Tortious Acts Affecting Markets

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May 25, 2005

Abstract

The present paper examines an injurer causing a temporary blackout to a firm as the primary victim but also affecting customers and competitors of the firm. Reflecting existing legal practice, the paper investigates efficiency properties of the negligence rule granting recovery of private losses but to the primary victim only. The regime is shown to provide efficient incentives for precaution provided that the primary loss exceeds the social loss from accidents. The main contribution of the paper consists of an explicit analysis of markets affected by a temporary blackout of one firm. The analysis reveals that the private loss exceeds the social loss indeed if the market is less than fully competitive. Moreover, the net social loss remains positive, no matter which market structure prevails.

JEL classification: K13, K12, D62

*The author wants to thank Christoph Engel, Martin Hellwig, Gerd Mühlheusser, Jose Penalva, Hans-Bernd Schäfer and Patrick Schmitz for useful comments on an earlier version of this paper. All remaining errors are mine. Support through SFB TR 15 is gratefully acknowledged.

1 Introduction

Tort law holds the promise of internalizing negative external effects, which otherwise would distort incentives for precaution. In fact, as I have shown elsewhere,[1] an extensive interpretation of the negligence rule would, in theory at least, allow to handle even complicated situations involving several parties and multilateral external effects. In practice, however, rather restrictive use is made of the instrument. Bussani and Palmer (2003) summarize the arguments in support of an exclusionary rule under the headline of "floodgates". Permitting extensive recovery of losses would overwhelm the courts. Widespread liability would place an excessive burden upon the defendant's human initiative and enterprise, enforcing a broad modern trend toward increasing tort liability.

To keep floodgates closed, some legal systems including the German one distinguish between damage to person or property from losses without antecedent harm to plaintiff's person or property. While such pure economic losses, as they are referred to, cannot be recovered, damage to property, including consequential loss, is granted recovery.

Bussani and Palmer present a bunch of case studies which aim at identifying a common core of principles governing tortious liability for pure economic loss in several European countries. Their cases cable I and cable II among others are of particular interest for the economic analysis of the present paper. Under cable II, the facts are constructed as follows. While operating his mechanical excavator, injurer A cuts the cable belonging to the public utility which delivers electricity to primary victim B. The unexpected blackout caused the temporary loss of production. B is claiming compensation from A for the damage caused by the loss of production. In the case of cable I, the only difference is that, in addition to loss of production, the blackout also caused damage to B's machinery.

Bussani and Palmer summarize the legal practice as follows. In Belgium, France, Greece, Italy, the Netherlands and Spain, lost production or lost profit will be compensated even in the absence of physical loss. These countries do not distinguish between damage to property and pure economic loss per se. In Austria, Sweden and Finland, the primary victim could recover

[1] See Schweizer (2005b).

damage to the machinery but would be denied recovery of lost production or profit. In Germany and Portugal finally, the primary victim would be granted recovery of both damage to the machinery and of lost production or profit under cable I, whereas it would be denied recovery under cable II. In other words, the rules governing such cases do not belong to the common core of European tort law.

The above cable cases involve externalities beyond the injurer and the primary victim. In fact, customers of B might also negatively be affected by accidents as B's shutdown or blackout may lead to temporary shortages on the market it serves. Party B's competitors, on the other side, may benefit from such an accident as they may face increased demand. To focus on the main issue at stake (and to keep floodgates closed), potential claims by secondary victims are ruled out. Moreover, parties enjoying windfall gains from accidents do not have to pay compensation for their benefits which is true under most if not all legal systems. Therefore, quite likely, a discrepancy between the private loss of the primary victim as compared to the social loss from accidents does arise which has been examined in the economic literature before.[2]

The main conclusions so far have been as follows. Under a regime of strict liability, to induce efficient precaution, the injurer should face damages equal to the social loss. Put differently, if just the primary victim can recover his private loss that is different from social loss, incentives would be distorted. More precisely, if private loss exceeds social loss there would be too much whereas, otherwise, there would be too little precaution.

Bishop (1982) argues that, in a range of cases, private economic loss caused by a tortious act is not a cost to society. His argument is widely accepted and used to justify legal practice which denies recovery of pure economic loss even to primary victims. Yet, as the present paper argues, that range of cases may be narrower than thought. As it turns out, if the primary victim operates in a fully competitive market then the social loss exceeds the primary victim's private loss such that granting recovery of private loss only, let alone denying recovery would induce too little precaution. The same holds obviously true if the primary victim serves its market as a monopolist.

[2]See, among others, Bishop (1982), Shavell (1987), Gilead (1997), Parisi (2003) and Dari Mattiacci (2003) for an extensive discussion of private versus social loss.

While the monopolist's customers may suffer as secondary victims from the temporary shutdown there is no party around who would benefit.

This leaves the more widespread case of imperfect competition in between. Here, as it turns out, the primary victim's private loss exceeds the social loss such that granting full recovery of private loss would induce, under a regime of strict liability, too much precaution indeed. Yet, as the social loss remains positive quite generally, imperfect competition does neither support Bishop's case of no cost to society. Denying recovery would induce too little precaution. Hence, under strict liability, there exist parameter constellations where granting recovery of private loss but to the primary victim only would outperform denying recovery and others where denying recovery would be socially preferable.

Yet, many tort cases are governed, not by strict liability, but by negligence rules. For becoming liable, the injurer must have violated a standard of conduct and his violation must have been the cause of the accident. Under such a negligence rule, the potential injurer has no incentives for precaution beyond the negligence standard. Therefore, if this standard is equal to efficient precaution the negligence rule provides incentives for efficient precaution provided that the injurer, if negligent, owes damages not below the social loss. Notice the case of no loss to society (if it occurs at all) would also qualify for efficient incentives under such a negligence rule.

The present paper identifies imperfect competition as the leading case where the primary victim's private loss exceeds the social loss. Since the bulk of cases will concern markets governed by such imperfect competition, on efficiency grounds, granting recovery of private loss but to the primary victim only without requiring the primary victim's competitors to compensate for windfall gains seems justified. Under the circumstances of cable II, this rule corresponds to legal practice in Belgium, France, Greece, Italy, the Netherlands and Spain. Under cable I, such a rule would also capture legal practice in Germany and Portugal. In any case, the rule is shown to provide efficient incentives for precaution provided that the private loss exceeds the social loss and that the negligence standard equals efficient precaution.[3] As a corollary, it follows that denying recovery of private loss to the primary victim, even if the loss is of pure economic nature, cannot be justified on

[3]For a closely related result, see also Dari Mattiacci (2003).

efficiency grounds, at least not if a blackout of a firm is at stake.

