Punitive damages in oligopolistic markets

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Abstract

This paper establishes that punitive damages can be an instrument to induce producers with market power to make socially optimal product safety investments. The underlying rationale is that producers' safety choices affect social surplus, whereas producers maximize producers' surplus. Punitive damages can remedy this discrepancy. We show that the optimal damages multiplier depends on characteristics of competition such as the number of firms, the degree of substitutability/complementarity if products are heterogeneous, firms' cost structures, and the mode of competition.

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1 Introduction

1.1 Motivation and main results

Punitive damages are an important aspect of civil liability in the United States and continue to stir up controversy regarding their impact on social welfare and their optimal design (see, e.g., Calandrillo 2010, Luban 1998, Viscusi 1998). The rationale put forth in the literature for awarding punitive damages is that some injurers may escape liability some of the time in which case incentives for care would be suboptimal if damages were set equal to harm. This possibility of escaping liability may be due to the difficulty for the victim to determine that the harm was the result of some party's act or to prove causation, or because the victim may not sue because of expected litigation costs (e.g., Polinsky and Shavell 1998). The view that punitive damages are only reasonable from an economic standpoint if they offset the tortfeasor's possibility of escaping liability is by now firmly embedded in the law and economics folklore (see, e.g., Calandrillo 2010, Miceli 2004, Visscher 2009). The so-called multiplier principle is accepted to such a degree as to be recognized by courts (Craswell 1999). However, it must be noted that this traditional rationale for punitive damages cannot explain many instances in which punitive damages have been awarded. For instance, in cases like the infamous Exxon Valdez case involving the oil spill along the Alaskan coastline in 1989, the likelihood of escaping suit is non-existent but, nonetheless, punitive damages were awarded with Exxon Valdez. Accordingly, when evaluated from the traditional standpoint, such punitive damage awards must be judged as inappropriate (Polinsky and Shavell 1998).

This study analyzes settings in which there is no possibility to escape liability but, nevertheless, establishes a welfare-enhancing role for punitive damages. In order to set the stage for our analysis, we briefly refer to the Ford Pinto case.[1] At the design stage, Ford decided to place the tank behind the axle, rendering the tank vulnerable in the event of rear-end accidents. Ford's decision was made despite the National Highway Transportation Safety Bureau bringing attention to fuel-system integrity at the time and the decision proved fatal for some of Ford's customers. The plaintiff in *Grimshaw v. Ford Motor Company* was awarded over

[1] See Schwartz (1991), for example, for a more detailed description.

\$2.5 million in compensatory and \$3.5 million in punitive damages. Another of numerous examples includes the pharmaceutical company Wyeth Pharmaceuticals, which was ordered to pay \$99 million in punitive damages over its mishandling of menopause drugs that helped cause three women's cancers, the company allegedly ignoring the drug's health risks.[2] Note that the companies from these examples are (very likely to be) firms with market power as holds true for firms in our analysis.

This paper provides a rationale for awarding punitive damages in products liability settings that relies on the structure of the market. We study a setup in which firms with market power are subject to products liability and determine product safety before choosing either price or quantity. Consumers do not observe product safety before the purchase of the good, but form rational expectations about it. We thus consider the product to be an experience good, i.e., consumers become informed about the level of precaution after the purchase, which often holds true in reality (Polinsky and Shavell 2010). Within our framework, we establish that it is optimal to use a tort damages multiplier above one in order to align firms' interests with those of the policy maker. Punitive damages are an instrument to incorporate repercussions that firms' decisions about safety have on consumers' surplus into firms' profit maximization. The divergence between private and social incentives is similar to, for example, the case of R&D that allows to lower marginal production costs (see, e.g., Tirole 1988). Lower marginal production costs imply an increase of both consumers' surplus and firm profits, while firms take only the latter into account. In contrast to these settings, however, in our framework, there is a remedy readily available to address the divergence which is already applied in reality.

We establish that the optimal damages multiplier depends on the characteristics of the market. In particular, we show that it depends on the number of firms serving the market, the degree of substitutability/complementarity if products are heterogeneous, firms' cost structures and thereby market shares, as well as on the mode of competition, namely competition taking place either in prices or in quantities. Note that all of these characteristics are closely linked to the relation of firm profits to social welfare. As a consequence, we find

[2] *Wyeth Must Pay \$134.1 Million in Menopause Drug Suit*, October 15, 2007 www.bloomberg.com.

that the optimal level of punitive damages stands in an intimate relationship with the profitability of the injurer's undertaking, a fact that has been established to hold for punitive damages empirically (Karpoff and Lott 1999).

The contribution of our paper is twofold. First and foremost, we propose a novel efficiency defense for the use of punitive damages in products liability settings. Second, we forward socially optimal damages multipliers based on market information that is empirically available, such as the number of firms in the market. This latter aspect may be utilized, for example, for designing jury instructions, given the fact that there is ample of evidence that individuals have difficulties in assessing appropriate punitive damages (see, e.g., Sunstein et al. 1998, Viscusi 2001).

1.2 Relation to the literature

The topic of punitive damages has received considerable attention in the law and economics literature. The main efficiency argument for the use of punitive damages relies on addressing the possibility of escaping liability and is prominently laid out in Polinsky and Shavell (1998).[3] However, the multiplier principle has been criticized on various grounds (see, e.g., Craswell 1999). It has been argued, for example, that the multiplier principle neglects litigation costs and injurer's investment in avoidance (see Friehe 2010 and Hylton and Miceli 2005), and that punitive damages might induce distortions with respect to decisions on firms' capital equipment and thereby deteriorate deterrence (Boyd and Ingberman 1999). Apart from the argument relying on imperfect enforcement, Cooter (1983) forwarded the rationale that punitive damages are required to offset illicit gains from noncompliance, while Hylton (1998) elaborates on the hypothesis that punitive damages should at times be used for complete deterrence instead of for internalization purposes. In a recent contribution, Chu and Huang (2004) forward a rationale for punitive damages as they are applied in practice, that is, often limited to outrageous misconduct and often tied to injurer's wealth. In contrast to all of the above contributions, this paper argues that punitive damages in products liability

[3] For an earlier discussion of the "rule of the reciprocal", see Cooter (1989). The most recent survey on punitive damages is Polinsky and Shavell (2009).

contexts are efficiency-enhancing for reasons pertaining to the market structure. The study closest to our undertaking is Daughety and Reinganum (1997). They consider the possibility that firms want to signal their product safety in an asymmetric information setting and establish that that there are minimum punitive damages required to arrive at a separating equilibrium. Moreover, they show that this minimum punitive damages level is decreasing in the level of competition in the market. Although the rationale for punitive damages is different in our setup, we similarly arrive at the conclusion that punitive damages cede to be of great importance when competition in the market is fierce.

