

Accident analysis: The role of liability rules – pecuniary losses.

(Draft)

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1. INTRODUCTION.

Accidents are an important social cost caused by transport. Policy makers can reduce this cost by the use of different instruments such as regulation (traffic rules, vehicle regulation...), liability rules, infrastructure measures and economic instruments (subsidies and taxes). The first option is called safety regulation or 'specific deterrence' and it imposes regulations on car driving. Think of speed limits, safety belts, technical regulations... The second option, called 'general deterrence', consist of confronting the car drivers with the real costs of their driving and by that, influencing their behaviour. Liability rules confirm with this description. The fact that you could be held liable makes car driving more expensive and thus more unattractive. The last instrument, taxes and subsidies, are not usually used to promote traffic safety.

In general, one can try to assess which instruments or which combinations of instruments are optimal in order to reduce the sum of the accident cost and the cost of the accident prevention.

In this paper we only consider liability rules and how they influence behaviour and accident cost. We first consider the consequences of different liability rules in a victim-injurer model. Then we look at a model where both parties have losses. The losses are assumed purely pecuniary. For both models we consider the case in which people are risk neutral and then introduce risk adversity and insurance. For the victim-injurer model with risk neutral agents we also look at what happens if we relax some assumptions. Finally, we conclude.

But we start with some definitions.

2. DEFINITIONS.

2.1. *Victim-injurer accident.*

By a victim-injurer accident we think of an accident between one injurer and one victim, in which only the victim experiences the accident loss. Think for example of an accident between a car and a bicycle. A crash between two cars is an example of an accident where both parties loose. Parties are assumed to be strangers to each other.

Injurers and victims will each have (at least potentially) two kinds of decisions to make. A decision whether, or how much to engage in a particular activity and a decision over the degree of care to exercise when engaging in an activity. Injurers and victims will be assumed to make

their decisions based on their expected utility. If people are risk neutral then their decisions will be affected only by their expected losses. They will not be influenced by the potential magnitude of their losses. Their utility of wealth equals their wealth (or is linear in their wealth), so their marginal utility of wealth is constant. If people are risk averse then they are concerned not only about their expected losses but also about the possible size of their losses. Risk-averse parties, in other words, dislike uncertainty about the size of losses per se. Their utility of wealth is increasing and strictly concave in their wealth, that is, their marginal utility of wealth is positive but decreasing.

2.2. Liability Rules.

We give a non-exclusive enumeration of possible liability rules. In the analysis, however we will not consider all of them.

(1) *No Liability.*

Each party bears his/her own losses.

(2) *Strict Liability.*

The injurer must pay for all accident losses that he caused.

(3) *Negligence Rule.*

The injurer will be held liable for accident losses he caused only if he was negligent, that is, only if his level of care was less than a level specified by courts, called due care.

x_i^* : due care level of injurer
 injurer at fault ($x_i < x_i^*$) → injurer liable
 injurer faultless ($x_i \geq x_i^*$) → injurer not liable

(4) *Strict Division of Accident Losses.*

Injurer and victim each bear a positive fraction of any accident losses that occur. The fraction is assumed to be independent of their level of care.

(5) *Strict Liability with the Defence of Contributory Negligence.*

The injurer is liable for the accident losses he causes unless the victim's level of care was less than his due care level.

x_v^* : due care level of victim
 victim faultless ($x_v \geq x_v^*$) → injurer liable
 victim at fault ($x_v < x_v^*$) → injurer not liable

(6) *Strict Liability with the Defence of Dual Contributory Negligence.*

The negligence criterion is applied to both the victim and the injurer. The victim only bears the losses if he is negligent and the injurer takes care, in all the remaining cases the injurer pays.

x_v^* : due care level of victim
 x_i^* : due care level of injurer

victim at fault ($x_v < x_v^*$), injurer faultless ($x_i \geq x_i^*$) → injurer not liable

victim at fault ($x_v < x_v^*$), injurer at fault ($x_i < x_i^*$) → injurer liable

victim faultless ($x_v \geq x_v^*$), injurer at fault ($x_i < x_i^*$) → injurer liable

(7) Strict Liability with the Defence of Relative Negligence.

