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Imperfect Observability, Tort Liability Rules, and Incentive for Care*

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Abstract

This paper studies an economic model of tort liability rules and considers litigation between a firm and a consumer, under the assumption that the consumer may not perfectly observe the firm's action. We compare two alternative tort liability rules: the Negligence rule and strict liability with contributory negligence. We consider the noiseless case as a benchmark, and show that under those two cases, the desirable tort liability rule is different. This result implies that even if the noise is sufficiently small, the situation can not be approximated by the noiseless model.

Keywords: tort liability rule, product failure, punitive damages, imperfect observability

JEL Classification: K13, K41

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1 Introduction

We consider a situation where an accident occurs for product failure. When the Negligence rule is applied, a victim who suffers a loss must attest to all of the following: (1) the occurrence of the damage, (2) the negligence of an injurer, and (3) a causal relationship between his negligence and the damage. This rule imposes severe burdens on the victims, and most of consumers might have to take the damage lying down, since there is asymmetric information between the injurers and the victims[1]. Therefore, many have considered that it is desirable to change the tort liability rule from the Negligence rule to rules based on strict liability, reducing victims' severe burdens in proving, and protecting them. Under rules based on strict liability, all the victims have to do is to attest to (1) the occurrence of damage, (2) the failure of the product, and (3) a causal relationship between the failure of the product and the damage. The change to rules based on strict liability has increased in the last decade. For example, the tort liability rules in Europe, Japan, and other countries have changed from the Negligence rule to rules based on strict liability.

So far, most of the literature on the comparison of tort liability rules have shown that the Negligence rule is desirable at least (see, Brown (1973), Shavell (1983), *etc.*). Therefore, they cannot explain why it should be desirable to change from the Negligence rule to rules based on strict liability. We develop an economic model of product failure which explains this change from the viewpoint of the firm's incentive to take care[2]. We introduce two

[1]For example, the technology of the product, as well as its production process, might be unknown to the victims.

[2]We do not consider the consumer's incentive for the deterrence of an accident. We have two reasons for focusing attention only on the firm's incentive to take care. First, the consumer's prevention costs maybe much less than the firm's. Therefore, it is more difficult to make the firm take due care than to make the consumer do it. Second, if the firm does not take care and an accident occurs, then many consumers might suffer damage. So the damage maybe more widespread if the firm does not take care, as opposed to a situation where it is rather the consumer who does not take care, in which case only she

important factors: imperfect observability and the process of litigation. Imperfect observability means that the victim cannot perfectly observe the injurer's action. The victim finds some evidence and we call the evidence a *signal*. The signal are mutually related to the firm's action and it is noisy.

We also consider the noiseless case, the case where the signal perfectly informs the consumer of the firm's action as a benchmark[3]. In the noiseless case, we get a different result from the one in the noisy case. To understand why both cases have different results as to what is the desirable tort liability rule, we should consider whether we can make the firm take care. In the noiseless case, if the consumer observes the "wrong" signal, she brings a suit against the firm since the signal implies that the firm surely did not take care. Thus, the Negligence rule gives the firm a stronger incentive to take care. In the noisy case, on the other hand, when the consumer observes the "wrong" signal, she regards the signal as a case of "bad luck" for the firm and believes that it does generally take care. This conclusively influences whether the consumer accepts the settlement offer or not. That is, in the noisy case, the consumer accepts the settlement offer under the Negligence rule, since she believes that the firm takes care and anticipates that the case goes against her. Therefore, the firm has a weaker incentive to take care in the noisy case. Under strict liability with contributory negligence, on the other hand, the consumer brings a suit if she takes care because she knows that the case is in her favor. Hence, the firm has a stronger incentive to take care. These imply that we can no longer discipline the firm's action using the Negligence rule in the noisy case.

This paper is organized as follows. Section 2 constructs the model of

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will suffer the loss. Furthermore, if we think of this model as a theoretical consideration of the Product Liability Law, an incentive for the firm to take care is more important.