In our study, we address the performance of liability in a market setting where firms have (at least some) market power.[4] For example, Boyd (1994) has studied a monopolist's safety and output choice and concluded that the optimal legal system is sensitive to the structure of the market, however, without relating to punitive damages. Marette (2007) allows for an endogenous determination of the market structure, either monopoly or duopoly, depending on minimum safety standards and consumers' information. We will assume that (i) firms first decide on product safety and then choose either price or output, (ii) safety investments are of a fixed nature, and thus not a function of output, and (iii) strict liability applies although we provide a robustness check as to the application of negligence in an extension. All of these assumptions are borrowed from Daughety and Reinganum (2006), who study a differentiated goods oligopoly without incorporating punitive damages. In contrast to Daughety and Reinganum (2006), the safety investment selected is private information in our setup so that we do not consider that safety investment may be distorted for strategic purposes (i.e., in order to influence competitors' price or output decisions at later stages). The importance of the setting in which care is fixed and not proportional to the activity level has also been emphasized recently by Nussim and Tabbach (2009). In another line of inquiry, Daughety and Reinganum (1995) explore signaling of a monopolist who first undertakes R&D and then sets the product's price, in order to analyze the impact of the sharing of losses between injurer and victim. Takaoka (2005) takes up the lead by Daughety and Reinganum (1995) and contributes by analyzing three different informational scenarios. In our contribution,

[4]Geistfeld (2009) provides a survey on products liability.

consumers cannot observe the product safety features but form rational expectations. This assumption has also been used by, for example, Baumann et al. (forthcoming) who provide a setup in which the reverse of punitive damages, i.e., liability less than harm may be optimal. In another study linking imperfect product-market competition and liability law, Bhole (2007) studies the optimal due care standard in a monopoly setting with legal error and establishes that having due care and a penalty multiplier as instruments available may imply that due care ought to be different from what would usually be considered desirable. In our setup, we allow for various market structures including monopoly and focus for the main part on strict products liability.

In addition, our analysis may be understood as investigating the link between product R&D and products liability. Viscusi and Moore (1993) provide an empirical analysis arguing that products liability depresses R&D when liability costs are high, but stimulates it for low and intermediate levels of liability costs. Similarly, in our setup, increasing the damages multiplier to its optimal level helps to increase the firms' investment in product safety before production.

The plan of the paper is as follows. Section 2 arrives at a statement about consumers' demand to be used throughout the paper. Section 3 analyzes the supply of a homogeneous good by an oligopolistic industry competing in quantities. Here we will take up the issues of market entry, heterogeneous cost structures of firms, and negligence liability. Next, Section 4 contrasts duopolistic price and quantity competition in a setting with heterogeneous goods. This enables us to highlight the importance of the mode of competition and of product differentiation for the optimal damages multiplier. Section 5 concludes the study.

2 Demand

We consider a continuum of identical consumers with the following utility function[5]

$$V = U(y_1, ..., y_n) + z \tag{1}$$

[5] The derivation of demand functions is similar to, e.g., Häckner (2000) and Daughety and Reinganum (2006).

where y_i is the quantity consumed of the product by firm i, $i = 1, ..., n$, and z represents a composite good. Regarding U, it holds that there is diminishing marginal utility in every dimension, i.e., $U_{y_i} > 0 > U_{y_i y_i}$ for all $i = 1, ..., n$ and the marginal rate of substitution between any two goods is decreasing. Consumers seek to

$$\max_{z, \{y_i\}_{i=1}^n} V \text{ subject to } M - \sum_{i=1}^{n} q_i y_i - z \geq 0 \tag{2}$$

where M is exogenous income, the price of the composite good is normalized to one, and q_i is the effective consumer price of firm i's product. This effective price of good i comprises not only the market price itself but also the expectations about the share of expected harm that will stay with the consumer, $q_i = p_i + (1 - \gamma)x(\bar{s}_i)h$. We assume strict liability throughout (except for a robustness check of our baseline analysis in Section 3.3). The probability x that the consumer will suffer harm h when consuming the good is dependent on the producer's actual product safety expenditures s_i invested before marketing the product to consumers, where $x' < 0 < x''$. It is important to note that the consumption choice depends on the consumer's expectations about firm i's safety effort, $\bar{s}_i$, instead of its actual level, s_i. This is important when we examine the firm's product safety decision because the effective price q_i is not a function of actual safety efforts but, instead, depends on expectations about it. However, due to consumers' rational expectations, the two levels of safety efforts, that is, expected and actual safety levels, coincide in equilibrium. The effective price q_i is also determined by the allocation of expected harm between the firm and the consumer, where $\gamma \geq 0$ indicates the firm's share. We will assume that there are no further adverse consequences from an accident due to consumption than the level of harm, which implies that we abstract from litigation costs, for example.

For the analyses to follow, we specify

$$U(y_1, ..., y_n) = \alpha \sum_{i=1}^{n} y_i - \left[\frac{\beta}{2} \sum_{i=1}^{n} y_i^2 + \delta \sum_{i=1}^{n} \sum_{j \neq i} y_i y_j \right] \tag{3}$$

where α, $\beta > 0$ and the sign and level of δ will determine whether goods are substitutes ($\delta > 0$) or complements ($\delta < 0$), and homogeneous ($\delta = \beta$) or heterogeneous ($\delta \neq \beta$), respectively, where $\beta \geq |\delta|$. For this specification of U, we can use $\partial U/\partial y_i - q_i = 0$, which follows from (2) by noting that the Lagrange multiplier must be equal to one given an interior solution, to state that

$$q_i = \alpha - \beta y_i - \delta \sum_{j \neq i} y_j \tag{4}$$

in the consumer's optimum for all i, $i = 1, ..., n$. Equation (4) will be the foundation for all demand functions to be used in this paper.

