

Imperfect competition, joint harm and market share liability

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Abstract

In this paper, we analyze the output and care decisions of firms competing *à la Cournot*, when they manufacture a good that may jointly harm some victims (different from their customers). We consider different liability sharing arrangements (*per capita* vs market share) to which firms are exposed, when the expected harm is related more than proportionally to the output of the industry. We find that compared to the *per capita* rule, the market share apportionment is better for victims and worse for consumers, in the sense that it leads to a lower level of output and higher expenditures in care. However, the net effect on the expected harm to victims is ambiguous, such that it is not clear that the market share rule is dominating in contexts where there is a hard uncertainty, such that it is not feasible to disentangle the influence of each firm on the harm borne by victims. We also show that no sharing arrangement induce the optimal levels of output and care expenditures. On the other hand, the analysis of the determinants of optimal decisions (output and care) and their comparison to the equilibrium levels appear as quite deceptive, in the sense that there is no reason to believe that the optimal level of output (care expenditures) is smaller (larger) than the equilibrium one attained under imperfect competition.

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1 Introduction

Following the recent *Distilbène litigation*¹, one have acknowledged a revival of the debate in France in tort cases with joint and several liability. Some French scholars (Molfessis 2015, Quézel-Ambrunaz 2010) have argued in favor of traditional solutions adopted for damages apportionment (leading to an equal allocation of the damage) compared to the market share rule from the perspective of consistency to admitted theories of causation, and adequacy to jurisprudence. Others have motivated the latter rule on the grounds that market shares may be a proxy for the likelihood of individual liability, in contexts of joint liability characterized by hard uncertainty and ambiguous causation (Ferey and G'sell 2013, G'sell 2010).²

The market shares rule in tort law first appeared in 1980 in the Californian case *Sindell v. Abbott Laboratories*, and up to now, Courts in USA have limited its use in the area of product liability in cases where the origin of the product is unknown/cannot be determined although the set of potential offenders is perfectly identified. However, the potential for the extension of the market share liability is broader both in scope (domains of law) and space. A typical example is illustrated by the progressive diffusion of environmental liability all around the world. At the European level, the Directive 2004/35/CE on environmental liability aims at "inducing operators to adopt measures and develop practices to minimize the risks of environmental damage". The directive let to the member states law the determination of the liability apportionment in case of multi party causation. Interestingly, the french law, at the article L. 162-18 of the environmental code establishes that when an environmental harm has multiple causation, then the damage must be divided among operators in proportion of their participation to the harm³. Although Courts have used the traditional solutions (including dividing the damages to victims equally between offenders) up to now, we believe that exists a potential for a shift to the solution of the market share rule. The main motivation is that situations having the potential to harm environment in relation with industrial and human activities (point-source pollutions) are characterized by hard uncertainty: it may be difficult, even impossible, to disentangle the influence of each individual offender on the total harm to victims.

Indeed, a large range of industrial activities, from the chemical to the oil sectors, have the power to provoke joint harm to several victims as third parties, or more broadly speaking to the environment. From this perspective, one also have to acknowledge that in raising the issue of liability and liability sharing, it turns out to be difficult to ignore the market structure where firms operate, and the imperfection of competition. Indeed, a crucial aspect regarding the extension of liability sharing arrangements to

¹See TGI Nanterre 10 april 2014 n 12/12349 and n 12/13064. Interestingly, both cases concerns the diethylstilbestrol (DES) , a product delivered to pregnant women and which caused years later injuries to the children exposed *in utero*.

²See also Dillbary (2011) for a different perspective on this debate.

³Article L. 162-18 du Code de l'environnement: *Lorsqu'un dommage à l'environnement a plusieurs causes, le coût des mesures de prévention ou de réparation est réparti par l'autorité visée au 2 de l'article L. 165-2 entre les exploitants, à concurrence de la participation de leur activité au dommage ou à la menace imminente de dommage.*

industrial activities relates to their impacts on the strategic interactions between firms, and the intensity of competition. This the central issues of our paper.