The injurer is liable for the accident losses he causes if the victim took due care. If, however the victim failed to take due care, the victim does not bear all the losses; rather he bears only a fraction of them, the fraction depending on his actual level relative to due care.

x_k^* : due care level of party k

injurer at fault ($x_i < x_i^*$), and victim faultless ($x_v \geq x_v^*$) → injurer bears 100%

injurer faultless ($x_i \geq x_i^*$), and victim at fault ($x_v < x_v^*$) → victim bears X%, with $X = f(x_v / x_v^*)$

(8) Negligence rule with the Defence of Contributory Negligence.

The injurer will not be liable for the accident losses he causes if he takes at least due care; and even if he does not, he will still escape liability if the victim failed to take due care.

x_k^* : due care level of party k

injurer faultless ($x_i \geq x_i^*$) → injurer not liable

injurer at fault ($x_i < x_i^*$), and victim at fault ($x_v < x_v^*$) → injurer not liable

injurer at fault ($x_i < x_i^*$), and victim faultless ($x_v \geq x_v^*$) → injurer liable

(9) Comparative negligence rule.

If only one of the parties is at fault, that party bears all the losses. But if both injurer and victim fail to take due care, each party bears a fraction of accident losses, where the fraction is determined by a comparison of the amount by which the two parties' levels of care depart from the levels of due care.

x_k^* : due care level of party k

injurer at fault ($x_i < x_i^*$), and victim faultless ($x_v \geq x_v^*$) → injurer bears 100%

injurer faultless ($x_i \geq x_i^*$), and victim at fault ($x_v < x_v^*$) → victim bears 100%

Both at fault [$(x_i < x_i^*), (x_v < x_v^*)$] → injurer and victim bear in proportion to negligence

2.3. Pecuniary versus Non-pecuniary Losses.

A pecuniary loss is the loss of a good, which has a substitute on the market. Market prices therefore determine the value of the good. An example of a pecuniary loss is the material damage that is caused by the accident.

A non-pecuniary loss can be seen as the loss of unique and irreplaceable commodities. The amount of the loss equals the utility of the good to the individual and this equals the reduction in social welfare due to the loss of the good. Examples of non-pecuniary losses are death, injury, emotional distress...

In this paper we will only consider pecuniary losses. We start with the simplest case, a victim-aggressor model.

3. VICTIM-AGGRESSOR.

3.1. Risk-neutral parties.

First, we consider the case where both injurers and victims are risk neutral. We will consider the model of bilateral accidents, in which both injurers and victims can influence the expected accident losses by their care and activity level. Remember that in a victim-aggressor model, only the victim has losses. We will base ourselves on Cooter & Ulen (1987), Landes & Posner (1987) and Shavell (1987).

3.1.1. The Social Optimum.

First we introduce some notation:

Subscript i and v stand for the injurer and the victim, respectively.

s_k is the level of activity of agent k .

$U_k(s_k)$ is the gross utility of a person of engaging in his activity at level s_k .

x_k is the level of care of agent k per unit of activity. The consumer price of care is assumed to equal unity and not to be a function of the level of care.

The expected accident loss $s_i s_v p(x_i, x_v) l(x_i, x_v)$ imposed on the victim depends on the activity level and the level of care of both agents, with $p(x_i, x_v)$ the probability of an accident with $\frac{\partial p}{\partial x_k} < 0$ and with $l(x_i, x_v)$ the losses with $\frac{\partial l}{\partial x_k} = l_{x_k} < 0$. Assume that an increase in the

activity level causes a proportional increase in the expected accident losses, given care. We will denote the expected accident losses as $s_i s_v L(x_i, x_v)$

In the social optimum, the degree of care and the activity level are such that they maximise the social welfare. This is the utility that victim and injurer derive from the activity minus the cost of care minus the expected accident losses.

$$\text{Max} \sum_{k=i,v} [U_k(s_k) - s_k x_k] - s_i s_v L(x_i, x_v) \quad (1)$$

The first order conditions. for x_k and s_k are:

$$x_k : 1 = -s_n L_{x_k}(x_i, x_v) \quad k, n = i, v; k \neq n \quad (2)$$

$$s_k : U'_k(s_k) = x_k + s_n L(x_i, x_v) \quad k, n = i; k \neq n \quad (3)$$

According to condition (2), the level of care should be chosen such that the marginal social costs of taking care (the price of x_k , which is assumed to be equal to unity) equals the marginal social benefits (reduction in expected accident losses). According to (3), the socially optimal activity level s_k is that value such that the social benefit of activity (marginal utility from an increase in activity level) equals the marginal social cost (the sum of the cost of taking optimal care per unit of activity and the increase in expected accident losses).

