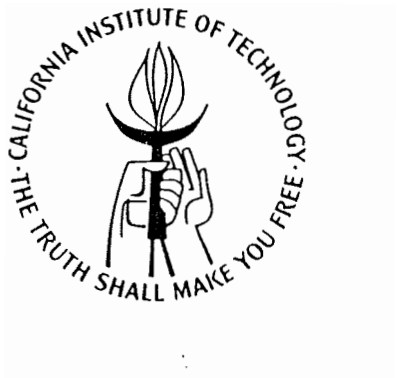
DIVISION OF THE HUMANITIES AND SOCIAL SCIENCES

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA 91125

RESPONSIBILITY, LIABILITY, AND INCENTIVE COMPATIBILITY

Talbot Page



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ABSTRACT

In this paper I ask what should be the assignment of liability for risks of toxic chemicals, and more generally. I develop a theory of liability, based on two principles. The first is responsibility as own-cost-bearing and is justified on the grounds of fairness. The second is efficiency and is justified on the grounds of welfare. These two principles provide a joint foundation to the theory of incentive compatibility, which is an important consideration in the design of liability systems.

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California Institute of Technology

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For more than 20 years Rohm and Haas manufactured chloromethyl-methyl-ether in its production of ion exchange resins. The chemical, along with a contaminant, bis-chloromethyl-ether (BCME) was batched up in large kettles, which were tended by workers, who in turn were exposed to their fumes. Workers began dying of lung cancer, and especially of a relatively rare form of lung cancer, an oat cell carcinoma. At first the management thought the cause was smoking, and told the workers so. Over several years the epidemiologic and bioassay evidence accumulated and increasingly identified BCME as the cause of the "excess" cancers. Rohm and Haas changed its process, but once exposed workers continued to die. By 1974, about 50 deaths were attributed to BCME, the deaths most clearly linked to the chemical. Several families sued Rohm and Haas, but eventually all settled out of court.

In this paper we ask what should be the assignment of liability for risks imposed by chemicals. Should there be strict liability or not? Should "unknowability" be a legal excuse? [1]. Does it matter in an essential way whether those who may be injured by chemicals are in contractual relationships with the manufacturers or distributors of the chemicals?

The paper proceeds as follows. I begin by describing principle of responsibility which identifies a transfer of harm and distinguishes between the actor and the acted upon. The principle is asymmetric as it points to a direction in assigning responsibilities.

I then consider an objection to this principle. Ronald Coase [2] argued that the concept of harm is reciprocal and that it is not possible to distinguish the actor and the acted upon. Coase argued especially against A.C. Pigou, who used the responsibility principle in his analysis of economic externalities [3]. Instead of the responsibility principle Coase argued in favor of an efficiency principle. The dispute between Coase and Pigou is particularly interesting because (without much exaggeration) one can say that Coase was the founder of law and ecomonics and Pigou was the founder of the economic analysis of pollution and congestion problems.

Although the general impression is that Coase and Pigou are strongly at odds, I find that foundationally they are surprisingly close. Pigou also uses an efficiency principle, which turns out to be the same as Coases's efficiency principle. The difference between Pigou and Coase is that Pigou used both

responsibility and efficiency principles while Coase used only the latter. However, I find nothing in Coase showing that the two principles are incompatible. And Coase's examples, chosen to illustrate the reciprocal nature of harm, are more asymmetric than they first appear, thus permitting application of the responsibility principle.

The question then arises: perhaps it is not an exclusive choice between the efficiency and responsibility principles. Pursuing this question, I find that the two principles provide a joint foundation to the economic theory of incentive compatibility. This theory is central to the understanding of tort law systems because of the central problems in the implementation of tort law, of fact finding and incentives to misrepresent. And in the theory of incentive compatability, I find that the responsibility and efficiency principles are not only not in conflict, they are complementary.

