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I. Introduction

The purpose of this chapter is to compare negligence rules and strict liability rules. They are the major rules of liability used in tort law to deal with situations where one person (the injurer) causes harm to another person (the victim). In England, France and Germany, for instance, the usual forms of liability are the comparative negligence rule and strict liability with the defence of relative negligence, and in the US it is the comparative negligence rule, the negligence rule with the defence of contributory negligence, and strict liability with the same defence. The details of these rules will be discussed below. Zweigert and Kötz (1996, secs. 40-43) provide a rigorous description of tort law in England, France and Germany. For the US, a good reference is Keeton et al. (1984, chs. 5, 11, 13).

Historically, it is interesting to observe the changes in the relative importance of different liability rules. Before the nineteenth century, for instance, strict liability was predominant in most common law jurisdictions. In the early and mid-nineteenth century, however, this changed with negligence and fault becoming the prevailing standard of tort liability, as Schwartz (1981) notes. Since the twentieth century, rules of strict liability have enjoyed a renaissance and have been applied more and more to determine who should bear the costs of an accident and to what extent. A good example of this phenomenon is the shift back to strict liability in products liability cases.

Moreover, tort law is much under debate because of the increasing number of cases where compensation for losses might substantially exceed the actual damage. In the US, for instance, damages awarded may exceed the losses sustained in the presence of 'punitive' damages where parties acted with ill will, i.e. when the harm was intentional, whereas in Germany higher awards are provided to give victims 'satisfaction' and to compensate them for nonpecuniary losses. The scope of harm and the size of judgements have become exceedingly expansive, and manufacturers pay extremely high premiums for products liability insurance to protect themselves against these awards. Many of them have withdrawn from the market entirely. This and various other results on the issue are presented by Priest (1991). Many economists and lawyers conclude that the tort system is in need of reform. Again, we

need to understand the basic principles of how different liability regimes work to be able to evaluate the alternatives to reform.

Tort law is one of those areas in the law where (micro)economic models can be successfully applied. Tort is about damages and has important economic implications. The economic approach to tort is therefore mainly concerned with examining the allocative effects, i.e. welfare effects, resulting from the application of different liability regimes. Landes and Posner (1987, p. 6) suggest that liability rules can be interpreted as a legal attempt to establish incentives for parties to achieve social efficiency objectives. One of the path-breaking studies in the development of the economic approach to tort is Calabresi (1970). The aim of tort law, he proposes, apart from the requirement for justice, is to minimise the social costs of a tort defined as the sum of total accident costs, administration costs, costs of properly allocating accident losses by means of insurance, and accident prevention costs of both the injurer and the victim. Again, the comparison between strict liability and negligence helps to determine which tort system is most suitable to improve welfare by, first, encouraging individuals to engage in safer activities by providing an incentive to do so, and second, encouraging individuals to make a given activity safer.

Throughout, we will be considering models of accidents involving two individuals, the injurer and the victim. Both of them are engaged in some activity, and both of them exercise a certain level of care. The decisions the parties have to make are twofold. They have to decide how much care they want to exercise and how much they want to engage in an activity. It is plausible to assume that accident prevention costs increase with the amount of care taken, and that expected damages decrease with the level of care, but increase with the amount of activity the parties engage in.

In the remainder of this chapter, we will first discuss unilateral accidents because they describe those situations where one party, i.e. the victim, has no influence on the probability and the size of damages. Also, it is easier to understand the more complicated discussion of the bilateral case which follows. Each section starts with a discussion of the rule of no liability before moving on to various forms of negligence and ending with various strict liability rules. At the end of each section, there is also a discussion on how results change when relaxing certain assumptions. In later sections we concentrate on several more specific topics of interest. First we analyse the rules if standards of due care are ill-defined. Second we analyze the question as to whether the costs of litigation are higher or lower under strict liability as compared to negligence. Third we elaborate on the decentralisation effect of strict liability and of negligence. Fourth we provide the discussion of the information generating consequence of negligence. Fifth, we analyze the effect of under-compensation if the tortfeasor is judgment-proof. Sixth we provide an analysis of the allocative effects of various liability rules when agents enter into a contractual relationship, which also implies a brief discussion on the distinction between tort law and contract law. Seventh we elaborate on product liability. Eighth we provide an analysis of cases of 'joint liability', i.e. situations where more than one tortfeasor contributes to the occurrence of an accident. Ninth, we extend the analysis by allowing for risk-averse individuals and imperfect insurance markets. Tenth we analyze the effect of optimistic and pessimistic behaviour of the injurer on the efficiency of strict liability versus negligence. In the last part the various aspects of the comparison between liability rules are summarised focusing on the question of whether the outcome under a specific liability regime is efficient or not.

II. Unilateral Accidents

The discussion here is mainly based on Shavell (1987) and Schäfer and Ott (2005). In the case of unilateral accidents which we focus on in this section, it is assumed that the victim cannot influence the amount of expected damages. Also, to keep things simple, we further assume

that the level of activity is constant. (This assumption will be relaxed below.) Therefore, if we denote accident prevention costs by c, the level of care by x, and if d measures the total amount of expected damages, then, abstracting from administration costs and assuming risk neutrality, the social objective function takes the form of:

$$\min c(x) + d(x) \tag{1}$$

Setting the first derivative with respect to x equal to zero we obtain the following solution:

$$c'(x) = -d'(x) \tag{2}$$

which simply states that the marginal cost to the injurer of taking an additional unit of care (left-hand side of equation (2)) should equal the marginal benefit to the victim represented by a reduction in the total amount of expected damages (hence the negative sign on the right-hand side of equation (2)). It should now be clear why microeconomic models can be applied so easily in law and economics as equation (1) is an extremely simple example of a standard optimisation problem recurring very frequently in any area of economic analysis.

We now consider the behaviour of the injurer under various liability rules, providing important insights as to the efficiency of these rules.

1. Rule of No Liability

If the injurer cannot be held liable for the harm she causes, and if she therefore does not have to bear the costs of an accident, she will choose the lowest possible level of precaution in order to minimise her costs. Since we assume that the total amount of damages is a decreasing function of the precaution level, the accident costs will be extremely high. As a result, the outcome of this liability rule is clearly not socially optimal.

2. Negligence

Under the negligence rule, the injurer will be held liable only if she exercised precaution below a level usually determined by the law and/or by the court. This level is called reasonable care or due care. Posner (1972) proposed an economic efficiency criterion which could be used to identify the efficient precaution level to establish it as the legal standard. It should be borne in mind that one of the most important objectives of tort law is to give the injurer an incentive to apply the efficient level of care that fulfils the optimality condition (2). Interestingly enough, the first person to describe this legal standard of care was not an economist, but a judge. Learned Hand (1947) suggested that an injurer is liable if her burden B of adequate precautions is less than the probability P that the accident occurs, multiplied by the size L of the injury. Note that Judge Hand's statement of the rule is unclear as to whether it refers to total or marginal levels of benefits and costs of caretaking, but we assume that he had marginal values in mind. Stated in algebraic terms, an injurer is negligent if the condition

$$B < PL \tag{3}$$

holds; and equality denotes optimality.

If the injurer exercised due care, she will not be held liable for the costs of the accident. Let us now suppose that the court or the law would set the level of due care equal to the socially optimal level of care. Would the negligence rule result in the socially optimal level of care being taken? The answer is yes, as can be seen very easily by noting that a self-interested person will choose her level of precaution to minimise her private costs. Would she

therefore want to choose a precaution level above the level of due care? No, because any care taken in excess of the standard set by the court would be more costly without reducing the costs of compensation since due care is enough to be non-liable. Would she, on the other hand, want to choose a precaution level below due care? No, because now she is running the risk of bearing the total amount of the expected damages.

3. Relaxing Assumptions

Note that in the previous section we made a few simplifying assumptions. First, we assumed that the court would set the level of due care equal to the socially optimal level. Second, it was assumed that the legal sanction imposed equals the harm actually caused and, third, the level of activity was held constant. We will now examine how the results change if we relax these assumptions one by one, i.e., we will discuss the effects of relaxing only one assumption at a time. Some of these issues are clearly presented by Cooter and Ulen (2004, chs. 8 and 9).

Let us first examine the question of how the results of the previous section change when the court sets a level of due care that is not equal to the socially optimal level. Suppose, for instance, that the court does not require any precaution at all. Under these circumstances, it is obviously cheapest for the injurer not to exercise any care because she will escape liability even without taking any care at all. Taking greater care would have no advantage, but would involve additional costs. Put more generally, the potential injurer will satisfy the legal standard even if it is pegged below the socially efficient level. The same applies to a legal standard above the socially efficient level, with one important exception, though. If the amount of precaution costs at the legal standard exceeds the total amount of precaution and expected damage costs at the socially optimal care level, then the potential injurer will ignore the legal standard and set her caretaking level at the lower socially optimal care level. This result changes if the injurer is not held liable for the entire accident losses, but only for the amount of damage in addition to the damage that would have been caused if the injurer had exercised the level of care set by the courts (partial liability). See, for instance, § 249 BGB under German law. For the US, see Kahan (1989). The first authors to describe this case are Schäfer and Ott (1986). Here, it is optimal for the injurer to exercise socially optimal care even if the legal standard is pegged above the socially efficient level. This is because by exercising the efficient level of care instead of the higher legal standard, precaution costs decrease by more than the imposed legal sanction increases. In general, however, we can say that in order to obtain an efficient outcome the court needs to set the due level of care equal to the socially optimal level of care.

