Product liability should reward firm transparency*

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Abstract

In this paper we analyze the role played by firms' transparency decisions on product liability standards. In particular we focus on firm decisions regarding transparency in product quality and safety information provided to the public. We find that even if transparency on product quality is not of direct importance to the Court, that is, is not informative as to findings of defectiveness of the product by the Court in a given case, the Law should optimally set product liability standards as a function of the firm's transparency in order to improve the incentives for the firm to provide the desired level of product quality. Courts should be more lenient (in terms of evidence showing that the manufacturer is not liable) with those firms more transparent to the market in terms of product features and manufacturing information. Our result holds when transparency does not reduce evidentiary uncertainty before the Court, but if the latter is the case, the argument for leniency is reinforced.
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1 Introduction

Firms are subject to different bodies of regulation that influence their incentives to invest in product safety. Some regulations emphasize the pre-market phase of the product while others become relevant once the product, when unsafe, is already in the market.

There are numerous examples of products that, once marketed, are found to be to a larger or lesser extent, unsafe. In these cases the manufacturer has an option. It can recall the product, and thus withdraw it from the market before it actually leads to injuries or before the number of accidents increases, or it can do nothing, and thus be left fully exposed to subsequent liability when the product causes harm to consumers.

One of the recent and significant widespread alarms concerning product safety, at least in Europe, has been that of the breast implants manufactured by the French company Poly Prosthese (PIP). Allegedly, in order to save an estimated one billion euros a year in production costs, PIP had been using industrial silicone (intended for use in mattresses) instead of medical grade silicone in the majority of its implants since 2001. In addition to a reported health issue surrounding the PIP implants' potential increased risk of cancer, there has been a concern that the implants may be linked to a rare form of cancer, namely anaplastic large cell lymphoma. Also, the French Society of Plastic Surgeons reports to have found that PIP implants present a rupture rate of 5.5% per year, compared to findings by the FDA[1] that the average rupture rate for all implants is 1% per year or 10% over 10 years.

Governments all over the world, from Western Europe to Latin America and Australia, took action concerning this product, including, in many cases, recommending the removal of PIP implants, and even assuming the cost of removal under certain conditions. Unsurprisingly, legal action ensued, and in addition to criminal prosecution of some of the major players, product liability suits have been filed in several countries against PIP, now in bankruptcy, and other firms

[1] United States Food and Drug Administration 'Report on the safety of breast implants,' released in June 2011.

that may have taken part in the manufacture and distribution of the implants and the inputs for their production.

Another recent example can be found in the automobile industry. Toyota Motor voluntarily recalled almost two million of a new generation of Prius vehicles it sold all over the world following a programming error that could cause their gas-electric hybrid systems to set off warning lights and shut down the vehicle as part of a fail-safe mode. The Toyota Prius was introduced in the United States in the year 2000 becoming the most successful of the alternative-engine models on the market. The company justified this recall by stating that "in rare circumstances, the hybrid system might shut down while the vehicle is being driven, resulting in the loss of power and the vehicle coming to a stop." The cars recalled were mostly in Japan and North America and less importantly, in Europe. According to the auto company the recall was announced before any accident resulting from the defect took place.

Toyota's quality reputation has also been challenged due to large-scale recalls over reports of unintended acceleration. Recently, Toyota had to stop the sale of Camry and Corolla models over concerns that around 30.000 new vehicles had faulty or malfunctioning heated seats. These recalls resulted in many settlements of billions of dollars for the company. This may explain the change of strategy of the company that, in light of the potential legal costs from litigation, has become more proactive in issuing recalls, and has also publicized them better.

In order to provide incentives for safety in the design and manufacture of products in cases such as the ones we have described, legal systems use most notably product liability law and the tort process. At least, these are the most important social institutions specifically tailored for such a purpose. In a courtroom, when dealing with a product liability case, evidentiary uncertainty surrounding the defective nature of a product seems to loom large, for reasons that will be presented below. Outside the courtroom, firms disclose and even publicize information to the market and to consumers concerning the design and manufacturing features of their products, even prior to bringing them to the market, in order to favor the opportunities for evaluation of

the product's quality. Often, they take steps to make this information more readily available, more credible (for instance, through certification of processes and products by certain bodies specializing in "quality audit and control"), and more understandable to consumers (by providing users' guides and manuals describing features and components).