3.1.2. Overview Results.

The injurer and the victim can take two decisions, one concerning the level of care and one concerning the level of activity. We assume the following:

- If compensation is paid to the victim, it is perfect.
- The court and the agents are perfectly informed and the law system functions perfectly. We assume no administrative costs or equal administrative costs for all rules.
- Victims always sue injurers.
- Injurers have the assets necessary to pay for harm.

(1) No Liability.

In this case the injurer never has to pay compensation. He will not take into account the costs he imposes on the victim. He will not take care ($x_j = 0$ whatever x_v) and will not restrict his activity level.

The victim on the other hand bears all the costs. Because $x_j = 0$, victims will select x_v in order to maximise $U_v(s_v) - s_v x_v - s_j s_v L(0, x_v)$. He will take optimal care and will engage in the optimal activity level in order to minimise his expected losses.

(2) Strict liability

In this case the injurer's problem becomes:

$$\text{Max}_{x_i, s_j} U_i(s_j) - s_j x_i - s_j s_v L(x_i, x_v)$$

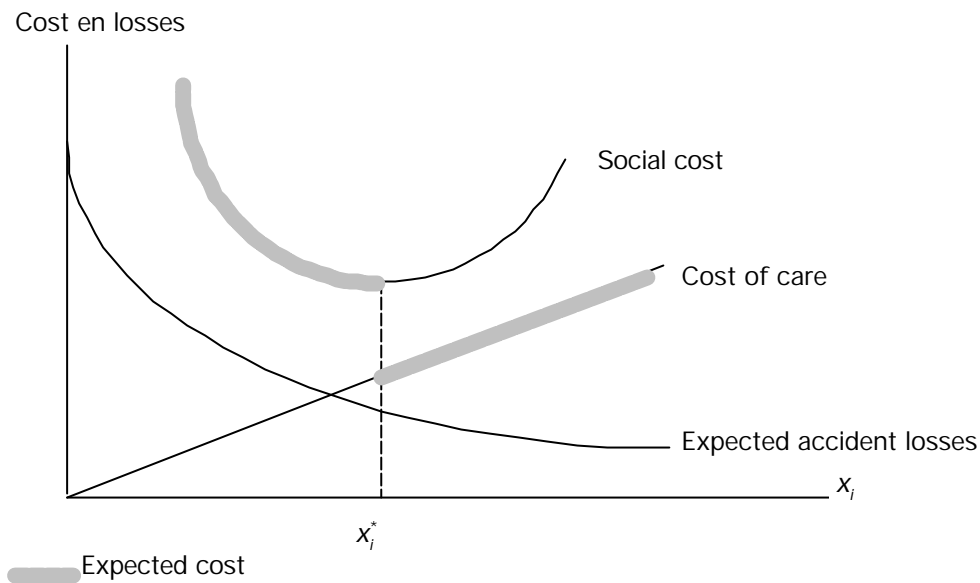
In choosing the activity level and the level of care, he will take into account the effect of his actions on the expected accident costs. In other words, the marginal social accident costs and benefits associated with his transport decisions are completely internalised.

The victim knows that he will be compensated perfectly for the accident losses, should an accident occur. His net utility function therefore is given by $U_v(s_v) - s_v x_v$. He has no incentive to reduce accident costs under this rule, since all accident costs are borne by the injurer. Consequently, his level of care will be zero and his activity level will be too high. He will not take into account the marginal social benefits of his precautionary behaviour ($-s_v L_{x_v}(x_i, x_v)$) and will not consider the variation in expected accident losses due to his activity ($s_v L(x_i, x_v)$).

(3) Negligence

Under this rule, the policy maker imposes a legal standard of care x_i^* with which the injurer must comply in order to escape liability. The injurer will choose to comply with the legal standard. He will not choose to take more care than what is legally required. If his level of care equals x_i^* , he will avoid liability and his costs will be $s_j x_i^*$. Choosing a higher level of care would only increase his costs while not giving him any additional benefit. The net utility function of an injurer who takes due care is therefore given by $U_i(s_j) - s_j x_i^*$. If the policy maker sets the legal standard at the efficient level, it can be shown that this net utility is always larger than the net utility he can attain when he does not comply ($U_i(s_j) - s_j x_i - s_j s_v L(x_i, x_v)$) (given that the victim's activity level is strictly positive). Therefore, he will choose to comply with the legal standard. If the legal standard is set at the efficient level, the injurer will be induced to take the efficient level of care.