The argument of the paper suggests several things: First, a greater emphasis on strict liability and correspondingly less emphasis on negligence. Second, a greater attention to problems of incentive compatibility, especially when there is asymmetric and fragmentary information. Third, a contrast with the way philosophers and legal scholars often look at principles of responsibility and efficiency. It is commonly held that both responsibility and efficiency are appealing normative concepts,

but are in conflict. One has to give up something of one to get more of the other. This paper suggests that such conflict is not inevitable and that it may be useful to look for ways in which various normative principles support each other.

A few words on the history of ideas may provide a context for this paper. Fletcher [4] traces how, beginning in the mid-nineteenth century, tort law has increasingly been viewed as a mechanism for maximizing social utility and efficiency. Coase's famous paper of 1960 strengthened this trend, and reliance on efficiency, often to the exclusion of other normative principles, became a defining feature of the new field of law and economics. In response, Fletcher, Epstein [5], Coleman [6] and others have attempted to ground tort law on normative principles other than efficiency. This paper is part of that response. But instead of focusing on some single alternative to the efficiency principle, I explore the complementary nature of two normative principles -- responsibility and efficiency.

I. The Responsibility Principle

We start with the common sense principle "When A's actions impose costs on B, A should be made responsible, by paying for these costs." I interpret the principle, which I will call the "responsibility principle," as a distributive principle. It tells

us in which direction cost bearing should go. In particular, the principle does not say that B should pay A to reduce the costs, nor does it say that A should necessarily pay B.

To apply the principle we need to be able to identify an actor A, a transfer of harm or cost, and a recipient B. In the transfer there is a notion of cause or action on A's part. "Making A responsible" includes the idea of a disincentive or constraint on A to affect A's behavior or welfare.

Although the principle is general, the language of causal flow incorporated in the responsibility principle is particularly apt for problems of potentially toxic chemicals. Some chemicals do cause physical harm. In epidemiology and toxicology, where the evidence of harm is developed, the language of causality is routinely used in sophisticated, operational detail [7].

I am not saying that the principle is not problematic -- the notions of both cause and harm are problematic. Nonetheless, in most cases, most people will agree on which way the principle points. They may disagree on how far it points (on how much responsibility, how strong the incentive, is enough). But, as I have stated it, the principle is silent on the appropriate degree of the responsibility. How much is not part of the principle; the fact that it points is its essence. It is a principle of asymmetry.

The principle is applied so ubiquitously in our everyday

life that it often goes unnoticed and unremarked. When a firm employs a worker, it transfers costs to the worker by taking his time and setting him to often unpleasant and repetitive tasks. It seems natural for us to think that the firm should pay something for these costs. Paying for its labor, we say uncontroversially, is simply a cost of doing business.

The principle of responsibility as own cost bearing is more ubiquitous than it casually appears, partly because it is so often implemented automatically, without direct state intervention. In ordinary business transactions the principle is automatically implemented, as long as the transactions are characterized by the two conditions of voluntary exchange: excludability and refusability. In everyday life traditions of reciprocity (and sometimes refusal when reciprocity is lacking) help implement the principle.

The normative appeal of the principle rests in large part, I think, on a simple idea of fairness. Thus we say that it is fair for you to pay for the costs you impose on others, and more strongly, it is unfair for you to impose costs on others without bearing at least some cost. In economic contexts, of which we are mostly concerned, another way of putting the matter is that economic actors should do their own cost bearing.

The principle is applied widely in pollution cases. For example, the Organization for Economic Co-operation and

Development (OECD is an organization including Western European countries, the U.S., and Japan) adopted the principle that "the polluter should bear the expenses of preventing and controlling pollution" [8]. Again we say that it is a cost of doing business for a firm to pay for its own pollution abatement and for the cost of pollution which is unabated.

The appeal of the responsibility principle may help explain an incident in Syracuse, New York just after an especially heavy fallout of soot and ash from a power plant belonging to Syracuse University. Several economists decided that this was an opportune time to ask residents for their willingness to pay for cleaner air, while the incident was fresh in their minds. Many of the residents were incensed by the phrasing of the question. Why should they have to pay anything? The university had injured them [9].

