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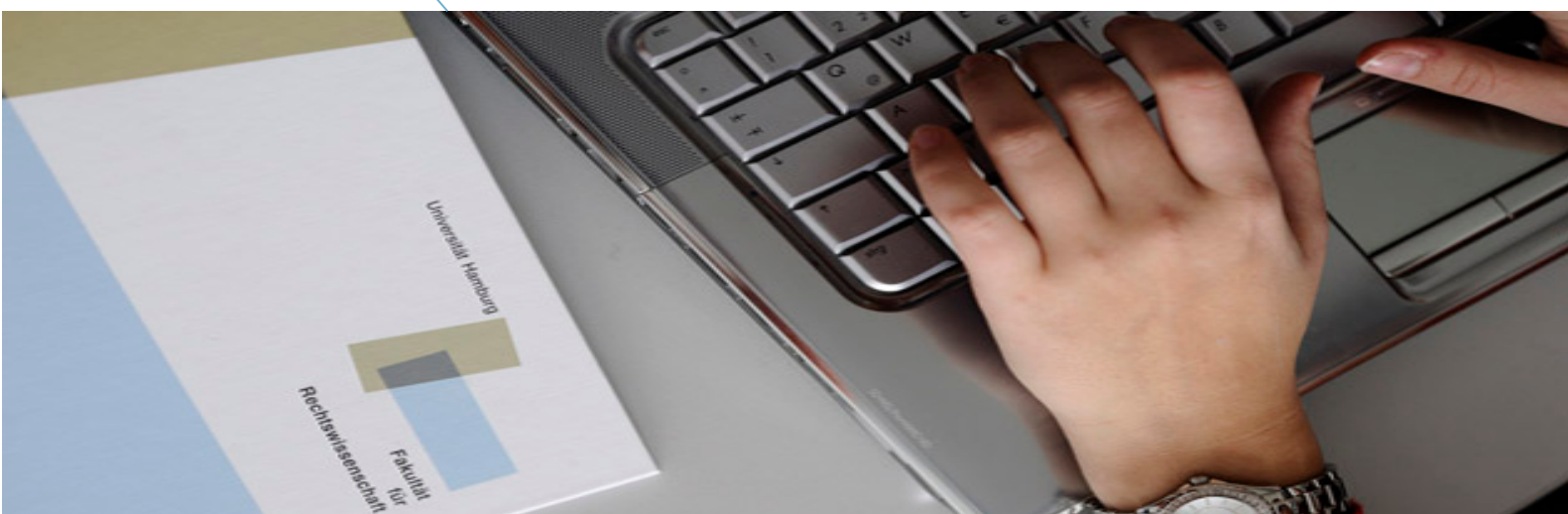
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Liability for third-party harm when harm-inflicting consumers are present biased

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Abstract

This paper analyzes the workings of liability when harm-inflicting consumers are present biased and both product safety and consumer care influence expected harm. We show that present bias introduces a rationale for shifting some losses onto the manufacturer, in stark contrast with the baseline scenario in which strict consumer liability induces socially optimal product safety and precaution levels. In addition, we establish that strict liability with contributory negligence may induce socially optimal product safety and precaution choices without aggravating the output level distortion.

Keywords: Liability; Present Bias; Product Safety; Consumer Precaution.

JEL classification: D91, H23, K13.

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1 Introduction

1.1 Motivation and Main Results

Time preferences are crucial to almost all choices and critically affect life outcomes (e.g., DellaVigna and Paserman 2005, Golsteyn et al. 2014, Koch et al. 2015, Meier and Sprenger 2010, Sutter et al. 2013). Time preferences are also important in the context of choices influenced by liability. Clearly, in that domain of decision making, present choices have implications for later behavior and future payoff consequences. For example, an individual's decision of whether or not to buy a car with a specific product safety level today will be guided by how carefully the individual expects to drive it and by the level of expected liability payments due after a possible car accident.

Time preferences are commonly represented by the exponential discounting model introduced by Samuelson (1937), which assumes that the discount rate is constant and choices are time-consistent. However, data on intertemporal decision making strongly suggests that immediate payoffs are special relative to future ones (i.e., that a bias favoring the present exists). This is incorporated in applied work using the $\beta - \delta$ framework introduced by Laibson (1997), which departs from the exponential discounting setup only in that there is additional discounting between the present and any point in time in the future (e.g., DellaVigna 2009, Frederick et al. 2002, O'Donoghue and Rabin 2015). The $\beta - \delta$ framework greatly improves the match between predictions and choice data. For example, Burks et al. (2012) emphasize that the $\beta - \delta$ model best predicts their data from a large-scale field experiment.

This paper considers the workings of liability when harm-inflicting parties have $\beta - \delta$ preferences. Specifically, in our setup, present biased consumers cause harm to third parties; the expected value of harm is determined by both product safety and consumer care. Consumers may be naive or sophisticated about their present bias (e.g., O'Donoghue and Rabin 1999). Sophisticated consumers understand that, in the future, they will make decisions subject to present bias, while naive consumers expect not to be subject to present bias in future decision making problems (although they are present biased in the current period). The sequence of our framework is important for understanding the role of present bias and consumers' naivety about it. In our model, a monopolist first chooses the product's safety and price level. Next, consumers determine whether or not to buy

a single unit of the product, anticipating how much precaution they will invest later on when actually using the product. At this point in time, payoff consequences from both taking precautions and possibly having to pay damages lie in the future. With regard to their belief about the level of their own future precaution, naive and sophisticated consumers differ. Only the latter understand that they will discount expected liability payments relative to precaution costs when the choice about consumer care is due (i.e., when actually using the product). After the purchase, consumers use the product and invest in precaution. In the event of an accident with others, consumers and/ or the firm may have to pay damages to the victim in the very last stage (depending on the liability regime).

For illustration, assume that a consumer orders and pays for a car today, begins using the car a month later thereby introducing the possibility of an accident, and ultimately pays damages for any harm suffered according to strict consumer liability several months after the accident. In this example, the lags between choices are at least one month. However, for present bias to influence decision making, lags need not even be as long. The relevant literature emphasizes that it is primarily about distinguishing the present from the future. For example, the evidence in Shapiro (2005) is consistent with a *daily* $\beta \approx 0.9$ and a daily $\delta \approx 1$. Estimates in Augenblick and Rabin (forthcoming) suggest an immediate gratification parameter of about 0.83.¹

Strict consumer liability for third-party harm is our benchmark regime, building on the efficiency properties highlighted by Hay and Spier (2005) for the setup we adopt.² For this benchmark liability arrangement, we find that there are three distortions when harm-inflicting consumers are present biased relative to the case when they are not. First, consumers underinvest in precaution due to the delayed payment of damages. Second, the firm underinvests in product safety. The firm's product safety incentives stem either from firm liability or consumers' demand for safety. Present biased consumers undervalue product safety due to the delayed payment of damages, leading to the firm's underinvest-

¹The existence and policy relevance of present bias has been the subject of an ever growing empirical literature. Early work is reviewed in DellaVigna (2009), for instance. More recently, Wang et al. (2016), for example, provide measurements of present bias and patience for 53 countries, highlighting that the heterogeneity between countries is much more pronounced in terms of present bias.

²As explained above, we depart from Hay and Spier (2005) by focusing on a monopolistic instead of a perfectly competitive market structure. However, this departure is inconsequential for the induced care incentives when consumers are time-consistent.

ment when consumers are strictly liable for all harm. As a result, making the firm liable for a share of the expected harm may increase the level of product safety (at the cost of reducing consumer precaution) and thereby increase welfare. The third distortion arising from the consumers' present bias concerns the level of output. Consumers perceive the price, that must be paid in the present, to be relatively more important than the consumption utility that is incurred only in the future. The distortion in terms of the critical consumption utility also responds to a variation in the level of losses shifted to firms in a possibly welfare-enhancing way.

Making consumers strictly liable for a multiple of the harm (i.e., using a damages multiplier) can induce socially optimal product safety and precaution incentives by debiasing the concern about damages payment. However, such a damages multiplier further distorts the consumers' choice about whether or not to buy. While a damages multiplier tailored to the present bias of a single consumer is in all likelihood not a realistic policy option, using strict liability with a defense of contributory negligence is. We establish that there are circumstances under which the care incentives of both the firm and the consumer are aligned with that of the social planner when that liability rule is in place. However, when present bias is severe or consumers are naive, the use of strict liability with a defense of contributory negligence may no longer be socially desirable. When subject to a liability rule with a consumer precaution standard, naive consumers anticipate to always comply but may ultimately decide not to comply. Moreover, the choice of a naive consumer not to comply may be endogenous to the firm's product safety choice, potentially leading to socially undesirable firm incentives.

1.2 Related Literature

That timing is important for legal incentives is well established. For example, Gravelle (1990) considers endogenous trial delay, Miceli (1999) explores the strategic use of delay during settlement negotiations, and Kessler (1996) empirically explores institutional causes of settlement delay.

Our paper builds on Hay and Spier (2005). They study consumer-induced harm to others and highlight, for example, that some firm liability is optimal when consumers' assets are insufficient to compensate harm. In our setup, we derive the same result – that is, firm liability may be socially desirable – albeit for a different reason, namely consumers'

present bias. Our contribution is related to Daughety and Reinganum (2013a) in that they also study a bilateral-care framework in the context of liability for harm resulting from product use. However, the two papers are clearly distinct because Daughety and Reinganum (2013a) study cumulative harm incurred by the consumer and we seek to establish the influence of present bias on the workings of liability.