Graphically:



Since the injurer escapes liability by choosing the due care level, he will not take into account the effect of his activity level on the expected accident costs. Therefore, his activity level will be too high compared to the social optimum. Of course, this result would change if the legal standard would be defined not only in terms of level of care, but also in terms of the activity level.

The victim knows that the injurer takes the due level of precaution, and that he will not receive compensation for the accident losses. Therefore, he responds as if there was no liability and he will set his activity level and level of care at the efficient level.

(4) *Strict liability with contributory negligence and comparative negligence*

These variants of the negligence rule give both parties incentives for efficient precaution. The mechanism is similar as in the case of the simple negligence rule. Under every variant of the negligence rule, one party can escape bearing the accident costs by complying with the legal standard. This party will take due care in order to avoid the cost of harm. However, he has no incentive to set his activity level at an efficient level, because, by conforming to the legal standard, he can avoid all liability.

Since the other party bears all accident costs, this party has an incentive to set both his activity level and his level of care at the efficient level, in order to maximise his net utility.

We summarise the effects of different liability rules on the level of care and the activity level. This table is based on Cooter&Ulen (1997)

Table 1: Efficiency of incentives created by liability rules.

	Care		Activity level	
	Injurer	Victim	Injurer	Victim
No liability	no	yes	no	yes
Strict liability	yes	no	yes	no
Negligence	yes*	yes*	no+	yes
Strict Liability + contributory negligence	yes*	yes*	yes	no+
Comparative Negligence	yes*	yes*	no+	yes

Source: Cooter & Ulen (1997)

'yes' = efficient incentives

'no' = inefficient incentives

(given behaviour of other party)

* = if the level of due care equals the social optimal level.

+ = if the standard of behaviour used to determine negligence is defined only in terms of care.

Firstly, we can conclude that certain liability rules lead to an efficient level of care by both parties. This is the case for all rules involving negligence. Secondly, we see that there exists no liability rule that always results in optimal levels of activity for both parties. This is caused by the fact that liability rules do not allow both 'players' to carry the accident cost. To correct for this, several approaches have been suggested. Shavell(1987) suggests that injurers pay in the case of an accident a fine equal to the expected accident losses to the state and that victims are not given compensation next to a negligence rule. One could also use a negligent rule to induce efficient care and complement it with a tax, which should provide incentives for efficient activity choices. Goerke (2001) proposes the use of monetary fines, which are not related to the occurrence of an accident. Think of fines for speeding, parking offences,... He shows that in order to obtain an efficient outcome, the standards have to be excessive.

Which liability rule to use depends on the persons that need to take care. If, for instance, it is optimal that only the injurer takes care, strict liability can lead to an efficient outcome. If both have to take care, the rule chosen should depend on whose activity level matters the most.

3.1.3. *Relaxing the assumptions.*

In this paragraph we leave our ideal world and look at what happens if our assumptions are relaxed. First, we look at the consequences of errors, made by the court or by the injurer. Next, the influence of vague standards and uncertainty is discussed. Thirdly, we relax the assumption of no or equal administrative cost and finally, the effect of non-uniform agents is considered. We base ourselves on Cooter & Ulen (1997), Emons (1990,1991), Endres (1991), Landes & Posner (1987) and Shavell (1987).

(1) **Errors.**

By errors we mean mistakes on the extent of harm, the cause of the accident and the actor's fault. These errors will influence the incentives. The influence will depend on the rule used.