The principle is applied not just in economics. It is at the heart of criminal law. We are told "Use a gun, go to jail." We are told that when one intentionally harms another he should be made to pay (and it is understood that "he" refers to the injurer not the victim). When the Godfather "makes an offer you cannot refuse" we smile because we see right through the offer to an extortionary threat and coercive causation.

The responsibility principle is an underpinning of tort law as well. In nuisance law we find frequent use of the word

"cause," much argument as to the actual causes, and frequent (but not universal) judgment against the "causer" of a nuisance. Civil law and criminal law share the common foundation of the responsibility principle; where the two differ is in the notion of intentionality in criminal law. (A second underpinning in tort law is efficiency; and we also find frequent reference to the weighing of utilities.)

For my purposes it is important to note that the responsibility principle, as stated at the beginning of the section, does not require us to think of A as the "bad guy" deserving blame. The association of the principle with criminal law may tempt us in that direction, but I want to resist the temptation. We can think of praise and blame, like intention, as separate concepts which may, or may not, be attached to the responsibility principle. In the case of BCME, Rohm and Haas did not pounce upon the technical faults and ambiguities of the studies (there always are faults and ambiguities) and delay remedial action on the grounds that BCME had not been proven to be the cause of the excess cancers. Instead, when it became clear that the bioassays and epidemiology suggested that it was likely that BCME was a potent carcinogen, Rohm and Haas promptly changed the process and greatly reduced exposure. When one finds reasons to blame it is easier to allocate responsibility. I am particularly interested in the harder but purer case where A's

actions are untainted by malice, sloth, or the intention to do harm.

Pigou, who was one of the first economists to write about the problem of environmental and social costs, adopted the perspective of the untainted case. As he put it,

> "the essence of the matter is that one person A in the course of rendering some service, for which payment is made, to a second person B, incidentally also renders services or disservices, to other persons C, D and E, of such a sort that technical considerations prevent payment being extracted from the benefited parties or compensation being enforced on behalf of the injured parties." (p. 159 (1932 edition)).

No malice, no bad intention, but still the same asymmetry. When A harms C, D or E, according to Pigou, A pays. Pigou suggested restrictive zoning and taxes (what we would now call externality taxes) as disincentives to restrict A's harmful activities. Besides harm, Pigou added the other logical possibility that A could benefit C, D, and E, in which case by the asymmetric principle A should be paid a "bounty" or otherwise benefited.

As I have defined it, the responsibility of bearing one's own costs is a partial principle. It says something about what should happen to A when A's actions generate costs. It does not say what should happen to B who may involuntarily bear the costs.

A second partial principle of responsibility is that when A's actions place costs on B (or harm B), B's well-being should be restored. This second partial principle of responsibility is one of restitution or corrective justice. It is possible to link the two partial principles together so that what A pays is what B gets. But it is important to note that the two principles can be considered separately. What A pays is not necessarily the same thing as what B gets. Separating the two partial principles of responsibility allows us another degree of freedom in designing institutions. For example, we may be able to find fairer and more efficient ways of compensating B than by relying on joint-and-several liability. As another example of the separation of the two principles in criminal law, we rely on the first partial principle but not on the second. When A injures B in a street crime, the government attempts to punish and restrain A, but little is done to compensate B.

In one form or another the responsibility principle goes back many centuries. In "Exodus" we find both partial principles combined:

> "When a man causes a field or vineyard to be grazed over, or lets his beast loose and it feeds in another man's field, he shall make restitution from the best in his own field and in his own vineyard." (Exodus, Ch. 22, v. 5).