Obviously, the legal and economic literature on product liability is too large to do justice to its main contributions here. Many issues concerning product liability and its social consequences have been illuminated by that literature. However, the connection between these two dimensions of the incentive problem affecting manufacturers of consumer goods, the incentives provided by the tort system on the one side, and the information willingly provided by the manufacturer to the public, on the other, appears to have remained largely unnoticed by the literature. In this paper we explore how product liability standards should be optimally set by legislators and courts in a setting characterized i) by evidentiary uncertainty, and ii) by firms that enjoy the ability to disclose relevant features of product design and of the manufacturing processes (which they may exercise, among other reasons, in order to avoid being held liable in a product liability suit). Our main finding is that product liability standards under evidentiary uncertainty should be decreasing with the level of (relevant) information provided by the firm to consumers. This result is not based on such information having an effect on reducing evidentiary uncertainty in Court.

Notice that our focus of interest is different from the one of remedial actions by manufacturers after the realization of quality levels and/or negative safety consequences of products. The incentives created by the legal system through product liability on product recall decisions by consumers has received an important degree of attention by the economic and economically-oriented literature: Ben-Shahar (1998, 2004, 2006), Hua (2009), Chen and Hua (2010). We are not concerned here with ex-post safety decisions, but with revelation of product-related information and investment in product quality when Courts have only imperfect direct verification of product quality.

Such a setting looks to us to be a natural one in which to think about incentives brought about by product liability. In the PIP case referred to above, it seems that the allegations of an unsafe production process of breast implants would be relatively easy to substantiate in Court, since unequivocal physical traces of the product revealing the way in which it was produced are, regrettably and literally, kept inside the victims' bodies. This case, in which industrial silicone and medical silicone may be clearly distinguished in each individual situation, may be considered as an outlier, an extreme example in terms of ex-post verifiability of product quality. In many, if not most cases physical and other evidence concerning how the product was designed and manufactured may not entirely dispel uncertainty about the actual safety investment by the manufacturer. Evidentiary uncertainty of this sort leaves ample room for mistakes in implementing liability rules set by product liability Law.

On the other side, it seems that the firms producing a good are probably well placed to generate, collect, and eventually disclose information concerning the safety features of its design and manufacturing processes, and also about the safety of resulting products. For instance, the firm may seek quality control certifications for its manufacturing processes and then reveal the results obtained. In addition, it may disclose the instances of product malfunctioning that have previously appeared. It may establish open recall procedures for its products, and other similarly oriented actions. Through these and other channels, the firm directly and indirectly conveys to consumers information about product safety. This paper focuses on the interplay between, on the one hand, these decisions, which we comprise as a whole under the term "firm transparency", and on the other, the strictness of product liability standards as applied in the tort process.

We do not provide a full literature review of the vast number of papers in the two main areas we study, but rather focus on the most relevant papers, so as to place our contribution in context, and help understand the implications of our results. The literature on evidentiary uncertainty in legal decision-making, starting with the initial contribution by Johnston (1987) is too voluminous even to attempt to register its milestones. In a recent paper [Ganuza et al (2015a)] we summarize

the relevant literature on evidentiary uncertainty and present what we think is a novel approach to handling problems of that kind in imposing liability. The approach uses type I and II errors to reformulate the problem in a way that simplifies its solution.

On firm disclosure and transparency in a setting of quality issues concerning products, the literature has examined different problems: ex post information, in terms of confidentiality or disclosure of settlement agreements between firms and the victims of product defects [Daughety and Reinganum (2005)]; disclosure of information and price signalling [Fishman and Hagerty (2003), Hotz and Xiao (2006), Daughety and Reinganum (2008)]; the incentives of firms to acquire information about products under mandatory or voluntary disclosure [Polinsky and Shavell (2010)]; liability for not disclosing information about product risk and product use [Cahoy (2007)].

Our main result, namely that liability for product-related accidents should be made more lenient when firms are more transparent in terms of providing information to the market and to consumers concerning their products and processes, has a flavor similar to that of prior contributions that have revealed positive effects of relaxing product liability. For instance, see Knoll (1997) on decisions to continue or discontinue production when net wealth may be negative, or Ben-Shahar (2004, 2006) on product recall. Shepherd (2013), in turn, finds empirical support for positive effects of reducing product liability on business activity and employment. All these, however, analyze entirely different settings and problems.

The prior related literature has not dealt with nor analyzed how product liability standards set in a context of uncertainty concerning the actual behavior of the firm should respond to the level of transparency chosen by the firm over its own design and manufacturing processes, which is the focus of our analysis.

The paper is organized as follows: Section 2 presents the basic model of product liability standards with evidentiary uncertainty given the information disclosed by the firm. Section 3 extends the model to the reaction by firms in terms of their transparency policy to the optimal product liability policies set by the legal system. Section 4 briefly concludes.