[3]If the manufactured goods have a simple structure, consumers can easily prove the firm's negligence. In this case, we may consider the situation as a noiseless case. For goods with a complicated structure, however, it is difficult for the consumers to determine the cause of the accident, so we rather have a noisy case. Since, as a trend, the structure of goods is getting more and more complex, we regard the noiseless case just as a benchmark.

product failure with the process of litigation. Section 3 analyzes the noiseless case as a benchmark. Section 4 investigates the noisy case. Section 5 gives the concluding remarks.

2 The Model

First, we construct the model to analyze the strategic decision problem of the injurer and the victim with the process of litigation. Second, we explain two alternative tort liability rules, each of which decides how to divide the damage. Third, we define parties who it is desirable to take care.

2.1 The Structure of the Game

There are two risk-neutral parties: a firm as a (potential) injurer and a consumer as a (potential) victim. The firm moves first and chooses N or V, where N is a nonviolating action, and V is a violating action. Examples of the nonviolating action are as follows: (1) the firm produces a user's manual for the manufactured good, writing the instructions before use and the corresponding warnings; (2) food factory always keeps the inside of the factory clean; (3) fast food store adjusts the heat of drinks (coffee, tea, etc.) not to be too hot, and so on. We assume that when the firm chooses the nonviolating action, it must pay the additional prevention cost $\gamma > 0$.

While we should explicitly examine whether the consumer is actually willing to buy the goods, we assume the consumer does buy it. This is because we are concerned with what happens after the consumer buys it.

The consumer moves second without observing the firm's action and chooses N or V. We call the action the consumer's first action. For example, the nonviolating actions are as follows: (1) the consumer follows the manual of the manufactured good; (2) the consumer puts a milk pack into a refrigerator; (3) the consumer does not eat food past its expiration date, and so on. If the consumer chooses the nonviolating action, she must pay the additional prevention cost $\delta > 0$.

The game ends if no accident which injures the consumer occurs. If the accident occurs, the game reaches the next stage.

The probability that an accident occurs depends on the actions of both parties, and is denoted by α_{ij}, where i means the firm's action and j means the consumer's first action. We assume throughout that the probabilities satisfy the following inequalities:

$$\alpha_{NN} < \alpha_{VN} < \alpha_{VV} \quad \text{and} \quad \alpha_{NN} < \alpha_{NV} < \alpha_{VV}.$$

Given the opponent's action, when each party takes N, the probability of occurring in an accident is reduced. The relation between α_{NV} and α_{VN} is not specified. When an accident occurs, the consumer is injured by a fixed amount of losses $L > 0$. We assume that both parties know L.

After an accident occurred, the consumer observes a signal that indicates the action of the firm[4]. There are two signals n or v, where n is the signal that the firm took N, and v is the signal that the firm took V. If the firm chooses V, the signal v is observed by the consumer with a probability one. On the other hand, if the firm chooses N, the signal n is observed by the consumer with a probability $1-\varepsilon$ with $\varepsilon \in (0,1)$, and the signal v is observed by her with the remaining probability ε. Hence, when the consumer observes v, she cannot exclude a possibility that the firm took N.

The firm voluntarily offers a fixed amount of settlement $S > 0$ after it is sued by the consumer. We assume that the firm offers the constant amount S regardless of its action, because the firm may find it costly to go to trial: for example, the (future) reduced profits due to tarnished reputation. The idea behind this assumption is to avoid further complication associated with the fact that the consumer would be able to obtain some information about

[4]In some cases, the signal may be observed by the consumer before an accident occurs. Consider the situation where an accident occurs immediately after the consumer observes the signal. Then, the consumer can not change her action. Therefore, the above situation can also obtain the same result as the case where the consumer observes the signal after an accident occurs. In other words, if we consider the situation in which the consumer chooses her first action and cannot change it, then the result is tantamount to observing the signal after an accident occurs.

the firm's action, if the settlement offer can vary depending on the firm's actions.