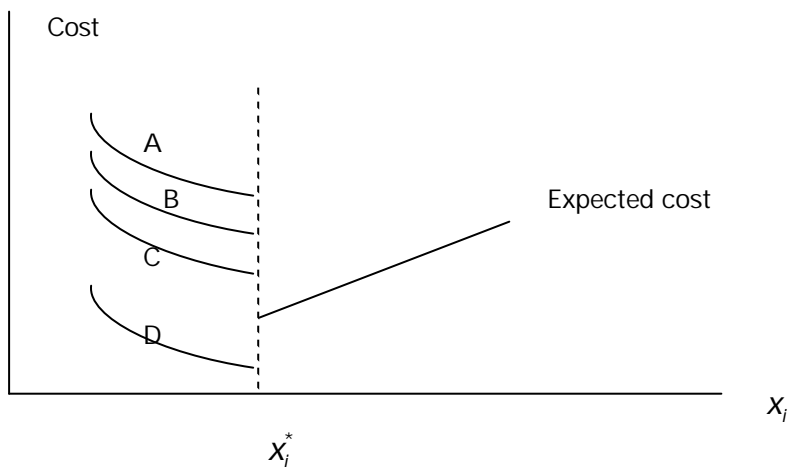
- (i) Mistakes in estimating harm by court

Strict liability. If the compensation is smaller than the harm, part of the accident cost is external to the injurer. His care level will be lower than optimal and his activity level higher. If the compensation he has to pay is larger, he will raise his care level above optimal. We see that the injurers' precaution responds in the same direction as the error.

Negligence rule. The injurer will not adapt his care level to small court errors (positive or negative) in setting the damages. If the error is large, this is, if he only has to pay a small fraction of the accident losses, it could be optimal to violate the standard. Endres (1991) shows that in this later case the injurer could be induced to take due care by a tax proportional to the degree of negligence.

Graphically:

Suppose B is the true cost. Small errors such as A and C have no effect on the level of care. Large errors such as D affect the level of care. Note that if there is an error in estimating the harm, due care is probably also set wrong. This is because court estimates due care using estimated harm.



Note that the conclusions stay if we interpret this problem as injurers making mistakes in estimating the expected harm.

(ii) Mistakes in findings of negligence

Strict liability. If negligent injurers are not found liable, the expected liability lowers. This cause injurers to lower their care. In general, the injurer will respond in the same direction as the error.

Negligence rule. We again find that injurers do not respond to small errors. We can use the same graph as before, but with a different interpretation.

(iii) Errors in setting legal standards

In reality due care does not equal optimal care. If due care is too small, the party will conform with this level and hence exercise suboptimal care. If due care is too large, we obtain either compliance or disobedience. Whether the injurer decides to keep the standard depends on a comparison of the cost of care when keeping the standard and the minimal total cost when violating it.

Also note that care can be defined in different dimensions. If the due level of care does not cover all these dimensions, the injurer will only comply with the efficient level for the dimensions covered.

(2) Vague standards and Uncertainty.

We will consider how people react under legal uncertainty. Assume that courts make purely random errors, or, what comes down to the same thing, that injurers make purely random errors in predicting what the court will do.

- (i) Random errors by the court computing damages/by the injurer predicting errors

Purely random errors will have no effect on the expected liability. Hence, there will be no effect on the level of care under any liability rule.

- (ii) Random errors in setting due care

Under a simple negligence rule the court can make random errors in setting the due level of care or in comparing the level of actual care with the standard or the injurer can make random errors in predicting the due level of care. This causes uncertainty for the injurer. Raising his care level costs relatively little and he will raise his care level to avoid being held liable.

- (iii) Stochastic element of care

Care often has a stochastic element. We can say that realised care $x_i = x_i^* + e$ with $e \sim IID(0, s)$. This means that $E(x_i) = x_i^*$. If $e < 0$ as the accident happens, the injurer will be found negligent. It is possible that the injurer will raise his level of care to avoid being negligent by accident.

We summarise these first two points with a table, based on Cooter & Ulen (1997)

Table 2: The effect of errors and uncertainty.

Liability rule	Court's error	Injurer's error	Effect on injurer
Strict liability	Excessive damage	Overestimates damage	Excessive precaution
Negligence	Excessive damage	Overestimates damage	None
Negligence	Excessive legal standard	Overestimates due care	Excessive precaution
Strict liability	Random error in damage	Random error in damage	None
Negligence	Random error in due care	Random error in due care	Excessive precaution

(3) Administrative costs

An accident causes three costs to arise: a precautionary cost, the cost of accidental harm and an administrative cost. A no liability rule leaves the accident losses where it falls, there is no reallocation. Hence, there are no administrative costs for reallocation. Under strict liability and negligence there is an administrative cost. Negligence will in general be more expensive per case than strict liability, but there are less cases under the negligence rule. There is also a difference in costs between uniform rules and 'case by case' in which the former is evidently

less expensive. With non-uniform parties, however, a uniform rule is distortive, as we will see in (4)

Note also that high litigation costs can cause the victim to make fewer claims. Hence, the injurer gets no signal that he is doing something wrong and he will take less precaution. If it is expensive for the injurer to litigate, he will take more precaution than optimal. We cannot be sure of the net effect.