2 A simple model of product quality

A firm manufactures a product of quality q. For simplicity, assume that there are two possible quality levels, low (q_L) and high (q_H). The cost of manufacturing a product of quality q is $c(q)$ where $c(q_H) > c(q_L)$. The quality of the product is associated with the probability that the product proves defective. Let $p(q)$ denote the probability that a product of quality q is defective, where $p(q_L) > p(q_H) > 0$. Also, for simplicity, assume that a defective product generates a fixed pecuniary loss to the consumer denoted by $D > 0$. To simplify the presentation and without loss of generality we let $c(q_H) = c$, $c(q_L) = 0$, $p(q_H) = p \in [0, 1]$ and $p(q_L) = 1$—that is, a poor quality product fails for sure, while only a fraction p of high quality products fail.

The firm's product is sold to a population of consumers who have information on its quality features and safety. The quality of such information (the firm's level of transparency) is summarized by an index $\delta \in [\underline{\delta}, \overline{\delta}]$ which is publicly observed by all market participants. In the first stage of the analysis we take δ as given. In the next stage we will consider the firm's optimal choice of δ. The firm's level of transparency, δ, is public information. We assume that the manufacturer's revenue function, $R(q, \delta)$, depends both on product quality, q, and the quality of the information available to consumers, δ. We also assume that the revenue function has the following properties:

- $R(q_H, \delta) > R(q_L, \delta)$ for all δ;
- If $\delta > \delta'$, then $R(q_H, \delta) > R(q_H, \delta')$ and $R(q_L, \delta) < R(q_L, \delta')$.

The first assumption means that higher quality leads to greater revenue regardless of the quality of information available to consumers. The second assumption means that more information implies greater revenue for a high quality product and lower revenue for a low quality one. These properties of the revenue function arise endogenously in a model in which firms compete and optimally decide the level of transparency and the pricing policy. Such a model includes a signaling component in the pricing policy. Fortunately, introducing these additional complications

is unnecessary as the results/assumptions are quite intuitive. The first of these simply states that for all levels of transparency as to product quality, those with a higher level generate more revenue for the firm, which is intuitive as more information makes the product more appealing to consumers. The second assumption states that transparency generates lower revenue for the low quality producer. This assumption implies an important property, namely that the revenue function is supermodular in quality and transparency,

$$R(q_H, \delta) - R(q_L, \delta) > R(q_H, \delta') - R(q_L, \delta').$$

Thus the assumption that the low quality producer has lower revenue with greater transparency implies a (weaker) property which is quite natural, namely that greater transparency benefits the higher quality producer more.

2.1 Evidence of product quality

Regardless of the manufacturer's quality decision, we assume the consumer will bring a case before the Court whenever the product fails and causes damages to a consumer.[2] The Court then rules whether the manufacturer has to pay damages (if the product is found defective, in our setting of low quality) or not (if the product is not deemed defective). If the Court holds the manufacturer liable, the firm has to compensate the consumer for the loss suffered by the failure of the product. The Court makes this ruling knowing the firm's choice of the level of transparency concerning quality, but without direct observation of the actual quality of the product.

In order to establish the actual quality of the product, the Court has to rely on the evidence brought before it in any admissible form: expert opinion and testimony, examination and cross-examination of experts and witnesses, other interviews, consumer reports, cost, profit, and price estimates, etc. Let the sum of evidence available to the Court be represented by a generic signal

[2] In order to simplify the analysis we disregard litigation costs, the possibility of the victim not bringing the case before a Court, and the possibility of settlement. We thus assume that all situations of product causing harm D will be brought to Court. This is a non-trivial assumption but one that allows us to abstract from other dimensions of the design of a tort system to optimize incentives for quality and safety.

$\pi_m \in [0,1]$, which represents an index of the amount of evidence indicating that the manufacturer has produced a high quality product. Formally, a signal π_m, is a realization of a random variable Π_m with distribution function $f_m(\pi_m|q)$. This distribution depends on the level of actual investment in quality undertaken by the manufacturer, $q = q_H$ or q_L. For convenience we assume that f_m is differentiable and non-zero on $[0,1]$. One of the implications of this assumption is that the evidence before the Court is insufficient to identify the product's quality with certainty. Let $F_m(\pi|q_j)$ denote the cumulative distribution function corresponding to the Court's signal.