In my own view, to deal adequately with toxic risks we need some form of both principles (but not necessarily making A's payment the same thing as B's restitution). While justified on the grounds of fairness, the principle of responsibility as own cost bearing provides incentives for A to undertake precautionary actions. Because we are dealing with potentially grave harms, there is often no possibility of restoring B's well-being once harmed. Thus it is especially important to get the decisions of adequate precaution right in the first place. At the same time, because we are dealing with potentially grave harms, it is also important not to forget B once harmed. In this paper I will say relatively little about the second principle, responsibility as restitution. This is not because I think that the second partial principle is not important -- I think it is -- but because I wish to concentrate on the first partial principle. In particular I am interested in the complementarity between the two normative principles of responsibility and efficiency. Since the first partial principle of responsibility gets most of the attention in this paper, for brevity, when there is no confusion, I will refer to it as I introduced it, as the "responsibility principle." When there might be confusion, I will refer to it as the first partial principle or "responsibility as own cost bearing."

Responsibility as own cost bearing need not always mean that the causal author of a harm should be liable, nor need

liability always rest on this principle. The traditional legal excuses of coercion and ignorance may apply. If A is coerced or is justifiably ignorant, his action may be involuntary, not "really his action," and hence the responsibility principle inapplicable (on the grounds of lack of agency). In such a case, a causal author might be excused from liability. Going the other way, an omission, such as a failure to warn, might be viewed as a failure of an affirmative duty and a ground for liability or some other sanction. In such a case one might be held liable without being a direct causal author.

Where there is uncertainty, the cost A imposes on B is often in the form of a risk, in other words, in the increased probability of harm. Thus when A drives his car he imposes an increased risk of injury to other drivers and pedestrians. Under the interpretation of responsibility developed in this paper, we should hold A responsible for this increased risk. And in practice we do so in several ways. We may require A to bear the burden of the risk, ex ante, by requiring him to buy insurance. We may also require A to bear the burden of the risk ex post, by requiring him to pay the cost of accidents he causes. Or we may require a mix of the two.

In addition, since A's driving imposes increased risks to the B's (pedestrians and others), which are involuntarily borne from the point of view of the B's, we may establish affirmative

duties constraining A's activities. We require A to be licensed and to pass driving tests and obey speed laws. And when A fails these duties, for example by speeding or reckless driving, we not only hold A responsible by fining him or suspending his license, but we also characterize the failure as "wrong" or "blameworthy." Going the other way, if A stays within the bounds of the prescribed duties and still causes an accident, we do not ordinarily think of his action as blameworthy, even though A imposes a harm, which is involuntarily borne by the victim. [10]

Taking into account the possibility of excuses and affirmative duties, the responsibility principle offers an answer to the original question: "How should liability be assigned?" It says the initial assignment should be to A.

According to this principle, Rohm and Haas should be liable (or held responsible in some way). Depending on the strength of the view, it suggests that liability should be strict and there should be no "unknowability" excuse. By making Rohm and Haas pay liability damages, the company is given the incentive to be more careful in the future; by having a rule of strict liability in place beforehand, the company, and other companies like it, is given an incentive to undertake testing and to avoid the harm in the first place.

In his discussion of environmental problems Pigou said little about either partial principle of responsibility. H used

the principle of responsibility as own cost bearing as though it were so natural it needed no discussion or justification. In addition Pigou adopted the efficiency principle. From 1912 the time of his first edition of Economics of Welfare, to 1960, economists considered Pigou's approach the conventional and obvious way of treating these problems. But in 1960 Coase published his attack on the "Pigovian tradition."

II. Objections to the Responsibility Principle

In the "Problem of Social Cost" Coase does not tell us explicitly what his normative criteria are or how they differ from Pigou's, but it is clear that Coase's main criterion is efficiency. I will take the efficiency principle to say: "If social state x is a potential Pareto improvement over social state y, then x should be chosen over y; further, any social state which is chosen should be Pareto optimal." As far as I know, Coase does not use the term Pareto optimal in the paper, although he refers to "optimal" (pp. 6, 16, 41), "optimum" (p. 13), "efficiency" (p. 18 (twice)) -- all in ways consistent with a criterion of efficiency. Further he refers to improving the value of the joint product of A and B (pp. 15, 16 (twice)) and weighing the net gains and losses of alternative social arrangements and choosing the one with the greatest net gain (pp. 26, 27). Under conventional

assumptions in welfare economics this process of weighing the value of joint production and maximizing net gains leads to efficiency.