Regarding the debates discussed above (liability sharing rules and internal consistency of law, or as proxy of probabilities), we take a agnostic view, and rather focus on a related point although neglected, which is the impact of liability sharing on market under imperfect competition, and the implications for the society/economy. Important is to remind that we consider here the potential of extension outside of product liability, but cases such as environmental law, competition law etc. The questions we ask, in cases absent of any (knowledge of the) possibility to disentangle multiple offenders' responsibility, are: which liability sharing arrangement (no liability, equal share, market share) can be considered as the best outcome ? Does it allow to reach an efficient outcome?

To do so, we use the basic framework of a duopoly in quantity *à la* Cournot, analyzing the simultaneous choice of care and output by two competitors producing an homogenous good. The expected harm to third parties who are not consumers of the good, is related to the market supply of good and to the aggregate expenditures in precaution. Firms operate in the industry under a rule of strict liability, augmented of a rule of damages apportionment. On the one hand, the harm can be equally shared among the firms (*per capita* rule), which is one of most common rule used by the Courts. On the other hand, the harm can shared among firms in proportion of their market share (market share liability). We believe that two other features of our set up are also specific to the problematic of environmental liability: first, we assume that the level of activity in the industry affects the expected harm to victims in a cumulative way, i.e. the expected harm per unit of output increases with the total industry output at a more-than-proportional rate.⁴; second, we assume that precaution is "durable" in the sense of Nussim and Tabbach (2009), that precautionary measures "may be effective or endure for all activity level, and certainly need not to be taken per unit of activity". As a typical example of durable precaution, one may think to investment in specific infrastructures corresponding to a (large) fixed cost, independent from the level of output.

In this set-up, two important results emerge. The first one is that, regarding the objective of safety (preserving victims wellbeing), no liability sharing regime strictly dominates the other one: the equilibrium output level of the industry is larger under a per capita rule than under a market share apportionment – which makes victims worse off *ex post*, since the harm in case of accident is higher. In contrast, and related to this first effect on the output, the equilibrium level of care expenditures is lower under the market share liability than under the equal sharing arrangement – which deteriorates the situation *ex ante* of the victims. The second result is that no sharing arrangement has the power to mimic the optimal levels of output and care expenditures. Maybe more important, the analysis of the determinants and comparison of optimal decisions to equilibrium levels of output and care display some uncomfortable, and clearly deceptive results: generally speaking, there is no necessity for the optimal output (care

⁴See also Daughety and Reinganum (2014) for a discussion in the context of product liability in the domain of medicine, food safety, but also pollution.

expenditures) to be smaller (larger) than what emerges market discipline and the incentives create by liability in the context of imperfect competition.

Section 2 present a brief survey of the literature. Section 3 introduces the model, and the benchmark associated with optimal decisions. Section 4 analyzes the equilibrium under Cournot competition under two different liability sharing arrangements, the *per capita* vs market sharing rule. Section 5 compares the two equilibrium outcomes with liability sharing to the social optimum. Section 6 concludes.

2 Relation to the literature

The first literature to which our paper is connected is about joint and several liability in contexts with multiple tortfeasors (see Kornhauser and Revesz (2000) for a review). Focusing on the incentives to take care, Landes and Posner (1980), Shavell (1985,1987) and Kornhauser and Revesz (1989) have first considered the standard question of the comparative advantages of strict liability vs negligence. Later on, Miceli and Segerson (1991) turn to the issue firms entry, but do not consider explicit strategic interactions between firms.