The literature on the economics of product liability considered a specific kind of bias early on, namely the possibility that consumers misperceive – usually underestimate – the expected harm (e.g., Geistfeld 2009, Polinsky and Rogerson 1983, Spence 1977). Miceli et al. (2015) provide a recent contribution on this topic. Contributions to this literature assume that only the firm influences the expected harm incurred by consumers. Accordingly, strict liability of the firm may be proposed as an easy fix of the underestimation-problem in many circumstances. Our paper considers a setup in which the expected harm is incurred by third parties and influenced by both the firm’s product safety and consumers’ precaution investments. Whereas the misestimation of expected harm can be remedied by an information policy, we are describing a phenomenon that is a consequence of non-standard preferences. Moreover, our distinction between naive and sophisticated consumers is not covered in existing liability literature but important in our context. For example, as we explain below, firms may have incentives to *exploit* naive consumers under strict liability with a defense of contributory negligence.

Baniak and Grajzl (2017) consider how another behavioral aspect influences the workings of liability, analyzing consumers who mispredict the extent to which they will use a durable product in the future. A common example of what they are interested in is *projection bias* where, for instance, somebody buying a sports car is likely to overestimate the extent to which he will enjoy the product in the future. Since the expected consumer harm in their framework is a function of the level of product usage, the implications of consumers’ mispredictions are contingent on the prevailing liability regime. Key distinctions between our work and theirs include our focus on harm to others, a direct regulatory control regarding consumer behavior via a possible consumer precaution standard, and the distinction between players who are aware of their bias and players who are naive about it. Furthermore, there are potentially two decisions that are distorted due to the present bias in our setup whereas they are interested in only one choice.

To the best of our knowledge, this paper introduces present bias into the literature

on the economics of tort law. In contrast, present bias has been considered in other domains of law and economics (see, e.g., McAdams 2011 and Baumann and Friehe 2012 for studies on criminal law and economics). Present bias has been dealt with in the literature in industrial organization (e.g., Heidhues and Köszegi 2018, Spiegler 2011). In many contributions from that branch of the literature, the focus is firms using multiple prices to potentially exploit consumers' bias, exploring in particular the relevance of back-loaded fees (e.g., DellaVigna and Malmendier 2004, Heidhues and Köszegi 2010). In the present paper, consumers pay a price upfront for a unit of the product.

1.3 Plan for the Paper

Section 2 presents the model. Section 3 discusses socially optimal choices. Section 4 elaborates on whether or not socially optimal incentives can be induced using liability law. Section 5 discusses two extensions, specifically the scenario in which the harm falls onto the consumer instead of on a third party and a different timing of events. Section 6 concludes.

2 The Model

Firm A monopolistic firm offers a product whose use has a tendency to harm others.³ The expected harm that a single unit of the product causes to third parties is $L(x, y)$, where x denotes the firm's product safety and y the consumer's precaution level. Product safety and precaution reduce expected harm at a diminishing rate (i.e., $\frac{\partial L(x, y)}{\partial i} < 0 < \frac{\partial^2 L(x, y)}{\partial i^2}$, $i = x, y$). Following Hay and Spier (2005, Section III), we abstract from interaction effects between product safety and precaution by assuming that the cross partial derivative of L is equal to zero.⁴ The firm's cost of product safety is $k(x)$, with $k(0) = 0 = k'(0)$, and is incurred as a fixed cost (as in Daughety and Reinganum 2006, for example). Product safety is observable by the consumer at the time of purchase. Production costs other than k are set to zero. The product's price is denoted by P .

³Focusing on a monopolistic firm is a common approach in the literature on the economics of liability (see, e.g., Daughety and Reinganum 1995, 2013a, Spier 2011). We thereby abstract from additional strategic effects due to the interdependence among firms in an oligopoly.

⁴Chen and Hua (2017) provide one of the few contributions on products liability with a bilateral-care model, and similarly abstract from an interaction of firm and consumer precautions.

Consumers Consumers either buy one or no unit of the product. Consumers differ in their (gross) valuation of the product’s use denoted v . We assume that the valuation is uniformly distributed in the interval $[0, V]$. We normalize the number of potential consumers to one. Consumers incur a cost $c(y)$ when they invest precaution y while using the product, where $c(0) = 0 = c'(0)$. Consumers are assumed to exhibit $\beta - \delta$ preferences. Under that assumption, intertemporal preferences from the perspective of period t can be represented by $U^t = u_t + \beta \sum_{\tau=t+1}^T \delta^\tau u_\tau$ with δ as the standard discount factor, such that $\beta = 1$ corresponds to exponential discounting while $\beta \in (0, 1)$ reflects present bias (e.g., O’Donoghue and Rabin 2015). We set $\delta = 1$ for notational simplicity and in order to focus on the implications of present bias alone.⁵ We will distinguish sophisticated and naive consumers, where a sophisticated (naive) consumer anticipates (does not anticipate) present bias applicability in future decision problems. Below, we represent the present bias that is actually *relevant* to the decision making by $\beta_R \in (0, 1)$, and distinguish it from the *anticipated* level of present bias $\beta_A \in \{\beta_R, 1\}$. For sophisticated agents, we have that $\beta_A = \beta_R$ while we have $\beta_A = 1$ for naive agents. We assume that the firm serves either naive or sophisticated consumers and is aware of this fact.⁶

Timing In Stage 0, the firm decides about product safety and price. In Stage 1, consumers observe both the price and product safety level and choose whether or not to purchase a single unit of the product. In Stage 2, consumers use the product such that the benefit of the product and the precaution cost materialize. An accident may occur. If it does, in Stage 3, possible damages payments are made.

3 The Social Optimum

We follow O’Donoghue and Rabin (2006a,b) and Heidhues and Köszegi (2010) and treat consumers’ present bias as an “error”.⁷ We thus specify a “standard” welfare measure that features no discounting as a result of a taste for immediate gratification. The social

⁵Note that the individual in period t considers utils in period $t + 1$ to be as valuable as utils in $t + 2$ when $\delta = 1$ and $\beta < 1$ apply. It is only when period $t + 1$ is reached that the same individual views utils in period $t + 1$ as more desirable than utils in period $t + 2$. This change in the relative desirability is important in our analysis and implies a stark contrast to the standard exponential discounting model.

⁶It is standard to assume that firms are aware of the shortcomings plaguing consumer decision making. See, for example, Heidhues and Köszegi (2018).

⁷O’Donoghue and Rabin (2006a), for instance, explain that a person able to choose future incentives would select long-run preferences.

planner would select the provision of the product and both product safety and precaution investments at levels to

$$\max_{\hat{v}, x, y} W = \frac{1}{V} \int_{\hat{v}}^V [v - c(y) - L(x, y)] dv - k(x), \quad (1)$$

where \hat{v} is the valuation of the marginal consumer such that consumers with $v \geq \hat{v}$ obtain a single unit of the product. The social planner's first-order conditions result as

$$W_{\hat{v}} = -\frac{1}{V} [\hat{v} - c(y) - L(x, y)] = 0 \quad (2)$$

$$W_x = -Q(\hat{v})L_x(x, y) - k'(x) = 0 \quad (3)$$

$$W_y = -Q(\hat{v})[c'(y) + L_y(x, y)] = 0, \quad (4)$$

where $Q(\hat{v}) = \frac{V-\hat{v}}{V}$ denotes the quantity, that is, the share of consumers who obtain a single unit. The socially optimal marginal consumer has a valuation equal to the sum of precaution costs and expected harm (see (2)). In condition (3), the marginal influence of product safety on the expected harm is weighted by the level of output to represent the marginal benefit of higher product safety. This results from the fixed-cost character of product safety investments. For socially optimal precaution, the marginal increase in costs incurred by the consumer balance the marginal reduction in the thirdparty's expected harm in (4).

In Section 4, we assume a monopolistic firm. This feature clearly bears on the resulting quantity. However, the socially optimal product safety and precaution levels as described in (3)-(4) still represent sensible benchmarks for a given level of output.

4 Decentralized Decision-Making under Liability

We will explore decision maker incentives under different liability schemes. In our baseline scenario, the consumer is strictly liable for a share α of the third party's expected harm, where $\alpha \in [0, 1]$, whereas the firm is responsible for the share $1 - \alpha$ of the expected harm. For most practical scenarios, when losses result from property damage, accurate estimations of property value is often difficult. Such estimations can be guided by policy decisions based on references and what constitutes admissible court evidence in determining the harm level (e.g., Kaplow and Shavell 1996). Difficulties in assessing harm are even more pronounced in the context of temporary or permanent physical harm and lost

earnings. The generosity of different legal regimes with respect to pain and suffering is a case in point for α employed as a policy instrument (e.g., Shavell 2004).

Our model follows Hay and Spier (2005) quite closely. Specifically, we depart from their framework by assuming consumers with present bias and by assuming a monopolist. Hay and Spier (2005) emphasize that setting $\alpha = 1$ yields optimal incentives. Accordingly, the policy $\alpha = 1$ will serve as a benchmark in our analysis.

4.1 Strict Consumer Liability for Share $\alpha \in [0, 1]$ of Expected Harm

Applying backward induction, our analysis starts in Stage 2, the last stage with modeled decision making (as Stage 3 includes only a possible and mandated compensation payment).

Stage 2 Consumers choose their level of precaution in Stage 2, seeking to

$$\min_y c(y) + \alpha\beta_R L(x, y). \quad (5)$$

The consumer is assumed to be liable for a share α of the third-party's expected harm, a payment that would be due only in Stage 3 which is why it is discounted by the relevant present bias β_R . The privately optimal level of precaution $y^*(\alpha, \beta_R) = y_R^*$ solves

$$c'(y_R^*) = -\alpha\beta_R L_y(x, y_R^*), \quad (6)$$

and is increasing in both α and β_R and is independent of product safety (as $L_{xy} = 0$). The socially optimal level of precaution results for $\alpha = 1 = \beta_R$ (refer to (4)).

