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# PRODUCT LIABILITY: DETECTING POTENTIAL RISKS IN NEW PRODUCTS

**Andrea Castellano , Gustavo Ferro**
**y Maximiliano Miranda Zanetti**

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**Product Liability: Detecting Potential Risks in New Products**[*]

**Andrea Castellano**[1], **Gustavo Ferro**[2] **and Maximiliano Miranda Zanetti**[3]

**Abstract**

The central hypothesis of this article is that liability regulation can foster firms' incentives to study the (potential) dangers of their products. We discuss alternative views and develop a formal model to analyze a firm´s incentive structure under the application of hindsight liability.

We find a new role for liability regulation: to foster voluntary investment in research aimed at detecting potential risks in new products. The model allows us to analyze the firm´s investment decisions in research under different scenarios, each of which has varying expected costs. We offer some alternatives for institutional design seeking incentive compatibility with the aim proposed.

**Key Words:** risk, regulation, product liability, incentives, asymmetric information.

**JEL Codes: K12, K22**

[*] The views of the authors do not necessarily represent the position of Universidad del Cema.

[1] Departamento de Economía, Universidad Nacional del Sur (UNS). Bahía Blanca, Argentina. acastell@uns.edu.ar, acastell45@gmail.com

[2] Universidad del CEMA (UCEMA) and CONICET. Buenos Aires, Argentina, gferro05@yahoo.com.ar, gaf97@ucema.edu.ar

[3] Departamento de Economía, Universidad Nacional del Sur (UNS). Bahía Blanca, Argentina, mmiranda@uns.edu.ar

## 1. Introduction

Launching new products can improve consumers' welfare but simultaneously expose them to damages and potentially challenging public policies if a market failure such as asymmetric information exists. Some of these interventions are present under the umbrella of quality and safety regulation (in food, drugs, and other products). Nevertheless, command and control regulations are only one possibility, among many.

If only homogeneous products were the object of the transactions, or if product differentiation were allowed but in a perfect information context, consumers would receive the expected quality on average. Thus, the characteristics and reliability of products would not require any quality regulation. But with heterogeneous goods and asymmetric information, the consumer may not receive said expected quality and she will likely suffer unimagined damages at the time of purchase.

The problems we try to address have to do with the inability of a product to satisfy an apparent need because of its malfunction, a shorter duration or shelf life, or a potential health hazard to the consumer. The consumer could find her welfare eroded concerning her expectations, whether the product fails because of a malfunction or affects the health of the consumer.

The factor that defines liability is often a product "defect", understood as an abnormal or unexpected feature that makes the good particularly hazardous. Three possible types of defect could be distinguished: *manufacturing defects*, in which the particular product deviates from the planned design, and thus a difference arises between product reality and design, normally after a failure in the manufacturing process; *design defects*, taking place when the product is made as planned by design, but causes risk of damage, which could have been avoided or reduced with an alternative design; and *warning defects*, in which product risks could have been reduced or avoided using suitable usage instructions or warnings not provided by the producer.

The effect of asymmetric information is an inefficient resource allocation in case of underestimating risks which yields excessive consumption, or overrated dangers, that lead to lower consumption than in the optimum. Some degree of intervention may be

necessary, and the available mechanisms encompass command and control via administrative regulatory norms and/or incentive-driven regulations through contract law and liability rules. Following Calabresi (1970), in the first case, the mechanisms are of a *specific deterrence* while in the second case, they are of a *general deterrence*. In quality regulation, particularly, the possibilities go from *product liability* (among the incentive-based mechanisms) to direct regulation or *product safety* (among command and control mechanisms).

When the solution to an economic problem includes regulatory options, we should be able to foresee the expected effects of the instruments in the agents' conduct, and the costs of the different alternatives at hand (Cooter and Acciarri, 2012).

