STRICT LIABILITY VERSUS NEGLIGENCE WHEN THERE ARE INTERDEPENDENCIES IN TAKING CARE

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Abstract

We generalize the standard model of tort law by analyzing potential injurers' decisions to exercise care when their effort involves interdependencies in the sense that the total risk of accident partly depends upon (care of) others. If potential injurers cannot coordinate their actions, then the externality from others implies that there is underinvestment in care and the equilibrium is below the social optimum. This allocation problem raises the question of coordinating the potential injurers' decisions via liability rules in order to increase individual and social welfare. We show that the negligence rule might achieve the social optimum while strict liability cannot induce an efficient outcome.

***Keywords:** liability rules, negligence, strict liability, interdependent risks*

Introduction

The main concern in law and economics theory is to find the socially optimal rule of tort liability under common scenarios. A liability rule determines the proportions in which all parties involved bear the loss in case of an accident. In reality, accident contexts may be quite complex and a problem which is often overlooked is the possible interdependence in injurers' behavior. Hence, potential injurers may affect each other in taking care. This paper studies optimal care of potential injurers when their effort involves such interdependencies so that the overall risk of being held liable for causing an accident partly depends upon (care of) others (an injurer is one who causes harm to another). We thus address the question as to how much care a potential injurer will take when his level of precaution affects not only his own accident probability but also that of others. This interdependency may be present in many accident contexts. To illustrate the problem, we may consider a typical automobile accident where the ultimate risk of causing an accident often depends upon others' driving behavior. There is thus some possibility of being adversely affected by others.

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Another example is product liability: The ultimate quality of an automobile producer's final product partly depends upon care of his subcontractors who may deliver less safe products due to cost pressure. One weak link may provoke a technical failure and lead the driver to cause an accident. Then, product liability of the producer partly depends upon his subcontractors' care.

More generally, if potential injurers cannot coordinate their care-taking decisions, then the externality from others implies that there is underinvestment in care and the equilibrium is below the social optimum. In other words: if all potential injurers together would decide how much care they should undertake, they would choose the socially optimal care level. The socially optimal care level is different from the individually optimal care level due to the externalities. This allocation problem raises the question of how to coordinate the potential injurers' actions via liability rules in order to increase social and individual welfare.

Common and competing liability rules are strict liability and the negligence rule. Under strict liability injurers must pay for all accident losses they cause, regardless of the extent of their care. Under the negligence rule an injurer is held liable for accident losses he causes only if he was negligent, i.e. only if his care level was less than a level specified by courts, the level of *due care*.

Without loss of generality, as will be discussed later in the concluding section, we study the unilateral-harm setting, where injurers' levels of care are the only determinant of risk (unilateral accidents). Some established results are: (1) Under strict liability, injurers choose the socially optimal level of care; (2) Under the negligence rule, assuming that courts set due care equal to the socially optimal level, injurers again choose the socially optimal level of care.

The paper is organized as follows. In the next section, we shortly discuss the literature mainly related to our analysis. In section 3, we introduce our model. As a point of reference, we first review the traditional case when there are no interdependencies in taking care. We study two identical individuals facing the opportunity to reduce their liability risk at some cost. Then we introduce externalities related to accidents (called spillovers or interdependencies in care) and compare the traditional scenario with the first-best scenario under externalities. We also study the symmetric pure-strategy (Nash) equilibrium under externalities. This equilibrium is the outcome of a situation where the potential injurers cannot coordinate their decisions related to care and each behaves in an individually optimal way making their decisions independent of one another. We compare this second-best scenario with the first-best (the one maximizing social welfare) and the base scenario when there are no interdependencies. In section 4, we address the question of how to improve individual and social welfare by internalizing the externalities via liability law. We show that the negligence rule might achieve the social optimum while strict liability cannot induce an efficient outcome. In the concluding section, we discuss how our results would be affected when interdependencies are present in a scenario involving bilateral accidents, i.e. when the victims' care level is also important in reducing accident risks. We also highlight other possible mechanisms in order to internalize the externalities and suggest directions of future research.