Also clearly related to our work is the literature about product liability and imperfect competition. The seminal papers by Polinsky (1980), Polinsky and Rogerson (1983) who first discussed the interplay between market power and standard liability rules have been extended to different market set up in the recent period (Baniak and Grajzl 2016, Baumann and Friehe 2015; Baumann and Friehe and Rasch 2016; Chen and Hua 2015; Daughety and Reinganum 2014). Contrary to the issues discussed here, those works are not considering the situation of third parties as victims, (i.e. victims without any contractual arrangement or market relationship with the industry), nor the context of joint liability, or the comparison of alternative liability sharing arrangements. Also worthy to note is the paper by Hamilton and Sunding (2000) who discuss the issue of firms entry in an asymmetric (quantity) oligopoly, as a response to an increase in their liability; nevertheless, apart of considering the case of product liability, they do not provide the characterization of the optimum, nor the comparative analysis between different sharing arrangements.

Finally, it is also worth quoting the paper by Nussim and Tabbach (2009) who challenge the foundations of the standard model of unilateral accident and care, for the reason that it treats care decisions as a non-durable input. The model we develop in the rest of the paper considers this as a serious point. Turning to the analysis of care and output decisions by firms, we take the view that care expenditures may be understood as investment in specific technology and/or infrastructures (dedicated to safety of industrial plants) with long run effects (over the period of production). As such, we treat them as is usual in the IO literature as a productive cost independent of firms output.

3 Model and benchmark

3.1 Setup and assumptions

The situation we are focusing on is one where the good produced provides some benefits to society (to consumers of the good), but accidental events may occur during the production process and victims in case of accident have no contractual nor market relationship with firms; in particular, victims and consumers are not the same persons. Moreover, we are considering a case of multiple liability but in a sense uncertain, since it is not possible to disentangle the influence of each individual firm on the aggregate harm to victims.⁵

To this end, we introduce a very simple model of imperfect competition, where firms may harm some victims/the environment and thus invest in precautionary measures to reduce the cost of liability. We consider the market for an homogenous product, where two firms compete *à la Cournot*. Both consumers and firms are risk neutral. The quantity of goods produced by firm i is denoted q_i ($i = 1, 2$), and $Q = q_1 + q_2$ represents the aggregate output of industry. The market demand is given by $P(Q) = a - bQ$, ($a > 0, b > 0$), consumers being not harmed by the product.

We assume that the expected harm $H(X, Q)$ has the form $H(X, Q) = Q^2 h(X)$, with $X = x_1 + x_2$ and x_i representing the level of care of firm $i = 1, 2$; moreover, we assume that for any $X > 0$, $h'(X) < 0$, and $h''(X) > 0$. This specific assumption captures the fact that the expected harm is related to the industry output ($\frac{\partial H}{\partial Q} = 2Qh(X) > 0$), without any possibility to disentangle the influence of each firm ($\frac{\partial H}{\partial q_1} = \frac{\partial H}{\partial q_2} = \frac{\partial H}{\partial Q}$); moreover the effect is cumulative ($\frac{\partial^2 H}{\partial Q^2} = 2h(X) > 0$) meaning that the higher the level of aggregate activity, the higher the marginal (expected) harm. Similarly, firms' individual precautionary measures are supposed to have the same (negative) impact on the expected damage ($\frac{\partial H}{\partial X} = \frac{\partial H}{\partial x_1} = \frac{\partial H}{\partial x_2} = Q^2 h'(X) < 0$), but returns to scale in the care activity are decreasing ($\frac{\partial^2 H}{\partial X^2} = Q^2 h''(X) > 0$). Finally, remark that this specific functional form may be understood as a case where the probability of accident is captured by $h(X)$, assuming $h(X) < 1$, and the damage in case an accident occurs is scaled by the (square of) output Q^2 . Although this is not the unique interpretation, we will adhere to it throughout the paper.