Because V is linear in the composite good z, the description of the households' objective allows us to describe consumer welfare by

$$CW^* = \alpha \sum_{i=1}^{n} y_i^* - \left[\frac{\beta}{2} \sum_{i=1}^{n} y_i^{*2} + \delta \sum_{i=1}^{n} \sum_{j \neq i} y_i^* y_j^* \right] - \sum_{i=1}^{n} q_i^* y_i^* \tag{5}$$

where we denote equilibrium values with an asterisk.

3 Punitive damages and homogeneous good competition

Consider n firms producing a homogeneous good at marginal cost c_i. We arrive at the relevant inverted demand function by setting $\delta = \beta$ in (4), which leads to

$$q = \alpha - \beta Y \tag{6}$$

where $Y = \sum_{i=1}^{n} y_i$. Note that from the consumers' point of view, goods produced by different firms are perfect substitutes in this section. Accordingly, there is one level of the effective price q. As explained in Section 2, the level of q at the same time must accord with

$$q = p_i + (1 - \gamma) x(\bar{s}_i) h \tag{7}$$

Firms compete by setting quantities, i.e., we consider Cournot competition. We examine price competition in the section analyzing the optimal damages multiplier in settings with heterogeneous goods.

The timing is such that firms select the safety level s_i at the first stage before choosing the privately optimal output at Stage 2. Regarding the information structure, we assume that neither consumers nor competitors can make their decision at the second stage contingent on the others' first-period choices, that is, firm i's determination of safety is private information.

In this section, we restrict the analysis to homogeneous goods and start with the assumption of symmetric firms. This allows us to straightforwardly derive the optimal damages multiplier and forward intuition for its level. Furthermore, the analysis of this baseline model enables us to generalize to circumstances with free entry, heterogeneous firms, and the application of negligence liability instead of strict liability.

3.1 Symmetric firms

The assumption of symmetric firms allows us to set $c_i = c$ for all i. Firm i's profits are then given by

$$\begin{aligned} \pi_i &= [p_i - c - \gamma x(s_i)h]y_i - s_i \\ &= [\alpha - \beta Y - EMC(\bar{s}_i, s_i, \gamma)]y_i - s_i \end{aligned} \tag{8}$$

where $EMC(\bar{s}_i, s_i, \gamma) = c + (1-\gamma)x(\bar{s}_i)h + \gamma x(s_i)h$ is the precursor of total social marginal costs per output unit, at this stage influenced by expectations about safety, the actual level of safety, and the level of γ should the expected and actual level of safety diverge.

At Stage 2, firms simultaneously determine output. Profit maximization results in the first-order condition

$$\frac{\partial \pi_i}{\partial y_i} = \alpha - 2\beta y_i - \beta Y_{-i} - EMC(\bar{s}_i, s_i, \gamma) = 0 \tag{9}$$

where $Y_{-i} = \sum_{j=1, j\neq i}^{n} y_j$. Accordingly, the output level which maximizes firm i's profits given the output by the other firms follows from

$$y_i = \frac{\alpha - \beta Y_{-i} - EMC(\bar{s}_i, s_i, \gamma)}{2\beta} \tag{10}$$

Stated differently, equation (10) gives the best response of firm i to given Y_{-i}. Using this information in equation (8), we arrive at

$$\pi_i = \frac{(\alpha - \beta Y_{-i} - EMC(\bar{s}_i, s_i, \gamma))^2}{4\beta} - s_i \tag{11}$$

At Stage 1, firms determine the investment in product safety. In view of (11), the first-order condition results as

$$\frac{\partial \pi_i}{\partial s_i} = \frac{\alpha - \beta Y_{-i} - EMC(\bar{s}_i, s_i, \gamma)}{2\beta}(-\gamma x'(s_i)h) - 1 = 0 \tag{12}$$

This condition clearly illustrates that consumers' willingness to pay does not react to changes in s_i, because firm i's actual safety investment at Stage 1 is private information. As a result, an increase in the level of safety only implies a decrease in the marginal liability costs γxh.

We are now in a position to evaluate the symmetric equilibrium in which the actual safety levels are not only in line with the expected ones but are also the same for all firms, $\bar{s}_i = s_i = s$. Regarding overall output, we obtain $Y = ny^*$. Stated precisely, the equilibrium outcome is

$$y^* = \frac{\alpha - MC}{\beta(n+1)} \tag{13}$$

$$q^* = \frac{\alpha + nMC}{n+1} \tag{14}$$

$$\pi^* = \frac{(\alpha - MC)^2}{\beta(n+1)^2} - s = \beta y^{*2} - s \tag{15}$$

where $MC = c + x(s)h$ mirrors the total social marginal costs per unit of output.

Before we turn to the social planner's choice of γ, for ease of comparison, we restate the firm's condition for privately optimal safety expenditures (12) using the equilibrium levels as

$$\frac{\partial \pi_i}{\partial s_i} = \frac{\alpha - MC}{\beta(n+1)}(-\gamma x'(s)h) - 1 = y^*(-\gamma x'(s)h) - 1 = 0 \tag{16}$$

We assume that the social planner seeks to maximize the sum of producers' surplus and consumer welfare. Similar to Daughety and Reinganum (2006), we consider a constrained social planner. The only instrument at the planner's discretion is γ, the damages multiplier. Stated precisely, the social planner takes the decentralized decision-making by the firms as he finds it but tries to achieve a favorable outcome by the selection of γ. Referring to equation (5), we can state consumer welfare, CW, for the present case as

$$\begin{aligned} CW^* &= \left[\alpha - q^* - \beta y^*(1/2 + (n-1)/2)\right] ny^* \\ &= \frac{n^2}{2}\frac{(\alpha - MC)^2}{\beta(n+1)^2} = \frac{n^2}{2}\beta y^{*2} \end{aligned} \tag{17}$$