Note also that it is very difficult for courts, legislatures and authorities to identify the efficient level of care in order to establish it as the legal standard. Due or reasonable care is usually identified by comparing what a reasonable person would have done under the circumstances with the actual precautionary activity of the injurer. An illustration of the reasonable person standard is provided by Posner (2007, p. 171). However, this standard is very vague and 'flexible'. Therefore, an alternative to decide whether an injurer was negligent or not without a specific standard of care would be, first, to ask what an injurer could have done (alternatively or in addition) to prevent the damage or to reduce the probability that it occurs. Then, the costs of the alternative or of the additional precaution activity are determined. If either the difference between the actual precaution costs and the costs of the alternative precaution activity or the costs of the additional precaution activity are less than the reduction in the total amount of expected damages as a result of the alternative or additional activity, the injurer will be liable.

Another assumption we made in the previous section is that the legal sanction imposed equals the harm actually caused. What will happen if we relax this assumption? Endres (1991, pp. 51-87) provides a rigorous and rather formal analysis of this question which is beyond the

scope of this article. From a more intuitive and less formal perspective we can say that, under the negligence rule, equality between harm and sanction is not essential as long as the sanction is sufficiently large so that the private costs of the injurer are minimised by conforming to the legal standard. However, once the legal sanction falls below a certain level, the injurer will minimise her costs by taking a level of precaution below the legal standard.

Under-compensation is one possibility, but over-compensation can also occur. This applies especially in cases of pure economic losses. It is well established that tortuous acts might uno actu lead to gains of one party and to losses of another party. To illustrate: If a chartered accountant overlooked that real estate is grossly overvalued in the balance sheet and that consequently the company is overindebted and must file for bankruptcy, this might lead to an overvaluation of the company's shares at the stock market. Some shareholders buy these overvalued shares and later suffer a loss, but those who sold the share at an overvalued price make a gain. They would have made a loss if the accountant had been careful. Both the loss and the gain were caused by the mistake of the accountant. If in that case the accountant is liable for the losses, his damage compensation is much higher than the social loss he caused. Whether this over-compensation results in over-deterrence depends on how the level of care is defined (Schäfer, 2004). If the level of care is well known and precisely defined, over-compensation cannot result in over-deterrence because the tortfeasor can reach the due level of care and escapes any compensation. We will show later that this result does not apply if the standard of due care is "muddy" and only known as a distribution function. Then over-compensation is likely to result in over-deterrence.

Finally, we relax the assumption of a constant level of activity to study the effects of an increase in the injurer's level of activity that will result in a proportional increase in the total amount of expected accident damages, given a specific level of care. This is essential when it comes to assessing the social utility of an activity. Finsinger and Pauly (1990) point out that the total net utility of a risky activity ought to be positive.

The first aspect can be dealt with quite easily by slightly modifying the optimisation problem as represented in equation (1). The social objective function now has to take into account that various levels of activity influence the utility u of the actor who is the injurer. It is plausible to assume that utility is an increasing function of activity. Those who are familiar with optimisation problems should also note that for a unique solution to exist, it is necessary to assume further that the utility function is well-behaved. From the total amount of utility we need, of course, to subtract the total costs of care, which are assumed to be equal to the level of activity, a, multiplied by the level of care, x. Finally, we need to subtract the total amount of expected damages d. Thus we obtain as the social objective function

$$\max u(a) - a\,x - a\,d(x) \tag{4}$$

To solve this maximisation problem we first have to determine the optimal level of care x^* by minimising the total costs of taking care as represented by the second and third terms in equation (4). Substituting into (4) and differentiating with respect to the level of activity we obtain

$$u'(a) = x^* + d(x^*) \tag{5}$$

which is the equivalent of equation (2) in the case of a constant level of activity. The interpretation is straightforward. The injurer should raise her activity as long as the marginal increase in utility she derives from raising activity exceeds the increment to total costs caused by doing so.

We can now move on to discussing whether the negligence rule can guarantee that an activity is socially useful. A simple example might illustrate this point. Assume that the utility of an activity is 100. The costs of the optimal level of precaution are 80, and the amount of

total damages is 30. Since the victim has to bear the costs of the accident when the injurer exercises due care and, therefore, is not liable, the injurer has a benefit of 20 from engaging in her activity. However, the net utility of the activity is clearly negative, meaning that the injurer should not engage in the activity in the first place. Since injurers will escape liability by taking due care, they have no reason to consider the effect that their activities have on accident damages. As a result, the rule of negligence can create incentives to exercise an optimal level of precaution, but it is unable to ensure that the social utility of an activity is positive.

Yet, there are exceptions where it can be easy for courts to observe the (lack of) social utility of an activity. In these cases, courts can set legal standards for both the optimal level of care and the optimal level of activity. However, because of information costs, it is generally difficult for courts to set both standards of caretaking and/or activity levels. Shavell (1987), and Landes and Posner (1987) focus on this issue.

4. Strict Liability

We will now turn the discussion to the major alternative of the rule of negligence: the rule of strict liability. Again, we start off by assuming that the legal sanction equals the actual damage and that the activity level is constant. Under strict liability, the courts do not have to set any level of due care because the injurer has to bear the costs of the accident regardless of the extent of her precaution. In this case, the expected amount of costs to the injurer of taking care x is

$$c\,(x) + d\,(x) \tag{6}$$

i.e., the injurer faces the *total* amount of costs caused by the accident. Since it is the self-interested injurer's objective to minimise her *private* costs and since, under strict liability, the total *social* costs just *equal* her private costs, the injurer will have an interest to minimise total accident costs. In other words, the social objective function (1) and the private objective function resulting from minimising equation (6) are obviously identical. Therefore, under the rule of strict liability in the case of unilateral accidents, the injurer will choose the socially optimal level of care.

As a result, both the rule of strict liability and the rule of negligence achieve the socially optimal level of care. There are, however, also quite a few differences. For instance, the division of costs under each rule is different. Under strict liability, the injurer has to bear the total amount of expected damages, whereas under the negligence rule, the victim has to bear the accident costs if the injurer exercised due care. Further differences appear when relaxing the assumptions we made.

5. Relaxing Assumptions for Strict Liability

As mentioned in the previous section, the courts do not have to set a level of due care. Under strict liability, all the courts need to do is to determine the size of the damage and to establish causation, whereas, under the negligence rule, the courts also need to determine the level of due care as a legal standard for the socially optimal level, and they have to determine the level of care actually taken in order to see whether the injurer was negligent or not. Proving negligence, however, can be difficult and costly.

Shavell (1987, p. 264) argues that under strict liability the number of claims is likely to be higher than under negligence because the victim has an incentive to make a claim whenever her damages exceed the costs of making the claim. Under negligence, on the other

hand, the injurer can escape liability by demonstrating that she has not violated the legal standard of care. Since under the rule of strict liability it is not necessary to establish that the injurer was negligent, the probability of trial should be lower because it is easier to predict who is likely to win the case. Consequently, voluntary payments made in the shadow of the law should be much more probable. There is not only more potential for disagreement leading to trial under the negligence rule, it is also plausible to assume that the average administrative cost per claim is higher under negligence because the issue of negligence must be adjudicated, as was mentioned above. As a result, one can expect the average costs of resolving claims to be higher under negligence because of both a higher probability of trial and higher costs per trial.

Another advantage of the rule of strict liability is that it is the injurer who has to bear the cost of searching for the optimal level of care, as Finsinger and von Randow (1991, p. 89) suggest. In many cases, he is better at deciding what precautions to exercise and to what extent he should do so because he is likely to be familiar with the hazardous activity.

An assumption we made is that the legal sanction equals the damage actually caused. In the previous section we saw that equality is not essential as long as the sanction is sufficiently large for the injurer to conform to the legal standard. Under strict liability, this result changes quite drastically. Whenever damages are not perfectly compensatory, i.e., compensation is below the level that would make the victim indifferent between no accident and an accident with compensation, the potential injurer does not have an efficient incentive to exercise the socially optimal level of care.

The easiest way to see this is by recalling optimality condition (2), which states that the marginal cost to the injurer of taking an additional unit of care should equal the marginal benefit to the victim represented by a reduction in the total amount of *expected* damages. Let us assume that the costs of taking care is a linear and increasing function of the level of care, i.e. any increase in the level of care leads to a proportional increase in accident prevention costs. We also assume that the functional relationship between the level of care and the reduction in accident damages is such that the exercise of precaution reduces expected damages, but at a decreasing rate. Expressed in more mathematical terms, the first derivative of this function is positive and the second derivative is negative. We now assume that the potential injurer knows and expects that the legal sanction generally does not equal the total amount of the accident damages, but that it equals a fraction of them only, because the tortfeasor remains anonymous, damages are higher than her personal wealth, victims are fully insured by first party or social insurance, or the damage is dispersed, which leaves the victim little incentive to litigate. This leads to a proportional downward shift of the damage reduction function. The crucial impact of the proportional shift is that, holding the level of care constant, the marginal reduction in damage and thus the marginal benefit of taking an additional unit of care is less than in the case of full compensation. Since, on the other hand, the cost function of taking care is assumed to be linear, the marginal cost of taking care remains constant. As a result, the optimality condition is no longer met under the circumstances given. In order for the cost minimising condition to be satisfied again, the potential injurer will reduce her level of care, which leads to an increase in the marginal reduction in damage by taking care. As a result, the potential injurer does not exercise the socially optimal level of care when damages are not perfectly compensatory.