The consumer decides whether she accepts the settlement offer: her second action is s or t, where s denotes the acceptance of the settlement offer, and t the rejection and go to trial. If the consumer accepts the settlement offer, she receives S. When the settlement is reached between the firm and the consumer, they do not have to pay additional cost. If the consumer rejects it, she brings a suit against the firm. Litigation is costly. Let $t_F > 0$ be the firm's cost of litigating, and $t_C > 0$ be the consumer's cost of litigating.

Judgment is given on the case according to the relevant tort liability rule. We assume that the court is omnipotent in the sense that, at the end of trial, it can correctly observe their actions. If the consumer goes to trial and the judgment is in favor of her, she receives a fixed amount of awards W. The awards are exogenously determined. We assume that both parties know the size of W, that $W - t_C > S$, and that $L > S$.

Now, we formalize their payoffs in this game. First, consider the payoffs when an accident does not occur. If the firm takes N, it pays $-\gamma$. While if the firm takes V, it pays nothing, that is, the firm's payoff is 0. If the consumer takes N, she pays $-\delta$, whereas she pays nothing if she takes V.

Next, given that an accident occurs, we consider their payoffs. The firm pays the following:

$$u_F(z) = \begin{cases} -t_F - \mu(a_F)\gamma & \text{if } a_{C_2} = t \text{ and the firm is winner,} \\ -W - t_F - \mu(a_F)\gamma & \text{if } a_{C_2} = t \text{ and the firm is loser,} \\ -S - \mu(a_F)\gamma & \text{if } a_{C_2} = s, \end{cases}$$

where $u_F(z)$ denotes the firm's payoff function which depends on z, z is terminal node, and $\mu(\cdot)$ is a function such that $\mu(N) = 1$ and $\mu(V) = 0$. a_F denotes the set of the firm's action and a_{C_2} denotes the set of the consumer's second action.

The consumer receives the following payoff:

$$u_C(z) = \begin{cases} W - L - t_C - \mu(a_{C_1})\delta & \text{if } a_{C_2} = t \text{ and the consumer is winner,} \\ -L - t_C - \mu(a_{C_1})\delta & \text{if } a_{C_2} = t \text{ and the consumer is loser,} \\ S - L - \mu(a_{C_1})\delta & \text{if } a_{C_2} = s, \end{cases}$$

where $u_C(z)$ denotes the consumer's payoff function which depends on z and a_{C_1} denotes the set of the consumer's first action. Which side wins trial depends on their actions and the tort liability rule, which we describe in detail in the next subsection.

We define both parties' strategy. We restrict our attention to pure strategy equilibrium The firm's pure strategy σ_F is N or V, because it is the first mover of this game and it moves just once. The consumer's pure strategy σ_C is more complicated. For example, let us consider the consumer's strategy $\sigma_C = \{N, t, t, s, s\}$[5]. This strategy is read as follows: (1) the consumer chooses N (the first component of σ_C) as her first action, (2) she chooses t (the second component of σ_C) if she has chosen N and then observed n after the accident, (3) she chooses t (the third component of σ_C) if she has chosen N and then observed v, (4) she chooses s (the fourth component of σ_C) if she has chosen V and then observed n, and (5) she chooses s (the fifth component of σ_C) if she has chosen V and then observed v.

The solution concept is Perfect Bayesian equilibrium[6].

2.2 Tort Liability Rules

We compare and analyze the following two tort liability rules:

- Negligence rule (Neg): The firm is liable if it is found negligent. Otherwise, the consumer is liable.

[5]The last four components of the strategy specify what she does at the information sets (N, n), (N, v), (V, n) and (V, v) respectively.

[6]Since we focus the pure strategy equilibrium, we exclude the belief from the description of Perfect Bayesian equilibrium.

- Strict Liability with Contributory Negligence (SLCN): The consumer is liable if she is found negligent. Otherwise, the firm is liable.