The social planner's objective may thus be stated as maximizing social welfare, SW,

$$\begin{aligned} SW^* &= n\pi^* + CW^* \\ &= n\left[\frac{(\alpha - MC)^2}{\beta(n+1)^2}\left(1+\frac{n}{2}\right) - s\right] = n\left[\beta y^{*2}\left(1+\frac{n}{2}\right) - s\right] \end{aligned} \tag{18}$$

by choosing the policy variable γ, which is equivalent to determining s in our setup. The corresponding first-order condition is given by

$$\frac{\partial SW^*}{\partial s} = n\left[\frac{\alpha - MC}{\beta(n+1)^2}(2+n)(-x'(s)h) - 1\right] = 0 \tag{19}$$

from which we obtain

$$y^*\left(-\frac{2+n}{1+n}x'(s)h\right) - 1 = 0 \tag{20}$$

This allows us to arrive at the following finding:

Proposition 1 *Assume Cournot competition between symmetric firms in an homogeneous product market. Then: (i) there is a damages multiplier* γ^B *that induces firms to select socially optimal safety investments; (ii) the multiplier is given by* $\gamma^B = 1 + 1/(1+n)$*, and is equal to* $3/2$ *in the monopoly case and decreasing in the number of firms, reaching one as* $n \to \infty$.

Proof. The required level of γ follows from comparing (20) and (16). The statement as to the change of the multiplier when the number of firms changes follows from the derivative of γ^B with respect to n. ■

The rationale for the optimal damages multiplier can be explained as follows. An increase in safety investments increases a firm's profits obtained in the market proportionally to output and the liability factor γ. The firm compares this marginal benefit with the additional outlays for safety investments, see equation (16). At $\gamma = 1$, the profit-maximizing safety investment with asymmetric information on safety is the same as the profit-maximizing investment with symmetric information. This is a well-established result. However, with imperfect competition, the socially optimal damages multiplier is higher than one because an increase in safety investment has a positive effect on consumers' surplus in addition to the effect on firm's profits. For example, in the case of a monopoly, consumer welfare amounts to half of the producer's surplus. Accordingly, the optimal damages multiplier is equal to 3/2 because this leads to the internalization of the positive externality of safety investments on consumers' welfare by the monopolist. With an increase in the number of firms, each firm's market share and output declines. The influence of safety investments by any single firm on consumers' welfare decreases as well, which implies that the socially optimal damages multiplier declines in the number of firms serving the market.

3.2 Endogenous market entry of symmetric firms

The above derivation of the optimal damages multiplier has taken the number of firms as given. In the following, we would like to establish that the optimality of using a damages multiplier above one is robust to allowing for an endogenous number of firms. In order to do this, we enrich the setting of the baseline model by an initial stage at which firms decide about entry sequentially, finding entry profitable as long as expected profits are greater than or equal to fixed entry costs K. This argument introduces the condition $\pi^* = K$, where π^* is defined as in equation (15). In addition, firms' first-order condition with respect to safety efforts, equation (16), must hold in equilibrium. Both equations contain the endogenous variables of safety investments s and the number of firms n, as well as the policy parameter γ. Rearranging equation (16) and using it in $\pi^* = K$, we obtain

$$\frac{\beta}{(\gamma x'(s)h)^2} - s = K \tag{21}$$

This equation is independent of the number of firms and would allow us to establish the relationship between the damages multiplier γ and safety investment s.[6] Consequently, we can focus on the market entry condition $\pi^* = K$ to establish the link between safety investments and the number of firms, which indirectly gives us the link between the policy parameter γ and the number of firms.

Total differentiation of $\pi^* = K$ yields

$$\left(2\frac{\alpha - MC}{\beta(n+1)^2}(-x'(s)h) - 1\right) ds - 2\frac{(\alpha - MC)^2}{\beta(n+1)^3} dn = 0 \tag{22}$$

[6] This relationship is positive with a higher damages multiplier resulting in increased safety investments.

Modifying both terms by the use of the firms' first-order condition with respect to safety investments, we arrive at

$$\frac{dn}{ds} = \frac{\frac{2}{\gamma(n+1)} - 1}{\frac{2\beta}{(n+1)\gamma^2 x'(s)^2 h^2}} = \frac{\gamma x'(s)^2 h^2}{\beta} \frac{2 - \gamma(n+1)}{2} \tag{23}$$

For $\gamma \geq 1$, the relationship between the level of safety investment and the number of firms is negative. Higher investment expenditures increase firms' fixed costs and thus reduce the number of firms in equilibrium.[7]

We now return to the social planner's optimization problem. With market entry costs, social welfare reduces to consumer welfare because equilibrium profits are equal to market entry costs. The first-order condition for a maximum of social welfare is then given by

$$\frac{dSW}{ds} = \frac{n^2(\alpha - MC)}{\beta(n+1)^2}(-x'(s)h) + \frac{n(\alpha - MC)^2}{\beta(n+1)^3}\frac{dn}{ds} = 0 \tag{24}$$

where the second term denotes the effect on consumer welfare due to the accompanying change in the number of firms serving the market. Making use again of the first-order condition for firms' safety investment, equation (16), the above expression can be simplified to

$$\frac{dSW}{ds} = \frac{(2-\gamma)n}{2\gamma} = 0 \tag{25}$$

This leads to the result:

Proposition 2 *Assume Cournot competition between an endogenous number of firms in an homogeneous product market. Then, we find that the second-best damages multiplier that maximizes social welfare is given by* $\gamma^E = 2$.