The main contribution of the present paper consists of pointing out that the discrepancy between the primary victim's private loss and the social loss depends on the structure of the affected market. While the extreme cases of monopoly and perfect competition are relatively easy to grasp, it is the case of imperfect competition in between that proves most challenging for intuition. Earlier findings on free entry under imperfect competition prove helpful in understanding the result.

Recall, if competition is less than perfect, free entry would lead to the range where social welfare is decreasing.[4] Therefore, social welfare under a blackout of the primary victim, net of the victim's fixed costs, exceeds social welfare without accident. Moreover, without the accident, the primary victim would earn revenues covering both fixed and variable costs. As a consequence, the primary victim's private loss is then easily seen to exceed the social loss.

The paper is organized as follows. Section 2 introduces the general setting. It examines the negligence rule with a standard of conduct where the injurer owes damages if his violation of the standard has caused the accident. If the standard equals efficient precaution and if damages are not lower than the social loss keeping the standard is an optimal strategy of the injurer. Moreover, if there are multiple optimal strategies all of them turn out to be efficient. This robust efficiency result turns out to hold quite generally. More restrictive assumptions are needed to show that other negligence rules, be it that they are relying on inefficient standards or be it that the injurer owes damages below the social loss, fail to provide efficient incentives.

Section 3 models the market affected by a blackout of the primary victim explicitly. A first subsection deals with monopoly and perfect competition. While the monopoly case is obvious, it is shown that, under perfect competition, the social loss exceeds the private loss of the primary victim provided that marginal costs are strictly increasing. The case of constant marginal costs is trivial as firms would earn zero profits and the accident would cause neither a private nor a social loss. The second subsection deals with the linear specification of the Cournot model. Unless the primary victim has marginal

[4] Weizsäcker (1980) has pointed out this result for the linear specification of Cournot quantity competition. Mankiw and Whinston (1986) have extended it to more general settings of imperfect competition.

costs low enough relative to his competitors to approach the position of a monopolist, his private loss is shown to exceed the social loss. Nevertheless, the social loss remains positive in general such that Bishop's range of cases where private loss is not a cost to society does not cover the linear specification of the Cournot model. The third subsection examines more general market structures to confirm the findings of the previous subsection beyond the linear specification of Cournot.

Section 4 takes up the view that entry choice may depend on the negligence rule in place. It is shown that entry choice would be distorted downwards even if the market were governed by perfect competition and if the negligence rule were perfect in the sense that it induces the injurer to take socially optimal precaution.

Section 5 investigates capacity choice. While entry choice is modelled as a binary decision, capacity choice faces a continuous range of alternatives. The market, again, is assumed to be governed by perfect competition. Capacity choice is shown to be distorted in the same direction as entry choice. However, for continuous capacity choice, the distortion arises even in the complete absence of accidents whereas for mere entry choice, distortions only arise if accidents are expected to occur. These findings hint at the fact that the blame for distortion of entry or capacity choice should not prematurely be put on the negligence rule as such.

Rather, as section 6 points out, the obligations involved are of a multilateral nature and, to restore full efficiency, would have to be handled as such. In fact, an extensive interpretation of the negligence rule which takes the multilateral nature into account would provide efficient incentives both for precaution and capacity choice. Section 7 concludes.

2 The general setting

The primary victim is assumed to be a firm supplying output to a given market and possibly facing competing firms. On the other side of the market, there are customers. In the absence of an accident, let W^0 denote social welfare, i.e. the sum of customers' and producers' surplus and G^0 the primary victim's profit. Moreover, let ΔS and ΔP denote the social loss and the primary victim's private loss, respectively, from an accident.

The potential injurer decides on precaution $r \in R \subset [0, \infty)$ whereas nature's random move is denoted by $\omega \in \Omega$. The accident technology $e(r, \omega) \in \{0, 1\}$ describes whether there is an accident ($e = 1$) or not ($e = 0$) if nature's move is ω and if the injurer has taken precaution r. The probability of an accident is then $\varepsilon(r) = E[e(r, \omega)]$. Let

$$R^* = \arg\max_{r \in R} [1 - \varepsilon(r)] \cdot W^0 + \varepsilon(r) \cdot \left[W^0 - \Delta S\right] - r$$

denote the set of efficient precautions. Equivalently, it holds that

$$R^* = \arg\min_{r \in R} r + \varepsilon(r) \cdot \Delta S.$$

Notice, without further restrictions, this set may contain more than one element.

In the following, negligence rules with a standard of conduct r_S and awarding damages ΔH are examined. Let $\Lambda(r, r_S, \omega) \in \{0, 1\}$ denote whether the injurer is found negligible ($\Lambda = 1$) or not ($\Lambda = 0$). If the injurer keeps to the standard he will never be found negligible, i.e. $\Lambda(r_S, r_S, \omega) = 0$ for all ω. Let $\lambda(r, r_S) = E[\Lambda(r, r_S, \omega)]$ denote the probability of becoming liable if the injurer has chosen precaution r. Then the injurer takes precaution from the set

$$R_I = \arg\min_{r \in R} r + \lambda(r, r_S) \cdot \Delta H.$$

I have the following three negligence rules in mind. The rule

$$\lambda(r, r_S) = \max [\varepsilon(r) - \varepsilon(r_S), 0] \tag{1}$$

is referred to as Kahan's rule as it has been proposed by Kahan (1989). While this rule was introduced to capture causality in the legal sense, I have argued elsewhere[5] that the rule may capture causality more closely if modified as follows:

$$\Lambda(r, r_S, \omega) = \max [e(r, \omega) - e(r_S, \omega), 0]. \tag{2}$$

In fact, Λ as defined by (2) holds the injurer liable only in states of nature where the accident has occurred ($e(r, \omega) = 1$) but would have been avoided if the injurer had kept to the standard ($e(r_S, \omega) = 0$). In general, unless

[5] See Schweizer (2005a).

monotonicity is imposed state by state, the modified version differs from Kahan's rule (1). In textbooks, finally, the rule

$$\lambda(r) = \begin{cases} 0 & \text{if} \quad \varepsilon(r) \leq \varepsilon(r_S) \\ 1 & \text{if} \quad \varepsilon(r) > \varepsilon(r_S) \end{cases}$$

is widely used to capture negligence. This rule, however, entirely fails to reflect the issue of causality.