Related Literature

The literature on efficiency of liability law is extensive. Pioneering work by Calabresi (1964), Calabresi (1970), Posner (1972) and Brown (1973) deals with the impact of the most important liability rules on parties' behavior. A more detailed and formal treatment is offered by Shavell (1987) as well as Landes and Posner (1987). For a complete characterization of efficient liability rules, the reader is referred to Jain and Singh (2002).

Kim (2006) studies optimal liability rules when a potential injurer's activity involves externalities that are unrelated to accidents. He shows that in the case where externalities are positive, the negligence rule might perform better than strict liability. Dharmapala and Hoffmann (2005) introduce an interdependency in cost of precaution. They assume that the injurer's precaution cost is affected by the magnitude of precaution undertaken by the victim and vice versa. Due to this cost externality, none of the standard tort liability rules induces socially optimal behavior. Friehe (2008) considers an injurer and two victims who may affect each other by taking care. He finds that standard liability rules fail to induce efficient behavior while only strict liability with a defence of contributory negligence may implement an efficient outcome.

Our analysis is also related to the literature on optimal loss prevention under uncertainty, especially to Kunreuther and Heal (2003), Hofmann (2007) and Muermann and Kunreuther (2008). Kunreuther and Heal (2003) analyze interdependent security problems where economic agents face a choice of investing in (full) protection or not investing at all. When there are risk externalities resulting from the agents' protective decisions, they show that there may be two equilibria: either everyone invests in protection or no one does. Hofmann (2007) and Muermann and Kunreuther (2008) study interdependencies in loss prevention decisions in an insurance setting. They show that the equilibrium protection level is below the social optimum and discuss how insurance may improve allocative efficiency.

The Model

In our model, accidents are supposed to be *unilateral*: injurers' behavior is assumed to affect accident risks, but victims' behavior is not. Therefore, victims play no role in our analysis. If, for instance, an airplane crashes into a building or a careless driver causes an accident involving pedestrians, victims could not have done much to prevent harm. We thus assume that the victims' actions are of minor importance in reducing risks. Potential injurers may reduce accident risks through their exercise of care.[1] For expositional convenience, we study two identical potential injurers, i and j, who may cause some accident loss of size $L > 0$ with probability p(.).[2] Consider injurer i whose loss probability $p(x_i)$ depends upon his care level $x_i \geq 0$. We assume $p'(x^i) \geq 0, p''(x_i) \geq 0$ and $p(0) = p \geq 1/2$ which seems plausible in common liability problems. Injurer i chooses his care level in order to reduce expected loss $p(x_i)L$. The cost of reducing expected loss is $c(x_i)$, where $c'(x_i) \geq 0$, $c''(x_i) \geq 0$ and $c(0) = 0$. We also assume that care is worthwhile to be undertaken, i.e. $|p'(0)| > c'(0)$. Denote the care level of injurer j by x_j. Potential injurers are risk neutral.[3]

No interdependencies

When there are no interdependencies, it is optimal for an individual injurer, say injurer i, to minimize expected total accident costs, i.e.[4]

$$\min_{x_i} K_i(x_i) = c(x_i) + p(x_i)L \tag{1}$$

The first order condition implying optimal individual care x_i is

$$c'(x_i^*) = -p'(x_i^*)L \tag{2}$$

which has the usual interpretation that the marginal cost of taking care equals the marginal benefit from an increase in care (in terms of reduced expected accident losses).[5]

Interdependencies: Social Optimum

Assume that the overall chance that injurer i causes a loss may be influenced by injurer j's care level x_j. This introduces a stochastic externality: the possibility of injurer i being adversely affected (contaminated) by injurer j. Let $q(x_j)$ denote the probability that injurer i is adversely affected by injurer j as a function of injurer j's care level, where we assume that contamination

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[1]Their level of activity is assumed to be fixed.

[2]The analysis can be extended to n individuals.

[3]This assumption is without loss of generality. Risk-averse injurers would act in the same way given there is a market for liability insurance and liability insurance is fairly priced. Then, risk-averse injurers will fully insure themselves against liability risk and, as a consequence, behave in a risk neutral manner.

[4]In the following, we simply write total accident cost.