Proof. This claim follows from (25), which holds only for the level of γ^E specified. ■

We find that the optimal damages multiplier in the presence of endogenous entry is equal to two. Punitive damages are thus even higher than for an exogenous number of firms and are independent of the resulting number of firms active in the market. It has to be noted

[7] For lower levels of the damages multiplier firms might profit from an increase in the multiplier due to the possibility of circumventing the problem of asymmetric information.

that, in this extension of the baseline model, the policy maker addresses two objectives with the considered policy lever γ. As was true before, the policy maker seeks to induce appropriate product safety investment by firms serving the market. In addition, however, the level of the damages multiplier gives the social planner a handle on the number of firms because $dn/d\gamma < 0$ for $\gamma > 1$. Since, when firms decide on market entry individually, the number of firms is excessive in our baseline model without policy interventions as firms do not internalize repercussions of their entry on market shares of competing firms (see, Mankiw and Whinston 1986), the planner finds it optimal to set punitive damages in excess of the level for the monopoly case in our baseline model in order to address excessive entry. The damages multiplier is only a second-best instrument in this endogenous entry setup as safety investment is distorted upwards. In contrast, if we were to allow for a second instrument besides γ, like a tax on market entry, the planner would choose to stick to the optimal damages multiplier established before, γ^B, and combat excessive market entry by using a positive tax on market entry.

3.3 Firms subject to negligence

In this section, we assume that firms are subject to negligence. This is meant as a robustness check for our baseline analysis and is warranted since, despite the widespread reliance on strict products liability, an aspect of negligence determines the definition of an actual product defect (see, e.g., Shavell 2004: 222). In implementing negligence, we will assume that there is uncertainty about the behavioral standard to which firms should stick in order to be free from liability, which is in the spirit of Craswell and Calfee (1986). As perceived by the firm, due product safety investment s_s is a random variable with support $[\underline{s}, \hat{s}]$ with cumulative distribution function $F(s)$. We assume that the support is so broad as to cause that taking care $\hat{s}$ is dominated by some lower safety level, i.e., uncertainty keeps its bite. Firms will be judged negligent if the product safety investment falls short of the realized behavioral standard. Consequently, the probability of being judged negligent is equal to $(1 - F(s_i))$ for firm i. In contrast, the actual standard will be smaller than firm i's safety investment with probability $F(s_i)$, in which case all losses stay with the consumer. This fact changes the effective consumer price to

$$q = p_i + (1-\gamma)h(1-F(\bar{s}_i))x(\bar{s}_i) + hF(\bar{s}_i)x(\bar{s}_i) \tag{26}$$

and firm i's profits to

$$\pi_i = [\alpha - \beta Y - (1-\gamma)h(1-F(\bar{s}_i))x(\bar{s}_i) - hF(\bar{s}_i)x(\bar{s}_i) - c - \gamma h(1-F(s_i))x(s_i)]y_i - s_i \tag{27}$$

The analysis of the second stage at which firms determine output at the same time runs parallel to that laid out for the baseline model, where we use

$$EMC_N(\bar{s}_i, s_i, \gamma) = c + \gamma h(1-F(s_i))x(s_i) + (1-\gamma)h(1-F(\bar{s}_i))x(\bar{s}_i) + hF(\bar{s}_i)x(\bar{s}_i)$$

instead of $EMC(\bar{s}_i, s_i, \gamma)$. At Stage 1, we obtain the first-order condition for safety investments given by

$$\frac{\partial \pi_i}{\partial s_i} = \frac{\alpha - \beta Y_{-i} - EMC_N(\bar{s}_i, s_i, \gamma)}{2\beta}(-\gamma x'(s_i)h)\left[(1-F(s_i)) - F'(s_i)x(s_i)/x'(s_i)\right] - 1 = 0 \tag{28}$$

Equation (28) can be restated by the use of the equilibrium levels (still given by (13)-(15)) as

$$\frac{\partial \pi_i}{\partial s_i} = \frac{\alpha - MC}{\beta(n+1)}(-\gamma x'(s_i)h)\left[(1-F(s_i)) - F'(s_i)x(s_i)/x'(s_i)\right] - 1 = 0 \tag{29}$$

The social planner's maximization of the sum of profits and consumers' welfare is not affected by the change in the applied liability rule, which is why the first-order condition (restated here for convenience) is still given by

$$\frac{\alpha - MC}{\beta(n+1)}\left(-\frac{2+n}{1+n}x'(s)h\right) - 1 = 0$$

This allows to arrive at the following finding:

Proposition 3 *Assume Cournot competition between symmetric firms subject to negligence liability in an homogeneous product market. Then, there is a damages multiplier γ^N that induces firms to select socially optimal safety investments given by*

$$\gamma^N = \frac{2+n}{1+n}\frac{1}{(1-F(s_i)) - F'(s_i)x(s_i)/x'(s_i)} \tag{30}$$

Proof. The required level of γ follows from comparing (20) and (29). ■

Very intuitively, the optimal damages multiplier for firms subject to negligence with an uncertain due care standard needs to address the distortions in firms' incentives due to uncertainty in addition to the discrepancy between privately and socially optimal safety investments. Note that, as long as the second term in (30) is greater than or equal to one, the multiplier under negligence will be at least as great as the one when firms are subject to strict products liability. This condition regarding the second term lends itself to a straightforward interpretation. Stated precisely, the second term will be greater than or equal to one if

$$\frac{F'}{F} \leq -\frac{x'}{x} \tag{31}$$

which will always hold if the accident probability reacts stronger to changes in s than does the distribution function F. This is very intuitive given that there are two consequences of having uncertain due care (see, e.g., Bartsch 1997): (i) the damage discount effect stemming from $(1-F(s_i))h < h$, and (ii) the liability effect stemming from private incentives regarding saving expected liability payments by increasing the level of safety investment, which can be seen in $-F'h$. The condition (31) may be read as a requirement that the damage discount effect trumps the liability effect as regards incentives for safety investment.[8]

3.4 Heterogeneous firms

Our baseline model examines symmetric firms. In this section, we explore whether the damages multiplier might be different in a setup with heterogeneous firm cost structures. In order to keep the analysis simple, we restrict it to the case of two firms with firm-specific constant unit costs c_i, where $c_i \neq c_j$. This leads to

$$\begin{aligned} \pi_i &= [p_i - c_i - \gamma x(s_i)h]y_i - s_i \\ &= [\alpha - \beta Y - EMC_i(\bar{s}_i, s_i, \gamma)]y_i - s_i \end{aligned} \tag{32}$$

where $EMC_i(\bar{s}_i, s_i, \gamma) = c_i + (1-\gamma)x(\bar{s}_i)h + \gamma x(s_i)h$.