As is easily seen, the three rules have in common that, for any level of precaution r, $\lambda(r, r_S) \geq \varepsilon(r) - \varepsilon(r_S)$ must hold. Moreover, if $\Delta H \geq \Delta S$ then

$$\lambda(r, r_S) \cdot \Delta H \geq [\varepsilon(r) - \varepsilon(r_S)] \cdot \Delta S. \tag{3}$$

The following proposition just makes use of (3) and, hence, it must be valid for all of the above negligence rules. The proposition claims that, at an efficient standard, keeping the standard is an optimal decision for the injurer and, if multiple decisions exist that are optimal, they all must be efficient provided that the injurer owes damages not lower than the social loss.

Proposition 1 *If $\Delta S \geq \Delta H$ and if the standard of conduct is efficient, i.e. $r_S \in R^*$ then $r_S \in R_I \subset R^*$ under any of the above negligence rules.*

Proof. For any level of precaution $r \in R$, it follows from (3) that

$$\begin{aligned} r + \lambda(r, r_S) \cdot \Delta H &\geq r + [\varepsilon(r) - \varepsilon(r_S)] \cdot \Delta S \geq \\ r_S + [\varepsilon(r_S) - \varepsilon(r_S)] \cdot \Delta S &= r_S = r_S + \lambda(r_S, r_S) \cdot \Delta H \end{aligned}$$

such that r_S would be an optimal choice of the injurer indeed.

For any other optimal strategy r, it holds for similar reasons that

$$r_S = r + \lambda(r, r_S) \cdot \Delta H \geq r + \varepsilon(r) \cdot \Delta S - \varepsilon(r_S) \cdot \Delta S$$

and, hence, that

$$r_S + \varepsilon(r_S) \cdot \Delta S \geq r + \varepsilon(r) \cdot \Delta S.$$

Since $r_S \in R^*$, the above inequality must be binding and r must be efficient as well. ■

The proposition provides a condition on the negligence rule which is sufficient for inducing efficient precaution. Notice, no assumptions on the shape of the accident technology were needed to establish the proposition. In the

following, I shall examine systematically the incentives arising from negligence rules which violate the condition, be it that $\Delta H < \Delta S$ or be it that the standard is excessive in the sense of $\max R^* < r_S$. In such cases, the three versions of the negligence rule would have to be treated separately. For simplicity, I shall focus on Kahan's rule (1) under the following additional assumptions.

The possible range of precaution is $R = [0, \infty)$. The probability $\varepsilon(r)$ is a differentiable, decreasing and convex function of precaution, i.e. $\varepsilon_r(r) < 0$, $\varepsilon_{rr}(r) > 0$. Finally, the Inada conditions

$$\lim_{r \to 0} \varepsilon_r(r) = -\infty \text{ and } \lim_{r \to \infty} \varepsilon_r(r) = 0$$

are also assumed to be met. Then the efficient level r^* must be interior and unique, satisfying the corresponding first order condition. Moreover, since the injurer's total costs $r + \lambda(r, r_S) \cdot \Delta H$ are a convex function of r, his optimal decision r_I is unique as well and satisfies

$$r_I = \arg \min_{r \leq r_S} r + \varepsilon(r) \cdot \Delta H = \min [r_H, r_S]$$

where

$$r_H = \arg \min_{r \in R} r + \varepsilon(r) \cdot \Delta H$$

denotes the optimal precaution under strict liability. From this analysis, the following conclusions can be derived.

First, if the injurer owes damages below the social loss then he has insufficient incentives for precaution. Second, if he owes damages equal to the social loss and if the standard is efficient or higher then the injurer obtains efficient incentives for precaution. Third, if the injurer owes damages in excess of the social loss but at an excessive standard then the rule provides excessive incentives for precaution. The following proposition summarizes these findings.

Proposition 2 *Suppose the above assumptions are met. Then, under Kahan's rule (1), the following incentives for precaution are provided:*

(a) If $\Delta H < \Delta S$ *then* $r_I \leq r_H < r^*$.

(b) If $\Delta H = \Delta S$ *and* $r^* \leq r_S$ *then* $r_I = r^*$.

(c) If $\Delta H > \Delta S$ *and* $r^* < r_S$ *then* $r^* < r_I$.

At excessive standards and under the assumptions of the above proposition, Kahan's rule provides efficient incentives for precaution only if damages owed by the injurer are equal to the social loss. Damages in excess of the social loss induce too much precaution whereas positive damages below the social loss provide too little incentives but still higher incentives than if damages were denied.

Under the modified Kahan rule (2) that takes causality fully into account, the systematic investigation of incentives would be more tedious. To illustrate the difficulties involved, consider the following example. Damages owed by the injurer are equal to the social loss but the standard of conduct is excessive. In contrast to claim (b) of the above proposition, the modified rule induces too much precaution in the example.

Example The injurer must choose from just two levels of precaution $R = \{0, 1\}$. The probabilities of an accident are $\varepsilon(0) = 4/5$ and $\varepsilon(1) = 3/5$, respectively, whereas it holds that

$$\text{prob } \{\omega : e(1, \omega) = e(0, \omega) = 1\} = 2/5.$$

Therefore, with probability $1/5$, a move of nature occurs which leads to an accident at precaution 1 but not at the lower precaution 0. Notice, in this example, monotonicity dose not hold state by state and, for that reason, the modified version (2) differs from Kahan's rule (1). Moreover, the social loss is assumed from the range

$$5/2 < \Delta S < 5.$$

A simple calculation shows that efficient choice would be $R^* = \{0\}$. Since

$$\begin{aligned} & 0 + \lambda(0, 1) \cdot \Delta S \\ = \; & [\varepsilon(0) - \text{ prob } \{\omega : e(1, \omega) = e(0, \omega) = 1\}] \cdot \Delta S > 1 + \lambda(1, 1) \cdot \Delta S, \end{aligned}$$

the injurer's choice would be $r_I = 1$ and would fail to be efficient in spite of the fact that the injurer if liable owes damages equal to the social loss.

The above findings allow to explore the negligence rule granting recovery of private losses ΔP but to the primary victim only. At an efficient standard of conduct, it follows immediately from proposition 1 that this rule provides efficient incentives for precaution if the primary victim's private loss exceeds

the social loss. Notice, this remains to be true even if there is no loss to society. If, however, the social loss exceeds the primary victim's private loss then this rule provides insufficient incentives for precaution as the injurer hazards the consequences of liability. Yet, the rule still outperforms the case where no damages were due.