[5]The second order condition is fulfilled. We have $K''(x_i) = c''(x_i) + p''(x_i)L > 0$ which ensures a minimum.

is 'perfect' in the sense that if a damage occurs it spreads with probability one to the other individual, i.e. $q(x) = p(x_j)$.[6] Hence, we have introduced an externality between the two potential injurers: there is possible contamination between injurer i and j. The total accident costs of injurer i are then

$$K_i(x_i, x_j) = c(x_i) + [p(x_i) + (1 - p(x_i)) \cdot p(x_j)]L \tag{3}$$

In order to determine the social optimum, let us consider the case where both potential injurers can contract on the externality. In this case, the Coase theorem leads to the socially optimal care level that minimizes aggregate total accident costs $K_A(x_i, x_j) \equiv K_i(x_i, x_j) + K_j(x_i, x_j)$ of both i and j:

$$K_A(x_i, x_j) = c(x_i) + c(x_j) + 2[p(x_i) + (1 - p(x_i)) \cdot p(x_j)]L \tag{4}$$

The first and second derivatives of the aggregate cost function with respect to x_i are

$$\frac{\partial K_A(x_i, x_j)}{\partial x_i} = c'(x_i) + 2[p'(x_i) - p'(x_i)p(x_j)]L \tag{5}$$

and

$$\frac{\partial^2 K_A(x_i, x_j)}{\partial x_i^2} = c''(x_i) + 2[p''(x_i) - p''(x_i)p(x_j)]L > 0 \tag{6}$$

Since the minimization problem is symmetric in i and j, we may denote the optimal solution by $x^*_{FB} = x^*_i(x^*_{FB}) = x^*_j(x^*_{FB})$. The first order condition for the first-best optimum x^*_{FB} reflects the incorporation of accident risk interdependence

$$c'(x^*_{FB}) = -2p'(x^*_{FB})(1 - p(x^*_{FB}))L \tag{7}$$

where the left hand side is the marginal cost of care and the right hand side is the marginal reduction in probability of causing an accident which is affected by both potential injurers respectively.

[6] As an illustration, we may think of the product liability example above, where a failure in a subcontractor's product may directly lead to failure of the final product. For instance, an automobile accident might be due to malfunction of brakes which might be provoked by several factors.

Interdependencies: Nash Equilibrium

When potential injurers cannot contract on the externalities, they will each behave in an individually optimal way. We now focus our attention on symmetric pure-strategy Nash equilibria of the game between the two potential injurers. Injurer j's reaction function is

$$x_i^*(x_j) \in \arg\min_{x_i} \; K_i(x_i, x_j) = c(x_i) + [p(x_i) + (1 - p(x_i))p(x_j)]L \tag{8}$$

satisfying the first-order condition

$$c'(x_i^*(x_j)) + p'(x_i^*(x_j))L - p'(x_i^*(x_j)) \cdot p(x_j)L = 0 \tag{9}$$

We may derive the slope of i's reaction function by differentiating the first-order condition with respect to and rearranging terms, which gives

$$x_i^{*\prime}(x_j) = \frac{p'(x_i^*(x_j)) \cdot p'(x_j)L}{c''(x_i^*(x_j)) + p''(x_i^*(x_j)) \cdot [1 - p(x_j)]L} > 0 \tag{10}$$

Hence, injurer i's strategy is a strategic complement to injurer j's strategy.[7] The symmetric pure-strategy Nash equilibrium $x_{SB}^* = x_i^*(x_{SB}^*) = x_j^*(x_{SB}^*)$ is thus determined by the condition

$$c'(x_{SB}^*) = -p'(x_{SB}^*)(1 - p(x_{SB}^*))L \tag{11}$$

implying equality of marginal cost of care and marginal benefit in terms of risk of accident. In contrast to the first-best scenario, it is not possible to internalize the externality in the form of marginal benefit from care taking of the other potential injurer. Comparing the first-best with the second-best optimum, we may again consider the first order condition for a first-best optimum (7) implying

$$c'(x_{FB}^*) > -p'(x_{FB}^*)(1 - p(x_{FB}^*))L \tag{12}$$

which, together with (11), yields $x_{SB}^* < x_{FB}^*$. The equilibrium care level is lower than the first-best one. We may conclude that the level of care in a society with interdependencies in care is *too low* from a social welfare perspective.

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[7] There might thus be multiple equilibria. However, assuming $p'''(x) \geq 0$ and $c'''(x) \geq 0$ implies and concavity of reaction functions leads to a unique Nash equilibrium.