Stage 1 Knowing the product's safety features (that were set by the firm in Stage 0), consumers choose whether or not to purchase a unit of the product. We normalize the outside utility to zero. Taking into account the timing of the payoff flows, a consumer with valuation v chooses to buy the firm's dangerous product if

$$\beta_R v - P - \beta_R [c(y_A^*) + \alpha L(x, y_A^*)] \geq 0. \quad (7)$$

The payment of the price is directly relevant to the consumer's utility and is experienced in the present, whereas both the consumption benefit and the precaution and liability

costs are realized in the future. With respect to the precaution and liability costs, it is the *anticipated* level of precaution which depends on the *anticipated* present bias – $y_A^* = y^*(\alpha, \beta_A)$ – that is relevant. Remember that $\beta_A = 1 > \beta_R$ for naive consumers and $1 > \beta_A = \beta_R$ for sophisticated consumers.

The weak inequality in (7) yields a valuation of the marginal consumer equal to

$$\bar{v}(P, x; \alpha, \beta_A, \beta_R) = \frac{P}{\beta_R} + c(y_A^*) + \alpha L(x, y_A^*), \quad (8)$$

such that only consumers with $v \geq \bar{v}$ actually purchase the product. The statement in (8) highlights that a significant present bias tends to deter consumers from purchasing the product since an important part of the consumer’s total cost is relevant in Stage 1 (namely the payment of the price), whereas benefits (and other costs, including those associated with liability damages) lie in the future.

Stage 0 The firm chooses product safety and price in Stage 0, anticipating how consumers decide in later stages. Profits can be stated as

$$\Pi = [P - (1 - \alpha)L(x, y_R^*)] Q(\bar{v}(P, x; \alpha, \beta_A, \beta_R)) - k(x). \quad (9)$$

While the ultimately implemented level of consumer precaution y_R^* features in the firm’s price-cost margin, the valuation of the marginal consumer builds upon the anticipated level y_A^* . The anticipated level is higher than the implemented level for naive consumers.

Maximizing Π with respect to the price yields P as a function of the level of product safety

$$P^*(x; \alpha, \beta_A, \beta_R) = \frac{\beta_R[V - c(y_A^*) - \alpha L(x, y_A^*)] + (1 - \alpha)L(x, y_R^*)}{2}. \quad (10)$$

Naive consumers (wrongly) anticipate that they will minimize $c + \alpha L$ with their choice of precaution. In contrast, sophisticated consumers understand in the present that they will ultimately implement too little precaution as a result of their present bias and thus fail to minimize $c + \alpha L$. This means that – for a given level of product safety – the price for naive present biased consumers exceeds the price for sophisticated consumers. Intuitively, sophisticated consumers understand *ex ante* that using the product will be associated with higher costs than the naive consumer anticipates.

Using the price (10) to restate the valuation of the marginal consumer as a function

of the level of product safety, we obtain

$$\bar{v}(x; \alpha, \beta_A, \beta_R) = \frac{V + c(y_A^*) + \alpha L(x, y_A^*) + \frac{1-\alpha}{\beta_R} L(x, y_R^*)}{2}. \quad (11)$$

The implied level of output is distorted relative to the first-best outcome due to the supply from a monopolistic firm and consumers' present bias. The valuation of the marginal consumer is lower when consumers are naive instead of sophisticated (since naive consumers wrongly anticipate that they will minimize $c + \alpha L$ with precaution), leading to a greater output with naive consumers (despite the fact that the price charged to naive consumers is higher).⁸

Using (10) and (11) to restate (9), we can state the firm's first-order condition for the optimal level of product safety as⁹

$$-Q(\bar{v}(x; \alpha, \beta_A, \beta_R))(\beta_R \alpha + 1 - \alpha)L_x(x, y_R^*) = k'(x). \quad (12)$$

The first term on the left-hand side gives the level of output. The last term represents the reduction in the expected harm due to higher product safety. The important difference between condition (12) and the one from the social planner's problem (i.e., condition (3)) is due to the term $(\beta_R \alpha + 1 - \alpha)$, which is strictly less than one for present biased consumers when they bear liability. In other words, for a given level of output, the firm has lower product safety incentives than the social planner. This is due to the fact that present biased consumers discount their share of the expected harm as it is a *future* cost. Consequently, present biased consumers underappreciate a marginal increase in product safety and this is reflected in demand. Considering the consumer's payoff in Stage 1, the acceptable level of price increase after a marginal increase in product safety is only

⁸Sophisticated consumers with $\beta_A = \beta_R$ consume less than in the benchmark with time-consistent consumers – which already features too little consumption due to the supply from a monopolistic firm – because they anticipate that they will not minimize $c + \alpha L$ with their precaution (i.e., they correctly predict their future costs from using the product). Additionally, there is a direct effect when $\alpha < 1$ from the firm's shifting expected liability payments via the price (the last term in the numerator of (11)). It is not clear that naive consumers consume less than what would result with time-consistent consumers given the precaution that they *actually* choose in Stage 2. They underestimate the future cost from consumption due to $\beta_A = 1$ leading them to think that they will minimize $c + \alpha L$. However, since there is an artificial scarcity introduced by the monopolistic firm, it is unlikely that naive consumers will actually overconsume relative to the efficient threshold $\hat{v} = c(y) + L(x, y)$ derived in Section 3 (where V from (11) must exceed $c + L$ in the statement of socially optimal valuation in order to have any consumers buying the product).

⁹Again due to $L_{xy} = 0$ implying $L_x(x, y^*(\alpha, \beta_A)) = L_x(x, y^*(\alpha, \beta_R))$. We assume that the second-order conditions for the firm's problem are fulfilled.

$-\alpha\beta_R L_x(x, y_A^*)$ whereas it should be $-\alpha L_x(x, y_A^*)$. The implied divergence between the level of chosen product safety from a social standpoint at a given output and the actual level selected by the firm is not contingent on consumer naivety or sophistication because the discounting of the share of expected harm applies to both types in the same way (as $L_{xy} = 0$).

This concludes our description of the outcome when the consumer is strictly liable for the share α of the expected harm. We now summarize the results and first attend to the benchmark scenario in which consumers are not present biased. Proofs of propositions are delegated to an appendix.

Proposition 1 (Consumers without present bias) *Suppose that $\beta_A = \beta_R = 1$. (i) Strict consumer liability for total harm (i.e., $\alpha = 1$) induces consumers to take optimal precaution and the firm to implement the socially optimal level of product safety for the given level of output. (ii) Sharing of liability between the firm and consumers (i.e., $\alpha < 1$) induces inefficient precaution by consumers, whereas the firm's product safety is still the socially optimal response to the resulting level of output.*

Considering only time-consistent consumers, our analysis delivers results similar to those derived in Hay and Spier (2005). Strict consumer liability for total harm induces first-best incentives with respect to product safety and precaution. Next, we turn to our research question, that is, the possible consequences of present bias for the workings of liability. We summarize our results in:

Proposition 2 (Present biased consumers) *(i) Present biased consumers take fewer precautions than consumers without bias. (ii) For a given output level, present biased consumers buy products with a lower level of product safety than consumers without bias when consumers are liable for some share of expected harm (i.e., when $\alpha > 0$). Naive present biased consumers receive safer products than sophisticated consumers. (iii) For given precaution levels anticipated in Stage 1, present biased consumers demand fewer units when compared to consumers without present bias when firms are liable for some share of expected harm (i.e., when $\alpha < 1$). Naive present biased consumers demand more when compared to sophisticated consumers. (iv) A decrease in present bias (i.e., a higher β_R for a given β_A for naive consumers or a higher β_R for sophisticated consumers)*

increases output, product safety, and precaution. (v) Full consumer liability cannot induce the socially optimal levels of both product safety and precaution, such that $\alpha = 1$ may not be the socially optimal allocation of expected harm.

We identify three distortions relative to the scenario with time-consistent consumers. First, present bias directly bears on consumers' precaution incentives in Stage 2 due to the discounting of future costs. Second, consumers' present bias implies that relying on consumer liability as an instrument to induce product safety works only imperfectly, because the consumer discounts expected liability payments and the firm responds to the implications for the consumers' willingness to pay in Stage 1. As a result, strict consumer liability for total harm cannot induce the socially optimal levels of product safety and precaution due to the distortions of present bias. Lowering the consumers' share of expected harm means that precaution falls whereas product safety and the level of output increases (where product safety and output levels counter each other regarding equilibrium levels due to the fixed-cost character of product safety). This makes it possible that some $\alpha < 1$ is preferred relative to $\alpha = 1$. The third key distortion is that present bias influences the purchase decision in a way that depends on the liability regime's allocation of losses. The reason is that the payment of the price is considered to be relatively more important and anticipated precaution is salient for the expected net benefit from using the product. The result in Proposition 2 (ii) about naive consumers obtaining relatively safer products results from the fact that naive consumers demand more and the firm's product safety investment being an increasing function of demand served.

To highlight the possibility that imposing some share of the third-party's losses on the firm can be socially optimal (Claim (v) in Proposition 2), we briefly present a numerical example. Using the functions $L(x, y) = 1 - x - y$, $c(y) = 12,000y^2$, and $k(x) = ax^2$ with $a \in \{760, 800, 1000\}$, together with parameter values $\beta_R = 4/5$, $\beta_A = 1$, $h = 1,500$, and $V = 3,500$, we obtain an interior level of α as maximizing welfare or either $\alpha = 0$ or $\alpha = 1$. We depict results for naive consumers in Figures 1-4 (findings for sophisticated consumers are qualitatively similar). The numerical example underlines what the comparative-statics result from Proposition 2 (v) suggested, that is, non-monotonic relationships between product safety and output on the one hand and the extent of shifting of expected losses on the other.