[8] If firms bear liability only for the harm actually caused by their negligence, as formulated by Grady (1983) and Kahan (1989), for example, uncertainty about the safety standard is, ceteris paribus, more likely to result in lower levels of safety investment, suggesting an even greater importance of punitive damages.

At Stage 2, the profit-maximizing response of firm i to given output by firm j results as

$$y_i = \frac{\alpha - \beta y_j - EMC_i(\bar{s}_i, s_i, \gamma)}{2\beta} \tag{33}$$

and leads to

$$\pi_i = \frac{(\alpha - \beta y_j - EMC_i(\bar{s}_i, s_i, \gamma))^2}{4\beta} - s_i \tag{34}$$

At Stage 1, firms's privately optimal investment in product safety is determined by

$$\frac{\partial \pi_i}{\partial s_i} = \frac{\alpha - \beta y_j - EMC_i(\bar{s}_i, s_i, \gamma)}{2\beta}(-\gamma x'(s_i)h) - 1 = y_i\,(-\gamma x'(s_i)h) - 1 = 0 \tag{35}$$

Next, we evaluate the equilibrium in which the actual safety levels are in line with expected safety effort, $\bar{s}_i = s_i$. Stated precisely, the equilibrium outcome is

$$y_i^{**} = \frac{\alpha + MC_j - 2MC_i}{3\beta} \tag{36}$$

$$q^{**} = \frac{\alpha + MC_i + MC_j}{3} \tag{37}$$

$$\pi_i^{**} = \frac{(\alpha + MC_j - 2MC_i)^2}{9\beta} - s_i = \beta y_i^{**2} - s_i \tag{38}$$

where $MC_i = c_i + x(s_i)h$ reflects the total social marginal costs per unit of output of firm i.

Before we turn to the social planner's choice of γ, for ease of comparison, we restate the firm i's condition for privately optimal safety expenditures (35) using the equilibrium levels as

$$\begin{aligned} \frac{\partial \pi_i}{\partial s_i} &= \frac{\alpha - \beta(\alpha + MC_i - 2MC_j)/(3\beta) - MC_i}{2\beta}(-\gamma x'(s)h) - 1 \\ &= \frac{\alpha + MC_j - 2MC_i}{3\beta}(-\gamma x'(s)h) - 1 = y^{**}(-\gamma x'(s)h) - 1 = 0 \end{aligned} \tag{39}$$

The social planner takes account of profits by both firms and consumers' welfare which can be stated as

$$\begin{aligned} CW^{**} =& \alpha(y_1^{**} + y_2^{**}) - (\beta/2(y_1^{**2} + y_2^{**2}) + \beta y_1^{**} y_2^{**}) - q^{**}(y_1^{**} + y_2^{**}) \\ =& \frac{(2\alpha - MC_1 - MC_2)^2}{18\beta} = \frac{\beta}{2}(y_1^{**} + y_2^{**})^2 \end{aligned} \tag{40}$$

The social planner maximizes social welfare

$$\begin{aligned} SW^{**} &= \pi_1^{**} + \pi_2^{**} + CW^{**} \\ &= \beta y_1^{**2} - s_1 + \beta y_2^{**2} - s_2 + \frac{\beta}{2}(y_1^{**} + y_2^{**})^2 \end{aligned} \tag{41}$$

Now, we suppose that the damages multiplier can be made contingent on the firm characteristics, as seems plausible and realistic with respect to punitive damages awards since, for example, a firm's market share is readily observable. In this case, we can look at the derivatives with respect to s_i.

$$\begin{aligned} \frac{\partial SW^{**}}{\partial s_i} &= \beta \left[3y_i^{**} + y_j\right] \frac{\partial y_i^{**}}{\partial s_i} + \beta \left[2y_j^{**} + y_i^{**}\right] \frac{\partial y_j^{**}}{\partial s_i} - 1 \\ &= -x'(s)h \left[\frac{5}{3}y_i^{**} - \frac{1}{3}y_j^{**}\right] - 1 = 0 \end{aligned} \tag{42}$$

Comparison of equation (39) and (42) yields that there is one type-specific multiplier that aligns the firms' interests with that of the policy maker and which is given by

$$\gamma_i^A = \frac{4}{3} + \frac{1}{3}(y_i^{**} - y_j^{**}) \tag{43}$$

Proposition 4 *Assume Cournot competition between asymmetric firms in a homogeneous goods market. Then, there is a damages multiplier γ_i^A that induces firm i to select socially optimal safety investment given by*

$$\gamma_i^A = \frac{4}{3} + \frac{MC_j - MC_i}{3\beta} \tag{44}$$

Proof. The required level of γ follows from equation (43) in combination with the equilibrium output levels. ■

The insight we gain from this variation of the model can be summarized as follows: The optimal damages multiplier depends on differences in market shares between firms which result from differences in marginal costs. An optimal damages multiplier of 4/3 would result for a duopoly if firms were symmetric. However, as the firm with the lower marginal costs serves a larger share of the market, its influence on consumers' welfare is more pronounced. This should be reflected in a higher punitive damages factor for this firm, and vice versa for the less efficient firm. Since marginal costs of production are inversely related to a firm's profit level, the result can also be read in that a higher damages multiplier should be applied to firms with a higher profit level.

4 Duopoly in heterogeneous goods markets

In this section, we consider competition between firms producing goods which are heterogeneous and allow for competition in prices and quantities. The case of differentiated goods is the more realistic one so that the additional insights are practically relevant. In order to maintain tractability, we will focus on circumstances in which two firms are active in the market.

The timing will be such that firms choose safety s_i at the first stage before choosing either the privately optimal price level or output level at Stage 2. We start with the examination of Bertrand competition.