Suppose that the tort-liability system works imperfectly in the sense that only a fraction of all victims actually bring suit and recover. Let us call the ratio of compensated victims to the total number of victims the enforcement error. The efficiency loss due to enforcement errors can be offset by augmenting compensatory damages with punitive damages. In order to restore efficient incentives for the potential injurer to exercise optimal care we need a punitive multiple (a multiplicative factor by which compensatory damages are adjusted to offset the enforcement error) that equals the inverse of the enforcement error. If,

for instance, only half of the total number of victims actually bring suit, then the courts should double compensatory damages when calculating total damages. Thus, compensatory damages and punitive damages add up to total damages. References for issues related to punitive damages and their allocative effects are Cooter (1982) and Kolstad, Ulen and Johnson (1990).

Finally, we relax the assumption of a constant level of activity. Recall that under negligence the net utility of an activity could be negative because the injurer had no reason to consider the effect that her activity had on others as she can escape liability by taking due care. Under strict liability, however, the injurer has to bear the total social costs of an accident, i.e., the sum of the total precaution costs and the total accident damages, regardless of the level of precaution she takes. She cannot escape liability, and the effects of activity on risk and accident costs are fully internalised. Therefore, the injurer will engage in an activity if and only if the net utility of that activity is positive.

More generally, given the possibility of escaping liability, the injurer will not be motivated to consider the effect on the total amount of harm of the level at which she engages in her activity. She will consider her private benefits only. Any increase in activity, however, will raise the total amount of expected accident damages given the level of care. Thus, the injurer will choose too high a level of activity (see for example Polinsky, 1980). Under strict liability, the injurer internalises the total amount of social costs and reduces the level of activity to the socially optimal level. This conclusion was first clearly stated by Shavell (1980).

6. Liability and Uncertain Legal Standards of Due Care

In the real world, legal standards of due care are frequently uncertain. Factors leading to uncertainty are, amongst others, courts' errors in determining due levels of care, courts' errors in assessing a party's true level of care, and parties' inability to control their momentary level of care. Craswell and Calfee (1984) focus on this issue. These sources of uncertainty change the deterrent impact of legal rules by creating two opposing effects. These effects can give even risk-neutral parties an incentive to over-comply or under-comply. Over-compliance enables potential injurers to increase the chance that they will not be held responsible for the social costs of their behaviour, thus giving themselves a margin of error to be sure that they avoid liability. However, uncertainty also reduces incentives to comply by creating a positive chance that someone who exerts less than efficient care will not be held liable.

In order to determine whether the net incentives are to under-comply or to over-comply, we need to know the relative strength of these two effects.

If the level of due care *(x)* is ill-defined, the tortfeasor knows only a probability distribution function, which attaches a probability of being liable *(h)* in case of an accident to every costs of care *c(x)*. This probability *(h(x))* decreases with *x*. In that case the cost function of the tortfeasor is

$$\min c(x) + d(x)h(x) \quad \text{This yields the first order condition} \tag{16}$$

$$c'(x)+d'(x)h(x)+h'(x)d(x)=0 \tag{17}$$

It is easy to see that this might lead to over- or to under-deterrence. Efficient deterrence will be provided only if the first order condition is met at the efficient level (cost) of care (x^*), i.e. if

$$c'(x)+d'(x^*)h(x^*)+h'(x^*)d(x^*)=0 \tag{18}$$

In other words: Muddy standards of due care might result in over-deterrence or in under-deterrence. The intuition behind this is the following. Whenever the tortfeasor increases her care level she faces three rather than two effects. Her costs of care increase, the expected damages she causes decrease and the probability of being held negligent also decreases. Depending on whether at the efficient level of care the two cost decreasing effects or the cost increasing effect of one more monetary unit of care is higher, the tortfeasor will reach a level of care which is either higher or lower than the efficient level of care.

We have already discussed that the damage compensation might be lower or – as in the case of pure economic losses – higher than total damages. To analyse the incentive effect of over- or under-compensation we assume that damage compensation is *md* with $m \neq 1$. Then with $m<1$ we have under-compensation, otherwise over-compensation. Consequently, the cost function to be minimized becomes

$$\min c(x) + md(x)h(x) \qquad \text{This yields the first order condition} \qquad (19)$$

$$d'(x)h(x)+h'(x)d(x)=-c'(x)/m \qquad (20)$$

In the case of under-compensation it is still uncertain whether under- or over-deterrence results, depending on the probability distribution function and on the damage function. It is, however, certain, that with a decreasing *m* under-deterrence must result if *m* becomes lower than a certain threshold value. If, for instance, $m \to 0$, it is obvious that the right hand side of (20) reaches a very high absolute value and therefore the equation is fulfilled only at very low values of *x,* indicating under-deterrence.

In the case of over-compensation, which we discussed for pure economic loss, we get a symmetric result. Over-compensation does not lead to over-deterrence in the negligence regime, as long as the standard of due care is precisely defined. If the standard is known only as a probability distribution, over-compensation must result in over-deterrence if *m* becomes large enough.

Over-deterrence or under-deterrence becomes certain in the case of over-compensation under the strict liability rule. With damage compensation of *md* and $m \neq 1$ the maximisation problem is

$$\min c(x) + md(x) \qquad \text{This yields the first order condition} \qquad (21)$$

$$c'(x)+md'(x)=0 \qquad (22)$$

This cannot yield the optimal result, which is $c'(x)+d'(x)=0$. Over-compensation $(m>1)$ always leads to over-deterrence, and under-compensation $(m<1)$ always leads to under-deterrence. Again, negligence is the more robust system if one relaxes assumptions and allows for damage awards that are higher or lower than the damages.

III. Bilateral Accidents

We now extend the analysis made above to cases where both parties in an accident may contribute to the accident costs. Again, this section is based mainly on Schäfer and Ott (2005), Shavell (1987), but also on Adams (1985), and Cooter and Ulen (2004). One of the first economists to study these issues was Brown (1973), who introduced the use of the assumption that the probability that an accident will occur is a function of the caretaking of both the tortfeasor and the victim. In fact, it is rare that an accident is due to one party (i.e. the injurer) only. It is much more common that the victim can also exercise some precaution to prevent an

accident. What makes bilateral accidents quite a complicated issue analytically is the interdependence of the parties' behaviour. We will see that in many cases the choice of one party in terms of levels of activity and care essentially depends on the other party's choice.

Since we now also have to take into account the victim's ability to reduce the probability or size of an accident, we need to modify the social objective function given above. If we denote the level of care taken by the injurer by x, as before, and if y measures the level of care taken by the victim, the social objective function now becomes

$$\min c(x) + c(y) + d(x,y) \tag{7}$$

where $d(x,y)$ denotes the total amount of expected damages which, of course, depends on the level of care exercised by both parties. Let x^* and y^* denote the socially optimal values of x and y.

There are now two conditions determining the optimal levels of care. First,

$$c'(x) = -d_x(x,y^*) \tag{8}$$

with d_x being the partial derivative of d with respect to x and with y assumed to be optimal. What it says is that the marginal cost to the injurer of taking an additional unit of care should equal the marginal benefit of the reduction in the expected cost of the accident, provided that the victim chooses the socially optimal level of care. Second,

$$c'(y) = -d_y(x^*,y) \tag{9}$$

which says that the marginal cost to the victim of increasing her level of care should equal the marginal benefit of the expected reduction in accident costs, provided that the injurer chooses the socially optimal level of care. The fact that the socially optimal solution requires that both parties exercise optimal care will be crucial in the analysis that follows.

1. The 'Cheapest Cost Avoider'

Before discussing and comparing the various liability rules in the case of bilateral accidents we want to examine cases which exhibit properties of both unilateral and bilateral accidents. This version can emerge when either the injurer or the victim (or a third person) is able to prevent the accident. Note the distinction: Unlike in the case of unilateral accidents, it is now not only the injurer, but also the victim who can prevent the accident. And unlike in the case of bilateral accidents where typically *both* parties need to exercise care to achieve the socially optimal and efficient outcome, it is now *either* the injurer *or* the victim who has to take care to achieve the socially optimal result.

As Calabresi (1970) argues, in these cases, the person should be held liable who could have prevented the accident with the least cost of taking care (the cheapest cost avoider). The idea is quite simple: We know that as long as property rights are well-defined and there are no transaction costs, trade between agents would result in an efficient allocation of resources when there is an externality, a conclusion commonly known as the Coase Theorem (see Coase, 1960). Furthermore, note that what is known as causation in tort law can be reinterpreted as an externality in economics. An externality can be defined as a cost that the action of a person imposes on others without their consent. The prevention of an accident would therefore be undertaken by the cheapest cost avoider. However, this solution will not be achieved because of prohibitive ex ante costs of bargaining about who should be held liable for possible accident damages. In this case, the courts should place the burden of

covering the costs of the accident on the individual who can avoid the accident at the lowest cost no matter whether it is the injurer, the victim, or a third party.