A higher value of π_m represents greater evidence that in the particular case of the accident before the Court the manufacturer produced a high quality product. To ensure that high product quality translates into more evidence that the manufacturer produced a high quality product, we assume that signals are monotone, that is, $f_m(\pi_m|q)$ satisfies the Monotone Likelihood Ratio Property (MLRP):

$$\frac{f_m(\pi|q_H)}{f_m(\pi|q_L)} \text{ is increasing in } \pi.$$

This condition ensures that more evidence is "good news" about product quality (Milgrom (1981)), that is, $\Pr(q_H|\pi_m)$ is increasing in π_m. Note that this condition is also satisfied by the signals of quality received by consumers through the choice of transparency levels by firms as will be explained below.

2.2 The Court's decision problem

The Court wishes to provide incentives to produce high quality products (otherwise the problem is trivial). We also assume that the Court is concerned with penalizing well-behaved firms, that is, with imposing liability on manufacturers of high quality products. This is a natural assumption since finding liable an innocent and careful manufacturer (Type I error) is the only error that can arise in equilibrium.

The Court can commit to a decision rule that is based on the evidence presented when the

product fails. We assume that the Court uses a threshold decision rule which is defined as follows: if the evidence brought before the Court π_m is above a given threshold level, $\bar{\pi}$, then the Court finds that there is sufficient evidence that the product was of high quality, and rules that there is no liability. On the other hand, if $\pi_m < \bar{\pi}$, then the Court finds the manufacturer liable for a defect, and the manufacturer has to pay the consumer an amount D in damages.[3]

Given the firm's level of transparency, δ, we refer to the threshold $\bar{\pi}(\delta)$ as the Court's evidentiary standard. This threshold could vary with the observed level of transparency, δ. In this section, where δ is given, we assume that the quality of the information available to the Court, $\bar{\pi}$ does not depend on δ.

For any level of transparency and Court's threshold rule characterized by the evidentiary standard, $\bar{\pi}$, the manufacturer will choose to manufacture high quality products if the profits (including the reduction of the expected liability costs) from doing so are greater than from manufacturing low quality ones, that is, if

$$R(q_H, \delta) - c - pF_m(\bar{\pi}|q_H)D \geq R(q_L, \delta) - F_m(\bar{\pi}|q_L)D. \tag{IC}$$

We focus on the interesting case where it is not in the manufacturer's self-interest to produce high quality products in the absence of potential liability, that is when $R(q_H, \overline{\delta}) - c < R(q_L, \overline{\delta})$. With this assumption, the Court may be able to encourage the production of high quality products via the tort system and its choice of the evidentiary threshold.

When setting an evidentiary threshold, the Court is interested, not only in encouraging high quality, but also to do so in a way that minimizes the burden on those firms that do the best they can-those who produce high quality: as we will see, this corresponds to setting the threshold so as to minimize Type I error. For any given case brought before the Court, when it uses a standard $\bar{\pi}$, Type I error is the probability that the Court mistakenly holds liable a manufacturer that is

[3]The assumption that the Court uses a threshold rule is harmless, as Ganuza et al (2015a) show in a more general setting that the Court's optimal decision rule in this informational setup (monotone signals) is a threshold rule. Additionally, threshold rules such a negligence or the requirement of defect, seem to be pervasive in the area of product-related accidents in most legal systems, though obviously the specific thershold and the factors underlying it vary greatly across legal systems and types of product.

actually "innocent", i. e., produced a high quality product. This probability is $F_m(\bar{\pi}|q_H)$. Minimizing Type I error is then equivalent to minimizing the expected liability of the manufacturers of high quality products. Similarly, the probability that the Court mistakenly acquits an unworthy defendant, a low quality manufacturer, is $1 - F_m(\bar{\pi}|q_L)$. The Court's problem can be written as:

$$\min_{\bar{\pi}} p\ F_m\left(\bar{\pi}|q_H\right) \quad \text{subject to (IC).} \tag{1}$$

2.3 Timing when δ is given

The timing of the model is as follows: 1) The law sets the evidentiary standard, $\bar{\pi}$. 2) The manufacturer chooses the quality of his product, consumers receive information on product's quality, and revenue $R(q, \delta)$ is realized. 3) Nature determines whether the product fails or not, as well as the Court's signal π_m according to the probabilities and information structures described above. 4) Finally, in case of product failure, the manufacturer may be forced to pay damages to the consumer according to the realized evidence and the Court's decision rule.