3 The affected market

In this section, the market affected by a tortious act is modelled explicitly. The primary victim is assumed to be a firm supplying output to a given market. Firm $i \in M = \{1, ..., m\}$ has cost function $K_i(x_i) = k_i(x_i) + \phi_i$ where ϕ_i denotes fixed costs of firm i. Marginal costs are positive and increasing ($dk_i(x_i)/dx_i > 0$ and $d^2k_i(x_i)/dx_i^2 > 0$). On the other side of the market, there are customers. The inverse demand function of the customers is denoted by $f(X)$ and is equal to the price at which demand would clear market supply X. The law of demand is assumed to hold, i.e. the inverse demand function is downwards sloping ($df(X)/dX < 0$). No matter whether markets are perfectly or imperfectly competitive, let x_i^0 and $X^0 = \sum_{i \in M} x_i^0$ denote output of firm i and aggregate output, respectively, if there is no accident. Then the profit of firm i amounts to

$$G_i^0 = g_i^0 - \phi_i = f(X^0) \cdot x_i^0 - K_i(x_i^0)$$

and customers' surplus amounts to

$$c^0 = \int_0^{X^0} f(X)dX - f(X^0) \cdot X^0$$

whereas social welfare amounts to

$$W^0 = w^0 - \sum_{i \in M} \phi_i = c^0 + \sum_{i \in M} g_i^0 - \sum_{i \in M} \phi_i = \int_0^{X(m)} f(X)dX - \sum_{i \in M} K_i(x_i^0).$$

If there is an accident, the blackout causes a temporary loss of production to the primary victim $v \in M$. Yet, the victim must still cover his fixed costs such that his private loss amounts to

$$\Delta P = g_v^0 = f(X^0) \cdot x_v^0 - k_v(x_v^0),$$

i.e. to revenues minus variable costs.

Depending on the shape of marginal costs, the other firms may be able to offset, in part at least, the victim's lost production. After the accident, the output of firm $i \neq v$ is x_i^{-v} and total output is $X^{-v} = \sum_{i \neq v} x_i^{-v}$. The profit of firm $i \neq v$ amounts to $g_i^{-v} = f(X^{-v}) \cdot x_i^{-v} - k_i(x_i^{-v})$ and customers' surplus to $c^{-v} = \int_0^{X^{-v}} f(X)dX - f(X^{-v}) \cdot X^{-v}$. The social welfare during the blackout of the primary victim net of fixed costs amounts to $w^{-v} = c^{-v} + \sum_{i \neq v} g_i^{-v}$. The social loss from an accident amounts to $\Delta S = w^0 - w^{-v}$ such that the discrepancy between private and social loss is

$$\Delta P - \Delta S = g_v^0 + w^{-v} - w^0. \tag{4}$$

Recall, it is the sign of (4) which matters if the efficiency of the negligence rule granting recovery of private losses but to the primary victim only is at stake. This sign turns out to depend on the market structure as I now want to show.

3.1 Monopoly and perfect competition

The simplest case is that of a primary victim serving the market as a monopolist. Since, by definition of a monopoly, there are no competitors that could benefit from the primary victim's blackout and since the customers loose their surplus, the social loss, not only, must be positive but must even exceed the private loss of the primary victim.

The same holds true if the primary victim serves a market governed by perfect competition, characterized by prices equal to market costs:

$$\frac{dk_i(x_i^0)}{dx_i} = f(X^0) \text{ and } \frac{dk_i(x_i^{-v})}{dx_i} = f(X^{-v})$$

In this case, too, it can be shown that $\Delta S > \Delta P$ must hold. The proof is relying on figure 1. Notice, that

$$-k_v(x_v^0) = \sum_{i \neq v} k_i(x_i^0) - \sum_{i \in M} k_i(x_i^0)$$

must hold and recall that total costs net of fixed costs are equal to the area under the appropriate supply curve. Since social surplus is equal to the area between demand and supply curves, the discrepancy $\Delta P - \Delta S$ must be equal to minus the area 123 in figure 1 and, hence, must be negative as claimed.

[Figure 1 here approximately]

Surprisingly enough, monopoly and perfect competition both lead to a situation where the social loss, not only, remains positive but even exceeds the private loss of the primary victim. Therefore, if the primary victim serves his market as a monopolist the negligence rule granting recovery but to the primary victim only induces too little precaution. Yet the rule still outperforms the rule that denies recovery. Moreover, neither monopoly nor perfect competition support Bishop's range of cases involving no loss to society.

3.2 Linear specification of the Cournot model

Let us assume that marginal costs c_i of firm i are constant such that total costs at output x_i amount to $K_i(x_i) = c_i x_i + \phi_i$. Inverse demand of customers is assumed linear $f(X) = A - X$. For this specification, all terms of interest can be calculated explicitly. In the following, the findings of some tedious but straightforward calculations are listed. Under quantity competition in the sense of Cournot, firm i maximizes profit

$$x_i^0 \in \arg\max_{x_i}(A - c_i - x_i - \sum_{j \neq i} x_j^0)x_i.$$

It follows from first order conditions that total supply and supply of firm i amount to

$$X^0 = \frac{m}{m-1} \cdot (A - c^a) \text{ and } x_i^0 = \frac{A - c^a + (m+1) \cdot (c^a - c_i)}{m+1},$$

respectively, where $c^a = \sum_{i \in M} c_i/m$ denotes average marginal costs. The solution is tacitly assumed to be interior such that all firms supply a possibly small but still positive quantity.

In the absence of an accident, the profit of firm i net of fixed costs amounts to

$$g_i^0 = (x_i^0)^2 = \frac{(A - c^a)^2}{(m+1)^2} + \frac{2(A - c^a) \cdot (c^a - c_i)}{m+1} + (c^a - c_i)^2$$

and the customers' surplus to

$$c^0 = \frac{1}{2} \cdot (X^0)^2 = \frac{m^2(A - c^a)^2}{2(m+1)^2}.$$

Hence, social welfare net of fixed costs amounts to

$$w^0 = c^0 + \sum_{i \in M} g_i^0 = \frac{(m^2 + 2m) \cdot (A - c^a)^2}{2(m+1)^2} + \sum_{i \in M} (c^a - c_i)^2.$$