This principle of cheapest cost avoider does however not lead to first best results if one relaxes informational assumptions (Garoupa and Dari-Mattiacci, 2009). If both the victim and the tortfeasor can take care and if it is efficient that only one of them should take care, the cheapest cost avoider principle leads to the first best outcome as long as the identity of the cheapest cost avoider is known ex-ante, i.e. when the actors take decisions to take care. This is often the case. For instance house owners are not supposed to invest against damages from trucks hitting their houses and they as well as the truck owners know this. But often the cheapest cost avoider is identified only ex post in the courtroom. In that case the parties know only a distribution function denoting the probability that the court will identify one of them as the cheapest cost avoider. If both parties fix their level of care simultaneously, the cheapest cost avoider might underinvest and the other party who should not take any care in the first best solution might overinvest. The problem is even aggravated if care is allocated sequentially. In that case the first mover will always invest regardless whether she is the cheapest cost avoider and the second mover might invest nothing, even if she is the cheapest cost avoider.

2. Rule of No Liability

As before, if the injurer cannot be held liable for the harm she causes, she will choose the lowest possible level of care, i.e. is zero, to minimise her cost. This may also lead the victim to exercise excessive care. As we have seen in the previous section, this is clearly not optimal because accident costs will be excessively high.

3. Negligence

Recall that the rule of negligence imposes the obligation to satisfy a legal standard of care usually defined as due care. The injurer is therefore liable unless he can prove that he has exercised due care. We now continue our analysis by introducing, discussing, and comparing several forms of the negligence rule (see for example Wittmann, 1986; Haddock and Curran, 1985). Let us begin with the simplest form of negligence.

Simple Negligence

The properties of this rule are basically the same as in the unilateral case, i.e., the injurer is liable if and only if her level of precaution is below the legal standard regardless of the precaution level exercised by the victim. Assume now that the level of due care chosen by the courts equals the socially optimal level. Injurers will therefore have an incentive to exercise due care in order to escape liability. Hence, the victim faces the costs

$$c\,(y) + d\,(x^*,y) \tag{10}$$

and will choose the level of care that minimises this expression. Setting the first derivative with respect to y equal to zero we obtain equation (9), one of the two optimality conditions in the bilateral case.

If the injurer expects that the self-interested victim will exercise due care, the same arguments as in the unilateral case apply. The injurer faces the costs

$$c\,(x) + d\,(x,y^*) \tag{11}$$

and will choose the level of care that minimises this expression. Again, setting the first derivative with respect to x equal to zero we obtain equation (8), the other optimality condition in the bilateral case.

Therefore, we can conclude that the simple negligence rule leads to socially optimal levels of care. The outcome is a Nash equilibrium which can be expected to emerge instantaneously because a rationally self-interested person will assume that another equally self-interested person has decided to exercise efficient precaution and, that being so, it is reasonable for that person also to exercise efficient precaution. Generally, a pair of strategies is said to be a Nash equilibrium if player A's choice is optimal given B's choice, and player B's choice is optimal given A's choice. It is standard in the literature to assume the existence of a Nash equilibrium. However, there might be problems of existence, even in the case of well-behaved functions (see, for example, Endres and Querner, 1995). It is also standard to discuss bilateral accidents in the context of a Nash framework (for a reference that points to alternative approaches see Endres, 1992). Finally, note that under the rule of simple negligence there is no need to establish a legal standard of care for the victim. This conclusion changes under the following rules.

Negligence with the Defence of Contributory Negligence

Under this rule, the injurer will be held liable if she does not take due care while the victim does. The injurer will not be held liable if she either takes due care or if the victim does not take care. In other words, in comparison to simple negligence, the injurer now has, apart from exercising due care, an additional possibility to escape liability by showing that the victim failed to take due care. To see whether this rule leads to a socially optimal outcome, we can use the same line of argument as before. If the injurer assumes that the victim takes due care to avoid liability, she will also have an incentive to do so for the same reason. This, in turn, leads the victim to take due care because she now has to bear the total amount of damages. She can minimise these costs by taking due care. Since the injurer is aware of this, it is reasonable for her to take due care herself and so on. Again, we have a stable and unique equilibrium, and a socially optimal result will be achieved.

Comparative Negligence Rule

The difference between this rule and the two previous ones is that, when both parties are negligent, the accident costs are divided between them in proportion to the extent of their negligence. One way of doing this is to calculate the ratio of the differences between the due level of care and the actual level of care.

If the courts choose optimal levels of due care, then both the injurer and the victim will exercise due care. The rationale is precisely the same as before. Again, we can conclude that the outcome under this rule is socially optimal.

When comparing the various versions of the negligence rule we come to the conclusion that none of these versions is more or less efficient than the others (efficiency equivalence theorem, see Orr, 1991; Rubinfeld, 1987). They all lead to socially optimal outcomes, provided that the courts set the legal standard of precaution at the efficient level, because self-interested agents have an incentive to choose the legal standard of care. The reason for this is, in essence, that whenever one party exercises due care, then it is entirely upon the other party to decide whether it alone will be held liable by failing to take due care. However, as White (1989) argues, there is empirical evidence that, in contrast to the equivalence theorem, contributory negligence provides better incentives to avoid accidents. If actors are risk averse and insurance markets are imperfect, relative negligence leads to a better risk allocation than contributory negligence, as it burdens the tortfeasor as well as the victim, if both are negligent.

An analysis of how these results change when relaxing and modifying some of the underlying assumptions will be given later. First we will examine various forms of strict liability.

4. Strict Liability

As in the previous section, there are several forms of the strict liability rule to consider. We begin with the simplest form of strict liability.

Simple Strict Liability
In this case, the injurer has to bear the total amount of accident costs regardless of the extent of her precaution. Conversely, the victim will be compensated for all costs imposed on her, which implies that the victim's marginal benefit of taking an additional unit of care is zero for any level of care. Thus, it is optimal for the victim to choose a zero level of care because at zero level the marginal cost of taking care equals zero, and her private optimality condition is satisfied. Of course, optimality condition (9) is not met and the outcome is not socially optimal because the marginal benefit of increasing the level of care exceeds the marginal cost to the victim.

Strict Division of Losses
Under this liability rule, the injurer has to pay a fraction f of the accident costs. Hence, the injurer faces the costs

$$c\,(x) + f * d\,(x,y) \tag{12}$$

and the victim faces the costs

$$c\,(y) + (1-f) * d\,(x,y) \tag{13}$$

It is crucial to note that the size of the fraction is assumed to be independent of the parties' levels of care. Thus, the first order conditions are

$$c'\,(x) = -f * dx\,(x,y) \tag{14}$$

and

$$c'\,(y) = -(1-f) * dy\,(x,y) \tag{15}$$

Comparing these optimality conditions with conditions (9) and (11) it is clear that, at any level of care, the marginal benefit of taking care is lower under strict division. Since parties save only a fraction of the true reduction in accident losses by taking care, they have too little incentive to exercise a socially optimal level of care.

Strict Liability with the Defence of Contributory Negligence
Under this rule, the injurer is liable for the accident losses unless the victim's level of care was lower than her due level of care. It is straightforward to show that under this rule the outcome is socially optimal, provided that the courts set the level of care for victims equal to the socially optimal level of care. The rationale is the same as under the various versions of the negligence rule. Since injurers will be liable for accident damages if victims take due care and therefore will not bear the accident costs, injurers will exercise due care to minimise accident costs. On the other hand, victims will exercise due care because they do not want to be found contributorily negligent. Again, the result is a socially optimal Nash equilibrium.

Strict Liability with the Defence of Relative Negligence
This rule is basically the same as the previous one with the following difference: If the victim is found negligent because she failed to take due care, she will have to bear only a fraction of her losses. If the fraction depends on the victim's actual level of care relative to due care, if it is sufficiently large, and if the courts choose the legal level of care equal to the socially optimal level of care, then the outcome is socially efficient. The rationale is the same as before.

5. Relaxing Assumptions

Recall the first simplifying assumption that the court sets the level of due care equal to the socially optimal level. In the section on unilateral accidents, we conclude that under strict liability the courts need only determine the size of the damage, whereas under negligence the courts must in addition calculate the socially optimal level of due care, and they have to determine the level of care actually taken in order to see whether the injurer was negligent or not.

In bilateral accidents, however, this result holds true only for the rule of simple strict liability which, as we saw in the previous section, does not achieve socially efficient results. Those forms of strict liability that lead to socially optimal outcomes have the same requirements with respect to their ease of application as the various rules of negligence. The only difference affecting the ease of application of the two rules is that under strict liability the courts do not need to determine the actual level of care of the injurer.

The second assumption concerns the equality between the legal sanction and the damage actually caused. In the case of unilateral accidents we see that, whenever damages are not perfectly compensatory, the potential injurer does not have an efficient incentive to exercise the socially optimal level of care. In the case of bilateral accidents, this result holds true only for, first, the potential injurer, and second, under the rule of simple strict liability.

For instance, it is important to note that, under simple strict liability, under-compensation would tend to create an incentive for the victim to exercise precaution by creating some residual liability. This is also how insurance companies deal with the problem of moral hazard. Since, however, the incentive problem of the potential injurer remains unsolved, under-compensation cannot lead to socially optimal results.

Also, we should note that under the rules of strict liability with the defence of contributory or relative negligence, equality between the legal sanction and the harm does not matter as long as the sanction is sufficiently large so that the private costs of the parties are minimised by conforming to the legal standard. These are, of course, the same results as under the rules of negligence.