2.4 Minimizing errors, maximizing incentives

We use the notation $\mathbb{T}_I\left(\bar{\pi}\right) = F\left(\bar{\pi}|q_H\right)$ to denote the Type I errors committed by a Court that imperfectly observes the injurer's actions and uses an evidentiary standard $\bar{\pi}$. Similarly, Type II errors occur with probability $\mathbb{T}_{II}\left(\bar{\pi}\right) = 1 - F\left(\bar{\pi}|q_L\right)$. Following the method proposed in Ganuza et al (2015a), we rewrite the Court's problem in terms of these errors. The Court's problem, on Equation (1), is equivalent to the following, more convenient, error minimization problem:

$$\begin{aligned} &\min_{\bar{\pi}} \mathbb{T}_I\left(\bar{\pi}\right) \\ \text{s.t.} \quad &p\mathbb{T}_I\left(\bar{\pi}\right) + \mathbb{T}_{II}\left(\bar{\pi}\right) \leq 1 - \frac{c - \left(R(q_H, \delta) - R(q_L, \delta)\right)}{D}. \end{aligned} \tag{2}$$

On the left hand side of equation (2) we find the errors generated by the Court's choice of evidentiary threshold, $\bar{\pi}$, which can be described more compactly using the weighted error function $\Phi(\bar{\pi}) = p\mathbb{T}_I(\bar{\pi}) + \mathbb{T}_{II}(\bar{\pi})$. The next result of Ganuza et al (2015a) characterizes the function $\Phi(\bar{\pi})$.

LEMMA 1 *The weighted error function is positive, continuous, and convex, and has a unique minimum on the interval* $[0,1]$ *at* $\pi_{\min}$. *The function takes values* $\Phi(0) = 1$ *and* $\Phi(1) = p$.

Let $\Phi_{\mathbb{D}}$ be the error function defined on the set $\mathbb{D} = [0, \pi_{\min}]$, so that $\Phi_{\mathbb{D}}$ is a decreasing function (and a higher standard increases the incentives to invest in product quality).

Figure 1 illustrates the shape of the Φ function (for $p = 0.75$) as well as $\pi_{\min}$, the interval $\mathbb{D}$, and the function $\Phi_{\mathbb{D}}$.

[Figure 1 around here]

On the right hand side of the equation 2 we find a key parameter of the model which we will denote by $\Delta(\delta, c) = c - (R(q_H, \delta) - R(q_L, \delta))$. We can interpret $\Delta(\delta, c)$ as the manufacturer's expected profit difference from switching from the high to the low quality product (net of the tort penalties). The next proposition characterizes the solution to the Court's Problem

PROPOSITION 1 *For all* δ, *there exists a level of net expected profit difference from switching from the high to the low quality product,* $\Delta_{\max} = (1 - \Phi(\pi_{\min}))D$, *such that if* $\Delta \leq \Delta_{\max}$ *then the optimal standard is* $\bar{\pi}^*(\Delta) = \Phi_{\mathbb{D}}^{-1}\left(1 - \frac{\Delta}{D}\right)$ *which is increasing in* Δ. *If* $\Delta > \Delta_{\max}$ *the Court cannot induce the manufacturer to produce high quality products.*

The intuition of this proposition is as follows: for a given $\Delta(\delta, c)$, there is a set of standards that generates enough incentives to induce the manufacturer to produce high quality products. As Type I error is monotonically increasing in the evidentiary standard, the Court chooses the minimum of these standards. If the economic profits from switching to the low quality increase, it becomes more difficult to induce high quality, and the Court has to increase the optimal standard.

Figure 2 illustrates Proposition 1 by characterizing the optimal evidentiary standard when $p = 0,75$, and $\frac{\Delta}{D} = 0.2$.

[Figure 2 around here]

In Figure 2 we can observe the set of standards that induce high care, $\mathbb{H}(\Delta)$, and the optimal standard, $\pi^*(\Delta)$–the lowest in this set. A higher Δ (corresponding to the lower green horizontal line at $\frac{\Delta}{D} = 0.23$), that is lower expected profit difference, implies a higher optimal evidentiary standard, π^{**}.

2.5 Consumer's information and the optimal Court policy

The Court's optimal evidentiary standard as characterized in Proposition 1 depends not only on the manufacturer's cost structure and the level of harm suffered by consumers from the product's failure, but also on the amount of information available to consumers. An increase in transparency (the amount of information available to consumers, parameterized by δ) helps consumers to better distinguish between high and low quality products. This, in turn, given our second assumption at the outset of section 2, increases revenues for a manufacturer who produces high quality products, and reduces revenue for those producing low quality ones, and thereby reduces the profits from switching to low quality (Δ is lower). This translates into an increase in the manufacturer's incentives to produce high quality products–even in the absence of liability–and reduces the need for Court intervention. Then, Court rulings can be more lenient, and so the Court optimally applies lower evidentiary standards.