4.1 Competition in prices (Bertrand)

The demand function stemming from inverting (4) for the case of two firms and heterogeneous goods (i.e., $\beta \neq \delta$) results as

$$y_i = \frac{1}{\beta^2 - \delta^2}[\alpha(\beta - \delta) - \beta q_i + \delta q_j] \tag{45}$$

for $i, j = 1, 2$, $i \neq j$. To be parsimonious with regard to notation, we will use $Z = \frac{1}{\beta^2-\delta^2}$ and $A = \alpha(\beta - \delta)$ in the following. Accordingly, firm i's profits are given by

$$\pi_i = (p_i - c - \gamma x(s_i)h)Z(A - \beta p_i - \beta(1-\gamma)x(\bar{s}_i)h + \delta q_j) - s_i \tag{46}$$

Firms simultaneously choose profit-maximizing prices at Stage 2. These are determined by the first-order condition

$$\frac{\partial \pi_i}{\partial p_i} = Z(A - 2\beta p_i + \beta c + \beta\gamma x(s_i)h - \beta(1-\gamma)x(\bar{s}_i)h + \delta q_j) = 0 \tag{47}$$

which results in a price equal to

$$p_i = \frac{A + \beta c + \beta\gamma x(s_i)h - \beta(1-\gamma)x(\bar{s}_i)h + \delta q_j}{2\beta} \tag{48}$$

Equation (48) may again be interpreted as firm i's best response to a given effective price of firm j. Using this price level allows us to restate firm i's profits as a function that no longer depends on p_i and is given by

$$\pi_i = Z\frac{(A - \beta EMC(\bar{s}_i, s_i, \gamma) + \delta q_j)^2}{4\beta} - s_i \tag{49}$$

At the first stage, firms seek to maximize profits by the appropriate safety investment s_i and arrive at the first-order condition

$$\frac{\partial \pi_i}{\partial s_i} = Z\frac{A - \beta EMC(\bar{s}_i, s_i, \gamma) + \delta q_j}{2}(-\gamma x'(s_i)h) - 1 = 0 \tag{50}$$

After having delineated private decision-making, we are now in a position to describe the symmetric equilibrium in which $s_i = s$ and $p_i = p$ hold. The equilibrium levels can be stated precisely as

$$p^+ = \frac{A + \beta c - \beta(1-2\gamma)x(s)h + \delta(1-\gamma)x(s)h}{2\beta - \delta} \tag{51}$$

$$q^+ = \frac{A + \beta MC}{2\beta - \delta} \tag{52}$$

$$y^+ = \frac{\beta}{\beta + \delta}\frac{\alpha - MC}{2\beta - \delta} \tag{53}$$

$$\pi^+ = \frac{\beta(\beta - \delta)}{\beta + \delta}\frac{(\alpha - MC)^2}{(2\beta - \delta)^2} - s = \frac{\beta^2 - \delta^2}{\beta}y^+2 - s \tag{54}$$

where we use $A = \alpha(\beta - \delta)$ and $Z = 1/(\beta^2 - \delta^2)$ in y^+ and π^+.

Before examining the social planner's choice of the damages multiplier in the case of Bertrand competition between two firms producing differentiated goods, we restate firm i's first-order condition for optimal safety expenditures using the equilibrium value of the effective price as

$$\frac{\beta}{\beta + \delta}\frac{\alpha - MC}{2\beta - \delta}(-\gamma x'(s)h) - 1 = y^+(-\gamma x'(s)h) - 1 = 0 \tag{55}$$

Finally, we turn to the planner's optimization. Consumers' welfare is critical for the social planner's maximization of social welfare and given by

$$U^+ = \alpha 2y^+ - \beta y^{+2} - \delta y^{+2} - 2q^+y^+ = \frac{\beta^2}{\beta + \delta}\frac{(\alpha - MC)^2}{(2\beta - \delta)^2} = (\beta + \delta)y^{+2} \tag{56}$$

With this in mind, we arrive at the following statement for social welfare

$$SW^{+} = 2\pi^{+} + U^{+} = \frac{(\beta+\delta)(3\beta-\delta)}{\beta} y^{+2} - 2s = \frac{\beta}{\beta+\delta}(3\beta-2\delta)\frac{(\alpha-MC)^{2}}{(2\beta-\delta)^{2}} - 2s \tag{57}$$

which implies that we may state the first-order condition for socially optimal safety expenditures as

$$\begin{aligned} &\frac{\beta}{\beta+\delta}\frac{3\beta-2\delta}{2\beta-\delta}\frac{\alpha-MC}{2\beta-\delta}(-x'(s)h) - 1 \\ =&\frac{3\beta-2\delta}{2\beta-\delta}y^{+}(-x'(s)h) - 1 = 0 \end{aligned} \tag{58}$$

This allows us to forward the following result:

Proposition 5 *Assume Bertrand competition between two symmetric firms producing differentiated goods. Then: (i) there is a damages multiplier γ^{P} that induces firms to select the socially optimal safety investment; (ii) the multiplier is given by $\gamma^{P} = 1 + (\beta-\delta)/(2\beta-\delta)$, and is decreasing in δ.*

Proof. The required level of γ follows from comparing (58) and (55). The statement as to the change of the multiplier when δ changes follows from the derivative of γ^{P} with respect to δ. ■

The social planner chooses a damages multiplier that is greater than one since $\beta > |\delta|$. The intuition for this optimal level of punitive damages is, again, closely linked to competition in the market. Both goods are substitutes when $\delta > 0$, so that price competition will be fiercer the closer δ is to β. The prescription for the optimal damages multiplier states that punitive damages are the more important the more distinct the products in the market are from the consumers' viewpoint. Since firms' profits increase in the degree of product differentiation, we again obtain a close link between a firm's profit level and the optimal design of punitive damages.

4.2 Competition in quantities (Cournot)

In this section, we return to quantity competition extensively analyzed in Section 3 for the case of homogeneous goods to consider the effects of differentiated goods on the damages multiplier. Given that the analysis itself is similar to the Bertrand analysis, our exposition will be brief.