(4) Non uniform parties

In general courts use an 'average man' concept of negligence, because of the information cost. However the social optimal level of care depends on the cost of taking care. This means that due care should vary. It is possible that the efficient level for a certain person is lower than the standard. Hence if this person exercises his optimal care level, he will be found negligent in the case of an accident. Emons (1990,1991) shows that liability rules that exhibit sharing features are superior to negligence rules if individuals are not identical.

3.2. Risk-averse parties and insurance.

With risk averse agents the social optimum involves not only the reduction of accident losses but also the protection of risk averse parties against risk. We want to know how this influence the incentives associated with liability.

We will consider a unilateral victim-injurer model. We assume that only the injurers' decisions have an impact on the probability of an accident and not on the severity.

We will base ourselves on Arlen (1990), Mattiacci (?), Posner (1998), Shavell (1987,2000) and Van den Bergh (1998).

3.2.1. The Social Optimum.

The presence of risk-averse parties means that the distribution or allocations of risk will in itself affect social welfare. Social welfare is raised not only by the complete shifting of risks from the more to the less averse or to the risk neutral, but also by the sharing of risks among risk-averse parties. Sharing risks reduces the magnitude of the potential loss that any one of them might suffer. This is why we introduce insurance. By introducing insurance, we also have to introduce moral hazard. Moral hazard exists when people can influence the risk. In this set-up, they can influence the probability of an accident happening by the choice of their level of care and activity. If insurers have perfect information at no cost about the insureds' risk reducing actions, then there is no problem. The insurers can link the terms of the policy to the insureds' risk reducing actions. If, on the other hand, insurers are not informed, as they will be in reality, then the insureds' ownership of insurance will affect their incentives to reduce risk. If the insured possesses complete coverage, the problem will be more serious, for they will have no reason to avoid losses. The existence of insurance thus can have a great impact on the preventive role of liability.

First, we consider the care-aspect. If an actor does not have to pay for his losses or his liability himself because he is insured, he will not take these costs into account when determining his behaviour. The care incentives then have to be provided by the insurance company. This is not always possible under each rule as we will see. In general, the insurance company can impose a

fixed amount which can not be recovered or use a bonus-malus system¹. As for the activity level, it might be possible to influence the activity level of parties through the insurance policy. For instance, the premium could be linked to the number of kilometres driven in a year.

Social welfare is again defined as the sum of the parties' expected utility.

Shavell (1987) shows that under the socially ideal solution to the accident problem, parties will make decisions about engaging in activities and about their exercise of care in the way that was earlier described. In addition, risk-averse parties- be they victims or injurers- will not bear risks, which is to say, their risks will be perfectly spread through insurance arrangements or will be shifted to risk-neutral parties.

3.2.2. *Overview Results.*

We assume that:

- injurers are always sued by victims
- injurers have assets necessary to pay for harm
- insurance premiums are actuarially fair, set by a competitive insurance industry.

(1) *No Liability.*

If injurers are not liable for accident losses, they generally will not reduce risks appropriately. They may engage in too much risky activities and will have no motive to take care. We will not have a social optimum.

Victims are left bearing all the risks if accident insurance is not available. This is socially undesirable if victims are risk averse. If accident insurance is available, risk-averse victims will purchase full insurance if they can. Full coverage will be offered because in this setting the victim does not influence the probability of an accident.

(2) *Strict Liability.*

Under strict liability victims are compensated for any losses; it is the injurers who bears the risk. If the injurers are risk neutral, they will take optimal care, as we saw before. If they are risk averse, social welfare will be lowered relative to the ideal if injurers engage in an activity not only because injurers will bear risk, but also because they may exercise too much care to avoid liability. In addition, injurers may be discouraged from engaging in an activity in the first place even though doing so would be socially optimal. The way of solving this is to reduce the magnitude of liability or to allow injurers to insure themselves.