INSERT FIGURES 1-4 HERE

4.2 Strict Consumer Liability with a Damages Multiplier

In Section 4.1, α was meant to represent different possible allocations of the expected harm between the firm and the consumer. Now, we address the possibility of a damages multiplier such that the consumer pays a multiple of expected harm in damages.¹⁰ Suppose that the consumer is obliged to pay γL when a judge rules in the case, where $\gamma \geq 1$. The idea of the damages multiplier in our context counters the discounting of the expected liability payments stemming from present bias.

In Stage 2, first-best precaution results when a damages multiplier $\gamma = \beta_R^{-1}$ is implemented by the policy maker. This is clear from the first-order condition

$$c'(y) = -\beta_R \gamma L_y(x, y). \quad (13)$$

Let us denote the level of precaution that solves (13) by $\tilde{y}(\beta_R, \gamma) = \tilde{y}_R$. At earlier stages, consumers expect to choose precaution according to \tilde{y}_A . Naive consumers (wrongly) expect to minimize $c + \gamma L$. As a result, with the use of a damages multiplier $\gamma > 1$, naive consumers anticipate to exert a level of precaution that exceeds the socially optimal level of precaution. In contrast, sophisticated consumers correctly anticipate that they will be induced to choose precautions that minimize $c + L$ only when $\gamma = \beta_R^{-1}$.

In Stage 1, with the use of a damages multiplier, the valuation of the marginal consumer results as

$$\tilde{v}(P, x; \beta_A, \beta_R, \gamma) = \frac{P}{\beta_R} + c(\tilde{y}_A) + \gamma L(x, \tilde{y}_A). \quad (14)$$

Raising the expected liability payments above the third-party's expected losses thus deters consumption due to $c + \gamma L > c + L$ for any product safety level by the envelope theorem. Since naive consumers are ignorant of their present bias affecting the precaution choice in Stage 2, they expect to minimize $c + \gamma L$ with their precaution level. This means that the valuation of the marginal consumer is again lower for naive consumers.

In Stage 0, the firm derives the profit-maximizing price as a function of product safety

$$\tilde{P}(x; \beta_A, \beta_R, \gamma) = \beta_R \frac{V - c(\tilde{y}_A) - \gamma L(x, \tilde{y}_A)}{2}, \quad (15)$$

¹⁰The idea of a damages multiplier was prominently raised in the rationalization of punitive damages (Polinsky and Shavell 1998), for example.

which leads to

$$\tilde{v}(x; \beta_A, \gamma) = \frac{V + c(\tilde{y}_A) + \gamma L(x, \tilde{y}_A)}{2} \quad (16)$$

and

$$-Q(\tilde{v}(x; \beta_A, \gamma))\beta_R\gamma L_x(x, \tilde{y}_A) = k'(x). \quad (17)$$

The firm's product safety is a socially optimal response to the given level of output if $\gamma = \beta_R^{-1}$.

We summarize our findings in:

Proposition 3 (Present biased consumers & Damages multiplier) *Strict consumer liability with an expected damages payment γL , with $\gamma = \beta_R^{-1} > 1$, induces socially optimal precaution and the level of product safety that is socially optimal given the level of output. However, using a damages multiplier in excess of one contributes to a downward distortion of demand.*

In terms of product safety and precaution incentives, using the right damages multiplier leads to socially optimal care levels. However, it is probably not reasonable to expect that courts can assess consumers' present bias since there will be variation in this regard across victims and private information about it. Relatedly, Craswell (1999) is critical of the *multiplier principle* as the multiplier would have to be calculated on a case-by-case basis.¹¹ The above proposition highlights that even if it were possible to use the individual-specific present bias to calculate the damages multiplier to debias the perceived expected damages, it may not be socially desirable as it aggravates another distortion of consumer decision-making.

4.3 Negligence-based Liability Rules

Our analysis above shows that incentivizing the right level of product safety and precaution is difficult using a variant of strict consumer liability. In the following paragraphs, we discuss the outcomes that negligence-based liability rules can induce. We will also turn to the liability rule labeled strict liability with a defense of contributory negligence, where the expected harm is fully shifted to the firm as long as the consumer complies with a precaution standard.

¹¹For instance, Chu and Huang (2004) emphasize that payments exceeding the level of harm are in practice awarded only for "outrageous" conduct, which further questions the practical implementability of any multiplier in excess of one.

4.3.1 Simple Consumer Negligence Rule

Under simple consumer negligence, the firm is never held liable for third-party harm. The consumer is held liable if she chooses a precaution level below the due precaution level and is exempted from liability if she complies or chooses a precaution level above the due level. Accordingly, the result will be similar to the analysis of strict consumer liability when precaution falls short of the standard and the consumer will lose any interest in firm product safety when precaution weakly exceeds the standard (as we are considering third-party harm). Socially optimal incentives with regard to both product safety and precaution levels cannot result in this institutional setting.

4.3.2 Double Negligence Rule Addressed at Consumer

In standard treatises of tort law, the injurer either chooses one action to address the level of expected harm – commonly labeled *care* – or has two actions available out of which only one can be included in negligence standards – commonly labeled *care* and *activity level*. In multidimensional problems, it may make sense to allow for more than one behavioral standard (e.g., Friehe and Langlais 2017).¹² Above, we emphasized that the problem with simple consumer negligence is that obedient consumers no longer value product safety. This is thus an instance where two standards of conduct are important, one with respect to consumer care and one with respect to the product safety featured by the product that the consumer enjoys. This double negligence rule is related to *res ipsa loquitur* as the occurrence of an accident with a product featuring insufficient product safety is taken as evidence of negligence by the consumer.

Specifically, under the envisioned double negligence rule, consumers are not liable for the third party's expected harm if both the level of product safety is sufficient and consumer care is at least as high as the standard, that is, if both $x \geq x^S$ and $y \geq y^S$, where we denote the due-care standards by x^S and y^S . We assume that due-care standards are set at socially optimal levels. The socially optimal level of consumer care is as defined in (4). The socially optimal level of product safety depends on output and we consider that

¹²Dari Mattiacci (2005) analyzes which of the injurer's precautionary measures should be included in the determination of negligence and which should not, considering particularly the gains derived from improved accident prevention and the administrative costs of the system.

the due level is implicitly defined by¹³

$$-\frac{Q(c(y^S) + L(x, y^S))}{2}L_x(x, y^S) = k'(x), \quad (18)$$

such that it builds upon output when the market is served by a monopolist and consumers who are not present biased. For that reason, this level of product safety will be an upper bound for the product safety levels that the firm seeks to implement with present biased consumers as output with present biased consumers falls weakly short of output with time-consistent consumers.

We are considering a setting with a monopolistic firm (i.e., we assume that there is only one kind of product supplied). Accordingly, if the product safety level provided by the firm is at least as high as x^S , consumers are “enabled” to be compliant with both standards as it will depend only on their selection of precaution whether they will be compliant if $x \geq x^S$. Suppose that $x = x^S$. In Stage 2, the consumer compares $c(y^S)$ and $c(y_R^*) + \beta_R L(x^S, y_R^*)$. With β_R sufficiently close to one, choosing to obey the precaution standard is preferred by the consumer. There exists a critical level $\bar{\beta}_R(x^S, y_R^*)$ that makes obedience of the precaution standard the consumer’s weakly preferred option. The critical level is implicitly defined by

$$\bar{\beta}_R(x^S, y_R^*) = \frac{c(y^S) - c(y_R^*)}{L(x^S, y_R^*)}$$

It follows from the assumption that due-care standards are set at socially optimal levels that

$$c(y^S) - c(y) < L(x, y) - L(x, y^S)$$

for any y and x (due to the assumption $L_{xy} = 0$). This ranking implies that $\bar{\beta}_R(x, y) < 1$ such that there are high (low) levels of present bias for which obeying the due-precaution standard is (is not) privately optimal.

For choices in earlier stages, the anticipated present bias is important. Sophisticated consumers correctly anticipate their present bias and thus understand clearly whether they will obey the standard (as it straightforwardly depends on whether $\bar{\beta}_R(x^S, y_R^*) < \beta_R$ holds). In stark contrast, naive consumers anticipate that they will comply with the precaution standard but fall short of compliance. Accordingly, in Stage 1, when consumers anticipate to comply with both standards (which is always true for naive consumers and for

¹³It will become clear below to what extent this benchmark influences our argumentation.

sophisticated consumers when $\beta_R > \bar{\beta}_R(x^S, y_R^*)$, the valuation of the marginal consumer can be stated as

$$\bar{v}^D(P^D; \beta_R) = \frac{P^D}{\beta_R} + c(y^S). \quad (19)$$

where D indicates the *double* negligence rule.

In Stage 0, the firm selects the price (as we are seeking to derive profits under the assumption $x = x^S$). The firm maximizes expected profits by charging

$$P^D = \beta_R \frac{V - c(y^S)}{2}$$

The induced level of valuation for the marginal consumer $\frac{V+c(y^S)}{2}$ does not reflect the third party's harm.¹⁴ Using the above price to restate firm profits, we obtain

$$\Pi^D = \beta_R \frac{[V - c(y^S)]^2}{4V} - k(x^S).$$

The firm can obtain this profit with naive consumers even when these consumers ultimately do not fulfill the precaution standard as $\beta_R < \bar{\beta}_R(x^S, y_R^*) < \beta_A = 1$, whereas sophisticated consumers have a demand according to (19) only if $\beta_A = \beta_R \geq \bar{\beta}_R(x^S, y_R^*)$.