PROPOSITION 2 *The Court's optimal evidentiary standard depends on the quality of information available to consumers. Higher levels of firm transparency and consumer information result in lower Court optimal liability standards for product-related accidents.*

Finally, we want to comment on two important extensions of the present model that are likely to reinforce our results. Firstly, we have assumed that the evidence available to the Court, the

informativeness of Π_m, is constant, and does not depend on the transparency level. A natural extension is to consider that better information on the product available to the market translates into better information for the Court. Ganuza et al (2015a) shows that optimal standards are lower when the quality of evidence (informativeness of the signal held by the court) is higher. In our setting, this effect would lead to even further reductions in the optimal evidentiary standards when firms are transparent with consumers.

More importantly, we have assumed that the transparency policy is fixed. Given that optimal standards are chosen so as to provide incentives to produce high quality (and high quality is always produced in equilibrium), if we allow the manufacturer to choose its level of transparency, $\delta \in \{\underline{\delta}, \overline{\delta}\}$, and the choice of δ is costless, the manufacturer will be minimizing its costs by choosing the highest possible level of transparency. Even if we make choosing a higher transparency level a costly decision, the cost savings due to lower standards, together with the lower expected penalties and higher revenues for producing high quality, it still may be incentive compatible for the manufacturer to choose a higher transparency policy. In other words, there are further gains from applying lower standards to manufacturers with high transparency policies. These lower standards not only reduce the penalties on the "innocent" high quality manufacturers, but also provide efficient incentives for firms to invest in transparency.

3 Implications and Conclusions

Manufacturers of consumer goods, in addition to investing in activities (design, manufacturing) that affect the level of quality of the goods they produce, and consequently, their rate of failure, malfunctioning or presence of defects, also engage in actions that convey information about the quality of their products to consumers. Accordingly, firms disclose information on things like product features, components, materials and their origin, processes, and the like, as well as try to make consumers take purchase decisions relying on that information. Obviously, the level of transparency of firms varies widely depending on the industry, target population of consumers,

and the individual characteristics of the firm. What we have shown in the paper is that if such information is reliable, and generates positive returns for manufacturers actually producing high quality goods, and negative returns for manufacturers actually producing low quality ones, it becomes an important factor bearing on the product liability decisions that Courts have to take when accidents happen and suits are brought.

If Courts were able to perfectly verify the actual levels of quality of the products which cause harm to consumers and end up in their dockets as tort cases, they could in principle provide perfect incentives to manufacturers based simply on those observed quality levels. However, in most cases that come up in reality Courts are unable to use such a simple mechanism to provide adequate incentives to invest in quality and safety, because there is significant uncertainty surrounding the product's quality level, or its defectiveness (to use the legal notion prevalent in product liability). This uncertainty is a reflection of the existence of failures and accidents despite the manufacturer's best efforts to provide quality. If we consider this fact into a more realistic model, which incorporates evidentiary uncertainty in the operation of liability for product failures, Courts should tailor the toughness of product liability to the transparency of the firm who may be subject to liability. The thresholds Courts impose on firms in order to be convinced of the existence or absence of a defect, and to determine liability accordingly, should be made to vary inversely with the openness and transparency policies adopted by firms. If a given manufacturer provides credible information to the market about its products and processes in terms of investment in quality, this should be rewarded in the tort process by a reduction in the toughness of evidentiary standards when a product liability case arises.

The relationship between the information provided and liability standards is also in line with the determination of defectiveness in product liability cases. A product is deemed defective whenever it does not meet the level of safety the consumer is reasonably entitled to expect. Encouraging firms' transparency would allow a better alignment between the expectations consumers are entitled to have regarding the level of product safety with the actual product quality the good

possesses. Consequently, the amount of errors resulting from evidentiary uncertainty in the tort process would be remarkably reduced.

This paper argues that encouraging firms' transparency on the public information they provide regarding the quality of their products by adopting a flexible approach to product liability standards set by Courts would encourage firms investment in product safety, and would also allow less Court errors, given that such information would allow a more accurate finding of defectiveness through the alignment between expectations consumers are entitled to have regarding a level of product safety, and the actual level of safety of the product.

As we have shown, this result does not depend on firms' transparency reducing evidentiary uncertainty per se, but on the idea that providing more credible information for consumers is correctly aligned with the proper incentives for the manufacturer to invest in quality. Obviously, if information is false, or is uncorrelated (or even worse, actually is inversely related) with the returns for the firm to provide high versus low quality products, the identified effect will no longer be present.

Our main result, we believe, may be useful for the actual operation of product liability law in various legal systems. It would advocate, for instance, the lifting of restrictions on bringing evidence before the Court concerning the overall behavior of the firm in terms of transparency, quality audit and control, and so forth. Moreover, reducing the expected liability of more transparent firms, if litigation comes (as it surely does) with associated costs, the likely reduction in litigation would allow further savings, and would reinforce the incentives to provide reliable information to consumers more generally.