Coase asserts at the beginning of his paper that the problem is reciprocal. Not to restrain A is to allow B to be harmed. But "To avoid harm to B would inflict harm on A." (p. 2). The implicit implication is that the types of harm are the same for normative purposes.

Coase's policy prescription is in two steps. First rights are defined and allocated (B might be given a right to be free from injury or A a right to injure). The second step is to let A and B bargain (with courts protecting rights and making bargains stick). Coase found that in the idealized case of two parties and zero bargaining costs that no matter which way the rights were initially defined and allocated the result from bargaining would be efficient. This result "astonished" Stigler [11] who wrote he had believed otherwise for years. But once pointed out, the result is very simple, since by assumption A and B costlessly bargain until all the gains of trade are squeezed out and by definition the resulting situation is efficient [12].

To accept Coase's assertion that the situation between A and B is normatively symmetric is to reject the responsibility principle, which consistently and asymmetrically allocates responsibility in favor of A. Apparently Coase's followers agree

on this rejection. Demsetz [13] wrote "An ethical symmetry of the problem should be underscored." As far as I can tell, neither Coase nor his followers offer a reason why the situation is normatively symmetric. The normative symmetry is simply asserted as so natural it needed no discussion or justification, much the way Pigou simply asserted the normative asymmetry of the situation. If anything, instead of neutrality, Coase's followers lean toward favoring A. As Stigler put it, "When a factory spews smoke on a thousand homes, the ideal solution is to arrange a compensation system whereby the homeowners pay the factory to install smoke reduction devices up to the point where the marginal cost of smoke reduction equals the sum of the marginal gains to the homeowners" [14]. Those who accept the responsiblity principle would agree with the residents of Syracuse who failed to see why it was "ideal" for them to pay the polluter to abate.

Thus it seems that the approaches of Pigou and Coase are very different. Pigou sees the matter as asymmetric in which A harms B and the problem is how to restrain A. Coase sees the matter as symmetric, one of maximizing joint net gains. As policy presumption Pigou favors taxes and zoning restrictions on A. Coase favors allocating rights and bargaining. For Coase there is no prescription that the allocation should favor B. In the case of significant bargaining costs, how the allocation comes out depends upon a "neutral" weighing of gains and losses associated with the

alternative possible allocations.

But the surprising thing is not how wrong Pigou was, but how close Pigou and Coase are. So far, I have said little about Pigou, besides his adoption of the asymmetric responsibility principle. To say more brings out the similarity between the two.

Pigou wanted to increase economic well-being by which we would call today "internalizing externalities." In a key passage Pigou wrote:

> "Suppose there are two roads ABD and ACD both leading from A to D. If left to itself, traffic would be so distributed that the trouble involved in driving a 'representative' cart along each of the two roads would be equal. But in some circumstances, it would be possible, by shifting a few carts from route B to route C, greatly to lessen the trouble of driving those still left on B, while only slightly increasing the trouble of driving along C. In these circumstances a rightly chosen measure of differential taxation against road B would create an 'artificial' situation superior to the 'natural' one. (p. 194 (1920 edition))

Pigou deduced that the proper amount of the tax, per cart driven, was equal to the marginal congestion cost it imposed on others. To estimate the proper amount of tax we must bring the "trouble" of travel within the "measuring rod of money," by

estimating the cost of the travel time which results from a marginal unit of congestion. When the appropriate externality tax (equal to the sum of the marginal congestion costs each driver imposes on others) is levied on each causer of congestion, economic welfare will be improved as much as possible. This meant to Pigou that the net gains of travel congestion costs would be maximized. Efficiency, in the form of maximizing the sum of private plus external benefits minus private minus external costs, was clearly an important normative principle for Pigou.