Let us turn to the productive costs of firms. Since we want to capture the situation where care is considered as a specific input in the process of production, with a durable nature, we will assume that the total cost of production of firm i is $C_i(q_i, x_i) = c_i(x_i)$, $\forall i = 1, 2$, with $c'_i(x_i) > 0$ and $c''_i(x_i) > 0$. To sum up, this specification implies for the sake of simplicity that total production costs of firm i reduce to the cost of care $c_i(x_i)$, the durable nature of care being captured by the fact that the cost of care as a specific input of production does not depend on firm's activity level (since it is independent from

⁵Firms are located at the same place and experience an accident at the same moment; or the damage is diffuse, being the outcome of several minor failures in the production process which are not observable by outside parties, but having large and cumulative effects above some threshold on victims or the environment in the long run etc.

the cost of the other productive inputs used by a firm to produce the good); moreover, it is transparent that we assume that the marginal cost of the other productive inputs is constant and null⁶ (as generally considered in the IO literature) - hence with regard to the use of (other) productive inputs, both firms are supposed to be identical.

However, we will introduce some heterogeneity between firms, assuming that at any given level of precaution, both the total and marginal cost of precaution are lower for firm 1 than for firm 2: $\forall x : c_1(x) < c_2(x)$ and $c'_1(x) < c'_2(x)$.

3.2 The benchmark: social welfare maximization

We first determine the socially optimal level of care and output, associated with the maximization of social welfare, which is defined as the sum of consumers' total utility $SC = \int_0^Q P(z)dz$ minus the total production costs of the output (including the cost of care) augmented of the expected harm. A benevolent planner can directly use the fact that decisions regarding care activity and output are separated from a technological point of view, since care is durable (i.e. does not interfere with the use of other productive inputs). Hence, given that firms are identical in terms of marginal cost of production and produce a homogenous good (firms outputs are perfect substitutes for consumers), the social planner will allocate the same level of output to each firm: $q_1 = q_2 = q$ such that $Q = 2q$. As a result, social welfare is given by:

$$W(q_1, q_2, x_1, x_2) = aQ - \frac{b}{2}Q^2 - c_1(x_1) - c_2(x_2) - Q^2h(X) \quad (1)$$

and the first-order conditions for an interior solution in Q^w, x_1^w, x_2^w are written:

$$a - bQ = 2Qh(X) \quad (2)$$

$$-h'(X).Q^2 = c'_i(x_i), \forall i = 1, 2 \quad (3)$$

Condition (2) means that, at the social optimum, increasing the output level must be pushed to the point where the marginal market proceeds are equal to the marginal cost associated with expected harm. From conditions (3), we deduce that the social optimum requires, for both firms, that the marginal cost of care expenditures equals the marginal benefit associated with the decrease in liability (expected harm). Remark that using equations (2) and (3), the optimal output levels (both aggregate and individual) may be written as a best response function to X^w : $Q^w = \frac{a}{b+2h(X^w)} = 2q^w$, which are strictly increasing in X^w . By the same token, the optimal levels of care may also be written as a best response to (decreasing in) the care level of the other competitor, implicitly defined by: $-h'(X^w). \left(\frac{a}{b+2h(X^w)}\right)^2 = c'_i(x_i^w), \forall i = 1, 2$.

⁶In words, we assume that $\forall i = 1, 2, C_i(q_i, x_i) = c_i(x_i) + kq_i$, with $k = 0$.

Remark that (3) implies $c'_1(x_1^w) = c'_2(x_2^w)$ at the optimum, and thus due to the difference in marginal costs of care, we also have : $x_1^w > x_2^w$.

4 Equilibrium with liability sharing

Having characterized the optimal solution, we now turn to the analysis of liability. We remind that we consider here a situation where the individual influence of each firm on the aggregate expected harm $H(X, Q)$ cannot be disentangled. For that reason, we consider that Courts set for the liability of both firms *in solidum*, and decide that damages to victims are shared between both firms. Let us denote as $L_i(X, Q)$ the amount of compensation accruing to firm $i = 1, 2$; we will consider alternative arrangements in the next paragraphs, according to which, firm's i liability is calculated such that $L_i(X, Q) = s_i \times H(X, Q)$ where s_i is firm's i liability share ($i = 1, 2$).