The firm may select $x < x^S$ and thereby induce the negligence of any agent who purchases the product. Non-compliance by the consumer would be evident to both naive and sophisticated consumers when they make the purchasing choice. In Stage 2, consumers select y_R^* and anticipate $y^*(1, \beta_A)$ in Stage 1 (as $\alpha = 1$). The valuation of the marginal consumer in Stage 1 as a function of product safety and price results as

$$\bar{v}^N(P^N, x; \beta_A, \beta_R) = \frac{P^N}{\beta_R} + c(y_A^*) + L(x, y_A^*). \quad (20)$$

Using the profit-maximizing price

$$P^N = \beta_R \frac{V - c(y^*(1, \beta_A)) - L(x, y^*(1, \beta_A))}{2} \quad (21)$$

as a function of product safety to restate firm profits, we obtain

$$\Pi^N = \beta_R \frac{[V - c(y_A^*) - L(x, y_A^*)]^2}{4V} - k(x) \quad (22)$$

¹⁴It will be greater than the socially optimal level of output if

$$\frac{V + c(y^S)}{2} < c(y^S) + L(x^S, y^S).$$

and the according first-order condition for product safety

$$\Pi_x^N = -\beta_R Q(\bar{v}^N(x; \beta_A, \beta_R)) L_x(x, y_A^*) - k'(x) = 0, \quad (23)$$

which yields a level of product safety $x^N(\beta_A, \beta_R)$ that falls short of x^S .

By selecting the level of product safety, the firm can choose between profit levels. Choosing $x = x^S$ instead of $x^N < x^S$ is thus preferable for the firm as long as

$$\frac{\beta_R}{4V} \left[[V - c(y^S)]^2 - [V - c(y_A^*) - L(x^N(\beta_A, \beta_R), y_A^*)]^2 \right] > k(x^S) - k(x^N(\beta_A, \beta_R)). \quad (24)$$

Since naive consumers anticipate to minimize $c + L$ whereas sophisticated consumers do not, the left-hand side appears greater for sophisticated consumers. However, the product safety level $x^N(\beta_A, \beta_R)$ will be smaller for sophisticated consumers due to smaller output in (23), countering the influence via precaution.

We summarize our results for the double negligence rule as follows:

Proposition 4 (Double Negligence Rule) *Suppose that a negligence rule with two standards for the consumer, x^S and y^S , applies. (i) When (24) and $\beta_R > \bar{\beta}_R$ hold, the firm chooses product safety according to the standard and consumers implement y^S . The level of output results as $Q((V + c(y^S))/2)$. (ii) Assume naive consumers. When (24) and $\beta_R < \bar{\beta}_R$ hold, the firm chooses product safety according to the standard and consumers implement y_R^* . The level of output results as $Q((V + c(y^S))/2)$. (iii) Assume sophisticated consumers. When (24) and $\beta_R < \bar{\beta}_R$ hold, the firm chooses $x^N < x^S$ and consumers implement $y_R^* < y^S$. The level of output results as $Q((V + c(y_A^*) + L(x^N, y_A^*))/2)$. (iv) When (24) does not hold, the firm chooses $x^N < x^S$ and consumers implement $y_R^* < y^S$. The level of output results as $Q((V + c(y_A^*) + L(x^N, y_A^*))/2)$.*

Proposition 4 (i) clarifies that compliance with the double negligence rule leads to an externalization of third-party harm such that the equilibrium level of output does not take adverse consequences for potential victims into account. The equilibrium output may fall short of or exceed the socially optimal level of output. This may arise from the failure to incorporate the externality emergent when consumers comply with the double negligence rule, which runs opposite to the contraction of output due to the monopolistic market structure.

4.3.3 Strict Liability with a Defense of Contributory Negligence (SLCN).

Under the negligence-based liability rules considered above, obeying the standard(s) is synonymous with the expected harm being no longer taken into consideration by both the firm and consumers. Under strict liability with a defense of contributory negligence, the consumer is held liable for harm when the level of precaution is substandard. Otherwise, the firm is held liable. As a result, there is no longer a risk of externalizing third-party harm. Daughety and Reinganum (2013a) consider a setup in which the firm and the consumer influence the expected harm incurred by the consumer, arriving at the result that the strict liability with a defense of contributory negligence rule induces desirable incentives when harm is cumulative. We will also arrive at the conclusion that there are circumstances in which this liability rule produces desirable outcomes. However, we also highlight that this need not result.

In Stage 2, as mentioned in our discussion of the double negligence rule, the consumer compares $c(y^S)$ and $c(y_R^*) + \beta_R L(x, y_R^*)$. When $\beta_R > (\leq) \bar{\beta}_R(x, y_R^*)$, the decision maker obeys (does not obey) the precaution standard. Compliance or non-compliance is correctly anticipated by sophisticated consumers whereas naive consumers (wrongly) expect to implement the precaution standard in any case.

In Stage 1, when consumers anticipate to comply with the precaution standard (i.e., when consumers are naive or sophisticated but with $\beta_A = \beta_R > \bar{\beta}_R$), the valuation of the marginal consumer results as

$$\bar{v}^C(P^C; \beta_R) = \frac{P^C}{\beta_R} + c(y^S), \quad (25)$$

which mirrors (19). It is important to note that naive consumers may wrongly anticipate own compliance with the precaution standard and thus wrongly direct a high willingness to pay the firm for the product. Sophisticated consumers who anticipate not to comply with the precaution standard (i.e., consumers for whom $\beta_A = \beta_R \leq \bar{\beta}_R$ applies), the valuation of the marginal consumer results as

$$\bar{v}^N(P^N, x; \beta_A, \beta_R) = \frac{P^N}{\beta_R} + c(y_A^*) + L(x, y_A^*). \quad (26)$$

In Stage 0, the firm selects product safety and price. Importantly, the level of product safety may influence whether consumers choose to comply in Stage 2 via its bearing on

$\bar{\beta}_R(x, y_R^*)$. For any level of product safety such that $\beta_R > \bar{\beta}_R(x, y_R^*)$, meaning that both naive and sophisticated consumers ultimately comply, the firm's expected profits

$$\Pi^C = [P^C - L(x, y^S)]Q \left(\frac{P^C}{\beta_R} + c(y^S) \right) \quad (27)$$

are maximized by

$$P^C = \frac{\beta_R(V - c(y^S)) + L(x, y^S)}{2}. \quad (28)$$

Using this price to restate firm profits, we obtain

$$\Pi^C = \frac{[\beta_R(V - c(y^S)) - L(x, y^S)]^2}{4V\beta_R} - k(x) \quad (29)$$

and the according first-order condition for product safety

$$\Pi_x^C = -Q(\bar{v}^C(x^C; \beta_R, y^S))L_x(x^C, y^S) - k'(x^C) = 0, \quad (30)$$

such that product safety $x^C(\beta_R)$ is socially optimal in view of the level of output.

When $\beta_A = \beta_R \leq \bar{\beta}_R(x, y_R^*)$, meaning that sophisticated consumers ultimately do not comply and correctly anticipate their non-compliance, the firm earns expected profits (22) which are maximized by the price P^N in (21) and the product safety x^N defined in (23).

When the consumer complies, the expected harm is borne by the firm which means lower profits as the consumer would discount the expected liability payments according to the present bias. The consumer complying with the precaution standard advantages the firm in that $c+L$ is actually minimized by the precaution implemented by the consumer. In contrast, the scenario in which the consumer is non-compliant induces a level of precaution y_R^* that implies a higher $c + L$, which is disadvantageous for the firm because it lowers the rents it can extract from consumers. When (29) is greater than (22), the firm prefers compliance on the part of the consumer.

The firm's choice of product safety may influence the consumer's incentives to obey the precaution standard. Suppose, for example, that the firm faces sophisticated consumers and that the difference $c(y^S) - (c(y_R^*) + \beta_R L(x^N, y_R^*))$ is positive but very small. The firm can induce a negative difference by decreasing product safety. This may be sensible for the firm if (29) is greater than (22).¹⁵ When dealing with sophisticated consumers, the

¹⁵A similar argument can be presented for the alternative scenario in which the difference $c(y^S) - (c(y_R^*) + \beta_R L(x^N, y_R^*))$ is negative but very small in absolute terms. The firm can increase product safety such that the difference becomes positive. This may be sensible for the firm if (29) is less than (22).

variation in the level of product safety has direct repercussions for the willingness to pay as these consumers understand the consequences for their compliance choice in Stage 2 and incorporate them at time of payment in Stage 1. However, naive consumers anticipate compliance and, for that reason, direct demand according to \bar{v}^C at the firm. The firm can influence the naive consumers' precaution choice in Stage 2 with the motivation of shifting the liability to consumers. Naive consumers will ultimately not comply when $\beta_A = 1 > \bar{\beta}_R(x, y_R^*) \geq \beta_R$ at the level of product safety implemented by the firm. When we remind ourselves of the (implicit) definition of $\bar{\beta}_R$, we find that the critical level is close to zero when β_R is close to one as the distinction between y^S and y_R^* vanishes. This means that influencing $\beta_R \leq \bar{\beta}_R$ using the level of product safety is promising particularly when β_R is notably smaller than one as

$$\frac{\partial \bar{\beta}_R}{\partial x} = -L_x(x, y_R^*) \frac{\bar{\beta}_R}{L(x, y_R^*)} > 0,$$

implying that the marginal impact of product safety on the critical level depends in turn on the level of the critical discount factor before the change in product safety.