Using the inverted demand functions described in equation (4), we find the profit-maximizing output at Stage 2 to equal

$$y_i = \frac{\alpha - \delta y_j - (1-\gamma)x(\bar{s}_i)h - \gamma x(s_i)h - c}{2\beta} \tag{59}$$

implying second-stage profits of

$$\pi_i = \frac{(\alpha - \delta y_j - (1-\gamma)x(\bar{s}_i)h - \gamma x(s_i)h - c)^2}{4\beta} - s_i \tag{60}$$

Firm i chooses safety expenditures at the first stage at the same time as firm j and sets it to fulfill

$$\frac{\partial \pi_i}{\partial s_i} = \frac{\alpha - \delta y_j - (1-\gamma)x(\bar{s}_i)h - \gamma x(s_i)h - c}{2\beta}(-\gamma x'(s_i)h) - 1 = 0 \tag{61}$$

In equilibrium, we obtain

$$y^{++} = \frac{\alpha - MC}{2\beta + \delta} \tag{62}$$

$$\pi^{++} = \beta\frac{(\alpha - MC)^2}{(2\beta+\delta)^2} - s = \beta y^{++2} - s \tag{63}$$

It is important to notice at this point that the denominator of y^{++} is different from the one obtained for the equilibrium price under Bertrand competition. This can be related back to the fact that decision variables are strategic complements in classical Bertrand competition and strategic substitutes in classical Cournot competition.

Finally, in equilibrium, the firm's first-order condition for product safety expenditures can be expressed as

$$\frac{\alpha - MC}{2\beta + \delta}(-\gamma x'(s)h) - 1 = y^{++}(-\gamma x'(s)h) - 10 \tag{64}$$

Next, we examine consumers' welfare in more detail to have both determinants of social welfare ready for the establishment of the socially optimal damages multiplier. Using for the effective price in equilibrium

$$q^{++} = \frac{\alpha\beta + (\beta + \delta)MC}{2\beta + \delta} \tag{65}$$

we arrive at

$$\begin{aligned} U^{++} &= 2\alpha y^{++} - \beta y^{++2} - \delta y^{++2} - 2q^{++}y^{++} \\ &= (\beta+\delta)\frac{(\alpha - MC)^2}{(2\beta+\delta)^2} = (\beta+\delta)y^{++2} \end{aligned} \tag{66}$$

This result enables us to maximize social welfare

$$SW^{++} = 2\pi^{++} + U^{++} = (3\beta+\delta)\frac{(\alpha - MC)^2}{(2\beta+\delta)^2} - 2s = (3\beta+\delta)y^{++2} - 2s \tag{67}$$

with respect to the level of the multiplier, which is in our case the same as seeking the optimal safety expenditure. Simplifying the first-order condition for ease of comparison, we establish

$$\frac{3\beta+\delta}{2\beta+\delta}\frac{\alpha - MC}{2\beta+\gamma}(-x'(s)h) - 1 = \frac{3\beta+\delta}{2\beta+\delta}y^{++}(-x'(s)h) - 1 = 0 \tag{68}$$

This completes the analysis, which is compactly summarized in:

Proposition 6 *Assume Cournot competition between two symmetric firms producing differentiated goods. Then: (i) there is a damages multiplier γ^Q that induces firms to select socially optimal safety investments; (ii) the multiplier is given by $\gamma^Q = 1 + \beta/(2\beta+\delta)$, and is decreasing in δ.*

Proof. The required level of γ follows from comparing (68) and (64). The statement as to the change of the multiplier when δ changes follows from the derivative of γ^Q with respect to δ. ■

Intuition as to the level and the adaptation of the damages multiplier in response to a change in δ follows that laid out for Bertrand competition. At this point, we are in the position to also compare the optimal damages multipliers in different modes of competition.

Proposition 7 *The optimal damages multiplier applicable to duopolistic firms who offer differentiated products and compete in prices surpasses (falls short of) the multiplier for quantity-setting firms if $\delta > (<) 0$.*

Proof. To establish this finding, we compare the levels of the optimal damages multipliers in both settings:

$$\begin{aligned} 1+\frac{\beta}{2\beta+\delta}=\gamma^{Q}(>) &< \gamma^{P}=1+\frac{\beta-\delta}{2\beta-\delta} \\ \beta(2\beta-\delta)(>) &< (\beta-\delta)(2\beta+\delta) \\ 2\beta^{2}-2\beta\delta(>) &< 2\beta^{2}+\beta\delta-2\beta\delta-\delta^{2} \\ \delta^{2}(>) &< \beta\delta \end{aligned} \tag{69}$$

Noting that $\beta > |\delta|$ completes the proof. ■

The result we obtain with respect to the dependence of the level of the optimal damages on the mode of competition can once again be traced back to the divergence of the private and social interest. The comparison of the optimal damages multiplier allows for further insights. As the calculations above show, we can establish that the difference in social benefits and benefits perceived by the firm out of higher levels of safety investment is proportional to output. For $\delta > 0$, i.e., the case in which goods are substitutes, the optimal damages multiplier is higher for price competition although firms' profits are lower with price competition, when compared to quantity competition. This can be traced back to higher firm output if firms compete in prices, so that it is the size of the firm measured in terms of output that guides the optimal damages multiplier and not necessarily the level of profits. However, in many circumstances the two measures will be positively related as in the above analysis of asymmetric cost functions.

5 Conclusion

The use of punitive damages has been rationalized as a means to offset the tortfeasor's probability of liability being less than one. In practice, punitive damages are often imposed even in classes of accidents with practically no possibility to escape liability. According to the standard rationale, punitive damages are unwarranted in these instances. This paper establishes that punitive damages are well suited to address another fundamental reason for private decision-makers' choosing socially inadequate behavior. Firms with market power select behavior to maximize profits and disregard its repercussions on consumers' welfare. We show that punitive damages are an instrument to remedy this discrepancy between the firms' objective and society's interest when it comes to product safety investment.

We find that the optimal damages multiplier is closely tied to the characteristics of competition in the market. This is due to the fact that the divergence between firms' interests and that of society will depend on the characteristics of competition too. In particular, we show that the optimal damages multiplier depends on the number of firms, the degree of substitutability/complementarity if products are heterogeneous, firms' cost structures, as well as on the mode of competition, namely competition either in prices or in quantities.

As a concluding note, we would like to point out that the optimality of damages above compensatory damages has proven to be robust to several variations of our baseline model. We conjecture that the general thrust of our analysis would also generalize to settings with more general demand and production functions, although the optimal damages level often will not be reducible to a simple number.

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