We analyze the case of products that are considered *a priori* risk-free but later become associated with relevant risks after consumption. The problem originates in the initial absence of information about its potential danger and ways to produce and disclose it. Our main hypothesis is that product liability can contribute to generating incentives for firms' research into the potential hazards of their products.

We explore a new role for liability that involves favoring a firm's voluntary investment in research when launching a new product on the market. We consider the specific design of an institution that contemplates that the firm can face liability when the causal link at the time of launching is unknown, essentially charging the firms with hindsight liability.

Shavell (1992) analyzes the parties' decisions to acquire information about the risk of undertaking an activity and the adoption of different levels of precaution under different rules of liability (particularly, strict liability and different rules based on negligence). Our model differs from Shavell's because it is specific to the case of product liability. We analyze the probability of discovering the dangerousness of the product.

After this introduction, the paper is organized into five sections. In the second, we briefly discuss the informational problem related to product innovation. Section three develops a formal model considering a liability regulation where the firms face hindsight liability. Section four considers some alternatives for institutional design, seeking incentive compatibility with the proposed goal. Section five concludes.

## 2. Innovation and unpredictable risks

Some new products are mere variants of existing goods whose risks are already known. Others are new brands that are offered without enough information on the type, magnitude, and probability of their potential harm. It is also possible that some new products are launched risk-free because, according to state-of-the-art knowledge at the time of issuing, they are assumed to be innocuous. Hence, after the product is consumed and some harm is reported, relevant risks begin to be associated with the good.

Information on potential damages is socially valuable as it influences the cost of the damage, the precautionary measures for its reduction, and the replacement for other products. The firm´s private cost should also be determined since it involves potential damage compensation, influencing modes, and the amount of information to produce.

Not all the alternatives to providing information are equally advantageous. Public agencies, for instance, could not possess special comparative advantages in their production. Also, the obligation to investigate implies that firms face relevant monitoring and enforcement costs. Thus, it is tempting to incentivize the private generation of information via proper legal mechanisms.

The latter is not free of problems since the production of information presents some features of public goods: not only because of the absence of rivalry but also for the empirical difficulty of excluding agents from their use. Institutions can contribute to generating incentives to produce efficient, new, and relevant information, and to disclose it in a complete and opportune way.

The institutional treatment of these kinds of risks is complex and we can distinguish two extreme visions: on the one hand, forbidding the development and marketing of a product until it has been proven innocuous or, on the other hand, not regulating it whatsoever given the benefits that the activity or the consumption of the good can generate. Many alternatives exist between both extremes, but we analyze just

one: a new role for liability when some scientific uncertainty exists in evaluating these risks.

The situations involved demand a systematic search for additional scientific evidence and a better comprehension of the risks, to establish the associated causal and probability relationships.

The sources of that desirable information could distinguish the following possibilities they are not mutually exclusive and they can be combined:

1) Financing the research exclusively with public funds.
2) Imposing mandatory research on behalf of the producer firms.
3) Generating incentives for a firm's voluntary research through the legal system.

Assuming asymmetric information and limitations on the regulator's resources, knowledge, and power, the third option is appealing. Thus, the decision to acquire information depends on the value that the same represents for the firm against the costs it faces when conducting research. Applying this criterion makes it necessary to analyze the agent's incentives. It is essential to detect and attribute the damage and determine how the liability will be applied. We explore a new role for liability: to favor the voluntary investments in research by firms that launch new, potentially harmful products on the market à la Dana (2009) and Ben Shahar (1998).

The distinction between *liability* and *hindsight liability* rests on the causal link between harm and a product, required to impose a damage claim against the firm in favor of the victim. If some court determines that no causal relationship could be borne, given the lack of sufficient knowledge when the harm was done, and no liability could be imposed on the producer of the good, Roman law countries state that the producer is not responsible because of *development risks*. In law systems that take that approach, the producer will be held responsible only if the causal relationship between harm and product was (or could have been) known at the moment the damage appears [*liability*], but no responsibility is borne if the relationship is found afterward. If, on the other hand, the statutory system determines that the producer must compensate for the damage even though the causal relationship was unknown when harm appeared, it is said that

*hindsight liability* applies. In such cases, the absence of scientific evidence about the causal link is not admitted as evidence.