If there is an accident leading to a blackout of the primary victim $v \in M$, social welfare net of fixed costs amounts to

$$w^{-v} = c^{-v} + \sum_{i \neq v} g_i^{-v} = \frac{(m^2-1)\cdot(A-c^{-v})^2}{2m^2} + \sum_{i \neq v}(c^{-v}-c_i)^2$$

where $c^{-v} = \sum_{i \neq v} c_i/(m-1)$ denotes average marginal costs after the accident. The discrepancy between private and social loss amounts to

$$\begin{aligned} & \Delta P - \Delta S \\ = \; & w^{-v} + g_v^0 - w^0 = \\ = \; & \frac{2m^2-2m-1}{2m^2(m+1)^2}\cdot(A-c^a)^2 + \\ & + \frac{m^2-2m-1}{m^2(m+1)}\cdot(A-c^a)\cdot(c^a-c_v) - \frac{2m+1}{2m^2}(c^a-c_v)^2 \end{aligned} \tag{5}$$

and the social loss to

$$\begin{aligned} \Delta S \; = \; & \frac{2m+1}{2m^2(m+1)^2}\cdot(A-c^a)^2 + \\ & + \frac{m^2+2m+1}{m^2(m+1)}\cdot(A-c^a)\cdot(c^a-c_v) + \frac{2m^2+2m+1}{2m^2}\cdot(c^a-c_v)^2. \end{aligned}$$

While it seems difficult to provide general intuition for the above terms, several limiting cases are more easy to grasp.

First, obviously it must hold that

$$\lim_{m\to\infty} \Delta P - \Delta S = 0.$$

In fact, for $m \to \infty$, Cournot competition under the linear specification is approaching the case of perfect competition. Under perfect competition and at constant marginal costs, firms would earn zero profit and a blackout would cause neither a private nor a social loss. Therefore, the discrepancy would vanish, well in line with the above limiting case under Cournot competition.

Second, suppose the primary victim produces very little even in the absence of a blackout ($x_v^0 \approx 0$). Then, the private as well as the social loss from a blackout would be negligible ($\Delta P \approx \Delta S \approx 0$, hence $\Delta P - \Delta S \approx 0$), in line with (5).

Third, suppose all competitors of the primary victim produce negligible quantities ($x_i^0 \approx 0$ for $i \neq v$) then the case is approaching that of a monopolist suffering from the blackout. For this case, the discrepancy has been shown, in

the previous subsection, to be negative, again in line with the corresponding property as derived from (5).

Fourth, if the primary victim has average marginal costs ($c_v = c^a$) and if there exists at least one competitor ($m \geq 2$) then the discrepancy must be positive ($\Delta P - \Delta S > 0$) as follows from (5). In this case, the formula coincides with the one where all firms have equal marginal costs and which is less messy to calculate.

Fifth, ceteris paribus, the discrepancy is a concave, the social loss a convex function of c_v. Therefore, a cutoff value $c^{\#} < c^a$ must exist such that the discrepancy $\Delta P - \Delta S > 0$ remains positive if and only if the marginal costs of the primary victim exceed this cutoff. In other words, unless the primary victim has relatively low marginal costs the private loss of the victim exceeds the social loss. The social loss is positive if the victim has average marginal costs. The social loss vanishes if the marginal costs of the victim are so high that his output becomes negligible. It then follows from convexity that the social loss is positive as long as the primary victim would remain active in the absence of an accident. In other words, the linear specification of Cournot does not confirm Bishop's case of zero social loss. However, it supports the use of the negligence rule granting recovery but to the primary victim only. The following proposition summarizes these findings.

Proposition 3 *Under the linear specification of the Cournot model, the primary victim's private loss exceeds the social loss if and only if the primary victim's marginal costs are not too small. The social loss always remains positive.*

So far, these claims have been established for the linear specification of Cournot. They hold beyond as I now want to show.

3.3 More general market structures

In this section, more general market structures are examined. Yet, for simplicity, firms are assumed to be symmetric. Inverse demand is assumed to obey the law of demand but need not be restrained otherwise. The cost function of each firm is $K(x) = k(x) + \phi$ where ϕ denotes fixed costs. Marginal costs are assumed to be positive and to be strictly increasing, i.e.

$dk(x)/dx > 0$ and $d^2k(x)/dx^2 > 0$. For a given market structure, let $x(m)$ and $X(m) = m \cdot x(m)$ denote output per firm and market supply, respectively, if m firms are active. It is assumed that output per firm decreases whereas market supply increases as more firms are brought in, i.e.

$$\frac{dx(m)}{dm} < 0 \text{ and } \frac{dX(m)}{dm} > 0. \tag{6}$$

Finally, since the case of perfect competition has already been dealt with, prices are assumed to exceed marginal costs, i.e.

$$f(X(m)) - \frac{dk(x(m))}{dx} > 0$$

holds for all m.

The profit per firm amounts to

$$G(m) = g(m) - \phi = f(X(m)) \cdot x(m) - k(x(m)) - \phi.$$

Social welfare amounts to

$$W(m) = w(m) - m \cdot \phi = \int_0^{X(m)} f(X)dX - m \cdot k(x(m)) - m \cdot \phi$$

and marginal welfare from adding a marginal firm amounts to

$$\frac{dW(m)}{dm} = G(m) + m \cdot \left[f(X(m)) - \frac{dk(x(m))}{dx} \right] \cdot \frac{dx(m)}{dm} < G(m)$$

and is strictly less than the profit per firm. Without entry barriers, firms enter until economic profits vanish, i.e. $G(m^0) = 0$. Therefore, at free entry, marginal social welfare $dW(m^0)/dm < G(m^0) = 0$ is negative. Due to imperfect competition, the market would sustain more firms than what would be second best.[6] Hence, under imperfect competition and free entry, social welfare with a blackout but net of the victim's fixed costs $W(m^0 - 1)$ exceeds social welfare $W(m^0)$ without accident. It follows that he discrepancy between private and social loss from the accident

$$\Delta P - \Delta S = W(m^0 - 1) - W(m^0) + G(m^0) = W(m^0 - 1) - W(m^0) > 0$$

would be positive indeed.

[6] This result is due to Mankiw and Whinston (1986).

Since fixed costs must be borne, with and without accident, the social loss amounts to

$$\Delta S = w(m) - w(m-1).$$

In the absence of fixed costs, any plausible market theory predicts that a higher number of firms would increase both competition and social welfare such that the social loss ΔS would remain positive quite generally. As a consequence, the case of imperfect competition does neither support Bishop's case of zero social loss. The following proposition summarizes the findings.

Proposition 4 *Under imperfect competition, the social loss from an accident remains positive. Moreover, under free entry at least, the primary victim's private loss exceeds the social loss.*

Therefore, the negligence rule granting recovery of private losses but to primary victims only provides efficient incentives for precaution. Denying recovery even to the primary victim, however, would typically provide insufficient incentives for precaution.