If $\beta_A = 1 > \bar{\beta}_R(x, y_R^*) \geq \beta_R$, consumer demand uses the cutoff (25), yielding firm profits

$$\Pi^T = P^T Q(\bar{v}^C) - k(x) \quad (31)$$

with index T indicating the “temptation” for naive consumers in Stage 2. The price that results as optimal is

$$P^T = \frac{\beta_R(V - c(y^S))}{2} \quad (32)$$

which indicates that, in Stage 0, there is an illusion of the expected harm disappearing. Profits result as

$$\Pi^T = \frac{\beta_R(V - c(y^S))^2}{4V} - k(x) \quad (33)$$

For any level of product safety, this level of profits will exceed Π^C , creating deception incentives for firms with naive consumers. When we scrutinize (33), we find that the firm actually no longer associates any benefit with product safety such that it will select product safety x^T such that

$$c(y^S) = c(y_R^*) + \beta_R L(x^T, y_R^*). \quad (34)$$

Clearly, for a level of β_R close to one, it is too costly for the firm to induce non-compliance on the part of the consumer. In other words, the option of “tempting” naive consumers is

preferable for the firm only when the consumer suffers from a relatively high present bias. The relevant profit levels speak in favor of letting naive consumers be due-precaution level obedient if

$$\Pi^C = \frac{[\beta_R(V - c(y^S)) - L(x^C, y^S)]^2}{4V\beta_R} - k(x^C) > \frac{\beta_R(V - c(y^S))^2}{4V} - k(x^T) = \Pi^T \quad (35)$$

We summarize our results for the scenario of a strict firm liability with a defense of contributory consumer negligence as follows:

Proposition 5 (Strict Liability with a Defense of Contributory Negligence) *(i)*

*Suppose that $\beta_R > \bar{\beta}_R(x, y)$ for relevant levels of product safety. Present biased consumers comply with the standard of precaution and the firm implements the socially optimal level of product safety given the level of output. The level of output results as $Q((V + c(y^S) + \beta_R^{-1}L(x^S, y^S))/2)$. *(ii)* Suppose sophisticated consumers and that $\beta_R \leq \bar{\beta}_R(x, y)$ for relevant levels of product safety. Consumers implement precaution y_R^* and the firm implements product safety x^N . *(iii)* Suppose naive consumers and that $\beta_R \leq \bar{\beta}_R(x, y)$ for all relevant levels of product safety. Consumers implement precaution y_R^* and the firm product safety x^T . *(iv)* Suppose sophisticated consumers. The firm may distort product safety somewhat upwards or downwards when $c(y^S)$ is somewhat higher (lower) than $c(y_R^*) + \beta_R L(x, y_R^*)$ for some relevant product safety levels.*

Proposition 5 (i) highlights that the use of strict liability with a defense of contributory negligence can under some circumstances induce the socially optimal levels of product safety and consumer care, and produce a level of output that factors the third-party externality. Clearly, the outcome is still distorted by present bias because the firm charges for the liability and the consumer must pay the price before any consumption utility is incurred. Proposition 5 (iii) brings attention to a possible exploitation of naive consumers. The firm may design the naive consumer's decision problem such that compliance with the standard is anticipated when the product is purchased but ultimately not implemented.

5 Extensions

In this section, we briefly attend to two variations of our assumptions used in the main analysis. First, it is interesting to mention differences between the scenario in which

victims are third parties and the scenario in which victims are consumers. Next, we vary our assumption about when consumption utility is incurred by the consumer.

5.1 Second-party Harm

Our main analysis uses the model by Hay and Spier (2005) and thus focuses on a product that may cause harm to third parties. In this extension, we will briefly discuss the case studied in Section 4.1 when harm falls onto consumers. The key distinction is that consumers bear expected harm in Stage 2 (i.e., in the period in which precaution is determined) and may receive compensation from the firm in Stage 3.

If we use the sharing of expected harm between the firm and the consumer using the parameter $\alpha \in [0, 1]$ again, in Stage 2, the consumer minimizes

$$c(y) + L(x, y)(1 - \beta_R(1 - \alpha)). \quad (36)$$

If the firm bears some of the expected harm, present biased consumers have a greater incentive to exert precaution because they discount the damages payment received only in the future. In contrast, if the firm bears no part of expected harm, then the present bias of the consumer is inconsequential for the level of precaution. Let us denote the level of precaution that results in Stage 2 by \hat{y}_R and the one that is anticipated in earlier stages by \hat{y}_A .

In Stage 1, the consumer will purchase the product if

$$v \geq \bar{v} = \frac{P}{\beta_R} + c(\hat{y}_A) + \alpha L(x, \hat{y}_A) \quad (37)$$

In Stage 0, we obtain

$$\bar{v}^S(x; \alpha, \beta_A, \beta_R) = \frac{V - c(\hat{y}_A) - \alpha L(x, \hat{y}_A) - \frac{(1-\alpha)}{\beta_R} L(x, \hat{y}_R)}{2} \quad (38)$$

and

$$-Q(\bar{v}^S)[\beta_R\alpha + (1 - \alpha)]L_x = k'(x) \quad (39)$$

as description of firm behavior. Again, if the firm bears all of the expected harm, the firm chooses the socially optimal response in terms of product safety for the given level of output, which is distorted by present bias. With strict consumer liability, firm incentives are distorted.

Proposition 6 (Present biased consumers & Second-party harm) *Strict consumer liability for total harm induces socially optimal precaution and suboptimal product safety for the given output when consumers are present biased and product use implies expected harm for consumers.*

Summarizing the above, present bias is influential for the workings of liability independent of whether the consumer is the victim or the harm-doer.

5.2 Product Valuation Incurred at Time of Purchase

In this section, we briefly revisit our analysis from Section 4.1 under the assumption that the valuation of the product is incurred at the time of purchase.

The consumer's precaution choice in Stage 2 is obviously unaffected. However, the consumer's purchase choice in Stage 1 changes as the requirement now reads

$$v - P - \beta_R[c(y_A^*) + \alpha L(x, y_A^*)] \geq 0, \quad (40)$$

giving a valuation of the marginal consumer equal to

$$\bar{v}(P, x; \alpha, \beta_A, \beta_R) = P + \beta_R[c(y_A^*) + \alpha L(x, y_A^*)]. \quad (41)$$

In Stage 0, the firm finds it profit-maximizing to charge a price

$$P^*(x; \alpha, \beta_A, \beta_R) = \frac{V - \beta_R[c(y_A^*) + \alpha L(x, y_A^*)] + (1 - \alpha)L(x, y_R^*)}{2} \quad (42)$$

and set product safety to fulfill

$$-Q(\bar{v}(x; \alpha, \beta_A, \beta_R))(\beta_R\alpha + 1 - \alpha)L_x(x, y_R^*) = k'(x). \quad (43)$$

As a result, key findings are not modified by the change in assumption regarding the timing of when the product benefit arises. However, it is important for the attractiveness of the damages multiplier as a policy option (discussed in Section 4.2). In Section 4.1, the consumer perceives only the payment of the price as a present flow, such that using a damages multiplier (which effectively brings expected liability to the present) magnifies the deterrence that results due to the discounting of the valuation. However, when that discounting of the valuation is not present (as in (40)), the use of the damages multiplier improves the consumer's purchase choice in the sense of bringing it closer to the alignment of actual costs and benefits.

6 Conclusion

Decisions and events in the context of liability are often spread out over time. For example, the time period between an accident and the payout of damages is significant in many (if not most) jurisdictions. This paper brings this important aspect from the tort setting to the time preferences postulated in much of the behavioral economics literature to inquire about repercussions for the actual workings of liability.

In a setup in which harm-inflicting consumers are present biased, we have established that the liability rule that is considered as the optimal one without present bias – strict consumer liability for total harm (see Hay and Spier 2005) – cannot induce the first-best allocation. In addition, we highlighted how consumers’ sophistication about their present bias influences results. Our analysis produces arguments for shifting (at least) some losses to the firm. Along these lines, we document that strict firm liability with a defense of contributory consumer negligence may attain desirable outcomes under many circumstances. However, we also highlighted that this liability rule may induce undesirable firm incentives particularly when it serves naive consumers.

The present paper presents a first inquiry into the matter, neglecting many aspects that deserve future research. For example, we have assumed that the productivity of product safety is independent of the level of precaution to simplify our discussion. However, with these assumptions, we exclude, for example, that sophisticated consumers may demand a higher level of product safety in order to compensate for the anticipated underinvestment in precaution.

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Appendix

A Proof of Proposition 1

The consumer without present bias who is liable for the share α uses the precaution that solves $c' = -\alpha L_y(x, y)$. The firm maximizes

$$\Pi = (P - (1 - \alpha)L(x, y^*(\alpha))) \frac{V - P - c(y^*(\alpha)) - \alpha L(x, y^*(\alpha))}{V} \quad (44)$$

with respect to the price to obtain

$$P^* = \frac{V - c(y^*(\alpha)) + (1 - 2\alpha)L(x, y^*(\alpha))}{2} \quad (45)$$

After inserting this into the profit function, we find that the firm's first-order condition for the level of product safety is

$$-L_x(x, y^*(\alpha)) \frac{V - c(y^*(\alpha)) - L(x, y^*(\alpha))}{2V} = k'(x). \quad (46)$$

The firm thus selects the socially appropriate level of product safety for the given level of output.

B Proof of Proposition 2

Claim (i) is a direct consequence of the fact that precaution costs arise in the decision-making period whereas expected liability payments arise in the future.

Claim (ii) is due to the fact that the valuation of product safety transmitted via the consumers' demand is too small (see (12)), again due to the fact that expected liability payments arise in the future whereas the payment of the price is due in the decision-making period. This result is thus only relevant when the consumer is liable for at least a part of the expected harm (i.e., when $\alpha > 0$). The fact that naive consumers obtain products with higher product safety stems from output being higher with naive consumers due to the naive consumers' (mistaken) expectation about the precaution that minimizes $c + \alpha L$ (see Claim (iv) about the higher level of output).