## 3. A model of a firm's research investment decision

What are the firm's incentives to conduct research (to generate information) and what are the possible institutional answers? If they are liable for development risks, the firm has incentives to determine whether the product is harmful to consumers. If the damage were assessed, the product should be recalled, to reduce the amount of compensation to be paid.

We present a model to analyze a firm's incentives under hindsight liability to explore the proper institutional design that favors a firm's investment in voluntary research. Obtaining more scientific evidence makes it possible to turn an ambiguous scenario into a risky one.

Viscusi and Moore (1993) find that competition forces innovators to introduce their products in the market too early, which raises the consumers' harm risk. On the other hand, the inclusion of punitive damages increases the costs of innovations and slows down the innovation rate. Furthermore, punitive damages prevent innovations from being introduced prematurely and will lead to a higher chance of innovations' defects being detected in time. Introducing the product at an earlier date may imply that the probability of harm will be higher, as less time will have been spent investigating the associated risks. However, the authors do not consider any uncertainty about possible damages that may be found in the future and do not refer to either damage causality or *hindsight liability*.

### 3.1. Product liability and the damage causal relationship

Let us assume that a firm is selling a good or service for an amount $a$ in a market, charging a price $p(a)$ (with $\frac{dp}{da} < 0$ that implies certain market power, perhaps originating from a patent or trademark), facing a production cost $C(a)$.

This product can (or cannot) generate some harm to consumers of magnitude $H$ after marketing. The probability of associating $H$ with the consumption of a quantity $a$ of the good is in principle unknown (Shavell, 1987). Harm increases for the time being without discovering the causal link (if it exists).

We assume:

1) The denomination $c$ to design one state of the world where a reasonable belief exists (according to conventional science) that a quantity of product $a$ causes a harm equal to $H$.

2) The denomination $\neg c$ (not c) to design another state of the world where a reasonable belief exists (according to conventional science) that an amount of good $a$ does not cause a harm equal to $H$.

To determine whether a product belongs to either case, scientific information is needed to evaluate risks properly. The information concerning the causal relationship between $H$ and $a$ can be provided by the same firm after deciding to invest in information, or it can be obtained in an independent or complementary way by third parties' research efforts, or by serendipity.

### 3.2. Implied costs

A firm causing harm can deal with two kinds of costs: compensation and research. Let *l* stand for the first one, corresponding to liability for damages caused by the products. For the sake of simplicity, we can assume (in case of showing that the product generates a harm H) that $l = H$, assuming s*trict liability*, where the harm should be compensated for, independently of the producer's guilt. Also, to simplify, the total harm will be proportional to sales. So, the amount of compensation will be $a \cdot l$ [even when it is possible that only a fraction of the consumers, say $\beta < 1$, suffer the harm and consequently sue. Hence, the compensation that the firm should face would be $\beta a l$].

The firm will only face a unit cost $l$ when scientific evidence of the causal relationship between the product and the harm exists. We assume development risks are the responsibility of the firm or that some hypothetical benefit of a prescription term that limits its liability does not exist.

The second cost component, $R$, represents research expenditures aimed at discovering whether the product is associated with a positive probability of harm to consumers. Three possibilities arise:

1) It is determined that the product causes harm $H$ (state $c$).

2) It is determined that the product does not cause harm $H$ (state $\neg c$).

3) Neither $c$ nor $\neg\, c$ is determined and uncertainty continues.

In the first two cases, research on the perils of the product motivates an alteration of the status quo. Thus, the firm should decide whether to stop offering the product in the first case or to continue offering it in the second and whether it would be necessary to recall units that have already been sold. The investment in research is conditioned by the probability of a result. In what follows, the pertaining beliefs about the likelihood of each possible result, represented in assumed probabilities, will be relevant to the investment decision.