Comparison with the Standard Case

In this section, we compare the first-best and the second-best care levels with the traditional scenario without interdependencies. Let us first compare the second-best level of care, x^*_{SB}, with care under the traditional scenario, x^*. Comparing the first order condition in the standard case when there are no interdependencies in care

$$c'(x_i^*) + p'(x_i^*)L = 0 \tag{13}$$

with the first order condition for a Nash equilibrium under interdependencies

$$c'(x^*_{SB})) + p'(x^*_{SB})L - p'(x^*_{SB}) \cdot p(x^*_{SB})L = 0 \tag{14}$$

implying

$$c'(x^*_{SB}) + p'(x^*_{SB})L < 0 \tag{15}$$

which, given (13) and the convexity of the function of total accident costs, yields $x^*_{SB} < x^*$. Hence, in a pure-strategy Nash equilibrium under interdependencies, the care level is lower compared to a situation when there are no externalities of taking care. This result is intuitively conclusive, since the potential injurers do not take into account the social benefit of their care on others. Therefore, they exercise less care than in a world without externalities.

We now compare x^* with socially efficient care under interdependencies, x^*_{FB}. The first order condition for a first-best optimum is given by

$$c'(x^*_{FB}) + p'(x^*_{FB})L + \underbrace{p'(x^*_{FB})L - 2p(x^*_{FB}) \cdot p'(x^*_{FB})L}_{<0 \text{ for } \bar{p} < 1/2} = 0 \tag{16}$$

implying

$$c'(x^*_{FB}) + p'(x^*_{FB})L > 0 \tag{17}$$

which, given (13) and the convexity of the function of total accident costs, yields $x^*_{FB} > x^*$. As a result, the optimal care level without interdependencies lies between individually optimal care under interdependencies and the social optimum under interdependencies: $x^*_{SB} < x^* < x^*_{FB}$.

Improving Welfare Through Tort Law

Social (and individual) welfare may be improved via an efficient liability rule. A liability rule is efficient if it induces the parties involved to take optimal care levels, that is, to take care levels which are total social cost minimizing.

In the absence of liability, the victim has to pay for all losses caused by an injurer. It is clear that each potential injurer will not exercise any care. Injurer i 's cost function, for instance, is then $c(x_i)$ which is minimized at $x^i = 0$. Therefore, the rule of no liability fails to attain the social optimum.

Under strict liability, an injurer must pay for all accident losses he causes regardless of his level of care. Injurer i 's total costs under strict liability are

$$K_i^S = c(x_i) + [p(x_i) + (1 - p(x_i))p(x_j)]L \text{ for all } x_i \tag{18}$$

Since the injurer's cost function is equivalent to (3), it is minimized at x^*_{SB}. As a result, strict liability cannot induce the social optimum.

Under the negligence rule, injurer i is held liable for an accident loss he causes only if he was negligent, i.e. only if his care level is less than some due care level x_d specified by courts. When there are interdependencies in care, the negligence rule implies injurer i 's cost function to become

$$K_i^N(x_i, x_j) = \begin{cases} c(x_i) + [p(x_i) + (1 - p(x_i))p(x_j)]L & \text{if } x_i < x_d \\ c(x_i) & \text{if } x_i \geq x_d \end{cases} \tag{19}$$

It is easy to see that the first-best level of care may be attainable by setting $x_d = x^*_{FB}$ as depicted in *Figure 1*. The negligence rule implements the first-best care level x^*_{FB} if the minimum of $K_i^N(x_i, x_j)$ is at $c(x^*_{FB})$ in equilibrium. Therefore, we must have