4 Anticipating accidents under perfect negligence rules

So far, firms took the entry decision without anticipating that they might possibly be disrupted from power supply by a cable accident. If such accidents were anticipated, entry choice would follow the logic of backward induction. To examine such entry choice , the situation must be modelled as a game in extensive form. At the first stage, firms decide about entry before, at the second stage, some random move of nature determines whether a potential injurer starts his activity and, if so, within hitting distance of one of the competing firms. Only at the third stage, it is the injurer's turn to take precaution before, at the fourth stage, another move of nature determines whether an accident actually occurs or not at the chosen level of precaution.

Suppose, at the first stage, m firms have decided to enter the market. At the second stage, with probability α, the injurer starts operating in the neighborhood of one of the competing firms. For simplicity, a symmetric setting is imposed such that, from the ex ante view, each firm expects the

injurer starting its operation next to its own site with probability α/m. At the third stage, the injurer after having started his activity in the neighborhood of one of the competing firms, chooses precaution $r \in R \subset [0, \infty)$. The expected social welfare amounts to

$$Y(m, r) = w(m) - m \cdot \phi - \alpha \cdot [r + \varepsilon(r) \cdot (w(m) - w(m-1))]$$

where $w(m)$ denotes the sum of customers' and producers' surplus net of fixed costs as a function of the number m of active firms.

Under a *perfect negligence rule*, the injurer is given incentives to choose socially optimal precaution

$$r^* = r^*(m) \in \arg\min_{r \in R} r + \varepsilon(r) \cdot [w(m) - w(m-1)]$$

and, by doing so, he avoids liability for accidents. Socially optimal precaution depends on the number of active firms.

Anticipating such behavior, a firm's expected profit from the perspective of the first stage amounts to

$$\Gamma(m, r) = g(m) - \phi + \alpha \cdot \frac{m-1}{m} \cdot \varepsilon(r) \cdot [g(m-1) - g(m)] - \frac{\alpha}{m} \cdot \varepsilon(r) \cdot g(m)$$

where $g(m)$ denotes the profit per firm net of fixed costs and in the absence of an accident. Notice, from the first stage's view, a firm does not know, if at all, whether it will benefit from a competitor being hit by an accident or whether it will end up as the primary victim itself.

Since the injurer is expected, by choosing socially efficient precaution, to escape liability, the number of firms m^0 entering under the present setting follows from $\Gamma(m^0, r^*(m^0)) = 0$. Even if the market is governed by perfect competition, the level of entry turns out to be insufficient as I now want to show.

Under perfect competition, the marginal surplus from adding a marginal firm is equal to the profit per firm, i.e. $dw(m)/dm = g(m)$. It follows that

$$\frac{\partial Y(m, r)}{\partial m} = g(m) - \phi - \alpha \cdot \varepsilon(r) \cdot [g(m) - g(m-1)]$$

must hold. Furthermore, under socially optimal precaution,

$$\frac{dY(m, r^*(m))}{dm} = \frac{\partial Y(m, r^*(m))}{\partial m}$$

must also hold. Since, finally,

$$\frac{\partial Y(m,r)}{\partial m} - \Gamma(m,r) = \frac{\alpha}{m} \cdot \varepsilon(r) \cdot g(m-1) > 0$$

it follows that, at free entry while anticipating accidents,

$$\frac{dY(m^0, r^*(m^0))}{dm} > 0$$

must hold such that entry would stop in the range indeed where social surplus is still increasing. Therefore, free entry while anticipating accidents would remain insufficient. The following proposition summarizes these findings.

Proposition 5 *Suppose the market is governed by perfect competition and liability is governed by a perfect negligence rule. Then entry choice would be distorted downwards.*

Notice, for the above analysis, the probability α of the injurer starting his activity in the neighborhood of one of the firms was assumed not to depend on the number of competing firms. Instead, one might assume that this probability is an increasing function of the number of firms because, the more firms are around, the more likely it becomes that the activity of the injurer is close to one of them. In such an extended setting, no doubt, entry choice would remain to be distorted.

5 Capacity choice

The previous section has dealt with entry choice while anticipating accidents. The present section examines the choice of capacity more generally. Capacity choice, again, is modelled as a game in extensive form. At he first stage, m firms decide about their capacities. At the second stage, the market is governed by perfect competition such that prices equal marginal costs. Even if accidents can be ruled out entirely, capacity choice suffers from distortion as I now want to show.

Capacity affects the cost structure of firms. At high capacity, fixed costs are high but marginal costs are low. Formally, if firm j operates at capacity κ_j and produces x units of output, its costs amount to $K(x,\kappa_j) = k(x,\kappa_j) + \phi(\kappa_j)$. The cost function is assumed to exhibit the following properties:

$$\frac{\partial k(x,\kappa_j)}{\partial x} > 0,\ \frac{\partial^2 k(x,\kappa_j)}{\partial x^2} > 0,\ \frac{\partial^2 k(x,\kappa_j)}{\partial x \partial \kappa_j} < 0 \text{ and } \frac{d\phi(\kappa_j)}{d\kappa_j} > 0.$$

Moreover, let $\kappa = (\kappa_1, ..., \kappa_m)$ denote the capacity profile chosen at the first stage.

Let $x_j = x_j(\kappa)$ and $X = X(\kappa) = \sum_j x_j(\kappa)$ denote output of firm j and total output, respectively, as functions of the capacity profile. Due to perfect competition, prices are equal to marginal costs, i.e.

$$f(X) = \frac{\partial k(x_j, \kappa_j)}{\partial x_j}$$

must hold for $j = 1, ..., m$. Differentiating these equations with respect to firm i's capacity leads to

$$\frac{df(X)}{dX} \cdot \frac{\partial X}{\partial \kappa_i} = \frac{\partial^2 k(x_j, \kappa_j)}{\partial x_j^2} \cdot \frac{\partial x_j}{\partial \kappa_i} + \delta_{ij} \cdot \frac{\partial^2 k(x_j, \kappa_j)}{\partial x_j \partial \kappa_i}$$

where δ_{ij} denotes Kronecker's symbol ($\delta_{ii} = 1$ and $\delta_{ij} = 0$ for $i \neq j$). It follows that positive values $\mu > 0$ and $\mu_j > 0$ exist such that

$$\frac{\partial x_j}{\partial \kappa_i} = -\mu_j \cdot \frac{\partial X}{\partial \kappa_i} + \delta_{ij} \cdot \mu$$

and, hence,

$$\left(1 + \sum_{j=1}^{m} \mu_j\right) \cdot \frac{\partial X}{\partial \kappa_i} = \mu > 0$$

must hold. As a consequence, total output increases, i.e. $\partial X / \partial \kappa_i > 0$, the output of all competitors decreases, i.e. $\partial x_j / \partial \kappa_i < 0$ for $j \neq i$, whereas the output of firm i increases, i.e. $\partial x_i / \partial \kappa_i > 0$ if firm i has increased its capacity.