Finally, the third assumption refers to the constant level of activity. Recall that in the case of unilateral accidents the rule of strict liability and the rule of negligence produced different results. Under negligence, the injurer had no reason to consider the effect that her activity has on others and would therefore choose too high a level of activity. Under strict liability, on the other hand, the injurer internalises the total amount of social costs and therefore reduces the activity level to the socially optimal level. The crucial condition in order for any liability rule to lead to a socially efficient level of activity is that the parties engaging in some activity must bear the total amount of accident losses. Otherwise only a fraction of the activity's costs are internalised, and the level of activity will be too high. As a matter of fact, though, it is impossible for both parties to bear the accident losses.

Therefore, results change quite drastically in the case of bilateral accidents as compared to unilateral accidents. As Shavell (1987, p. 29) puts it, the reason, in essence, is that for injurers to choose the correct level of activity they must bear accident losses, but for victims to choose the correct level of activity they, too, must bear accident losses. Yet, of

course, injurers and victims cannot both bear accident losses under a liability regime, but the problem can be nicely solved by using Pigou taxes, which has led Baumol and Oates (1988) to prefer a system of Pigou taxes to liability as a matter of principle. Under a Pigou tax the injurer minimises the sum total of damages and abatement costs. As the payment goes to the state rather than the victim, the victim has an incentive to do the same. Consequently the pair of optimal abatement costs of the injurer and the victim is a Nash equilibrium.

As a result, in bilateral accidents no liability rule leads to socially optimal levels of activity. This implies that the net utility of an activity can be negative, as the following example illustrates. In bilateral accidents, an activity is socially useful if the utility to the injurer less the precaution costs to both the injurer and the victim less the costs of the accident is positive. Assume now that the utility is 100, optimal precaution cost to the injurer is 40, optimal precaution cost to the victim is 30, and the expected accident cost is 50. Obviously, the activity is not socially useful because its net utility is negative. Note, however, that under both the rule of negligence and the rule of strict liability the injurer will engage in the activity. Under negligence, his private utility is 100 - 40 = 60, and under strict liability, his private utility is 100 - 40 - 50 = 10. This is because, as noted above, the injurer does not take into consideration the precaution cost of the victim.

A theoretical possibility to achieve a socially optimal outcome would be to establish the legal obligation for the injurer to bear her own precaution cost, the accident cost, and also the precaution cost of the victim (see for example Rose-Ackerman, 1989).

A particular problem with consequences on the efficiency ranking of the negligence rule vis-a-vis the strict liability rule is interdependence between victims (Friehe, 2007). Here the damage for each particular victim decreases with the level of care of the tortfeasor and a particular victim's level of care but it *increases* with the level of care of other victims. This constellation is often observed in crime behaviour. If potential victims of crime invest in safety and if the criminals know this, the investment will reduce the crime rate but will also divert crime to other victims with lower investment levels. This effect might give incentives to increase the private investment against crime above its socially optimal level. A similar effect can arise in tort law. Wild animals from a forest can destroy crops of farmers. The forest owner as well as each farmer can reduce damages. But if the farmer invests, he also diverts animals to other farmers. In this case the negligence rule with the defence of contributory or comparative negligence cannot induce the first best outcome, whereas the strict liability rule with the defence of contributory or comparative negligence leads to efficient levels of care.

To analyse this, assume one tortfeasor who invests x and two victims who invest y_1 and y_2 to reduce damages. Assume further that there exists a triple of strictly positive optimal levels of care $\{x^*,y_1^*,y_2^*\}$ which lead to optimal damages d_1^* and d_2^* for the two victims. Assume further the existence of a negligence rule with the defence of contributory or comparative negligence. And assume that courts define the optimal levels of care as the due levels of care. This implies that victims bear all costs of accidents under the efficient combination of costs of care. We ask whether this combination $\{x^*,y_1^*,y_2^*\}$ is a Nash equilibrium. The tortfeasor has no incentives to deviate from the social optimum, as otherwise she must pay damages, which are by definition of optimality higher than her savings of care costs. (In the case of full liability as opposed to partial liability they are even higher by the fixed amount of $d_1^*+d_2^*$ as the residual risk shifts from the victim to the tortfeasor as soon as the tortfeasor is negligent). In the social optimum $\{x^*,y_1^*,y_2^*\}$ both victims have to bear the damages because the tortfeasor is not negligent. If victim 1 increases her costs of care above y_1^*, this has two effects. It reduces the damages of victim 1 partly because fewer damages occur. But by definition of optimality this decrease must be lower than the additional

expenses. However it also decreases the damages of victim 1 by an additional amount and increases the damages of victim 2 by the same amount. Due to this diversion effect it is privately profitable for victim 1 to invest more than y_1*. The same reasoning applies for victim 2. Consequently the efficient combination of levels of care $\{x^*,y_1^*,y_2^*\}$ is not a Nash equilibrium under the negligence rule and victims have an incentive to overinvest.

This odd consequence cannot happen under a strict liability rule with the defence of contributory or comparative negligence. We again ask whether the triple $\{x^*,y_1^*,y_2^*\}$ is a Nash equilibrium. We again assume that the courts fix the due level of care of victims at y_1^* and y_2^* respectively. Victim 1 has no incentives to increase her costs of care above y_1.
Otherwise her costs of care would increase, but the resulting damage reduction would only reduce the damage compensation of the tortfeasor which leaves victim 1 with a pure increase of her costs. Victim 1 has also no incentives to reduce the costs of care below the optimal level, as this would lead to negligence and burden her with all damages thereby increasing her total costs in spite of the savings of costs of care. The same reasoning applies for victim 2. The tortfeasor has no incentive to deviate from x* either because - by definition of optimality - a reduction of the cost of care below x^* would increase the damage compensation by more than the saved amount of costs of care. And for the same reason an increase of the costs of care above x^* would reduce damages and damage compensation by less than the additional costs of care. In case of the described interdependence of victims therefore the strict liability provides efficient deterrence whereas negligence results in overinvestment on the side of the victims.

IV. Litigation Costs

The cost of litigation might be higher or lower under strict liability as compared to negligence, depending on various factors. First, the number of cases which lead to a damage compensation is strictly higher under strict liability than under negligence because under negligence some losses are borne by the victim whereas under strict liability any loss caused by the tortfeasor leads to compensation. Second, the degree of legal certainty is higher under strict liability as compared to negligence. Under strict liability the plaintiff has to give evidence on causation and on the level of damages. Under negligence, the plaintiff has also to show that the tortfeasor did not reach the due level of care. As the due level of care is often ill-defined ex-ante, there are more cases under negligence in which plaintiff and defendant might have different views on the outcome of litigation and, therefore, go to court. Under strict liability, however, the quota of cases in which the outcome is clear must be higher. Therefore, the quota of cases in which damage compensation is paid in the shadow of the law, without litigation, is higher under strict liability. In these cases, the costs of transferring wealth from the tortfeasor to the victim are relatively low. Third, the cases which lead to litigation cause less litigation costs under strict liability as compared to negligence because less information (on causation and on the level of damages) is needed under strict liability as compared to negligence as an additional requirement for a damage award.

In cases of bilateral damages, however, the cost advantage of lower costs of litigation per case might disappear. In that case the court has to fix a due level of care for the victim (y^*). For this level to be efficient, the court must know the injurer's (x^*) as well as the victim's efficient care to be able to arrive at the socially efficient combination of care levels (x^*,y^*).

V. The Decentralisation Effect of Strict Liability and Negligence

An important advantage of strict liability is seen in its decentralisation or self-selection effect (Cooter and Ulen, 2004, p. 388). If different tortfeasors have different costs of care, the optimal level of care, which minimises the sum of the costs of care and the expected damages, is different for each tortfeasor and it decreases with increasing per unit costs of care. Under strict liability each tortfeasor has an incentive to minimise these costs as they are the costs of the society as well as her private total costs. This leads to a self-selection and tortfeasors with high per unit costs of care will exhibit a lower level of care than tortfeasors with low unit costs of care. Therefore strict liability leads every individual tortfeasor to reach the cost minimising and socially optimal care level.

It has been argued that this efficiency result is not reached under a negligence regime, in which courts fix a due level of care according to the "reasonable man" standard or the pater familias standard. If this due level of care is somewhere in the middle between the optimal standard of a high and a low cost tortfeasor, both of them get the wrong incentives and the low cost tortfeasor allocates too little care and the high cost tortfeasor allocates too much care. Several authors have shown that this argument is not quite right for several reasons (Rubinfeld, 1987; Bar-Gill and Ben-Shahar, 2003; Miceli, 2006). They have also shown that somewhat different rules of negligence can lead to an efficient self-selection of tortfeasors also under a negligence standard.

Sometimes courts can observe that optimal standards are different for different groups of tortfeasors. Then they can fix different levels of due care. For instance courts often fix due levels of care which are higher for experts than for laypeople. This leads experts to use a high level of care and laypeople to use a comparatively low level of care, which are both efficient. But self-selection of different groups of tortfeasors also occurs if courts cannot observe different costs of care of different groups of injurers and have no choice but to fix one due level of care for all potential injurers.