This seems to go well in line with other contributions dealing with the optimal design of product liability law that emphasize the interaction of legal sanctions with other factors and incentive mechanisms, such as reputation, as we have analyzed in related work (Ganuza et al, 2015b).

A Appendix

Proof of Lemma 1: We include this proof for completeness since it can be also found in Ganuza et al (2015a). The values of Φ are obtained by direct evaluation while the existence and uniqueness of the minimum is obtained by looking at the derivative of Φ:

$$\Phi'(\pi) = f(\pi|q_L)[p\frac{f(\pi|q_H)}{f(\pi|q_L)} - 1].$$

As the likelihood ratio integrates to one (with respect to $f(\pi|q_L)$) and is monotone, Φ has at most one sign change (from negative to positive). As the likelihood ratio is increasing it starts off negative so that the minimum of Φ is either in the interior of $[0,1]$ or at $\pi = 1$. Uniqueness comes from the differentiability of f. ■

Proof of Proposition 1: net expected profit difference from switching from the high to the low quality product, $\Delta_{\max} = (1- \Phi(\pi_{\min}))D$, such that if $\Delta \leq \Delta_{\max}$ then the optimal standard is $\bar{\pi}^*(\Delta) = \Phi_{\mathbb{D}}^{-1}\left(1 - \frac{\Delta}{D}\right)$ which is increasing in Δ. If $\Delta > \Delta_{\max}$ the Court cannot induce the manufacturer to produce high quality products.

The level $\Delta_{\max}$ is determined as the solution to $\Phi(\pi_{\min}) = 1 - \frac{\Delta_{\max}}{D}$. For $\Delta > \Delta_{\max}$, for all $\pi \in [0,1]$, $\Phi(\pi) > 1 - \frac{\Delta}{D}$ so that it is not possible to induce high care. For c and $\leq c_{\max}$, let $\mathbb{H}(c)$ be the set of π that satisfy the incentive compatibility contraint for a given c. The set $\mathbb{H}(c)$ is a closed interval such that for all $\pi \in \mathbb{H}(c)$, $\Phi(c) \leq 1 - \frac{c}{D}$, and the minimum of $\mathbb{H}(c) = \Phi_{\mathbb{D}}^{-1}\left(1 - \frac{c}{D}\right)$. As $\Phi_{\mathbb{D}}$ is decreasing and $1 - \frac{c}{D}$ is decreasing in c , $\Phi_{\mathbb{D}}^{-1}$ is increasing in c. Also, as $\Phi'(1) \neq 0$, if $c < c_{\max}$, $H(c)$ is a non-singleton set so that $\min H(c) < 1$.For all δ, there exists a level of net expected profit difference from switching from the high to the low quality product, $\Delta_{\max} = (1- \Phi(\pi_{\min}))D$, such that if $\Delta \leq \Delta_{\max}$ then the optimal standard is $\bar{\pi}^*(\Delta) = \Phi_{\mathbb{D}}^{-1}\left(1 - \frac{\Delta}{D}\right)$ which is increasing in Δ. If $\Delta > \Delta_{\max}$ ■

Proof of Proposition 2: From Proposition 1 we know that the optimal standard is $\bar{\pi}^*(\Delta)$ in Δ, and $\Delta(\delta, c) = c-(R(q_H, \delta) - R(q_L, \delta))$ is decreasing in δ, which implies that $\bar{\pi}^*$ is decreasing in δ. ■