Tables 1 and 2 depict the two tort liability rules. Depending on the combination of actions by both parties, the matrices indicate who is liable, who is the loser.

		Consumer	
		N	V
Firm	N	C	C
	V	F	F

Table 1: Neg

		Consumer	
		N	V
Firm	N	F	C
	V	F	C

Table 2: SLCN

2.3 Social Desirability

Given the opponent's action, it is socially desirable if the prevention cost of the party is smaller than the decrease in damages by taking care. We define the party that it is socially desirable to take care:

$$\gamma \leq (\alpha_{VN} - \alpha_{NN})L, \tag{1}$$

$$\delta \leq (\alpha_{NV} - \alpha_{VV})L, \tag{2}$$

$$\gamma + \delta \leq (\alpha_{VV} - \alpha_{NN})L. \tag{3}$$

(1) and (2) means that, given that the opponent takes care, it is socially desirable for each party to take care when each party's prevention cost is smaller than the difference in expected damages[7]. (3) means that it is socially desirable for both parties to take care. We assume that (3) holds.

3 The Noiseless Case

In this section, we consider the noiseless case ($\varepsilon = 0$) as benchmark[8]. When the firm takes the nonviolating action, the consumer surely observes the

[7]This formulation of the negligence standard was first stated by Judge Learned Hand in United States v. Carroll Towing Co., 159 F. 2d 169 (2d. Cir. 1947).

[8]Since there is no noise for firm's action, the consumer correctly infers its action.

signal n. On the other hand, if the firm takes the violating action, the consumer surely observes the signal v.

3.1 the Negligence rule

Intuitively speaking, an equilibrium in which both parties take the nonviolating action exists only when both γ and δ are not too large. The following result gives a complete characterization of the range of γ and δ.

Proposition 1. *A Perfect Bayesian equilibrium where each party takes N exists if and only if*

$$\gamma \leq \alpha_{VN}(W + t_F) - \alpha_{NN}S, \tag{4}$$

$$\delta \leq (\alpha_{NV} - \alpha_{NN})(L - S). \tag{5}$$

In the Perfect Bayesian equilibrium, the consumer's strategy is $\sigma_C = \{N, s, t, s, t\}$.

We examine how the incentives of the firm and the consumer to choose N are affected under Neg when W increases. First, the right-hand side of (4) shows that when W increases, the firm's marginal benefit of choosing N is positive. Given the consumer's equilibrium strategy, the increase of W reduces the firm's benefit only when it chooses V, because in this case (and only in this case) the consumer chooses to go to trial. Thus, it is attractive for the firm to choose N and it is encouraged to choose N. The right-hand side of (5) shows that the consumer's marginal benefit of choosing N have no relation to the increase of W. This result is the same as that of Polinsky and Rubinfeld (1988), who concluded that by positively adjusting W, the injurer has a stronger incentive to choose N under Neg.

The situation where $W > L$ is interpreted as "*punitive damages*". Punitive damages also makes the firm with greater costs take N under Neg. From (4), however, the adoption of punitive damages gives the firm the excess incentive to take care. The court must order W smaller than L in order to achieve the social desirability.

Corollary 1. *The socially desirable award W is the following:*

$$W = L - t_F - \frac{\alpha_{NN}}{\alpha_{VN}}(L - S).$$

3.2 Strict Liability with Contributory Negligence

The following result characterizes the range of γ and δ under SLCN and that the case where each party chooses N is a Perfect Bayesian equilibrium in the situation of perfect observability.

Proposition 2. *A Perfect Bayesian equilibrium in which each party chooses N exists if and only if*

$$\gamma \leq (\alpha_{VN} - \alpha_{NN})(W + t_F), \tag{6}$$

$$\delta \leq \alpha_{NV}(L - S) - \alpha_{NN}\{L - (W - t_C)\}. \tag{7}$$

In the Perfect Bayesian equilibrium, the consumer's strategy is $\sigma_C = \{N, t, t, s, s\}$.