4.1 Care and output under *per capita* apportionment

Let us assume first that strict liability is augmented with a damage rule consisting in an equal share of the damage between the firms: they have to compensate victims with an equal share of in expected harm ($s_1 = s_2 = \frac{1}{2}$).

In this case, firm $i = 1, 2$ chooses a level of output and care in order to maximize its profit

$$\max_{q_i, x_i} \Pi_i(q_i, x_i) = (a - bQ)q_i - c_i(x_i) - \left(\frac{1}{2}\right) Q^2 h(X) \quad (4)$$

The first-order conditions for firm i (denoting the other competitor as j) require that :

$$a - 2bq_i - bq_j = Qh(X) \quad (5)$$

$$-h'(X) \cdot \frac{1}{2} Q^2 = c'_i(x_i) \quad (6)$$

Obviously, (5)-(6) have the same interpretation compared to (2)-(3). However, two characteristic features are noticeable here. First comparing equation (5) to (2), we observe that firms do not fully bear the total harm to victims (RHS in (2), the marginal increase in the expected harm). Due to the per capita apportionment, they only support half of it (RHS in (5)). Second, comparing equation (6) and (3), a similar effect appears, given that each firm invests in care activity according to their private marginal benefit (LHS in (6)) reflecting the decrease in expected liability, which is half of the social marginal benefit (LHS in (3)). We return to this in more details in the last paragraph, however these simple observation suggest that strict liability with equal damage sharing rule introduces distortions both on the output and care levels.

Note that turning now to the equilibrium, we verify indeed that equilibrium values of the output and care levels are different from the optimal ones: it can be observed that the firms being identical in terms of productive marginal cost (the influence of care activity on the cost of the other inputs being null), condition (5) is identical for both firms: this implies that firms at equilibrium produce the same a level of output, $q_1 = q_2 = q$. Using (5) for $i, j = 1, 2$ we obtain the equilibrium aggregate and individual output levels which are given by respectively: $Q^{pc} = \frac{2}{3} \frac{a}{b + \frac{2}{3}h(X^{pc})} = 2q^{pc}$ where X^{pc} is the aggregate expenditures in care. Now, using (6), the equilibrium levels of care x_i^{pc} for $i = 1, 2$ is implicitly defined as a best response to (decreasing in) the aggregate care level by: $-h'(X^{pc}) \cdot \frac{2}{9} \left(\frac{a}{b + \frac{2}{3}h(X^{pc})} \right)^2 = c'_i(x_i^{pc})$, $\forall i = 1, 2$. Once more, due to the difference in marginal costs of care, we also observe that: $x_1^{pc} > x_2^{pc}$.

4.2 Care and output under market share apportionment

Let us assume now that strict liability is augmented with a damage rule based on the individual market share of each firm: firms have to compensate only a share of the expected harm determined in proportion to their market share ($s_i = \frac{q_i}{Q}$, $i = 1, 2$).

Firm $i = 1, 2$ chooses now a level of output and care which maximize the profit :

$$\max_{q_i, x_i} \Pi_i(q_i, x_i) = (a - bQ)q_i - c_i(x_i) - \left(\frac{q_i}{Q} \right) Q^2 h(X) \quad (7)$$

The first-order conditions for firm i (denoting its competitor as j) require that :

$$a - 2bq_i - bq_j = (Q + q_i) h(X) \quad (8)$$

$$-h'(X) \cdot q_i Q = c'_i(x_i) \quad (9)$$

Once more, (8)-(9) have the same interpretation compared to (2)-(3). However, two characteristic features are noticeable here. Comparing conditions (8) and (2), it is obvious that once more firms do not fully bear the social cost of their market activity (RHS in (2)), and in thus the marginal cost due to ltheir individual liability is smaller (RHS in (8)) than at optimum. Finally, comparing equation (9) and (3), we conclude that in setting of their care expenditures, firms only consider their private marginal benefit (LHS in (9)) reflecting the decrease in their expected liability, which is smaller than at optimum (LHS in (3)). Hence, the same conclusion applies here: strict liability with a damage sharing rule based on market share introduces distortions both on the output and care levels.