If courts use the reasonable man standard and if this standard is too low for some tortfeasors and too high for others, it is certain that those with low per unit costs of care will reach this standard to avoid liability. Therefore they reach a level of care at which one additional unit of care will reduce the expected damages by more than one unit. This leads to inefficiency. The incentive effects of the reasonable man standard on tortfeasors with high per unit costs of care are however ambiguous. At the reasonable man standard the costs of care for the tortfeasor with high unit costs of care are higher than his optimal costs of care. He will reach the due level of care as long as the sum total of his optimal costs of care plus the damage compensation at this level of care are higher than the costs of due care. To illustrate, assume that the costs of due care are 30, the optimal costs of care for the high cost tortfeasor are 10 and the damages are 15 at this level of care. In this case, the tortfeasor will allocate efficient care and pay damages as his total costs are then lower than 30. If, however, at the efficient level of care the damages are 25, he will comply with the standard. In the first case the negligence rule leads to efficient incentivesfor high cost tortfeasors whereas in the second case this result is not obtained. Those groups of tortfeasors with an efficient level of care which is lower than the due level of care will sometimes have incentives to reach the due level of care and sometimes they will get incentives to reach the efficient level of care. The latter result usually occurs if the due level of care is very much higher than the efficient level of care.

The consequences of a reasonable man standard if injurers have different costs are again different if the liability rule is the so-called partial liability, also known as the "difference principle" (Kahan 1989). Under this rule, damage compensation of the careless injurer is always the difference between the harm done and the harm which would have occurred at the due level of care. It is interesting that this rule guarantees that a tortfeasor will

reach the efficient level of care whenever the due level of care is higher than the efficient level of care. To understand this result, assume that the tortfeasor reaches the due level of care with a certain amount of costs. In that case he pays no damages. If – starting from the due level of care – he reduces his care level to a level which is still inefficiently high, he pays only the damages which he actually causes by deviating from the due level of care. By definition of efficiency, however, his cost of care savings must then exceed the additional damage he causes. This argument holds until the tortfeasor has reached her efficient level of care. Therefore under the difference principle the reasonable man standard leads to inefficiently low care for tortfeasors with low per unit costs whose efficient level of care is higher than the due level of care. It leads however to self-selection of tortfeasors whose unit costs of care are high and whose optimal level of care is lower than the due level of care. All of them have an incentive to allocate efficient care.

Miceli (2006) used this insight to criticise the reasonable man standard, which is lower than the efficient care level of some tortfeasors and higher than the efficient level of other tortfeasors. He proposed a standard of due care which is equal to the efficient care level of the tortfeasor with the lowest per unit costs of care. Such a standard would hold injurers to the "highest degree of vigilance, care and precaution" (Miceli, 2006, p. 359). This would lead to a self-selection of all injurers with different costs of precaution. Each of them would have incentives to reach her efficient level of care just as under strict liability. This favourable result hinges however on the smooth working of the difference principle.

Summarising, we can say that strict liability leads to a perfect and efficient self-selection of all injurers with different per unit costs of care. It is not true that no self-selection exists under negligence. But the same desirable result as under strict liability is only obtained under a negligence standard of the "highest degree of vigilance" as compared to the "reasonable man standard". This is not enough. This rule must be combined with a comprehensive form of the difference principle. Full self-selection of injurers with different costs of care under negligence would therefore require far-reaching changes of the negligence rule and the strict use of the difference principle (partial liability).

VI. The Information Generating Consequence of Negligence

Negligence generates public information on safety technology

The negligence rule is usually the base line. In civil law countries, negligence is the general rule and strict liability is an exceptional rule codified in specific statutes. In common law countries, strict liability is imposed in case of abnormal dangerousness of an activity (Posner, 2005; Rosenberg, 2007). It is difficult to see what explains this. Strict liability with the defence of contributory or comparative negligence leads to efficient results in most cases. Negligence leads to efficient results only if courts fix a due level of care that is equal to the efficient level of care, or if they fix a due level of care that is too high (under partial liability) or much too high (under full liability), so that the tortfeasor prefers the efficient level of care even if this leads to compensation. The strict liability rule, therefore, seems to dominate the negligence rule in terms of giving the right incentives.

One can argue that negligence is superior to strict liability because it generates more public information about the due and the efficient level of care (Ott and Schäfer, 1997; Feess and Wohlschlegel, 2006). Under strict liability each company fixes a level of care which maximises total profits. The level of care actually chosen remains private knowledge of the firms, which have no incentive to disclose it to their competitors. Under the negligence rule courts use the private cost calculations of companies to fix due levels of care, and court decisions based on this information find their way into precedents and commentaries. The negligence regime therefore produces more generally accessible information about safety technology than the strict liability rule. If the efficient standard of care does not vary much

across firms within an industry, the negligence rule therefore produces valuable spill-overs from firm to firm via the legal system, which the strict liability rule cannot provide. Under the negligence rule, courts aggregate and transmit private knowledge as to the optimal care level from informed companies to companies with inferior information by adjusting the due level of care over time as a response to the information obtained from observing the activity level of informed companies. In contrast, under strict liability, courts cannot transmit private information as to the optimal care level because they do not have an instrument to reveal and aggregate information from prior accidents caused by informed companies.

Information generated by the negligence rule alleviates principal-agent problems

A similar argument can be put forward for cases of vicarious liability. Vicarious liability is the liability of a principal for a damage caused by her agent. If the agent causes damage to a third party, the third party may have a damage claim against the principal if the agent is liable either under strict liability or because she was negligent. If the agent is liable, two possible consequences arise. The liability of the agent may trigger automatically the liability of the principal. This is the most important rule. Alternatively, the principal is liable for the agent only if she has not reached a due level of care in selecting or supervising the agent.

We consider here one of the four possible combinations of vicarious liability, the one which makes the principal strictly liable for the negligence of her agent. This rule can alleviate the principal-agent problem between employers and employees, as Demougin and Fluet (1999) have shown.

A worker might hide her type from the principal, which might lead to a higher probability of damages after hiring the agent (hidden information), or she might choose a low level of care for her own benefit and at the expense of the principal (hidden action). To illustrate: Suppose that, in a chain store, a customer gets hurt because a sales person has dangerously stockpiled heavy goods. The chain store manager (the principal) can only imperfectly monitor the effort of the sales person (the agent). Suppose that the victim of an accident can show the negligent behaviour of the sales person in court. In other words, assume that the victim has better information about the effort of the agent than the principal. This is a likely situation in many instances in which the victim but not the employer can observe the care level of an employee.

Under the negligence rule the manager obtains information in court about the negligent behaviour of his employee. This makes it possible for him to write a contingency contract under which the employee is sanctioned if she has negligently caused a damage which triggers vicarious liability. Put differently, the store manager may sanction the sales person if it is accurately established in court that he has negligently caused damage to the victim. This possibility alleviates the principal-agent problem within firms.

In contrast, consider the principal-agent problem under a strict liability rule, under which the causation of a damage by the agent triggers the liability of the principal. Under this rule, no information about the agent's negligence is generated in a judicial proceeding. Consequently, a contingency contract between the principal and the agent contingent on the negligent causation of an accident cannot be formed. By contrast, negligence generates information from the victim and thus allows for contracts which alleviate the principal-agent problems in firms.

All in all it can be said that the negligence rule has the advantage of generating more valuable information for third parties than the strict liability rule. This is an advantage which has been overlooked in much of the literature.

VII. Strict Liability vs. Negligence if the Injurer's Wealth is Lower than the Damage

We have discussed the effect of under-compensation, which leads to under-deterrence under strict liability and to efficient deterrence or under-deterrence under the negligence regime. A particular case of under-compensation arises if the tortfeasor is judgment-proof, i.e., if her total wealth is lower than the damage. In order to analyse this case sufficiently, one has to differentiate between two case groups of such injurers.

First group: The tortfeasor allocates costs of care which do not reduce her total wealth, for instance by allocating time and effort, but not money. Consider a car driver who takes optimal care when driving. Her level of care does not change her total wealth. In this case the only possible inefficient result is under-deterrence.

Second group: The tortfeasor expends monetary costs of care which reduce her wealth. Take for example a medical doctor who invests in costly equipment to reduce damages or an auditor who hires more staff to make a better audit. In this case it is possible that the liability rule provides the judgment-proof injurer with incentives to reach a level of care which is too low or too high (Beard, 1990; Miceli and Segerson, 2003).

The intuition behind the result in the second group of cases is that every increase in investment in care must reduce the expected liability by more than the effect of the increased care on the expected damages. When the injurer takes the decision to invest in care, this decision must reduce her expected liability. If for instance the injurer invests one Dollar more to increase her care level, the immediate consequence is that her liability is reduced by one Dollar in case of damage. Thus, in the eyes of the injurer, the cost of one Dollar of care is less than a Dollar, but rather a Dollar minus a Dollar multiplied with the accident probability. The injurer is in a situation as if her investment in care were cross-subsidized by a reduction of wealth, which is lost anyway in the case of an accident. If at the efficient level of care this reduction in the injurer's perceived costs of care is higher than the effect that the injurer's remaining assets are less than the damages, the injurer will invest more than the optimal level of care. This result is, however, restricted to a rule of strict liability. It cannot occur under negligence, provided that the due level of care is equal to the efficient level of care. The intuition behind this is straightforward: Under negligence, an injurer has never any incentive to invest more than the due level of care as this shifts all residual risks to the victim.

Another surprising result of inefficient deterrence for the judgment-proof injurer under negligence and strict liability becomes apparent if one includes the rules of evidence for negligence (Demougin and Fluet, 2006). This rule can be either preponderance of evidence, as in common law jurisdictions, or full proof, as in several civil law jurisdictions.

