

$$P(ny) = \frac{dc}{dy}(a, y) + ag'(y), \tag{1}$$

$$g(y) = -\frac{dc}{da}(a, y). \tag{2}$$

Expression (1) equates the market price with marginal social damage, the sum of marginal private cost and marginal external cost. Expression (2) equates total external damage with the marginal cost of providing product safety. That is, (2) states that the socially optimal level of product safety occurs where the marginal cost of investing in safety measures is equal to total external damage at the equilibrium level of output.[1]

In the case of direct regulatory controls, the short run competitive equilibrium (SRCE) is described with regard to three policy instruments: a tax on output, *t*, a subsidy on safety provision (i.e., a tax on "negative" safety), *s*, and a fine on accidents, *f*. We can completely characterize the SRCE as the solution to

$$\max_{\substack{a \geq 0 \\ y \geq 0}} Py - c(a, y) - ty - sa - fay.$$

[1] A similar result is derived by Marino (1991).

Using the definition of the inverse demand curve, *a,y* satisfy the first-order conditions

$$P(ny) = \frac{dc}{dy}(a,y) + af + t\,, \tag{3}$$

$$s + fy = -\frac{dc}{da}(a,y)\,. \tag{4}$$

Proposition 1. For appropriately chosen policy pairs t,s *or* f,s, *the short-run competitive equilibrium coincides with the short-run social optimum.*

Proof. It is necessary to show that if a^*,y^* are a short-run social optimum, then there exists a policy pair t^*,s^* or f^*,s^* such that a^*,y^* are a short-run competitive equilibrium.

For the case of taxation, suppose a^*,y^* solve (1) and (2) and define $s^*=g(y^*)$ and $t^* = ag'(y^*)$. Then, when f=0, it follows immediately from (1) and (2) that a^*,y^* also satisfy (3) and (4).

For the case of a fine-subsidy pair, suppose that a^*,y^* satisfy (1) and (2) and choose $f^* = g'(y^*)$ and $s^* = y^*\left(g(y^*)/y^* - g'(y^*)\right)$. For such a f^*, it is clear from (1) that a^*,y^* will also satisfy (3) when t=0. To see that a^*,y^* also satisfy (4), rewrite (2) as

$g(y^*) + s^* - s^* + f^*y^* - f^*y^* = -\frac{dc}{da}(a^*,y^*)$, or,

$$s^* + f^*y^* = -\frac{dc}{da}(a^*,y^*)\,. \tag{5}$$

It is obvious from (5) that a^*,y^* satisfy (4). Q.E.D.

The result in Proposition 1 is fairly transparent: with two distortions, it is possible to achieve the social optimum with two policy instruments. However, the case of fines on accidents is of some independent interest. If the purpose of a fine on accidents is to achieve economic efficiency, rather than to serve as a compensatory mechanism for injured parties, the optimal per unit fine is assessed according to the marginal damage, not the average damage, associated with product failure. When fines are assessed on accidents, moreover, the socially optimal policy control may involve the taxation, not the subsidization, of product safety. If the marginal damage of each firm's output exceeds the average damage at the optimal point, then the first-best policy pair involves a fine on accidents equal to marginal damage and a tax on product safety equal to the difference between marginal and average damage.

In the long-run, entry (exit) may occur and the number of firms is endogenous. Using the definition of the inverse demand curve, we can completely characterize the long-run social optimum (LRSO) as the solution to

$$\max_{\substack{a\geq 0\\ y\geq 0\\ n\geq 0}} \int_0^{ny} P(z)dz - nc(a,y) - nag(y).$$

The first-order conditions are

$$P(ny) = \frac{dc}{dy}(a,y) + ag'(y), \tag{6}$$

$$g(y) = -\frac{dc}{da}(a,y), \tag{7}$$

$$yP(ny) = c(a,y) + ag(y). \tag{8}$$

With respect to the regulatory controls (*t*,*f*,*s*), we can completely characterize the long-run competitive equilibrium (LRCE) by the conditions

$$P(ny) = \frac{dc}{dy}(a,y) + af + t, \tag{9}$$

$$s + fy = -\frac{dc}{da}(a,y) \tag{10}$$

$$yP(ny) = c(a,y) + yt + as + ayf. \tag{11}$$

Proposition 2. There exists no t,s *pair such that the long-run competitive equilibrium* *coincides with the long-run social optimum.*

Proof. It is necessary to show that if t is the tax on output and s is the subsidy on product safety, then if a^*, y^*, n^* satisfy (6), (7), and (8), they will not also satisfy (9), (10), and (11). First notice from (6) and (7) that t, s must meet the conditions of Proposition 1 for a LRSO. To complete the proof, we must show that $t = t^*$ and $s = s^*$ will not satisfy (11) for a^*, y^*, n^*.