We study comparative statics on the incentives of the firm and the consumer according to changes of W. We show that by increasing W both parties have a stronger incentive to choose N. The right-hand side of (6) and (7) show that when W increases, both parties' marginal benefit is positive for choosing N. Given the consumer's equilibrium strategy, the increase of W increases the firm's benefit since, by choosing N, the incidence of an accident decreases and the firm's expected payment to the consumer reduces. Thus it is attractive for the firm to choose N and it is encouraged to choose N. Given the firm's strategy, the increase of W brings the incentives of the consumer to choose N. Hence, the consumer is encouraged to choose N.

From (6), we obtain the following result for the award to achieve the social desirability.

Corollary 2. *The social desirability achieves when the court order $W = L - t_F$.*

We shall examine which tort liability rule is desirable from the viewpoint of the firm's cost parameter. Then, we focus on the firm's incentive to take care because of the following two reasons. First, comparing the firm's prevention cost with the consumer's one, we can expect that the firm's prevention cost is higher. This implies that it is more difficult to give the firm the incentive to take care rather than the consumer. Second, even if the consumer takes V, only she will suffer the damage. However, if the firm takes V and an accident occurs, many consumers will suffer, and it is likely to spread. Therefore, we consider that it is important for the firm to choose N, and focus on the issue of the firm's incentive to take care.

Firms will have different prevention costs of taking N, and the legal authority will not be able to observe those costs. Therefore it is in the authorities's interest to choose the tort liability rule under which a number of firms are willing to take N, which we define as the desirable tort liability rule.

Suppose that δ is fixed so as to satisfy (5) and (7). This assumption implies that the consumer's prevention cost may be small: for example, the consumer puts a milk pack into a refrigerator. Since, in equilibrium, the firm chooses N if (4) and (6) are satisfied, the right-hand side of those equations signifies the critical value for which it is willing to take N. Under each tort liability rule, the court ordered W so as to achieve the social desirability. Therefore, the right-hand side of (4) is equal to that of (6), and which tort liability rule is desirable is not obvious. We define the desirability, using social welfare (the sum of the firm's and consumer's payoff) in equilibrium outcome. Under Neg, social welfare in equilibrium outcome become

$$-\gamma - \delta - \alpha_{NN} L. \tag{8}$$

Under SLCN, social welfare in equilibrium outcome become

$$-\gamma - \delta - \alpha_{NN} L - \alpha_{NN}(t_F + t_C). \tag{9}$$

Subtracting (8) from (9), we obtain $\alpha_{NN}(t_F + t_C) > 0$. Under Neg, the case is resolved to out-of-court settlement. On the other hand, under SLCN, the

case goes to trial and each party must additionally incur the litigation cost and it is a source of loss. Therefore, in the noiseless case, Neg is desirable although the firm has the same incentive to choose N. This result is the same as Shavell (1983).

Proposition 3. *In the noiseless case, Neg is more desirable than SLCN.*

4 The Noisy Case

In the previous section, we studied the noiseless case, in which the consumer correctly infers the firm's action *ex post*. Our conclusion was that Neg is desirable. In this section, we analyze the noisy case, in which the consumer cannot perfectly observe the firm's action *ex post*. We may think that if the noise ε is sufficiently small, the desirable tort liability rule in the noisy case is identical with the desirable one in the noiseless case, *i.e.*, Neg. Contrast to the previous case, we show that we do not obtain the expected result.

As in the previous section, we show that an equilibrium where each party takes N exists. Next, we compare two alternative tort liability rules in order to examine which rule is desirable.

4.1 the Negligence rule

As shown in Section 3, an equilibrium where each party chooses N exists only when both γ and δ are not too large. The following result characterize such rages of γ and δ.

Proposition 4. *A Perfect Bayesian equilibrium where each party takes N exists if and only if*

$$\gamma \leq (\alpha_{VN} - \alpha_{NN})S, \tag{10}$$

$$\delta \leq (\alpha_{NV} - \alpha_{NN})(L - S). \tag{11}$$

In the Perfect Bayesian equilibrium, the consumer's strategy is $\sigma_C = \{N, s, s, s, s\}$.