This investment in research to determine the perils of the product has some features of a public good: if the information is disclosed, the firm that produced it will not accrue all the benefits of its production. Besides, the incentives to produce the information do not coincide with the incentives to disclose it since a result c will correlate with a positive cost $l$ while one result in $\neg$c will lead to $l = 0$, and the same is true of the continuity of the status quo.

If the results of the investigation are that the product is harmful, and they are hidden, the firm should not pay $l$, at least until a third party establishes the causal relationship between the product and the harm.

Among the determinants of $R$ we find two elements: money and time devoted to research. The firm will be interested in investigating while the causal link between

product and harm goes undetected. The spending on research will increase with the sales level: $R(a)$ with ${dR}/{da} > 0$.

### 3.3. Investment in research and damage causality

Let us call *assertive result* $E$ the discovery of a state of the world $c$ or $\neg c$, which under the research financed by the firm has a probability that is positively related with $R$, called $\pi$. $E$ may not be achieved (denoted as $\neg E$ ) with probability $(1-\pi)$. Thus, $\pi$ will depend positively on the firm's research effort, $\pi(R)$ with $\partial\pi/\partial R > 0$.

We assume that the probability of finding the causal relationship between the product and the possible damage caused by the firm is independent of third parties possibly discovering the association of the product with the damage. We assume that third parties can discover the link with probability $\theta$. That is, states $E$ or $\neg E$ can be achieved with probability $\theta$ or $(1-\theta)$, respectively.

We assume *hindsight liability*; even in the case that the causal link was unknown at the time the damage occurred, the firm should compensate retroactively for such harm if after some time state $c$ is determined. Instead, if some state of the world $\neg c$ or $\neg E$ is found, no compensation will be paid.

Thus, the firm can face three situations:

1) $E$ and $c, l = H$ and the firm should compensate for $al$.
2) $E$ and $\neg c, l = 0$. The firm does not pay any compensation.
3) $\neg E$ , $l = 0$ since no harm can be traced to the firm's actions.

We call $\Phi$ the probability that the firm's investigation reaches $c$ and $(1-\Phi)$ the $\neg c$ event probability, given that the research determines a state $E$; $\alpha$ stands for the probability that a third party finds $c$ and $(1-\alpha)$ the probability that third parties find $\neg c$, given an assertive state of the independent investigation.

We also assume that there is an external, objective state of the world, independent of the research efforts, which determines that certain goods may cause some damage. Thus $\Phi$ is relatively independent of $R$.

To sum up, the causal link could be established either through some investment by the firm or by a third party; everyone can reach a state of certainty or indeterminacy with some probability; and if it is possible to find the certainty result using either of the two ways, the product can be harmful or not with a certain probability. Table 1 presents all alternative results and their implied probability.

**Table 1: Alternatives to establish or reject the causal relationship**

| | | |
|---|---|---|
| **Firm's investment (endogenous action)** | Scenario $E$ with probability $\pi$ | Scenario $c$ with probability $\Phi$<br>Scenario $\neg c$ with probability $(1-\Phi)$ |
| | Scenario $\neg E$ with probability $(1-\pi)$ | |
| **Third parties' investment (exogenous action)** | Scenario $E$ with probability $\theta$ | Scenario $c$ with probability $\alpha$<br>Scenario $\neg c$ with probability $(1-\alpha)$ |
| | Scenario $\neg E$ with probability $(1-\theta)$ | |

### 3.4. Firm's decision and hindsight liability

A firm adopting rational choices will spend resources to attain scientific information on the potential harm its product can cause, given that it implies an expected cost reduction against the opposite alternative. To avoid the complexity of intertemporal issues, we assume a zero discount rate, an assumption that can be eliminated in possible extensions. Also, for the sake of simplicity, we assume that the discovery of the state *c* does not harm the product's reputation and, therefore, its sales.