In the case that insurance is available we should distinguish between two cases. In the first case the insurers can determine the injurers' level of care. Victims will be protected against risk by definition of strict liability and injurers, if risk averse, will purchase liability insurance. And since insurers can observe the level of care, full coverage will be offered and provisions will be included to induce optimal care. The premiums paid will equal expected losses. Note that the outcome is socially optimal because victims can not influence the accident risk. If insurers cannot observe the injurers' level of care, policies will usually be less than complete coverage.

¹ A bonus-malus system can influence the level of care, but is not perfect. This is because there is not enough diversification in the system.

The premium rate will be lower than the premium for full coverage. But if the injurers are risk averse and cannot buy full coverage, this means that the social outcome will not be optimal. In addition, the fact that they are not responsible for all of the losses induces them to take less than optimal care.

The conclusion however stays that the availability of liability insurance will still be socially desirable. We reason as follows: since victims are always compensated under strict liability the existence or non-existence of a liability insurance does not affect their social welfare. Hence the only thing on which the liability insurance has an influence is on the welfare of the injurers. Since injurers choose to buy insurance, it must be that the insurance makes them better off.

(3) Negligence rule.

In this case injurers will not bear risk provided they take due care, which they will decide to do. Hence there are no particular problems when injurers are risk averse, and they will not exercise excessive care or be discouraged from engaging into a socially desirable activity. Their activity level will even be too high. Victims on the other hand will bear their losses and as a consequence social welfare will be lowered if victims are risk averse and not insured.

If insurance is available, victims will buy full accident insurance coverage². Injurers will not buy insurance because the premium would be too high to make it worth buying. Since all injurers who would own an insurance would act negligently, insurers' cost and the premium would equal the level of expected accident losses produced by negligent behaviour. Injurers would therefore be better off not to buy insurance but to take due care.

We summarise with a table:

Table 3: : Efficiency of incentives created by liability rules

	Care	Level of activity	Insurance	
	Injurer	Injurer	Injurer	Victim
No liability	No	No	No	Full insurance
Strict liability	Yes ^a	Yes ^a	Partial insurance ^b	No
Negligence	Yes [*]	Excessive	No	Full insurance

a: if risk neutral or full insurance; too much care and too little activity if risk averse and no insurance

b: If insurers cannot observe the level of care

*: if due care= socially optimal care

We see that in a unilateral victim-injurer model we can obtain a social optimum under strict liability if the injurer is risk neutral or if insurers have perfect information.

² Victims can buy this, because they cannot influence the accident risk. In a bilateral setting and because in general, insurance companies cannot observe the level of care, victims will only be able to buy partial coverage.

4. BOTH PARTIES HAVE LOSSES.

We'll base ourselves on Boyer & Dionne (1987) and Landes & Posner(1987).

4.1. Risk neutral parties.

4.1.1. The Social Optimum.

The social optimum stays the same as in the victim-aggressor model. Care and activity should be such that they maximise the utility that the victim and the injurer³ derive from the activity minus the cost of care minus the expected accident losses. The two parties now share expected accident losses.

Denote I^i the losses of the injurer and I^v , the losses of the victim, where $I^i + I^v = 1$. We get

$$\begin{aligned} & \text{Max}_{k \neq v} \sum [U_k(s_k) - s_k x_k - I^k s_i s_v L(x_i, x_v)] \\ & = \text{Max}_{k \neq v} \sum [U_k(s_k) - s_k x_k] - s_i s_v L(x_i, x_v) \end{aligned} \tag{4}$$

which is the same as before.

4.1.2. Overview results.

We assume the following:

- If compensation is paid, it is perfect.
- The court and the agents are perfectly informed and the law system functions perfectly. We assume no administrative costs or equal administrative costs for all rules.
- Parties have enough assets necessary to pay for the harm.

(1) No liability

Parties will tend to minimise $I^k s_i s_v p(x_i, x_v) / (x_i, x_v) + s_k x_k$. Since parties do not carry all the losses, they will not take optimal care and will be engaged in too much activity.

(2) Strict liability.

Under strict liability, parties compensate each other. Both are fully compensated so they will not take optimal care nor activity level.

(3) Negligence.