If (10) and (11) are satisfied with strict inequalities, the Perfect Bayesian equilibrium given by Proposition 3 is unique in this game.

(10) and (11) show that the increase of W has no effect on both parties' incentive to choose N. In the noisy case, even if the consumer observes the signal v, she regards it as "*bad luck*" if she believes the firm to take N. Therefore, the consumer accepts the settlement offer in equilibrium, which implies that W does not influence the consumer's incentive to choose N. Given the consumer's equilibrium strategy, even if W increases, the *ex post* amounts which the firm must pay the consumer is unchanged, which furthermore implies that the increase of W does not affect the firm's incentive to choose N. This result differs from the one of Polinsky and Rubinfeld (1988) and implies that, in the noisy case, introduction of punitive damages does not affect the firm's incentive to choose N under Neg.

From the assumption $L > S$, we obtain the following result.

Corollary 3. *In the noisy case, the social desirability is never achieved under Neg.*

4.2 Strict Liability with Contributory Negligence

The following result specifies the ranges of γ and δ in which both parties choose N.

Proposition 5. *A Perfect Bayesian equilibrium in which both parties choose N exists if and only if*

$$\gamma \leq (\alpha_{VN} - \alpha_{NN})(W + t_F), \tag{12}$$

$$\delta \leq \alpha_{NV}(L - S) + \alpha_{NN}\{L - (W - t_C)\}. \tag{13}$$

In the Perfect Bayesian equilibrium, the consumer's strategy is $\sigma_C = \{N, t, t, s, s\}$.

Under SLCN, the consumer brings a suit the firm regardless of the firm's action if she takes N. On the other hand, the consumer accepts the settlement offer regardless of the firm's action if she takes V. This is because the consumer wins the trial if she chooses N and she looses if she choose V. Therefore, the condition in Proposition 4 is identical to that in Proposition

2, and we can obtain the same result on the change of W and the award to achieve the social desirability.

As in the previous section, we focus on the firm's incentive to choose N in order to examine the desirable tort liability rule. Suppose that δ is fixed so as to satisfy (11) and (13). If the firm has the prevention cost which satisfy (10) and (12), it takes N in equilibrium. Subtracting the right-hand side of (10) from that of (12), we obtain $(\alpha_{VN} - \alpha_{NN})(W + t_F - S) > 0$ from the assumption $W - t_C > S$. This leads to the following result.

Proposition 6. *In the noisy case, the firm has a stronger incentive to choose N under SLCN.*

This conclusion depends only on whether ε is positive or zero. This result is robust even if ε is sufficiently small. The above results differ from Shavell (1983) that Neg is desirable since, in the noisy case, the firm pays the consumer less awards under Neg than under SLCN.

5 Concluding Remarks

This paper studied the economic model of tort liability rules. We showed that the desirable tort liability rule in the noiseless case differs from the one in the noisy case. In the noiseless case, Neg is desirable, whereas SLCN is desirable in the noisy case. This result depends only on whether $\varepsilon = 0$ or $\varepsilon > 0$. Therefore, this implies that even if the noise is sufficiently small, the situation cannot be approximated by the noiseless case, and suggests to the importance of explicitly analyzing the model with imperfect observability. In the noisy case, under Neg, if an accident occurs and the consumer observes the "wrong" signal v, she regards it as "*bad luck*" for the firm if she believes the firm to take N. Hence, the consumer receives the firm's settlement offer. Under SLCN, on the other hand, even if an accident occurs and she observes the "wrong" signal, she brings a suit against the firm since she knows the case is in her favor. Hence, in the noisy case, it is more attractive for the firm to choose N under SLCN than under Neg.