Suppose that a^*, y^*, n^* satisfy (9), (10), and (11) and let $s^* = g(y^*)$ and $t^* = ag'(y^*)$. For such a s^*, t^* it is clear from (9) and (10) that a^*, y^*, n^* will also satisfy (6) and (7). However, for such a tax-subsidy pair, a^*, y^* will not satisfy (8). To see this, rewrite (8) as $y^* P(n^* y^*) = c(a^*, y^*) + a^* g(y^*) + y^* t^* - y^* t^* + a^* s^* - a^* s^*$, or,

$$y^* P(n^* y^*) = c(a^*, y^*) + y^* t^* + a^* s^* - a^* g'(y^*) . \tag{12}$$

From (12) it is apparent that a^*, y^*, n^* will not satisfy (11) when $f=0$. Q.E.D.

Proposition 3. There exists a f,s *pair such that the long-run competitive equilibrium coincides with the long-run social optimum.*

Proof. It is necessary to show that if a^*, y^*, n^* are a long-run social optimum, then there exists a policy pair f^*, s^* such that a^*, y^*, n^* are a long-run competitive equilibrium.

Suppose that a^*, y^*, n^* satisfy (6), (7) and (8) and choose $f^* = g'(y^*)$ and $s^* = y^*\left(g(y^*)/y^* - g'(y^*)\right)$. For such a f^*, s^* it is clear from (6) and (7) that a^*, y^*, n^* also satisfy (9) and (10) when $t=0$. To see that a^*, y^*, n^* also satisfy (11), rewrite (8) as

$$y^* P(n^* y^*) = c(a^*, y^*) + a^* g(y^*) + a^* y^* f^* - a^* y^* f^* + a^* s^* - a^* s^*$$

or

$$y^* P(n^* y^*) = c(a^*, y^*) + a^* s^* + a^* y^* f^* \tag{13}$$

Clearly, (13) coincides with (11) when $t=0$. Q.E.D.

Corollary. If marginal social damage equals average social damage at y, then a fine of* $f^* = g'(y^*)$ *on accidents achieves both the short-run and the long-run social optimum.*

When firms fail to recognize the external damages associated with product failure, three sources of inefficiency arise through separate distortions in output level, safety provision, and the equilibrium number of firms. Unlike the case of Pigouvian taxation, the use of accident fines allows the regulator to effectively control three distortions with only two instruments. The intuition behind this result is that a fine, which is assessed on a multiplicative relationship between output and safety provision, creates a non-linearity between the policy instruments. An increase in the fine affects both the level of output and the degree of producer care for the representative firm, while an increase in the subsidy changes only the marginal valuation of product safety.

For completeness, we next examine the long-run efficiency properties of tort liability. With respect to a producer liability rule, the LRCE can be completely characterized by

$$P(ny) = \frac{dc}{dy}(a, y) + ag'(y), \tag{14}$$

$$g(y) = -\frac{dc}{da}(a, y), \tag{15}$$

$$yP(ny) = c(a, y) + ag(y). \tag{16}$$

Equations (14), (15), and (16) coincide with (6), (7), and (8). It follows directly that the LRSO and LRCE coincide under a system of producer liability rules, hence a producer liability rule leads to first-best resource allocations in both the short- and the long-run.[2]

3. Structural Implications of a Change in Producer Liability Exposure

[2] This result is also derived by Hamada (1976), Shavell (1980), and Landes and Posner (1985).

Unlike previous papers that have focused on the structural implications of producer liability when firm solvency is important, attention is confined here to the case of a fully capitalized industry without divestiture incentives. The results described below demonstrate that *de novo* entry in the face of increased producer liability, as observed by Ringleb and Wiggins (1990) in the 1967-80 period surrounding rapid changes in U.S. liability law, is consistent with an alternate hypothesis of purely structural change.

Consider, as in Shavell (1980) and Marino (1991), the case in which production costs increase linearly with output, $c(y,a) = yc(a)$, where $c_a < 0$ and $c_{aa} > 0$. Next, denote the (inverse) demand elasticity as $\eta = -P'Y / P$ and the elasticity of the slope of the damage function as $\xi = g_{yy} y / g_y$.

Let θ be a shift parameter in the liability function of the representative firm such that $g = g(y;\theta)$. Without loss of generality, an increase in producer liability is represented by the condition $g_\theta(y;\theta) > 0$, while an increase (*resp. decrease*) in the marginal injury relation is represented by the condition $g_{y\theta}(y;\theta) > 0$ (*resp. < 0*). It is also helpful to define for future reference the ratio of change in the marginal and average injury relation, $\varepsilon_\theta = g_{y\theta} y / g_\theta$, as the elasticity of the shift in liability structure.

Proposition 4. If $c(y,a)/y = c_y(y,a)$, *increased producer exposure to tort liability*

(i) increases product safety,

(ii) increases the output of a representative firm if and only if $\varepsilon_\theta < 1$,

(iii) increases the number of firms if and only if $\varepsilon_\theta - 1 > (\xi / \eta)(ag / Py)$.