It is a well-established research result that under strict liability the judgment-proof tortfeasor usually prefers a lower level than the efficient level of care because his expected liability is lower than the expected harm he causes. This leads to under-compensation and thus – in the case of strict liability – to under-deterrence.

We now turn to the analysis of the negligence rule. If under negligence the rule of evidence for negligence is full proof, a certain quota of all negligently caused damages may not be compensated. In anticipation of this consequence, the cost minimizing level of care of the tortfeasor is likely to be below the social optimum. Under preponderance of evidence for negligence, the careless tortfeasor faces a higher risk of being convicted and paying damages. This per se increases deterrence. A larger number of negligent tortfeasors have to pay compensation than under the full proof rule. However, under the preponderance of evidence rule more non-negligent tortfeasors are convicted as negligent and must pay compensation. This per se reduces deterrence because the incurrence of costs for the due level of care may not be rewarded by evading liability. Demougin and Fluet (2006) show, however, that the overall effect of the rules of proof for negligence leads to the following social ranking of negligence versus strict liability for judgement-proof tortfeasors.

(1) Negligence with preponderance of evidence for the proof of negligence
(2) Strict liability
(3) Negligence with full proof of negligence

This result should, however, only be taken as a first approach to the problem rather than as a clear ranking of evidence rules in common law countries over those in civil law countries. In civil law countries full proof for negligence is only the baseline. It is often changed if the plaintiff has difficulties to show evidence and if information is asymmetric between plaintiff and defendant. In such cases courts may find other ways to alleviate the burden of proof for negligence or may even reverse the burden of proof. The overall effect of the multiplicity of such rules of evidence for negligence is still unknown.

VIII. Liability and Contracts

In the previous sections of this article, we concentrated on situations where parties do not enter into contractual relationships because of high transaction costs such as the costs of bargaining. The notion of transaction costs, however, is crucial for the analysis of liability and deterrence. Recall the basic insight of the Coase Theorem, which says that when parties can bargain with each other in order to settle their disagreements, their behaviour will be efficient regardless of the underlying rule of law. This implies that, whenever transaction costs are low, people enter into contractual relationships and the rules of contract law apply. Conversely, whenever transaction costs are high, people do not enter into contractual relationships and the rules of tort apply. There are a few areas, however, where tort law and contract law seem to merge, such as 'products liability' and 'implicit contracts'.

We now examine the allocative effects of various forms of liability rules in those cases where parties have entered into contractual relationships. We assume profit-maximising behaviour of firms and perfect competition. That is, the price of a product equals total unit costs including liability costs. It is also assumed that rational consumers buy a product only if the utility of the product exceeds its *perceived* price, i.e., the price actually charged plus *expected* accident costs not covered by liability payments.

If the customers' knowledge of risk is perfect, firms will take optimal care under any liability rule, even under the rule of no liability. This is because customers would immediately discover whether or not firms took less than optimal care. Thus, the perceived price of the product including expected losses would be higher than the product price of firms exercising optimal care. The potential loss of customers forces firms to exercise optimal care regardless of the underlying rule of liability. Also, the level of consumption is optimal because the price of the product as compared by customers with their utility includes expected accident losses.

These results change, however, once we assume that customers have imperfect knowledge of the risk associated with a product. If customers cannot determine product risks, they will not reward firms for making products safer. Therefore, firms do not have any incentive to take optimal care unless there is some rule of liability. Moreover, under the rule of no liability and under the negligence rule, the level of consumption will not be optimal. Only under strict liability does the misperception of risks not matter because customers are fully compensated for their losses anyway, and market prices reflect the true risk of accident losses. In all other cases, market prices, and thus consumption, are either too high or too low.

IX. Negligence under the Disguise of Strict Liability, Liability for Design Defects

In product liability the general rule is strict liability. In the European Union the council directive 85/374/EEC provides "that the producer shall be liable for damage caused by a

defect in his product". Upon closer inspection, however, it is unclear whether for design defects this is a rule of strict liability or of negligence. This depends on how courts conceptualise a design defect. They can use two alternative tests, the "risk utility test" or the "consumer awareness test". Under the risk utility test the court asks whether the product was designed to be reasonably safe. In that case the product is not defective even if it caused an accident to the victim. The risk utility test therefore asks whether those who prepared the blue print for the product were negligent. The Learned Hand test must therefore be applied to the design of the product. If courts use this test, producer liability for design defects is negligence under the disguise of strict liability.

Under the consumer awareness test courts ask whether consumers regard the product as safer than it actually is. In that case the producer is liable regardless of the product's safety. This is an informational conceptualisation of the design defect.

The risk utility test carries the disadvantage that civil courts often rely on biased expert opinion. They might face a "cartel of silence" of engineers who depend on the industries that produce the goods. This might lead to a standard of safety which is lower than optimal. Even if the standard is optimal, consumers who are unaware of the risk face unexpected damages and consequently buy too many of the dangerous goods. By contrast, the information required for the consumer awareness test can be provided by uninterested experts, for instance by pollsters. Under the consumer awareness test all unexpected damages are internalised in the price of the product. Therefore, the decision to buy reflects the product's dangerousness, even though consumers underestimate the damages. The disadvantage is that the consumer might overuse the product and thus cause a higher than efficient level of harm. Courts usually cannot observe the excessive use and therefore cannot reduce damage compensation under the defence of contributory negligence. However, this result might also occur – albeit to a lesser extent – under the risk utility test if the consumer believes that the product is safer than it actually is. This applies even if she correctly believes that in case of damage there is no claim. It is, therefore, a question still open to empirical research whether the conceptualisation of "design defect" should be based on the producer's negligence or on information asymmetry between the producer and the consumer.

X. Multiple Tortfeasors

We now turn to the case of multiple tortfeasors. Landes and Posner (1980) were the first authors to study the incentives to take care in the case of multiple tortfeasors, yet restricting their attention to negligence. For a more general discussion see Kornhauser (1989).

We will consider situations where there is more than one injurer affecting the probability of accident losses. Furthermore, we need to distinguish between cases where injurers act independently with the victim's harm being indivisible, and cases where injurers act together (in concert) to cause the victim's harm.

Under strict liability, injurers who act independently will not always act optimally in equilibrium. Assuming that each injurer is liable for a fixed fraction of losses only, any increase in the injurer's exercise of care diminishes her liability by only a fraction of the reduction in expected losses, which induces the injurer to take a level of care that is clearly below the optimal level of care. When injurers act together, however, their minimisation problem obviously turns into a situation exactly equivalent to the one where there is only a single injurer. Thus, under strict liability and if injurers act in concert, injurers take optimal care. Note that this result is not obtained if injurers pay a fraction that is identical to their probability of causation.

Under the rule of negligence, we obtain different results. Injurers will now act optimally (they will take due care) in equilibrium both in cases where they act independently and in cases where they act together, provided that the due level of care is optimally

determined, of course. Again, the analysis is straightforward and is precisely analogous to the previous analysis of situations of bilateral accidents. If one injurer alone fails to take due care, she will be held liable for the total amount of accident losses. A rationally self-interested injurer will now assume that another equally self-interested injurer has decided to exercise efficient precaution and, that being so, it is reasonable for that injurer also to exercise efficient precaution. Note that this outcome is unique and stable, and that it also holds true if injurers act in concert.

XI. Risk Aversion, Liability Law and Insurance

So far we have constrained our analysis to the case of risk-neutral parties. We will now extend the analysis by allowing for risk-averse individuals, and we will discuss the interaction between risk aversion, liability law and insurance.

Risk aversion depends on the concavity of the utility function of wealth, i.e., the rate at which utility losses grow with losses of wealth. The concavity of the utility function implies that a $1,000 loss will cause greater harm to a person with assets of $10,000 than to a person with assets of $100,000. The shifting of risks from the more to the less risk-averse will raise social welfare given that social welfare is the sum of the individuals' expected utilities. Social welfare will also increase if risks are shared among risk-averse parties, thereby reducing the potential extent of the losses that each party might suffer.

One way of shifting and sharing risks is by insurance. Insurance can be described as a private system substitute for liability law in which contracts determine the allocation of risks. In the theory of insurance, a distinction has to be made between the cases in which the insured persons can influence risks and the cases in which they cannot. In the situations where the probability of damage cannot be affected by the actions taken by the insured persons, an insurance policy that offers complete coverage is socially optimal. If the insured, however, can influence risks, complete reimbursement creates the problem of moral hazard: The individual has no incentive to take any care at all.

We now turn to the discussion of the interaction between risk aversion, liability law and insurance. Under the assumption that injurers are subject to liability, but that there is no insurance, the comparison of liability rules shows that the rule of negligence is preferable when victims are less risk-averse than injurers, and the rule of strict liability is preferable when the reverse holds true. The rationale behind these results is that under the negligence rule injurers will not bear any risk when taking due care, whereas victims will bear their losses. Thus, social welfare will be lower if victims are more risk-averse than injurers. The outcome is quite different under the rule of strict liability. Injurers will bear risk regardless of the level of care they take. If injurers are more risk-averse than victims, social welfare will decrease.

Under the assumption that insurance is available, both the rule of negligence and the rule of strict liability yield socially optimal outcomes because individuals, if risk-averse, can obtain liability insurance. The more efficient rule is the one that costs less. Assuming, for instance, that consumers can insure more cheaply than manufacturers, strict product liability should be limited.