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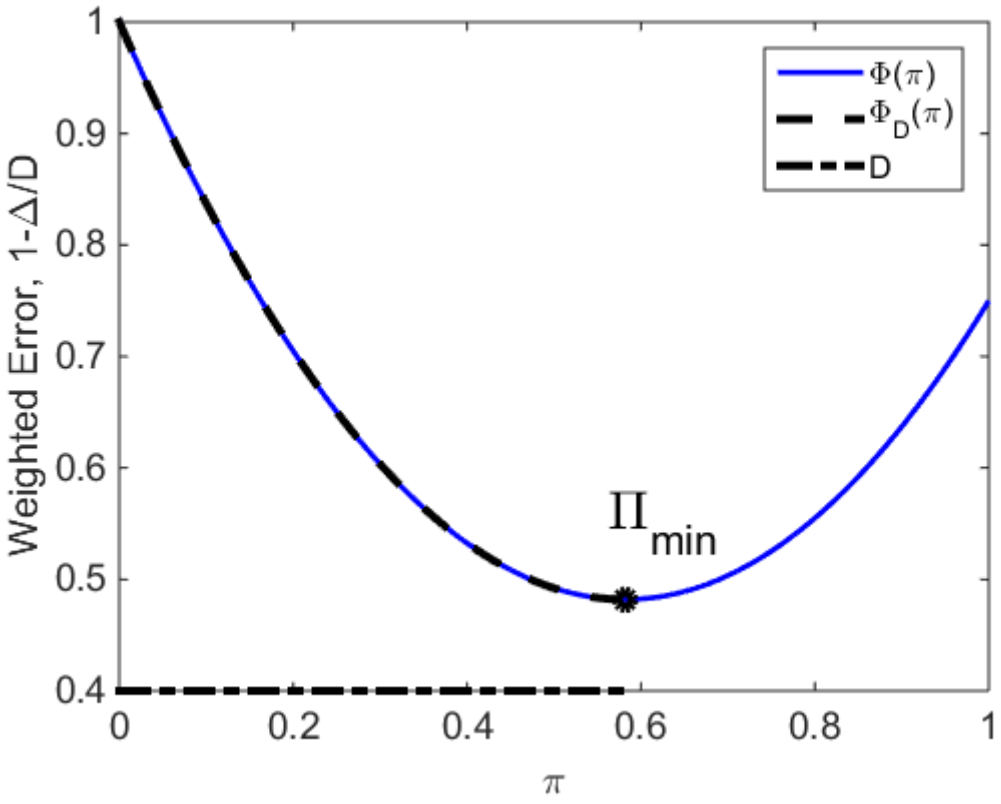
Weighted Error, 1-Δ/D
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.2
0.4
0.6
0.8
1
π
Φ(π)
Φ_D(π)
D
Π_min

FIGURE 1

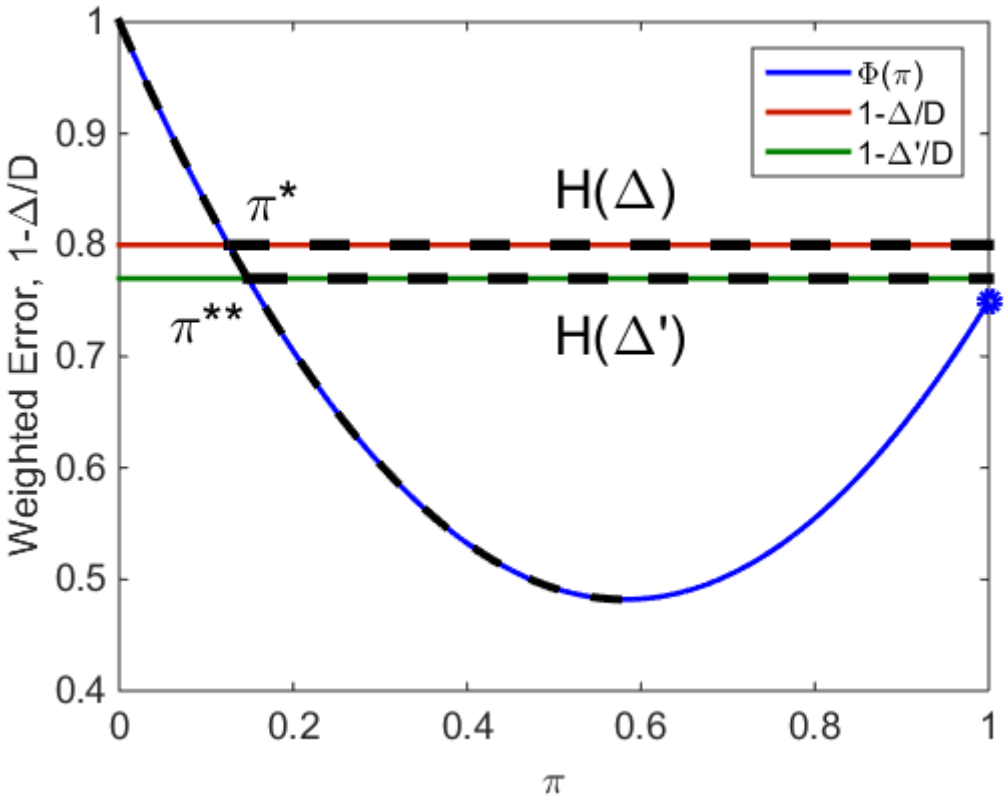
Φ(π)
1-Δ/D
1-Δ'/D
H(Δ)
H(Δ')
π*
π**
Weighted Error, 1-Δ/D
π
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.2
0.4
0.6
0.8
1

FIGURE 2