Proof. Making the appropriate substitutions in expressions (14), (15), and (16) and simplifying yields $g_y = g / y = -c_a$. Perturbing the conditions for a LRCE in (14), (15), and (16), and making use of the envelope theorem gives

$$\begin{bmatrix} nP' - ag_{yy} & 0 & P'y \\ 0 & -yc_{aa} & 0 \\ nP'y & 0 & P'y^2 \end{bmatrix} \begin{bmatrix} dy \\ da \\ dn \end{bmatrix} = \begin{bmatrix} ag_{y\theta} \\ g_\theta \\ ag_\theta \end{bmatrix} d\theta, \tag{17}$$

where $g_{yy} > 0$ by the Routh-Hurwicz stability conditions. Solving (17) yields $\frac{dy}{d\theta} = \frac{g_\theta(1-\varepsilon_\theta)}{g_{yy}y}$, $\frac{da}{d\theta} = \frac{-g_\theta}{c_{aa}}$, and $\frac{dn}{d\theta} = \frac{g_\theta\left[ag_{yy} - nP'(1-\varepsilon_\theta)\right]}{P'g_{yy}y^2}$, respectively, where $g_\theta > 0$ for an increase in liability exposure. Inspection of the first two terms completes parts *i* and *ii*. Noting that the denominator of the third term is negative, entry occurs following an increase in liability exposure if and only if $\xi a g_y + \eta P < \eta P \varepsilon_\theta$. Substituting $g_y = g / y$ and simplifying completes the proof. Q.E.D.

In response to an increase in liability exposure, firms that internalize tort liability as a component of production costs change their operating scale to equate marginal and average cost inclusive of the increased injury expense. Thus, if the change in the marginal injury relation exactly coincides with the change in the average injury relation ($\varepsilon_\theta = 1$), increased exposure to tort liability has no effect on the productive scale of a representative firm.[3] Conversely, the level of output associated with minimum average cost decreases for a competitive firm whenever the upwards shift in the average cost curve exceeds the change in marginal cost, as in the case of internalized liability and $\varepsilon_\theta > 1$. For a sufficiently large value of the shift elasticity, the reduction in productive scale by incumbent firms makes entry attractive despite the increased liability exposure in

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[3] Such a result is familiar to competitive models in which firms choose a single variable (e.g., output) subject to a linear penalty schedule (e.g., a unit tax).

the industry. Entry is more likely to occur in a hazardous sector following an increase in tort liability when inverse demand is price elastic, the marginal damage function is price inelastic, and the increase in marginal damage is large relative to the change in average damage. Furthermore, *de novo* entry is more likely when total revenue is large relative to the total injury associated with product failure, a condition under which firm solvency is not likely to be an issue.

Example. Consider a market with linear demand, $P(ny) = A - \alpha ny$, and a quadratic damage function, $g = b + \beta y^2$. Increased exposure to tort liability is represented by an increase in either b or β. Suppose that each of n competitive firms has the cost function $c(a, y) = cy / a$. Solving equations (14), (15), and (16) for the equilibrium level of output and safety provision for each firm yields $y^* = (b / \beta)^{0.5}$ and $a^* = (c / 2)^{0.5}(b\beta)^{-0.25}$. It is immediately apparent that the equilibrium output level of each firm is increasing in b and decreasing in β, while the probability of product failure is decreasing in both b and β. Thus, regardless of the nature of the increase in producer liability, the level of safety provision increases. Using the definition of inverse demand, the equilibrium number of firms is $n^* = \left(\frac{A - P^*}{\alpha}\right)\left(\frac{\beta}{b}\right)^{0.5}$, from which it follows directly that entry occurs whenever the ratio β/b increases in response to the change in liability structure.

The above example indicates that, in general, no clear correspondence can be drawn between *de novo* entry and the level of firm solvency. Specifically, divestiture incentives are not a necessary condition for entry to occur in a hazardous industry. The entry of new firms in response to increased liability exposure leads to qualitative predictions regarding divestiture only in the case where the average injury relation increases to a greater extent than the increase in the marginal injury relation.

IV. Concluding Remarks

The paper has shown that Pigouvian taxation fails to achieve a socially optimal outcome in a long-run competitive equilibrium in which both output and safety provision are taxed (subsidized) according to their marginal contributions to social damage. The analysis demonstrated that a system of fines on accidents and subsidies (taxes) on product safety provision are capable of achieving first-best resource allocations; however, the optimal policy pair assesses a per-unit fine on marginal, not average damages, and potentially involves the taxation, not the subsidization, of product safety investments. The analysis further revealed that tort liability achieves a first-best resource allocation in both long and short-run equilibria, which highlights the appeal of legal controls in hazardous sectors.

The paper also demonstrated that entry and loss of incumbent market share can occur purely through market forces following an increase in producer liability. The implication of this finding is that a divestiture incentive is not a necessary condition for small firm entry to occur in response to increased exposure to tort liability. Entry (exit) of competitive firms generally occurs following nonuniform changes in the marginal and average components of the liability function, even when solvency is not an issue. In particular, entry occurs when the increased exposure to tort liability sufficiently increases the marginal injury relation relative to the change in the average injury relation. The implications of this result contrast sharply with that of divestiture-induced entry, as the entry of firms following increased producer exposure to liability is associated with first-best levels of output and safety provision in the hazardous sector.

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