The profit of firm j amounts to

$$G_j = G_j(\kappa) = g_j - \phi(\kappa_j) = g_j(\kappa) - \phi(\kappa_j) = f(X) \cdot x_j - K(x_j, \kappa_j)$$

whereas social welfare net of fixed costs amounts to

$$w = w(\kappa) = \int_0^{X(\kappa)} f(X) dX - \sum_j k(x_j, \kappa_j).$$

Therefore, the marginal increase of social welfare from increasing the capacity of firm i amounts to

$$\begin{aligned} \frac{\partial w}{\partial \kappa_i} &= f(X(\kappa)) \cdot \frac{\partial X}{\partial \kappa_i} - \sum_j \frac{\partial k(x_j, \kappa_j)}{\partial x_j} \cdot \frac{\partial x_j}{\partial \kappa_i} - \frac{\partial k(x_i, \kappa_i)}{\partial \kappa_i} \\ &= \sum_j \left[f(X(\kappa)) - \frac{\partial k(x_j, \kappa_j)}{\partial x_j} \right] \cdot \frac{\partial x_j}{\partial \kappa_i} - \frac{\partial k(x_i, \kappa_i)}{\partial \kappa_i}. \end{aligned}$$

Similarly, the marginal increase of firm i's profit from increasing its capacity amounts to

$$\frac{\partial g_i}{\partial \kappa_i} = f(X(\kappa)) \cdot \frac{\partial x_i}{\partial \kappa_i} - \frac{\partial k(x_i, \kappa_i)}{\partial x_i} \cdot \frac{\partial x_i}{\partial \kappa_i} + \frac{df(X(\kappa))}{dX} \cdot \frac{\partial X}{\partial \kappa_i} - \frac{\partial k(x_i, \kappa_i)}{\partial \kappa_i}$$

and, hence, the discrepancy between social and private benefit from increasing firm i's capacity remains positive, more precisely

$$\frac{\partial w}{\partial \kappa_i} - \frac{\partial g_i}{\partial \kappa_i} = -\frac{df(X(\kappa))}{dX} \cdot \frac{\partial X}{\partial \kappa_i} > 0.$$

In other words, expanding capacity under fully competitive pressure gives rise to a positive externality such that non-cooperative behavior will lead to capacities that are distorted downwards even in the complete absence of accidents.

In the next section, I shall argue that capacity choice gives rise to obligations that are of multilateral nature. To restore full efficiency, the negligence rule would have to take the multilateral nature into account. Anticipating such findings, the distortion of capacity choice identified by the present and the previous section should not prematurely be attributed to the negligence rule as such but rather to the unilateral approach to negligence as taken so far.

6 Multilateral negligence rules

While any of the above settings could be used to make the point, the present section rather adds a new twist by looking at a setting where the victim holds extra capacity, not to lower its marginal costs, but as a backup against accidents. The injurer decides on precaution $r \in [0, \infty)$. There are just two firms, the potential victim v and its only competitor c. If an accident occurs the victim suffers from a private loss $\Delta P > 0$ whereas its competitor enjoys a windfall gain $\Delta Q > 0$. Following habits in the earlier literature, the customer's loss is neglected such that the net social loss amounts to $\Delta S = \Delta P - \Delta Q$ and exceeds the victim's private loss.

If capacities are just hold as a backup against accidents capacity choice affects the probability of a private loss arising from an accident. Let $\kappa \in [0, \infty)$ denote the victim's capacity choice. Then the victim's private loss

ΔP and his competitor's windfall gain ΔQ arises with probability $\varepsilon(r, \kappa)$. The efficient precaution and capacity (first best) solves

$$(r^*, \kappa^*) \in \arg\min r + \kappa + \varepsilon(r, \kappa) \cdot \Delta S. \tag{7}$$

To fully capture causality, the probability of an accident is again thought as arising from the interaction with a random move $\omega \in \Omega$ of nature. The probability of an accident $\varepsilon(r, \kappa) = E[e(r, \kappa, \omega)]$ can then be derived from the accident technology $e(r, \kappa, \omega)$ similarly as before.

Under a unilateral negligence rule with efficient standard of conduct and granting recovery of private losses to the victim, the injurer owes damages

$$D_i(r, \kappa, \omega) = \max\left[e(r, \kappa, \omega) - e(r^*, \kappa, \omega), 0\right] \cdot \Delta P$$

to the victim. It follows from the proof of the next proposition that, under such a unilateral negligence rule, the best response of the injurer to the efficient capacity choice would be efficient precaution, well in line with the findings of section 3. Yet, the victim's best response to efficient precaution would consist of excessive capacity. As said before, the blame for distorted capacity choice should not be put on the negligence rule as such but rather on its unilateral nature.

Strictly speaking, by holding excessive capacity, the victim inflicts harm on his competitor. To reflect this fact, suppose the victim would owe damages

$$D_v(r, \kappa, \omega) = \max\left[e(r, \kappa^*, \omega) - e(r, \kappa, \omega), 0\right] \cdot \Delta Q$$

to his competitor accordingly. This rule takes into account that excessive capacities impose a negative externality on the competitor as the probability of his enjoying a windfall gain would be diminished. In any case, the above multilateral negligence scheme where injurer and primary victim both owe damages would restore full efficiency as the following proposition establishes.

Proposition 6 *Efficient precaution and efficient capacities are a Nash equilibrium under the above multilateral negligence scheme.*

Proof. Suppose, first, that the victim has chosen efficient capacity $\kappa = \kappa^*$. Let $d_i(r, \kappa) = E[D_i(r, \kappa, \omega)]$ denote expected damages owed by the injurer. Then the injurer bears total expected costs

$$r + d_i(r, \kappa^*) \geq r + \left[\varepsilon(r, \kappa^*) - \varepsilon(r^*, \kappa^*), 0\right] \cdot \Delta S \geq r^* = r^* + d_i(r^*, \kappa^*)$$

that attain their minimum at efficient precaution. Hence, efficient precaution r^* is the injurer's best response to efficient capacity κ^* of the victim.