Claim (iii) takes the level of precaution anticipated in Stage 1 as given. These are the same for naive present biased consumers and consumers without present bias. When $\alpha < 1$, the demand of naive present biased consumers is less because of the fact that the cost component stemming from firm liability is inflated by the inverse of the present bias (see (11)). For sophisticated present biased consumers, there additionally is the understanding that in fact $c + \alpha L$ will not be minimized by the choice of precaution, implying that naive present biased consumers demand more than sophisticated ones (an effect reinforced by the higher product safety for naive consumers).

Claim (iv) reports a comparative-statics result for naive and sophisticated consumers.

Turning to naive consumers first, we have to evaluate the following system of equations

$$YA := c'(y_A) + \alpha\beta_AL_y(x, y_A) = 0 \quad (47)$$

$$YR := c'(y_R) + \alpha\beta_R L_y(x, y_R) = 0 \quad (48)$$

$$VM := \beta_R[V + c(y_A) + \alpha L(x, y_A)] + (1 - \alpha)L(x, y_R) - 2\beta_R v_M = 0 \quad (49)$$

$$X := -L_x(x, y_A)[\beta_R\alpha + 1 - \alpha]\frac{V - v_M}{V} - k'(x) = 0 \quad (50)$$

where the first (second) equation describes the precaution level anticipated (implemented) by naive consumers, the third equation describes the critical level of valuation v_M , and the fourth equation gives the profit-maximizing level of product safety. For a change in the level of β_R , we derive the following results

$$\frac{dy_A}{d\beta_R} = 0 \quad (51)$$

$$\frac{dy_R}{d\beta_R} = \frac{-YR_{\beta_R}}{YR_{y_R}} > 0 \quad (52)$$

$$\frac{dv_M}{d\beta_R} = \frac{YR_{\beta_R}(VM_x X_{\beta_R} + VM_{y_R} X_x) - YR_{y_R} VM_{\beta_R} X_x}{YR_{y_R}(VM_{v_M} X_x - VM_x X_{v_M})} < 0 \quad (53)$$

$$\frac{dx}{d\beta_R} = -\frac{YR_{y_R}(VM_{v_M} X_{\beta_R} - VM_{\beta_R} X_{v_M}) + YR_{\beta_R} VM_{y_R} X_{v_M}}{YR_{y_R}(VM_{v_M} X_x - VM_x X_{v_M})} > 0 \quad (54)$$

with $YR_{y_R} = c''(y_R) + \alpha\beta_R L_{yy}(x, y_R) > 0$, $YR_{\beta_R} = \alpha L_y(x, y_R) < 0$, $VM_{v_M} = -2\beta_R < 0$, $VM_{y_R} = (1 - \alpha)L_y(x, y_R) < 0$, $VM_{\beta_R} = V + c(y_A) + \alpha L(x, y_A) - 2v_M < 0$, $VM_x = \beta_R\alpha L_x(x, y_A) + (1 - \alpha)L_x(x, y_R) < 0$, $X_x = -L_{xx}(x, y_A)[\beta_R\alpha + 1 - \alpha]\frac{V - v_M}{V} - k''(x) < 0$, $X_{\beta_R} = -L_x\alpha > 0$, and $(VM_{v_M} X_x - VM_x X_{v_M}) > 0$ to ensure a profit maximum of the firm.

When we consider sophisticated consumers instead, the system of equations is

$$YR := c'(y_R) + \alpha\beta_R L_y(x, y_R) = 0 \quad (55)$$

$$VMS := \beta_R[V + c(y_R) + \alpha L(x, y_R)] + (1 - \alpha)L(x, y_R) - 2\beta_R v_M = 0 \quad (56)$$

$$XS := -L_x(x, y_R)[\beta_R\alpha + 1 - \alpha]\frac{V - v_M}{V} - k'(x) = 0. \quad (57)$$

For a change in the level of β_R , we derive the following results

$$\frac{dy_R}{d\beta_R} = \frac{-YR_{\beta_R}}{YR_{y_R}} > 0 \quad (58)$$

$$\frac{dv_M}{d\beta_R} = \frac{YR_{y_R}(VM_x X_{\beta_R} - VM_{\beta_R} X_x) + YR_{\beta_R} VM_{y_R} X_x}{YR_{y_R}(VM_{v_M} X_x - VM_x X_{v_M})} < 0 \quad (59)$$

$$\frac{dx}{d\beta_R} = -\frac{YR_{y_R}(VM_{v_M} X_{\beta_R} - VM_{\beta_R} X_{v_M}) + YR_{\beta_R} VM_{y_R} X_{v_M}}{YR_{y_R}(VM_{v_M} X_x - VM_x X_{v_M})} > 0 \quad (60)$$

Claim (v) is a consequence of the fact that, while $\alpha = 1$ maximizes the consumer's interest in the expected harm and for that reason minimizes the underinvestment problem regarding precaution, it maximizes the distortion of the firm's product safety incentives. It may be that departing somewhat from $\alpha = 1$ improves welfare overall. Evaluating social welfare as a function of α , we consider

$$\max_{\alpha \in [0,1]} \tilde{W} = \frac{1}{V} \int_{\bar{v}(\alpha)}^V [v - c(y(\alpha)) - L(x(\alpha), y(\alpha))] dv - k(x(\alpha)), \quad (61)$$

with

$$\frac{d\tilde{W}}{d\alpha} = \frac{\partial \tilde{W}}{\partial \bar{v}} \frac{d\bar{v}}{d\alpha} + \frac{\partial \tilde{W}}{\partial x} \frac{dx}{d\alpha} + \frac{\partial \tilde{W}}{\partial y} \frac{dy}{d\alpha} \quad (62)$$

For sophisticated consumers, it is clear that there is too little consumption in the market equilibrium, which is also likely for naive consumers (i.e., $\partial W/\partial \bar{v} < 0$). In addition, regarding both kinds of care, there is (at least weak) underprovision (i.e., $\partial W/\partial x > 0$ and $\partial W/\partial y > 0$).

The *direct* effects of decreasing α from $\alpha = 1$ are: (i) consumers' precaution decreases, (ii) firm's product safety increases, and (iii) the valuation of the marginal consumer increases. This implies that the influence on the level of safety may provide an argument for a lower level of α .

Considering the equilibrium effects instead of the direct effects only, we obtain for *naive* consumers

$$\frac{dy_A}{d\alpha} = \frac{-Y A_\alpha}{Y A_{y_A}} > 0 \quad (63)$$

$$\frac{dy_R}{d\alpha} = \frac{-Y R_\alpha}{Y R_{y_R}} > 0 \quad (64)$$

$$\frac{dv_M}{d\alpha} = \frac{Y R_{y_R} [V M_x X_\alpha - V M_\alpha X_x] + Y R_\alpha V M_{y_R} X_x}{Y R_{y_R} (V M_{v_M} X_x - V M_x X_{v_M})} \quad (65)$$

$$\frac{dx}{d\alpha} = -\frac{Y R_{y_R} [V M_{v_M} X_\alpha - V M_\alpha X_{v_M}] + Y R_\alpha V M_{y_R} X_{v_M}}{Y R_{y_R} (V M_{v_M} X_x - V M_x X_{v_M})} \quad (66)$$

with $Y A_\alpha = \beta_A L_y(x, y_A) < 0$, $Y R_\alpha = \beta_R L_y(x, y_A) < 0$, $V M_\alpha = \beta_R L(x, y_A) - L(x, y_R) < 0$, $V M_{y_A} = 0$, $X_\alpha = -L_x(x, y_A)(\beta_R - 1) \frac{V - v_M}{V} < 0$, $X_{v_M} = (\beta_R \alpha + 1 - \alpha) L_x(x, y_A) / V < 0$.

Whereas the change in precaution is unambiguous, there are opposing effects when it comes to output and care. For the level of output, there is a direct effect that speaks for a decrease in the cutoff v_M . For the level of product safety, however, there is a direct effect that speaks for a decrease in product safety which influences the level of output in turn. As a result, the comparative-statics results for a change in α are not clear.

Doing the same analysis for *sophisticated* consumers, we obtain

$$\frac{dy_R}{d\alpha} = \frac{-Y R_\alpha}{Y R_{y_R}} > 0 \quad (67)$$

$$\frac{dv_M}{d\alpha} = \frac{Y R_{y_R} [V M_x X_\alpha - V M_\alpha X_x] + Y R_\alpha V M_{y_R} X_x}{Y R_{y_R} (V M_{v_M} X_x - V M_x X_{v_M})} \quad (68)$$

$$\frac{dx}{d\alpha} = -\frac{Y R_{y_R} [V M_{v_M} X_\alpha - V M_\alpha X_{v_M}] + Y R_\alpha V M_{y_R} X_{v_M}}{Y R_{y_R} (V M_{v_M} X_x - V M_x X_{v_M})} \quad (69)$$

which delivers the same results.

The numerical example at the end of Section 4.1 highlights the possibility that $\alpha = 0$ or an interior level of α may be socially optimal.