In this approach, Pigou pioneered cost-benefit analysis. Cost-benefit analysis, I hasten to add, is a misnomer. Cost-benefit analysis, as it is actually practiced, is more than analysis. It is a decision procedure, with three main ingredients. First, it uses the distinction between private and external costs and between private and external gains [15]. Second, it attempts to evaluate the costs and gains (benefits) in some commensurate way, usually as Pigou would put it, by the measuring rod of money. Third, it compares the sum of benefits minus costs (private plus external) under alternative institutional arrangements and chooses the arrangement which maximizes the sum of net benefits. In doing so, it embodies the efficiency principle. Later this principle would be described and more rigorously developed by Hicks, Kaldor, Mishan and others, as the principle of potential Pareto improvement (also known as the Hicks-Kaldor criterion). The

particular form of the efficiency principle embraced by Pigou was the simpler one of maximizing the total net benefits, private plus external, over alternative institutional arrangements. To summarize Pigou's approach to the problem of road congestion is to list the three main ingredients of modern cost-benefit analysis. The distinction between private and external is particularly Pigou's contribution.

A succinct, and I believe apt, summary of Coase's approach in "The Problem of Social Cost" is that Coase applied cost-benefit analysis to tort law. Coase's approach is characterized by the same three ingredients. He also embraced the efficiency principle, and in the same simpler form as that used by Pigou. To say this is not to belittle Coase's contribution. Before Coase, tort law was, in the words of Prosser, "an impenetrable jungle" [16]. In applying cost-benefit analysis to law, Coase tamed the jungle into a formal garden. He provided a systematic, coherent view, which in developed form can be seen, for example, in Polinsky's An Introduction to Law and Economics [17].

If I am right, that at bottom Coase is doing little more than applying the cost-benefit approach that Pigou pioneered, then Coase's attack on Pigou is not what it seems on the surface. It is a classic instance of the son disowning the father, while not noticing that he is a chip off the old block.

Since the two efficiency approaches overlap so thoroughly

we can recast the Pigovian approach in Coase's terms. Coase says, (for the case of zero bargaining costs and ignoring the problem mentioned in note 12) efficiency can be obtained no matter which way the rights are allocated. Thus, we can allocate them to B. To do so is consistant with the responsibility principle. Coase says that the result of bargaining is efficient. Next, we let the government subsume the role of bargaining by having it impose the cost of the external damages on A, the same amount that would arise in an efficient bargain with B. Thus in terms of Coase's own argument, both the responsibility principle and the Pigovian policy prescription of government restriction on A can lead to efficiency.

Coase offers examples and argues that Pigovian taxes lead to inefficiency, but the arguments fail on technical grounds [18]. Indeed if Coase had succeeded in constructing an efficiency argument against Pigou, his attack would be self wounding, since we could recast his argument into an attack on one of his subcases. However, Baumol and Oates [19] and others have developed the Pigovian approach in rigorous detail, so it would be surprising for Coase's efficiency attacks to succeed in wounding either Pigou or himself.

It is important to untangle the dispute between Coase and Pigou, because by now a whole generation of economists and legal scholars have come to believe that Pigou was "wrong" and Coase

"right" and with Pigou being wrong the responsibility principle "mistaken." In contrast with this now conventional view, I find that their efficiency analyses are essentially the same and both substantially "correct." The source of the dispute is in the choice of normative premises: Pigou accepts both the responsibility and efficiency principles and Coase accepts only the efficiency principle.

The efficiency principle is symmetric. A dollar's worth of benefits accruing to A is as good as a dollar's worth of benefits accruing to B. Since Coase relies solely on the efficiency principle it is unsurprising that Coase viewed externalities as symmetric.