The superiority of strict liability over negligence in cases of excessively dangerous activities and variable activity levels is not a general result, as Nell and Richter (2003) have shown. If courts cannot observe the optimal activity level and integrate this into the concept of negligence, strict liability outperforms negligence if injurers as well as victims are risk neutral, or if insurance markets are perfect (see section 7 above). If, however, insurance markets are imperfect or if insurance coverage is not available, this result loses generality. This becomes most obvious for very dangerous and catastrophic accidents, in which often one

tortfeasor causes harm to a large number of victims. In such a case strict liability would allocate all risk to one person whereas in the absence of insurance coverage, an efficient risk allocation would spread the risk between victims and injurer. This inefficient risk allocation will cause the injurer to choose an activity level which may be too low from a social point of view. In such a case a liability cap which re-distributes some of the damages to the injurers would improve the risk allocation and would prevent the injurer from choosing an inefficiently low level of activity. Alternatively, in such cases strict liability could be replaced by negligence. If then the harm to the injurer is a technical external effect which is not internalized by the price system, the overall welfare effect is unclear. On the one hand, negligence would improve the risk allocation as the damages are distributed on more shoulders. On the other hand, injurers would choose the efficient level of care, and would also choose an inefficiently high level of activity and thus increase the damages to an inefficiently high level. It depends on the parameters whether the overall benefit from a negligence rule would then be lower or higher than from a strict liability rule.

If with imperfect insurance coverage liability works through a market and if victims must ultimately pay the price for the liability in a product price, the situation becomes different. In that case negligence strictly outperforms strict liability because the tortfeasor will reach an efficient level of care. But as the residual risk is borne by the victims, they will keep the level of activity down by buying fewer dangerous products. As the risk allocation is better under negligence than under strict liability, consumers and buyers will choose an activity level that is higher and socially superior to the extremely low activity level which a non-insured producer would choose under strict liability.

XII. Relaxing Behavioural Assumptions of Rational Choice

The large majority of tort law models assume a maximising tortfeasor who can map information into unbiased subjective probability values. This rules out optimistic and pessimistic attitudes of the injurer. It is, however, a well-known result of psychological research and behavioural economics that individuals tend to exhibit optimistic and pessimistic behaviour. For instance, individuals underestimate the likelihood that they will be involved in a car accident (Guppy, 1993). Furthermore, individuals tend to be unrealistically optimistic as to health or environmental risks (Sunstein, 1997; Weinstein, 1989). Furthermore, recent research suggests that individuals are pessimistic as to the risk of highly salient and catastrophic accidents such as earthquakes. They overestimate the probability of occurrence (Gigerenzer, 2005; Jolls, Sunstein and Thaler, 1998).

If ambiguity is introduced, i.e., if the injurer can be either optimistic or pessimistic and consequently overestimates or underestimates the probability of an accident, the standard results of the efficiency of strict liability versus negligence change somewhat (Teitelbaum, 2007).

First, in the case of optimism the expected value of damages corrected for the influence of optimism is lower than the expected value under full rationality. Consequently, under strict liability the tortfeasor will reach a level of care which is lower than the efficient level of care.

Second, in the case of pessimism the perceived value of damages is higher than under full rationality. Accordingly the level of care is higher than optimal. To illustrate: An optimistic car driver might not care to use the safety belt. And the widely reported asbestos cases have led to pessimism, which pushed up the investment expenditure for asbestos decontamination to an unreasonably high level.

Third, under negligence different outcomes are possible. Assume that the due level of care is equal to the efficient level of care and that the tortfeasor has to pay the full damages. In

that case, the tortfeasor will reach the due and efficient level of care provided that the minimum of her perceived damage costs plus her costs of care are higher than the costs of due care. If these costs are, however, lower than the due costs of care, she will reach an inefficiently low level of care. The result changes if the difference principle (partial liability) is used. Under this principle, the tortfeasor can deduct those damages that would have occurred if she had reached the due level of care. Under that condition, it is certain that the perceived minimum of the costs of damage compensation and the costs of care are lower than the costs of due care. All in all, it can be said that in the case of optimism negligence leads to better results than strict liability in some cases. In the case of pessimism, negligence leads to better results than strict liability in all cases. This proposition holds for the basic model of unilateral accidents with a fixed activity level.

This leads Teitelbaum (2007) to the suggestion that negligence is more robust to ambiguity than strict liability and that negligence is likely to outperform strict liability if the injurer is pessimistic. This might again add to the explanation why the negligence rule and not the strict liability rule is regarded as the baseline in tort law in both common law and civil law countries.

XIII. Comparing Strict Liability and Negligence

Let us now summarise some of the main results of the previous sections. In the case of unilateral accidents, both the rule of strict liability and the rule of negligence achieve a socially optimal outcome, provided that courts set the level of due care equal to the socially optimal level of care, that the legal sanction equals the harm, and that the level of activity is constant. Relaxing these assumptions provides further insights favouring the rule of strict liability. Under strict liability, all the courts need to do is to determine causation and the size of the damage, whereas, under the negligence rule, the courts also need to determine the level of due care as a legal standard for the socially optimal level, and they have to determine the level of care actually taken in order to see whether the injurer was negligent or not. These information requirements are difficult and costly to satisfy. Moreover, the average costs of resolving claims tend to be higher under negligence.

Another important advantage of the rule of strict liability emerges when allowing for variable levels of activity. Under negligence, the injurer has no reason to consider the effect that her activity has on others because she can escape liability by taking due care. Thus, the injurer will choose too high a level of activity. Under strict liability, the injurer internalises the total amount of social costs and reduces the level of activity to the socially optimal level.

So far the results suggest that the rule of strict liability achieves socially optimal results provided that damages are set at the perfectly compensatory level. What happens, though, when an accident is bilateral, requiring both parties to take precaution against accidents? Now the efficiency of the rule of strict liability becomes problematic because, even though strict liability may at first create the right incentives for potential injurers, it will create an incentive problem for potential victims and will in return lead injurers to exercise suboptimal care. Strict liability is the mirror image of no liability. One rule fails to create incentives for precaution by the victim, the other rule fails to create incentives for precaution by the injurer.

Therefore, our analysis suggests that in the case of bilateral accidents we should apply either a negligence rule or a rule of strict liability with the defence of contributory or relative negligence. All of them lead to socially optimal outcomes, provided that the courts set the legal standard of precaution at the efficient level, because self-interested agents have an incentive to choose the legal standard of care.

The efficiency of negligence disappears if negligence standards are ill-defined ex ante and if therefore the tortfeasor does not know at which level of care her probability of being held negligent becomes zero. Depending on the probability distribution function which maps a level of care onto a probability of being held negligent by the court, this might lead to under-deterrence or to over-deterrence or – by chance – to optimal deterrence. If a muddy standard of due care is combined with over-compensation, over-deterrence becomes inevitable, whenever the rate of over-compensation reaches a threshold level. The equivalent outcome shows up in cases of under-compensation.

Strict liability also trumps negligence in the case of interdependency of victims, i.e., if increased care of one victim increases the damages of another victim.

The negligence rule is usually the base line around the world. In civil law countries, negligence is the general rule and strict liability is an exceptional rule or codified in specific statutes. In common law countries negligence is the baseline and strict liability is imposed in case of abnormal dangerousness of an activity (Posner, 2005; Rosenberg, 2007). Given the basic analysis of negligence versus strict liability it is difficult to see what explains this. Strict liability with the defence of contributory or comparative negligence usually leads to efficient results. Negligence leads to efficient results only if courts fix a due level of care which is equal to the efficient level of care, or if they fix a very high due level of care, such that the tortfeasor prefers the efficient level of care even if this leads to compensation. The relative merits of the negligence rule as the baseline are not visible under the basic analysis.

A major drawback of the rule of strict liability in unilateral accidents, though, emerges when we relax the assumptions. Whenever damages are not perfectly compensatory, i.e., compensation is below the level that would make the victim indifferent between the case of no accident and that of an accident with compensation, the potential injurer does not have an efficient incentive to exercise the socially optimal level of care under the strict liability rule. A symmetric result obtains in case of over-compensation under strict liability The negligence rule is more robust with regard to deviations of damage compensation from damages, for instance if injurers are judgment-proof or remain undetected. This important advantage of the negligence rule however disappears if due levels of care are ill-defined ex ante.

An important advantage of the negligence rule is that it produces more publicly available information on safety technologies than the strict liability rule. The level of due care which is generated by the court system becomes a public good. Under strict liability no such revelation mechanism for the technology to prevent damages exists. Moreover, under the negligence rule courts have to establish negligence and this information might be used within firms to improve the incentives for their workers and employees in cases of vicarious liability. Strict liability does not generate such information.

The negligence rule is socially superior to the strict liability rule in the case of multiple tortfeasors. This case requires a sharing rule that distributes the damage compensation payments among tortfeasors. Often the individual contribution of a tortfeasor is not known. The courts use an equal share rule for all tortfeasors. This rule leads to under-deterrence under strict liability but to efficient deterrence under the negligence rule.

Research which includes ambiguity of actors such as optimism and pessimism finds that the adverse effects of ambiguity are smaller under negligence than under strict liability.

A comparison of negligence and strict liability must also include the effects of procedural rules as evidence rules for proving negligence. These rules vary across legal orders and their effects can reverse the social ranking of negligence versus strict liability.

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