If we think that consumers are insured against any risk, since liability schemes protect them, then independence between harm and prices is a reasonable assumption. Since we are focusing the analysis on the economic incentives to invest, we will simplify the decision of the firm, considering the problem of fixing price and quantity already solved.

To isolate the problem of incentives for research, we will henceforth suppose that the firm has already solved its optimization problem of how many units to produce [$a$ is fixed]. On the one hand, this fulfills the aim of isolating the problem of incentives for research in a compact, simple way. On the other hand, it is a quite reasonable

modeling choice since research on a product is normally a very long process, and most of the time it's not yet complete by the time of product launching (and thus is independent of quantity choice). A possible extension to this work could tackle both decisions simultaneously, perhaps assuming simple demand functions, as commented in the conclusions.

If it is proven that the product is harmful, the firm should compensate consumers for all units sold since the good is already on the market. If the causal link is not verified, no compensation will be paid, and the determination of the relationship depends partially on the firm's decisions.

A key element to consider is the probability that a third party discovers the causal link between a product and damage. In turn, in the assertive scenario it is possible to reach $c$ or $\neg c$ [here probabilities $\theta$ and $\alpha$ are relevant]. We will consider a (risk-neutral) firm that maximizes expected profits (or minimizes expected costs). This is the prevalent modeling choice for the firm. Alternatives include assuming some form of risk aversion, or a managerial view of firm decision that explores another objective, rather than profit maximization.

At this point, let us precisely model the possible interactions between the firm and third parties in the language of Game Theory:

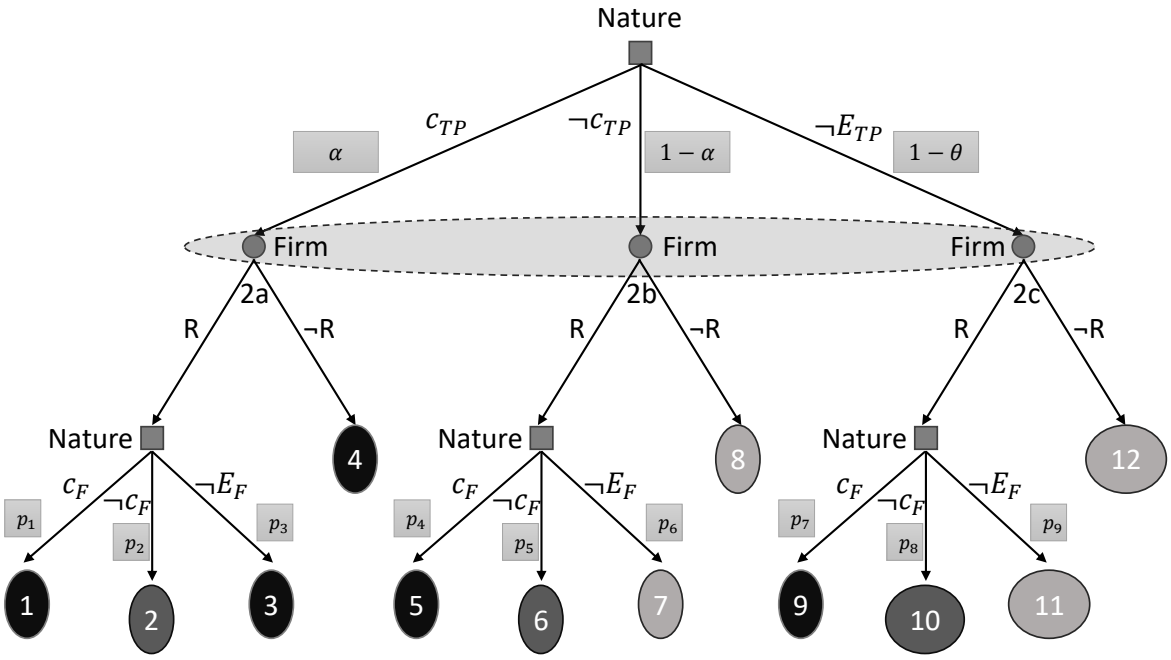


Figure 1. The extensive form (game tree) represents the general case of interaction between the firm's and third party's research.