We verify here that the equilibrium does not coincide with the optimum. Using (8) which is similar for $i = 1, 2$, it can be concluded once again that firms produce the same level of output, $q_1 = q_2 = q$. Thus the solution to equation (8) correspond to Q^{ms}, q^{ms} respectively the aggregate and individual levels of output, which are given by: $Q^{ms} = \frac{2}{3} \frac{a}{b + h(X^{ms})} = 2q^{ms}$, with X^{ms} the aggregate level of care. In

turn using (9) the equilibrium levels of care x_i^{ms} for $i = 1, 2$ is implicitly defined as a best response to (decreasing in) the aggregate care level: $-\frac{2}{9} \left(\frac{a}{b+h(X^{ms})} \right)^2 h'(X^{ms}) = c'_i(x_i)$, $\forall i = 1, 2$. Obviously, due to the difference in marginal costs of care, we also observe that: $x_1^{mc} > x_2^{mc}$.

5 Discussion

5.1 Comparison of *per capita* vs market share liability rules

We now compare the per capita rule of apportionment with the market share rule of apportionment.

Let us first compare conditions (2) and (5), using that at equilibrium under both liability sharing rules, both firms produce the same quantity; this implies that (2) and (5) may be equivalently written as:

$$\begin{aligned} a - 3bq &= 2qh(X) \\ a - 3bq &= 3qh(X) \end{aligned}$$

In words, they have the same LHS (marginal market proceeds, which decrease in q); but both RHS (corresponding to the marginal cost of liability) verify all else equal (for a given X) $2qh(X) < 3qh(X)$. As a result, it comes that for a given value of aggregate care expenditures, X , we obtain that $q^{pc} > q^{ms}$ (and thus $Q^{pc} > Q^{ms}$). The intuition of the result is as follows. As we know from first order conditions, a firm chooses its level of output such that the marginal market proceeds equal the increase of the individual expected liability (victims' expected compensation accruing to her). However, under the *per capita* this latter increases proportionally to the market output, whereas, under the market share apportionment it increases more than proportionally to the market output. Since the marginal benefit is the same in both situations, then firms always produce more under a per capita rule than under a market share rule of apportionment.

However, we have to take into account the feedback effect of care activity levels (indeed, X is not the same but is specific to each liability regimes, as we now explain). For that purpose, let us turn now to conditions (6) and (9); given that under both liability sharing rules, the levels of output satisfy $Q = 2q$, (6)-(9) can also be written the same way as:

$$-h'(X).2q^2 = c'_i(x_i), \forall i = 1, 2$$

In contrast to what holds for the determination of market outputs, they have the same RHS (the marginal cost of care, which increases in x_i). However the difference in both LHS (corresponding to the individual marginal benefit of liability, decreasing in care) reflects the influence of the market equilibrium.

Thus since we have seen that (for a given X) $q^{pc} > q^{ms}$ – implying thus $2(q^{pc})^2 > 2(q^{ms})^2$, it comes that $x_i^{pc} > x_i^{ms} \forall i = 1, 2$ (and thus $X^{pc} > X^{ms}$).

To complete the argument, let us return to the determination of the output levels, and assess the feedback effect of care activity on equilibrium outputs. Note that since $X^{pc} > X^{ms}$, we obtain $h(X^{pc}) < h(X^{ms})$: this means the cost of liability passed to each firm with the adjustment of precautionary measures is smaller under the first regime (equal sharing) than under the second (market share), implying a smaller operating cost for firms, and thus reinforcing the differential effect on the level of market output initially analyzed.