In the noisy case, we showed that the increase of the amount of awards, W, has no effect on the firm's incentive to take N under Neg. Furthermore, this result implies that punitive damages do not work well. This is because in equilibrium the consumer settles with the firm since the case goes against her if she believes the firm to take N. Under SLCN, on the other hand, the increase of W strengthens both parties' incentive to take care. This is because both parties' benefit to choose N increases.

Under Neg, in the noisy case, the increase of S becomes attractive for the firm and less attractive for the consumer. This is because the increase of S is profitable for the firm in order to increase the firm's benefit. On the other hand, it is less attractive for the consumer owing to decrease in the consumer's benefit of choosing N. Under SLCN, the increase of S has no effect on the firm's incentive to take care because the consumer goes to trial even if it makes an offer. For the consumer, since the increase of S decreases the consumer's benefit, it is less attractive.

Appendix

Proof of Proposition 1. Since the consumer can correctly infer the firm's action, we characterize a Perfect Bayesian equilibrium in this game. Suppose that both parties take N and that an accident occurs. If the consumer takes t, then she obtains her payoff $-L - t_C - \delta$ since the tort liability rule is Neg. If the consumer takes s, she obtains $S - L - \delta$. Therefore, it is optimal for the consumer to choose s. Hence, the best payoff the consumer can obtain when she chooses N is $\alpha_{NN}(S - L) - \delta$ from an *ex ante* viewpoint.

Suppose that the firm takes N and the consumer takes V and that an accident occurs. If the consumer takes t, she receives $-L - t_C$. If the consumer takes s, she receives $S - L$. Hence, taking s is optimal for the consumer. Therefore, the best payoff the consumer can receive when she chooses V is $\alpha_{NV}(S - L)$ as well. This implies that choosing N is optimal for the consumer if and only if (5) holds.

Next, we characterize the consumer's strategy. Suppose that the firm

takes V and the consumer takes N and that an accident occurs. If she takes t, she obtains $W - L - -t_C - \delta$. If the consumer takes s, she obtains $S - L - \delta$. By the assumption $W > S$, it is obviously optimal for the consumer to take t. Suppose that both parties take V and that an accident occurs. If the consumer takes t, she receives $W - t_C - L$. If the consumer takes s, she receives $S - L$. From the assumption $W - t_C > S$, it is optimal for the consumer to take t. Therefore, the strategy of the consumer is $\sigma_C = \{N, s, t, s, t\}$.

Finally, we characterize the firm's best response. Suppose that an accident occurs. Given the consumer's strategy σ_C, the firm obtains $-S-\gamma$ if it takes N. If the firm takes V, it obtains $-W-t_F$. Thus, the expected payoffs which the firm can receive are $-\alpha_{NN}S-\gamma$ and $-\alpha_{VN}(W-t_F)$ respectively. Hence, choosing N is optimal for the firm if and only if (4) holds. ■

Proof of Proposition 2. Suppose that both parties take N and that an accident occurs. If the consumer takes t, she receives $W - t_C - L - \delta$. This is because SLCN is applied. If the consumer takes s, she receives $S - L - \delta$. Hence, by the assumption $W - t_C > S$, taking t is optimal for the consumer. Therefore, the best payoff the consumer can obtain when she chooses N is $\alpha_{NN}(W - t_C - L) - \delta$.

Suppose that the firm takes N, the consumer takes V and an accident occurs. If the consumer takes t, she receives $-t_C - L$. If the consumer takes s, she receives $S - L$. Therefore, taking s is optimal for the consumer, and the best payoff the consumer can receive when she chooses V is $\alpha_{NV}(S-L)$. This implies that the consumer is willing to choose N if and only if (7) holds.

We characterize the consumer strategy. Suppose that the firm takes V, the consumer takes N and an accident occurs. If the consumer takes t, she obtains $W - t_C - L - \delta$. If the consumer takes s, she obtains $S - L - \delta$. Therefore, by the assumption $W - t_C > S$, it is optimal for the consumer to take t.