Figure 1 represents the most general view of the possible interaction between the firm and third parties. This is the standard way of modeling such interaction under a game theoretic framework (Fudenberg and Tirole, 1991). The firm has to decide whether to do research, not knowing the 'state of the world', that is, if the product is harmful or not, whether the firm or a third party will find the real state, etc. Different states of the world have different probabilities, which have been described above. The agent's "Nature" represents the randomization of the distinct outcomes. Since the firm ignores such information, it should decide on every possible scenario. This is represented in the figure by an informational set comprising the nodes 2a, 2b, and 2c. The probabilities $p_1, p_4$ and $p_7$ are all set to the same value in this work [$\theta$]. Likewise, $p_2 = p_5 = p_8 = 1 - \theta$ and $p_3 = p_6 = p_9 = 1 - \pi$. That implies statistical independence between studies. The setting could be made more intricate, but the main idea, that of thinking of research as insurance in trying to understand whether the product is safe, remains, except for the case in which rival research is a perfect substitute good.

Ovals represent outcomes at terminal stances. For instance, oval 2 represents the situation in which the third party has concluded that the product may be harmful,

although the firm has evidence to think otherwise. The situation outlined in Oval 2 is one of those in which investment in research proves valuable: the firm has evidence to contradict third parties' reports and to state that the product may be innocuous. Though the interaction could be made more complex, in this work we took the setting in which no information is withheld, and the firm can use research showing no harmfulness to deny responsibility.

If $\theta = 0$ (or $\alpha = 0$), the firm faces two additional costs besides production costs: research and compensations:

$$C(a) + R(a) + al \tag{1}$$

If the firm does not spend $R(a)$, it will never face claims for liability since the state of the world will always be $\neg E$, and its expected cost will only be $C(a)$. Thus, the firm will not find it profitable to conduct research: for $\theta = 0$, and any given value of $a$ , the expression (1) will be even greater than $C(a)$ .

Setting this possibility aside, we should analyze the incentive structure when $\theta > 0$ and $\alpha > 0$. If the firm does not invest in research, and if the causal link between product and harm is established by a third-party effort with probability $\theta$ of reaching $E$ and probability $\alpha$ of a scenario $c$ , the expected costs of the firm will be:

$$\theta\{\alpha[C(a) + al] + (1 - \alpha)C(a)\} + (1 - \theta)C(a) \tag{2}$$

If we consider that the scenario is $\neg E$ with probability $(1 - \theta)$, or $\neg c$ with probability $(1 - \alpha)$, the compensation should be $l = 0$. Arranging, we have:

$$C(a) + \theta\alpha al \tag{3}$$

Note that the probability of discovery of the causal link by a third party influences the firm´s decision (even when it does not invest) because it will reduce production

levels. This can be seen through the computation of the marginal cost under these circumstances, resulting in $C'(a) + \theta\alpha l$, greater than the production marginal cost.

This decision can be rational for the firm if it suspects that the research is not conducive to any assertive result $E$ or if it expects to obtain the assertive result $\neg c$. In this sense, the firm will act as a free rider concerning the third party's research investment. Although the firm considers that its product is harmless, it knows that it lacks arguments to persuade buyers about that harmlessness and assumes that others could produce that information, or at least that nobody can objectively (scientifically) prove the opposite. A third party may choose whether to disclose that information or not. Though that possibility may be open, we will from now on assume that the parties disclose information. A possible extension with somewhat different results can be devised assuming that the third party decides to hide the findings. It is also possible, even beyond our current goal, to extend the interaction under a Game Theory framework to tackle the incentives of information disclosure for both agents.