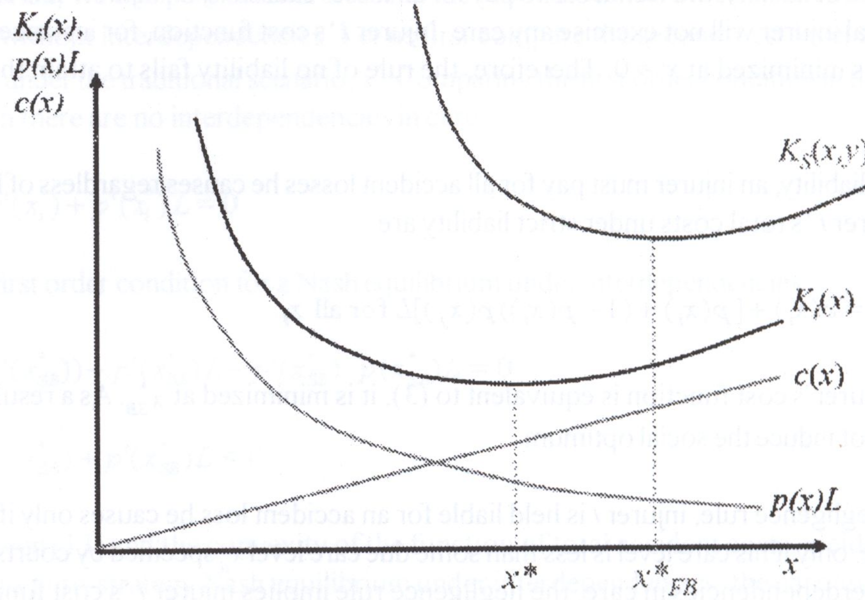
$$c(x^*_{FB}) < K_i(x^*_{SB}, x^*_{SB}) \tag{20}$$

This is always true since

$$c(x^{**}_{SB}) < c(x^{**}_{FB}) < \underbrace{c(x^{**}_{SB}) + p(x^{**}_{SB})L(2 - p(x^{**}_{SB}))}_{K_i(x^{**}_{SB}, x^{**}_{SB})} \tag{21}$$

implying that indeed the minimum of $K_i^N(x_i, x_j)$ is at $c(x^*_{FB})$ in equilibrium.

Figure 1: Interdependencies in care: negligence rule induces social optimum.



Discussion and Conclusion

In this paper, we analyze a scenario where potential injurers' care levels are interdependent, i.e. the magnitude of care by a potential injurer affects other injurers' accident probability. In this setting, the symmetric Nash equilibrium is the outcome of a situation where the potential injurers cannot coordinate their decisions related to care, and each behaves in an individually optimal way making their decisions independent of one another. We compare this second-best scenario with the first-best one (maximizing social welfare) and the one when there are no interdependencies. We show that the equilibrium care level is below the socially optimal level. We then address the question of how to improve individual and social welfare by internalizing the externalities via tort law. We find that the negligence rule may achieve the social optimum while strict liability cannot induce an efficient outcome. We show that while strict liability and no liability cannot induce the social optimum, the negligence rule can improve individual and social welfare. It leads to socially efficient care levels.

What happens if we consider *bilateral accidents*? Assuming that injurers as well as victims can take care and thereby lower accident risks, the way in which injurers bahave may depend upon how victims behave, and conversely. As before, in the absence of liability, injurers do not take any care and thus the outcome departs from the optimal. In contrast, victims bear their losses and have an incentive to take care. The overall outcome, however, is not optimal. Imposing strict liability cannot induce the social optimum, as well, due to the externality. Moreover, since victims are fully compensated by injurers for all accident losses, they are in fact indifferent to the occurrence of losses and thus do not take care. This strengthens our result that strict liability cannot be optimal when there are interdependencies. Under the negligence rule, however, if due care is chosen to equal the socially efficient level, then injurers are led to take due care (in order to avoid liability) and thus victims are also induced to take optimal care since they bear their losses in case of an accident if injurers take due care.

Of course, in the bilateral-harm setting, the negligence rule with defense of contributory negligence may also induce optimal care levels if injurers' and victims' levels of due care are chosen by courts to equal the socially optimal levels.[8] Injurers take due care to avoid liability given that victims take due care. And victims take due care presuming that injurers take due care. The defense of contributory negligence is, however, a superfluous addition to the negligence rule since victims take optimal care under the negligence rule already. This rule might make sense in situations where it seems necessary to provide victims with an additional incentive to take care.

For future research, it seems interesting to study how the equilibrium and social optimum are affected in a world where the level of an injurer's activity and care level as a determinant of risk create externalities to others.

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[8]Under this rule, an injurer is not liable for accident losses he causes if he takes at least due care, and even if he does not, he still escapes liability if the victim too failed to take due care.

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