Suppose that both parties take V and that an accident occurs, the consumer receives $-t_C - L$ if she takes t. If the consumer takes s, she receives

$S - L$. Therefore, it is optimal for the consumer to take s. Hence, the consumer's strategy is $\sigma_C = \{N, t, t, s, s\}$.

Next, we characterize the firm's best response. Suppose that an accident occurs. Given the consumer's strategy, if the firm takes N, it obtains $-W - t_F - \gamma$. If the firm takes V, it obtains $-W - t_F$. Thus, the expected payoffs which the firm can receives are $-\alpha_{NN}W - t_F - \gamma$ and $-\alpha_{VN}(W + t_F)$, respectively. Therefore, it is optimal for the firm to take N if and only if (6) holds. ■

Proof of Proposition 4. First, we show the consumer's strategy. Suppose that both parties take N and that an accident occurs. If the consumer observes the signal n and takes t, she receives $-t_C - L - \delta$. This is because Neg is applied. If the consumer observes n and takes s, she receives $S - L - \delta$. Hence, it is optimal for the consumer to choose s. If the consumer observes v, since she believes that the firm took N, taking s is optimal for her. In that case, the consumer receives $S - L - \delta$. Therefore, the best payoff the consumer can receive when she chooses N is $\alpha_{NN}(S - L) - \delta$.

Suppose that the firm takes N, the consumer takes V, and an accident occurs. If she observes n and takes t , she obtains $-t_C - L$. If the consumer observes n and takes s, she obtains $S - L$. Therefore, it is optimal for her to take s. If the consumer observes v, since she believes the firm take N, taking s is optimal for her. In that case, she obtains $S - L$. Therefore, the best the consumer can obtain when she chooses V is $\alpha_{NV}(S - L)$. Hence, it is optimal for the consumer to take N if and only if (11) holds, and the consumer's strategy is $\sigma_C = \{N, s, s, s, s\}$.

Next, we characterize the firm's strategy. We assume that the consumer chooses N in her first action and all s in her second action. If the firm takes N, it receives the payoff $-S - \gamma$. This is because we consider Neg as the tort liability rule. If the firm takes V, it receives $-S$. Given the consumer's strategies, therefore, the expected payoffs which the firm can receive are $-\alpha_{NN}S - \gamma$ and $-\alpha_{VN}S$ respectively. Hence, choosing N is optimal for the firm if and only if (10) holds. ■

Proof of Proposition 5. Suppose that both parties choose N and that an accident occurs. If the consumer observes the signal n and takes t, she receives $W - t_C - L - \delta$. This is because SLCN is applied. If the consumer observes n and takes s, she receives $S - L - \delta$. Hence, by the assumption $W - t_C > S$, it is optimal for the consumer to take t. If the consumer observes v, she takes t. This is because the consumer knows that since she is not in violation, the firm must pay her the amount of awards. Therefore, given that the firm takes N, the best payoff the consumer can receive when she chooses N is $\alpha_{NN}(W - t_C - L) - \delta$.

Suppose that the firm takes N, the consumer takes V, an accident occurs. If she observes n and takes t, she obtains $-t_C - L$. If the consumer observes n and takes s, she obtains $S - L$. Therefore, taking s is optimal for her.

If the consumer observes v, since she believes that the firm took N, she takes s. In that case, she receives $S - L$. Therefore, the best payoff the consumer can receive when she chooses V is $\alpha_{NV}(S - L)$. Hence, choosing N is optimal for the consumer if and only if (13) holds, and her strategy is $\sigma_C = \{N, t, t, s, s\}$.

We assume that an accident occurs. Given that $\sigma_C = \{N, t, t, s, s\}$, if the firm takes N, it receives $-W - t_F - \gamma$. If the firm takes V, it receives $-W$. Hence, given the consumer's strategies, the expected payoffs which the firm can receive are respectively $-\alpha_{NN}W - t_F - \gamma$ and $-\alpha_{VN}W$. Therefore, choosing N is optimal for the firm if and only if (12) holds. ■

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