Suppose, second, that the injurer has chosen efficient precaution r^* and, hence, escapes liability. Let $d_v(r,\kappa) = E[D_v(r,\kappa,\omega)]$ denote expected damages owed by the victim. Then the victim bears total expected costs

$$\begin{aligned} & \kappa + \varepsilon(r^*,\kappa)\cdot\Delta P + d_v(r^*,\kappa) \\ \geq\ & \kappa + \varepsilon(r^*,\kappa)\cdot(\Delta P - \Delta Q) + \varepsilon(r^*,\kappa^*)\cdot\Delta Q \geq \\ \geq\ & \kappa^* + \varepsilon(r^*,\kappa^*)\cdot\Delta P = \kappa^* + \varepsilon(r^*,\kappa^*)\cdot\Delta P + d_v(r^*,\kappa^*) \end{aligned}$$

that attain their minimum at efficient capacity. Hence, efficient capacity κ^* is the victim's best response to efficient precaution r^* as well. This establishes the proposition. ■

The above proposition shows that an extensive interpretation of the negligence rule would restore full efficiency with respect to both precaution and capacity choice.[7] However, to keep the floodgates closed, existing legal systems would probably hesitate to rely on such an extensive interpretation of the negligence rule.

7 Concluding remarks

The present paper examines an injurer who directly affects a primary victim but also indirectly affects the victim's customers and competitors. In fear of floodgates, existing legal systems are reluctant to grant recovery of losses to secondary victims. Arguments in favor of such exclusionary practice hint at the other fact that beneficiaries enjoying windfall gains from accidents do neither have to pay compensation. While it is not explicitly claimed that benefits and losses balance exactly, the arguments implicitly allude to a discrepancy between the private loss to the primary victim and the social loss from accidents. The argument is used to justify the restrictive use of granting recovery to indirectly affected parties and, at times, even to the primary victim.

While a discrepancy between private and social loss distorts incentives for precaution under a regime of strict liability, this need not be the case under

[7] See Schweizer (2005c) for another setting where a multilateral version of the negligence rule restores full efficiency.

a negligence rule. In fact, if precaution generates a negative externality to third parties then granting recovery of private losses to primary victims in excess of social losses does not provide excessive incentives as liability would be waved at and beyond efficient precaution.

The present paper explicitly examines the market which may be affected by the tortious act of the injurer. While under both monopoly and perfect competition, the social loss exceeds the primary victim's private loss, the more likely case of imperfect competition in between turns out to enhance the performance of the above negligence rule.

The dividing line under actual legal systems such as the German one is the nature of loss. While damage to person or property can be recovered, pure economic losses cannot. In cases such as cable I and II, this practice is likely to deny recovery of losses to parties that are only indirectly affected by accidents. The analysis of this paper justifies such an exclusionary rule on economic grounds. Yet it fails to justify that even the primary victim may be denied recovery if the harm suffered from an accident classifies as pure economic loss. In fact, since cases such a cable I and II seem to be isomorphic from the economic perspective, an exclusionary rule with respect to the primary victim remains difficult to explain.

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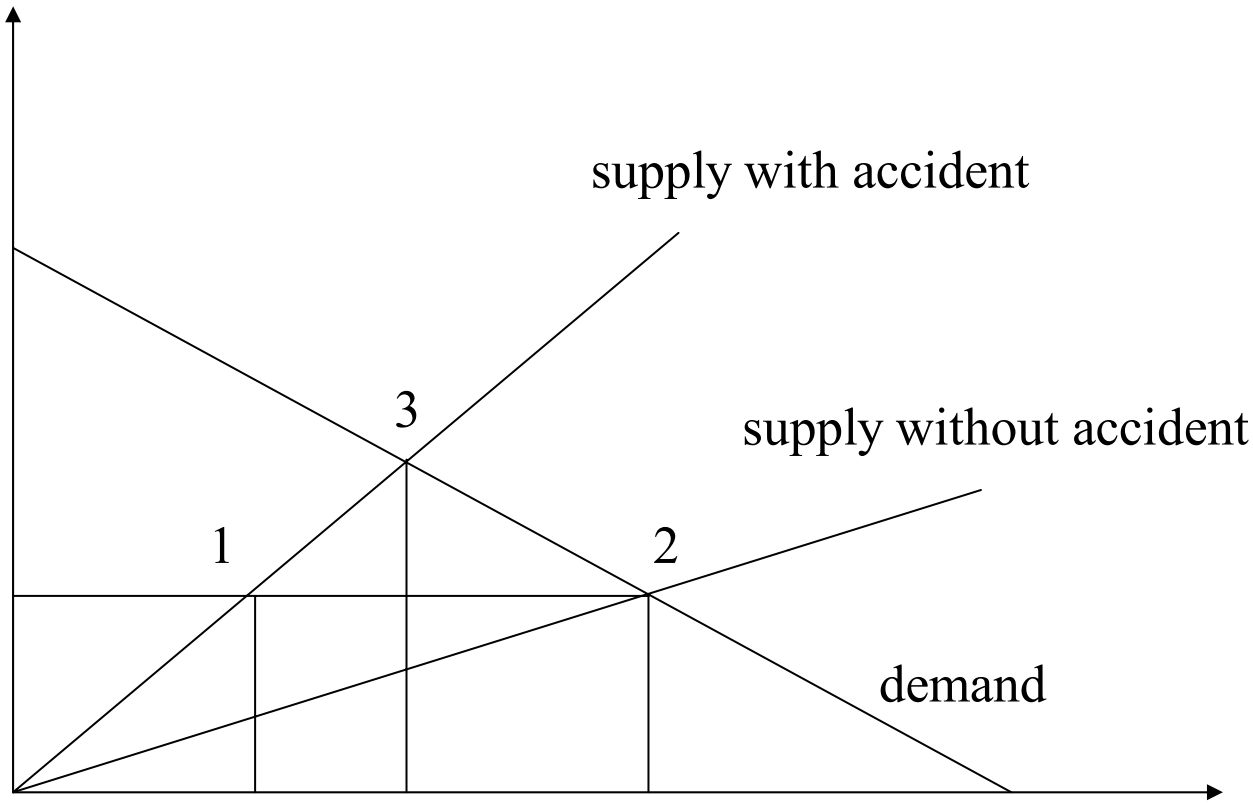

Figure 1: discrepancy between private and social loss