We summarize the results in the next proposition:⁷

Proposition 1. *When liability is allotted between firms according to their market share, both the aggregate market supply and the aggregate expenditures in care are smaller at equilibrium than when liability is equally shared among firms ($Q^{ms} < Q^{pc}$; $X^{ms} < X^{pc}$; $h(X^{ms}) > h(X^{pc})$). In contrast, the equilibrium expected damage may be larger as well as smaller ($Q^{ms} \cdot h(X^{ms}) \gtrless Q^{pc} \cdot h(X^{pc})$).*

It is important to remark that under both liability sharing rules, firms obtain exactly the same market share at equilibrium, which is $\frac{1}{N}$. Thus, the impact of liability sharing is mainly driven by the market adjustment: liability sharing implies a contraction in the individual level of output (and thus the contraction of the market supply allows an increase in the equilibrium price), this one in turn providing firms with incentives to reduce their expenditures in precaution. As previously discussed, this market adjustment is more important under the liability regime based on market share liability rule, than under the equal share rule. In a sense, this means that the consumers of the good are more affected (in terms of surplus/utility loss) under the market share liability rule, than under the equal sharing arrangement. In contrast, the effect on victims in terms of expected damage is ambiguous, meaning that whether the market share is better or worse than the equal share liability regime in controlling risky activities, is still an open issue.

Indeed, from the *ex post* point of view, victims are better off under the market share liability rule, than under the equal sharing arrangement: in cases where an accident occurs, the effective damage to victims is smaller under the market share liability rule, than under the equal sharing arrangement. However, as a result of weaker incentives to invest in care provided by the market share liability rule, compared to the equal sharing arrangement, the probability of accident is also larger with the first rule. Hence, the *ex ante* point of view does not allow to conclude.

⁷Remark that under a no liability regime, the equilibrium corresponds to a level of output equal to $Q^{nl} = \frac{2a}{3b} > Q^{pc}$ associated with no investment in care, such that the expected harm is $(\frac{2a}{3b})^2 h(0) > \max \left\{ (Q^{pc})^2 h(X^{pc}), (Q^{ms})^2 h(X^{ms}) \right\}$.

5.2 On the inefficiency of liability sharing rules

Finally, we consider here the issue of the distortions introduced by strict liability under the different liability sharing arrangements considered here.

For that purpose, let us write conditions (2) and (3) as (using once more that at optimum: $Q = 2q$)

$$\begin{aligned} a - 2bq &= 4qh(X) \\ -h'(X).4q^2 &= c'_i(x_i), \forall i = 1, 2 \end{aligned}$$

The first line shows that compared with Cournot competition (whatever the liability sharing rule), the optimal level of output is the result of two opposite effects: on the one hand, a higher marginal benefit (LHS in the first equation) in terms of market proceeds; on the other hand, a higher marginal cost of liability (respectively RHS of the first equation, for a given X). The net effect is thus ambiguous, all else equal, and the optimal individual output (and thus the optimal market supply) may be smaller, as well as larger than under any regime of liability sharing.

The second line shows now that, when both the accident externality (full expected damage) and the market externality are jointly internalized, the marginal benefit (LHS) associated with care expenditures is, all else equal (specifically for a given output level Q or q), larger than under any regime of liability sharing - the marginal cost of precautionary measures being the same; thus, all else equal (for a given q) this suggests the tendency for optimal care expenditures to be larger than the equilibrium one⁸. However, the final size of the marginal benefit of care depends on the output level, meaning that given the ambiguity in the comparison between q^w , q^{pc} or q^{ms} , then the comparison between optimal care expenditures and equilibrium ones is also ambiguous.