IV. Coase's Examples

Coase offered four legal examples to show that the problem of social cost is symmetric. The examples were well chosen [20]. It seems in each case that the court might decide either way in assigning liability. His examples suggest a plausibility to his claim of symmetry. But the examples do not undermine the responsibility principle, because it is easy to identify complicating factors which are asymmetric. For Coase's examples the factors work in opposing directions. We cannot infer that they exactly offset each other, in these or other cases.

The first case is that of the doctor and the confectioner, whose noise interfered with the doctor's consulting practice. The "stuff" of harm is the noise transferred. This observation suggests, *prima facie*, that the actor is A, the confectioner and the recipient is B the doctor.

But there are complicating factors. The doctor moved next to the confectioner, so we might contend that the doctor was also an actor, partly causing the harm. Further, the doctor did not complain until eight years later when he began using his stethoscope, and this change in practice might be viewed partly causative. These complicating factors point in the opposite direction, lending a surface plausibility to the claim that the entire situation is "symmetric." (The court decided in favor of the doctor.)

In the second case a weaver used chloride of tin to dye his matting. The "stuff" of transfer was sulphate of ammonia, which was released into the air by a neighboring manufacturer. The sulphate of ammonia drifted onto the weaver's property, reacted with the weaver's chloride of tin, and darkened his matting. Again by looking at the physical transfer, we would conclude that A the manufacturer caused the harm, but again there is a complicating factor. This time A argued that the weaver's use of chloride of tin was "unusual, not according to the custom of trade." Since the conventional way of finding causal attribution

is against a background of the "normal course of affairs" [21], it would not be surprising for the court to find that B also contributed to the cause of harm. The outcome of the case was that, although the court found B to have a right to be protected from A's sulphate of ammonia emissions, the injunction against A was not granted.

In the third case the lines of causality are even more tangled. The plaintiff found that his chimneys no longer drew because the defendent had erected a wall (on the defendant's own property) which obstructed the plaintiff's ventilation. Normally we think of smoke as the stuff of harm transferred, but this time A's smoke harms A, not B. B was sued on the grounds that B's building caused A's smoke to stay with A. As we might expect, the courts had trouble deciding this one. First they decided in favor of the plaintiff, but reversed on appeal.

The last case was decided on the basis of squatter's rights ("doctrine of the last grant"). A brewer used a ventilation shaft which emptied into a neighbor's well. The well owner sued the brewer but lost on the grounds that since the shaft had existed for sixty years and the brewer had used it over this time, the brewer had obtained the right to its further use.

Several possible confusions lurk in Coase's examples. First, it is clear that while the confectioner's noise harms the doctor, the doctor's stethoscope does not harm the confectioner.

As Epstein puts it, "The problem only takes on the guise of reciprocity when the party harmed seeks his remedy in court" (p. 165). It is important not to confuse a physical harm with the effects of a remedy.

Second, in Coase's examples, particularly in case of the chimneys and the wall, there are complications. In interpreting who is the actor, and who responsible, it is often sensible to view more than one party as an actor. In such cases responsibility may be shared, and the payment of the most responsible reduced. But it is a confusion to infer that the liabilities will be exactly offset, or that because there may be shared responsibility, the responsibility principle does not apply. (I will shortly discuss examples of joint responsibility from Pigou and the theory of incentive compatibility.)

And third, the problems of interpretation encountered in applying the responsibility principle to Coase's approach, which focuses on economic cost and joint production of cost, is simpler and more parsimonious. But this too is a confusion. The same ingredients which underlie the responsibility principle are entailed in the concept of economic cost. To apply the responsibility principle it is necessary to identify the four ingredients: actors, causal transfer, harm and recipient. The economic concept of cost entails the concept of a production function. A production function, in turn, embodies a concept of

factors which can vary and a causal transfer between a particular choice of factors and an outcome. The choices are made by actors. Changes in well-being are associated with alternative outcomes determined by the factors. The changes in well-being define the costs or harms to individuals, the recipients. The same four ingredients are built into the concept of economic cost. More generally, these four ingredients underly the concept of an economic game, as I still illustrate in the next section.