If the firm invests, there are four possible scenarios (upper half of Table 1):

1) Finding $E$ and $c$,
2) Finding $E$ and $\neg c$,
3) Finding $\neg E$ while no third party finds $E$,
4) Finding $\neg E$ while a third party finds $E$, that is, discovers $c$ or $\neg c$.

That scenario description points out one of the more important incentives of the research: given that a firm's and third party's efforts (see the lower half of Table 1) are not perfectly correlated, a firm's research has the strategic benefit of protecting the actor in circumstances where the studies could show the harmlessness of the product, even when a third party finds evidence to the contrary.

Although we assume here total independence between a firm's and a third party's results of the research, this incentive to self-protect through their investigation will only vanish when the findings collected by the company and the third party are perfect substitutes. Hence, if both studies yield the same outcome, the incentive to free ride is complete.

If the firm invests and determines a state $E$ with probability $\pi$, the expected costs are:

$$\Phi[C(a) + R(a) + al] + (1 - \Phi)[C(a) + R(a)] \quad (4)$$

The first part of (4) describes the expected costs with probability $\Phi$ if the product is harmful. The second part with probability $(1 - \Phi)$ describes the costs implied if the product is harmless to consumers (state $\neg c$ ).

If the firm makes the research effort incurring in $R(a)$ but finds the scenario $\neg E$ with probability $(1 - \pi)$, then two situations are possible: either the harm is never discovered (even when it exists), or its harm is established by a third party's action. In this case the expected costs are:

$$\theta\{\alpha[C(a) + R(a) + al] + \ (1 - \alpha)[C(a) + R(a)]\} + (1 - \theta)[C(a) + R(a)] \quad (5)$$

In (6) we relate (4) and (5) to combine the scenarios $E$ and $\neg E$, with probability $\pi$ or $(1 - \pi)$, respectively. Thus, if the company invests in research, its expected costs will be:

$$\pi\{\Phi[C(a) + R(a) + al] + (1 - \Phi)[C(a) + R(a)]\} + (1 - \pi)\{\theta\{\alpha[C(a) + R(a) + al] + \ (1 - \alpha)[C(a) + R(a)]\} + (1 - \theta)[C(a) + R(a)]\} \quad (6)$$

Rearranging conveniently (6):

$$C(a) + R(a) + al[\pi\ \Phi + (1 - \pi)\theta\alpha] \quad (7)$$

Now we can compare situations when the research is completed (7) and when it is not (3).

The firm has incentives to invest if the expected cost when researching (7) is lower than when no investment is made for all possible $a$ (3):

$$C(a) + R(a) + al[\pi\, \Phi + (1 - \pi)\theta\alpha] < C(a) + \theta\alpha al \tag{8}$$

Rearranging we obtain:

$$R(a) + al\pi(\Phi - \alpha\theta) < 0 \tag{9}$$

If $R(a)$ is positive, the fulfillment of this condition demands that $\theta\alpha > \Phi$; that is, that the probability that a third party reaches state $E$ and within $E$ to $c$ must be greater than the probability that the firm reaches scenario $c$.

Besides, it is necessary that the absolute value of $al\pi(\Phi - \alpha\theta)$ be greater than $R(a)$. If research only makes sense for the firm when the probability of achieving an *assertive result* before any other agent is lower than the probability that a third party succeeds, then all investment seems wasteful. Nevertheless, the cost of research is not only conditioned by probabilities but also by the value of $R$.

The standard treatment under which *hindsight liability* is charged on the firm provides incentives to invest for those firms that can do it more efficiently, that is, with lower costs than competitors or third parties. However, the incentives under a standard treatment may be insufficient to induce firms to do research into the harmfulness of their products.

## 4. Alternative institutional designs

One regulatory option is to exempt firms from liability if some damage occurs because the product´s causal link is unknown, and the harm is discovered afterward. The other possibility is making the firm liable even under those circumstances. The firm then faces *hindsight liability,* or, in other words, they are not exempt from liability.