The results are summarized in the last proposition:

Proposition 2. *Whatever the damage sharing arrangement adopted (equal share vs market share), strict liability augmented with a damage sharing rule leads to an inefficient outcome, both in terms of output and care expenditures, under Cournot competition and durable care. However, both the direction and size of the distortions is undetermined: the equilibrium levels of output and care expenditures may be too high, as well as too low compared the optimal ones.*

Simple calculations may help in understanding the different forces driving the total effect. Since the market adjustment process is all in this framework, we can calculate for example:

⁸This tendency is exacerbated (mitigated) when the optimal output is larger (smaller) than at the Cournot equilibrium.

$$\begin{aligned}
q^w - q^{pc} &= \frac{a}{6} \frac{b - 4 \left(h(X^w) - \frac{1}{2} h(X^{pc}) \right)}{(b + 2h(X^w)) \left(b + \frac{2}{3} h(X^{pc}) \right)} \\
q^w - q^{ms} &= \frac{a}{6} \frac{b - 4 \left(h(X^w) - \frac{3}{4} h(X^{ms}) \right)}{(b + 2h(X^w)) (b + h(X^{ms}))}
\end{aligned}$$

This suggests that, in a case where the market demand is weakly (highly) sensitive to price – in the sense that b is large (respectively, small) – there is a pressure for the optimal output to be set at a higher (lower) level compared to the Cournot level, whatever the sharing arrangement prevailing. However, the feedback influence of the difference in care expenditures and probability of accident, may work in different directions.⁹ Remark specifically that it is not necessary that $h(X^w) > h(X^{ms})$ to have an opposite tendency for the optimal output to be smaller than at equilibrium: if $h(X^w)$ is not too small compared to $h(X^{ms})$, then $h(X^w) - \frac{3}{4}h(X^{ms}) > 0$ and $h(X^w) - \frac{1}{2}h(X^{pc}) > 0$ may hold.

6 Conclusion

The paper shows that although it is easy to compare the consequences of liability under the different regimes of damage sharing for the consumers of the good, things are less clear for the victims. As a main conclusion, it is not clear that the market share rule is dominating the *per capita* rule in contexts where there is a hard uncertainty that prevents from disentangling the influence of each firm on the occurrence of accidents and harm borne by victims. Under strict liability with damage sharing, firms have an incentive to reduce the output level, because of the additional cost due to liability load, the contraction in output being larger under the market share rule than under the equal sharing arrangement – despite firms share half of the market under both regimes at equilibrium. In turn, as the output decreases, firms' liability exposure is reduced, justifying to cut individual expenditures in care. As a result, regarding the issue of the control of risk through tort law and liability regime, there is a trade-off between a smaller damage in case of accident (market share rule) or a smaller probability of accident (equal share arrangement). Turning to the issue of efficiency, the analysis is quite deceptive. Compared to the discipline imposed by liability under imperfect competition, the optimal level of output is influenced by contradictory forces (both the marginal benefit and the marginal cost associated with production increase), which cast some doubts on the general structure of incentives exerted on care expenditures.

This work may be extended in several directions, to start with, relaxing the assumption of firms symmetry in terms of production cost, and/or turning to the case of non durable care activities. As the cost structure of firms changes in both situations, introducing cross effects between care and other

⁹Remark that it is not necessary that $h(X^w) > h(X^{ms})$ to obtain $h(X^w) - \frac{3}{4}h(X^{ms}) > 0$ and $h(X^w) - \frac{1}{2}h(X^{pc}) > 0$. If $h(X^w)$ is not too small compared to $h(X^{ms})$, then the feedback influence of care expenditure on the difference in outputs will be negative.

productive inputs, it can be anticipated that the analysis of strategic interactions at the market stage and incentives to invest in precaution will become richer but less clearcut. However, it is important to analyze the effect of liability sharing on competition and care expenditures, and mainly how it affects firms market shares at equilibrium. A neglected aspect in the arguments of pros and cons the market share apportionment solution, comes from the fact that these market shares are not exogenous, but they reflect the structure of incentives designed by tort law and liability rules, given the characteristic features of the competitive environment. Hence, assessing the influence of alternative competitive environments is also at the top of our agenda of research.

7 References

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