Figures

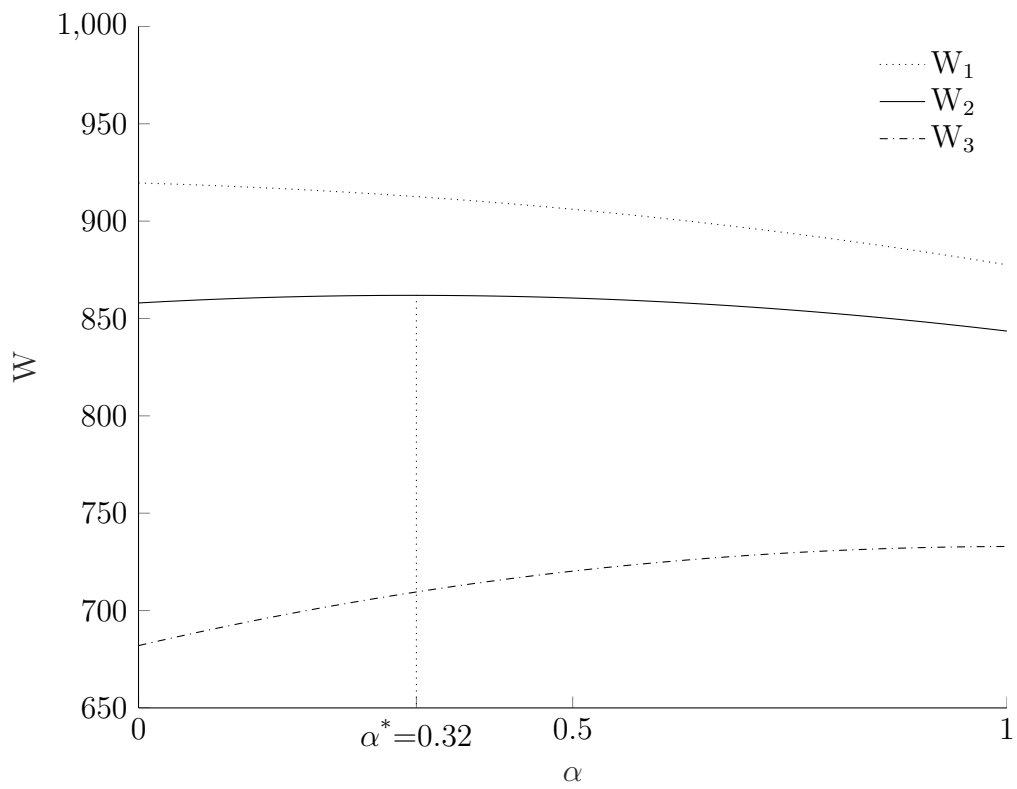


Figure 1: Welfare as a function of α with naive consumers ($k(x)$ being either $760x^2$, $800x^2$ or $1,000x^2$)

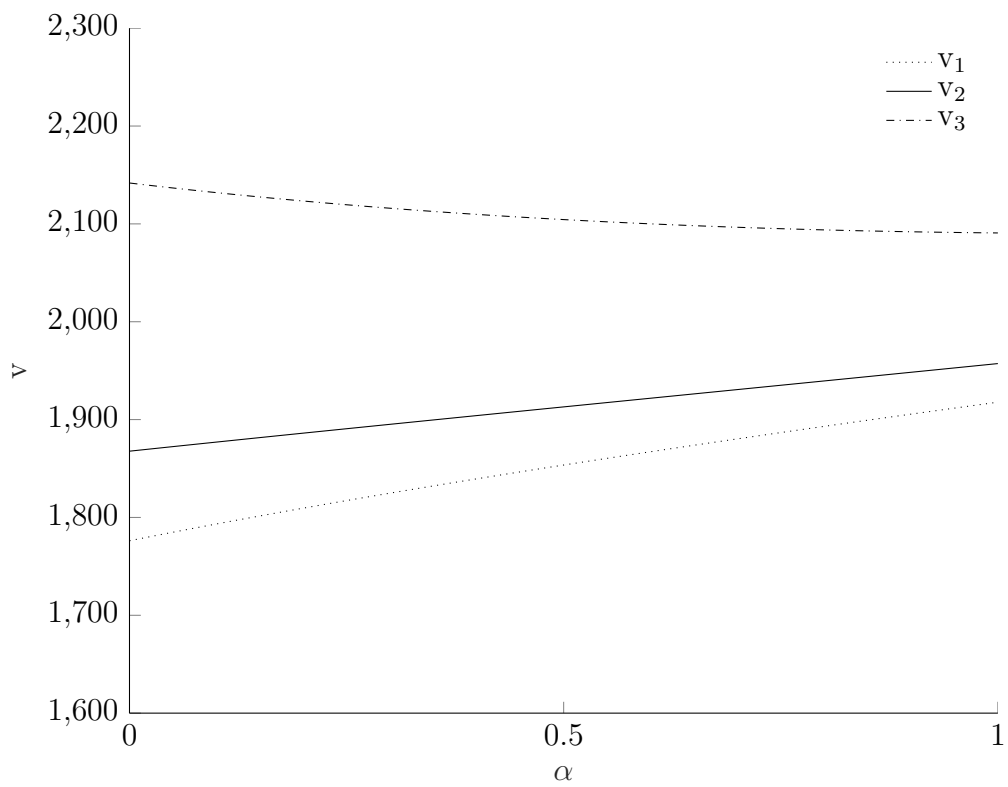


Figure 2: Valuation of the marginal naive consumer as a function of α ($k(x)$ being either $760x^2$, $800x^2$ or $1,000x^2$)

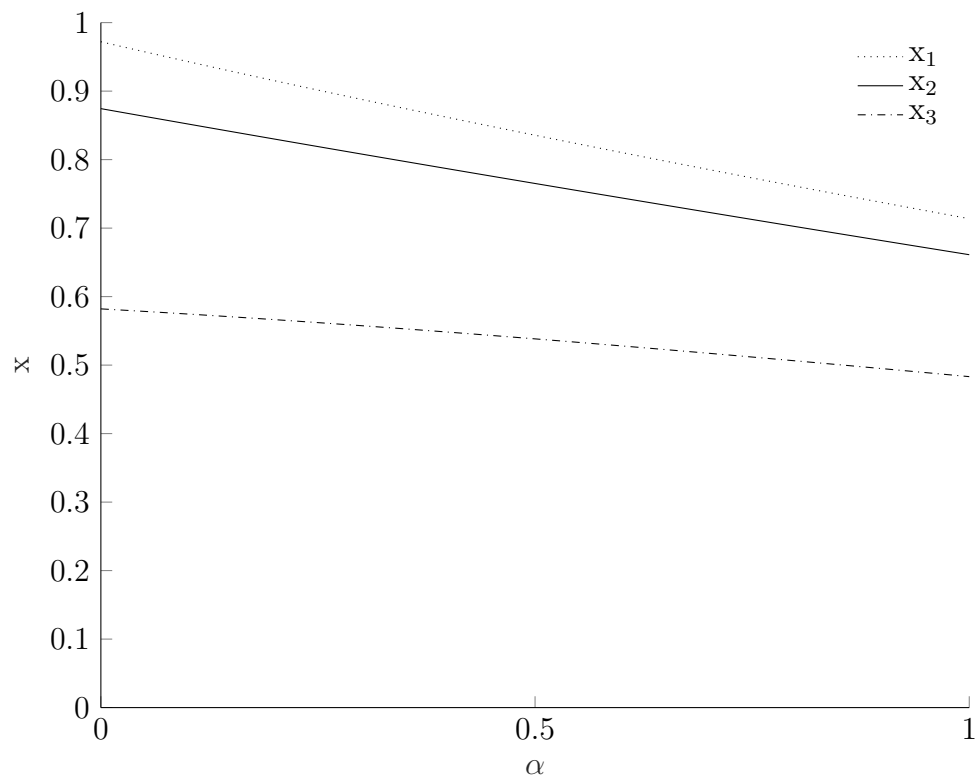


Figure 3: Product safety implemented for naive consumers as a function of α ($k(x)$ being either $760x^2$, $800x^2$ or $1,000x^2$)

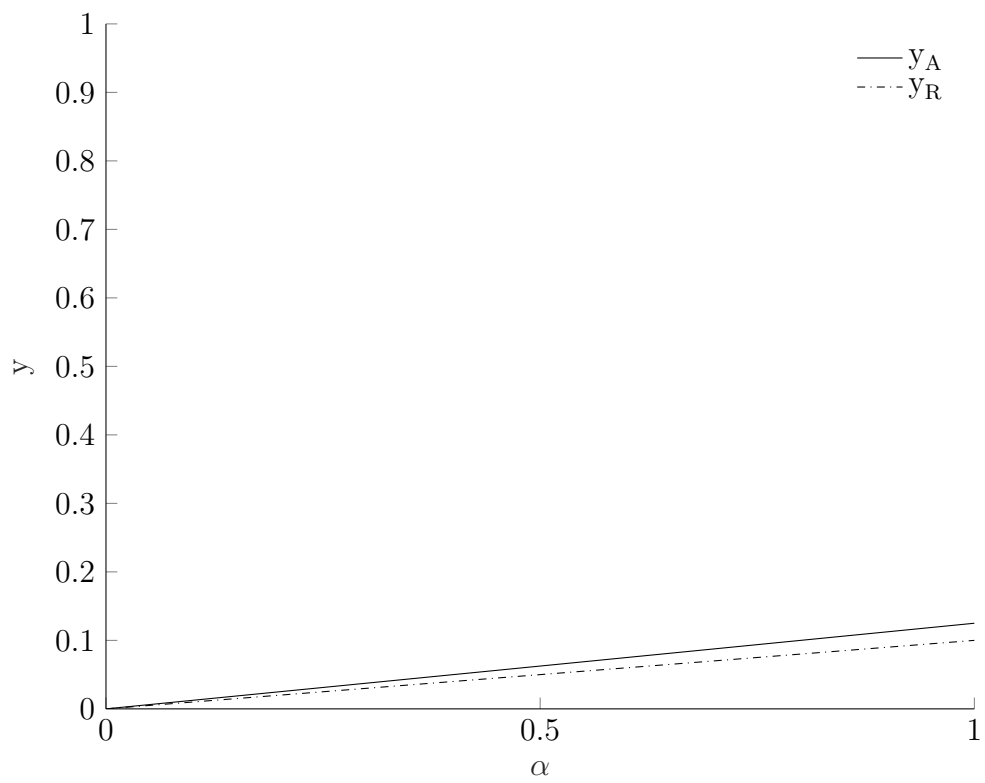


Figure 4: Precaution implemented as a function of α