Because of the above results, the option with *hindsight liability* is superior to the other. Even when the incentives to conduct research are limited under the former, the latter is worse since it never prompts the production of new information.

Incentives for research appear if the expected cost of research is lower than the cost of avoiding the investment. This means that the probability of establishing the causal link between product and harm by a third party will be greater than the firm, and this alternative has a greater likelihood than the chance of the firm to do so. Given such a narrow edge, we can conclude that the standard system does not generate enough incentives for firms to do research into the harmfulness of their products.

Beyond this preliminary conclusion, it is still possible (and desirable) to reform the design of *hindsight liability* so that it conforms more accurately to the present aim. Some common legal tools, each with its limitations, make it possible to progress towards the objective.

The problem concerning information production is mixed with another one, separable but not so distant: the disclosure of information once it has been generated. Withholding the information could benefit the firm that collects it since no compensations are due so long as it remains unknown, and it is possible to imagine the incentives for all the firms in a sector to cartelize and thus avoid the disclosure of relevant information once it has been produced.

Changes in the liability system should contemplate both production and disclosure problems. We see three possible regulations that can be applied jointly or individually.

The first consists of reducing liability costs when a firm conducts research and discloses the findings. It could lead to two different compensations: $al_1$ if the firm discovers the causal link and $al_2 > al_1$ if a third party does. With $0 \leq al_1 < al_2$, there is some freedom to fix compensations, depending on certain magnitudes and constraints; in one extreme case the firm could be exempt of any liability ($al_1 = 0$). With such changes, the condition (8) becomes:

$$C(a) + R(a) + al_1[\pi\, \Phi + (1-\pi)\theta\alpha] < C(a) + \theta\alpha al_2 \qquad (10)$$

For the firm's expected cost to be lower when it carries out the research, it is necessary that $\theta\alpha l_2 > l_1[\pi\,\Phi + (1-\pi)\theta\alpha]$. The legal system can work at a value of $l_1$. For one extreme case, $al_1 = 0$ (no liability at all), it is only necessary that $R(a) < \theta\alpha al_2$ to produce the incentives for research; that means the expected compensation when a third party discovers the causal link will be greater than the cost of the research.

The second possibility consists of increasing the compensation of the firm that does no research or does not discover the harmfulness of the product, while another party does. The most accessible legal instrument to achieve this could be by imposing *punitive damages*. These are the amounts imposed on firms causing harm in addition to the amount of harm caused (*compensatory damages*) and which can be granted, partially or totally, to the victim.

A third option, which can be applied jointly with either of the above, is applying *punitive damages* to the firms that withhold information, aggravating the liability concerning the standard case. This is equivalent to establishing that $al_2 > al_1$, where $al_2$ could be the value of the compensation including punitive damages. These can be imposed considering guilty behavior and not disclosing information without demanding changes in the design of the institution. This last option is conceivable if it were possible to prove that the information had not been disclosed.

## 5. Conclusions

We studied the efficiency of instruments addressing potential damages to consumers caused by new products whose harmfulness has not been determined.

Liability can contribute to generating incentives for firms to conduct research and disclose information about the potential hazards of consuming their new products.

We present a model to evaluate whether *hindsight liability* does produce incentives for firms to do research into a new product´s dangers. The model allows us to analyze a firm´s decision under different scenarios, defined by the expected costs. Defining the causal link between products and harm is key.

We find a new role for liability: favoring investment in voluntary research by firms that launch potentially harmful new products. We conclude that the traditional liability approach plus some suggested innovations can contribute to these aims.

There are some possible extensions, of differing degrees of complexity, such as: considering simultaneously price or quantity choice along with investment decision, introducing simple behavioral functions and evaluating the results, contemplating a positive discount rate to analyze a finite number of periods in a dynamic model, exploring the decision to cease production, or designing a Game Theory framework where the competitors discover the information before the firm does and decide whether to disclose it.

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