Under the negligence rule, the losses lie where they fall if both are negligent or if both take care. Neglecting activity for a moment, we get the following problem:

	Care of the victim	
C ar	x_v^0	x_v^*

³ We will keep the injurer-victim notation, although both influence the accident losses and both loose.

x_i^0	$I^i s_i s_v L(x_i^0, x_v^0) + s_i x_i^0$ $I^v s_i s_v L(x_i^0, x_v^0) + s_v x_v^0$	$s_i s_v L(x_i^*, x_v^*) + s_i x_i^0$ $s_v x_v^*$
x_i^*	$s_i x_i^*$ $s_i s_v L(x_i^*, x_v^0) + s_v x_v^0$	$I^i s_i s_v L(x_i^*, x_v^*) + s_i x_i^*$ $I^v s_i s_v L(x_i^*, x_v^*) + s_v x_v^*$

If the injurer takes due care, the victim will also choose due care and vice versa. If the injurer takes less than due care, the victim will compare $I^v s_i s_v L(x_i^0, x_v^0) + s_v x_v^0 > s_v x_v^*$. If I^v is small and $s_v x_v^* - s_v x_v^0$ is large, then the victim will prefer x_v^0 . If the victim chooses x_v^0 , the injurer will make the same calculation. On first sight it looks as if there are two equilibrium, $(x_i^*, x_v^*), (x_i^0, x_v^0)$, but (x_i^0, x_v^0) is not an equilibrium.

Since

$$\begin{aligned}
 & I^v s_i s_v L(x_i^0, x_v^0) + s_v x_v^0 < s_v x_v^* \\
 & + \underline{I^i s_i s_v L(x_i^0, x_v^0) + s_i x_i^0} < s_i x_i^* \\
 & s_i s_v L(x_i^0, x_v^0) + s_v x_v^0 + s_i x_i^0 < s_v x_v^* + s_i x_i^* \\
 & \Leftrightarrow x_i^* \text{ and } x_v^* \text{ minimize } L(x_i, x_v) \\
 & \rightarrow (x_i^0, x_v^0) \text{ can not be an equilibrium}
 \end{aligned}$$

Intuitively, if the victim takes less than due care, the injurer chooses due care because then the costs are shifted to the victim. The victim also knows this and will take due care. The same applies to the injurer.

We summarise:

Table 4: Efficiency of incentives created by liability rules.

	Care		Activity level	
	Injurer	Victim	Injurer	Victim
No liability	no	no	no	no
Strict liability	yes	no	yes	no
Negligence	yes*	yes*	no+	no+

'yes' = efficient incentives

'no' = inefficient incentives

(given behaviour of other party)

* = if the level of due care equals the social optimal level.

+ = if the standard of behaviour used to determine negligence is defined only in terms of care.

We see that although negligence induces optimal care by both parties, the activity levels of both parties is not optimal.

5. CONCLUSION.

Transport causes accidents, which are an important social cost. There are different instruments to reduce this cost. In this paper we only looked at one instrument, liability rules. They confront drivers with the real cost of their activity. We looked at the influence of different liability rules

on the behaviour of people for different models, assuming that the losses were purely pecuniary. We started with some definitions and gave an overview of different rules.

In the first model, a bilateral victim-injurer model with risk neutral agents, we found that there exist rules that lead to efficient care levels for both parties. This was the case for all rules involving negligence. However there does not exist a liability rule that results in optimal activity levels for both parties. For this model we looked at what happened if we relaxed some of our assumptions. First, we found that with a rule of strict liability an error of the court in assessing damages distorts, but that random errors have no influence. With a rule of negligence we found that errors in setting due care distort more than errors in damages and that vague standards lead to excessive precaution. We also looked at the role of administrative cost and non-uniform parties

For the second model, a unilateral victim-injurer model with risk averse parties, we found that in a socially ideal solution two conditions were met. First of all, the level of care and activities should minimise the expected accident losses plus the cost of care and secondly, risk averse parties should be left with the same wealth regardless of whether an accident occurs. We saw that we could obtain a social optimum under a rule of strict liability if the injurer is risk neutral or if insurers have perfect information.

Our third model is a bilateral model in which both parties have losses. The social optimal level of care and activity turned out to be the same as in our first model. Again we could obtain the social optimal level of care, but now none of the parties exercised the optimal activity level.

This is only a first attempt in analysing the effects of liability rules. There are many possible extensions. First of all, we could look at what happens if losses aren't purely pecuniary. Death, invalidity,... can alter the utility of the parties and this will have major consequences on our analysis. Furthermore we could look at what happens in our second model if both parties could influence accident losses. Another possible extension is to complement liability rules with other instruments.

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