Pigou's example of highway congestion is simpler than Coase's examples. Each driver on the congested route is an A, imposing congestion costs on every other driver on that route (and each driver on the congested route is also a B as he waits in line). The toll, or congestion tax, falls on each A, in the role of a source of congestion, in proportion to the marginal damage he imposes on others. The situation is asymmetric in that each A pays and is not paid to drive less. The net result looks symmetric because every driver on the congested route imposes congestion costs on the others and every driver pays. But in the example, Pigou does not call for restitution of each B's loss in welfare from others' actions (only for an efficient reduction in congestion).

An example which separates the roles of A and B is that of an airport and nearby homeowners. The example may at first seem symmetric in causation. It is sometimes argued that by moving

near the airport and then complaining of aircraft noise the homeowners cause harm to the airport. At the same time, of course, the aircraft cause harm to the homeowners. Nonetheless, a straightforward application of the responsibility principle suggests that the stuff of harm is the noise, and that it comes from A the airport, and goes to B the homeowners. Thus the airport should bear a restrictive disincentive on its production of noise. The responsibility principle, as own cost bearing, does not say that B should be compensated. And in fact, to preserve efficient incentives, the homeowners should not be compensated conditioned on living close to the airport. Avoiding such conditional compensation avoids an incentive for too many people to live close to the airport. (If we wish to maintain efficient incentives and to apply, in addition, the principle of responsibility as restitution the homeowners could be compensated, conditioned on their locating before the airport was built or on the airport's efficient noise level after their locating.)

The point is that in the airport example the responsibility principle as own cost bearing is consistent with efficiency, and it is easy to identify A, B, and the stuff of harm. The usual difficult cases are where the various ingredients of the responsibility principle point in opposing directions, as in Coase's examples, or when there is joint causation on B's part. When the recipient's actions jointly contribute to the harm, then

by the responsibility principle itself, A's liability is reduced. Thus in the example of highway congestion, each A contributes only a small part of this total harm, and correspondingly pays only for a small part of the total harm.

V. Incentive Compatibility

The asymmetry inherent in the responsibility principle and Pigou's use of it surfaces (surprisingly) in the theory of incentive compatibility, which deals with incentives to misrepresent. To see this, consider the problem of choosing the level of a public good. For efficiency, the standard theory goes, the government attempts to maximize the sum of individuals' true willingness to pay. However, if the government asks individuals to report their willingness to pay, for alternative levels of the public good, there will be incentives to misrepresent and to "free ride."

Under the most known and studied procedure for dealing with this problem, the Groves mechanism, each individual is made responsible for the consequences of his actions. For each individual i the level of the public good is first calculated on the basis of the sum of everyone but i's reported willingness to pay and then on the basis of the sum of everyone's, including i's, reported willingness to pay. The difference between the two sums

of willingness to pay of others is the "harm" resulting from i's action (his action is his representation of his willingness to pay and its impact on the collective choice). The fundamental result is that by requiring i pay this difference, the procedure induces a dominant strategy for truthful reporting. Each individual i is made responsible for the harm he imposes on others and in consequence all have truthful dominant strategies.

The essential ingredients of the theory of incentive compatibility are: (i) a strategy set for each individual from which he chooses his action (his report in the Groves mechanism); (ii) a joint outcome "determined" by the individual actions and the game form (the chosen level of the public good); (iii) a measure of harm from each i's action (the net benefits to each recipient j with and without i's action); (iv) each i is made responsible for his action by being made to pay for this harm; and (v) the payment is to the government and there is no "budget balance."

The surprising thing is that this is the same list of features which appear in Pigou's analysis of highway congestion. Each driver has a strategy set which describes his choice of routes; the joint decision causes the congestion; each driver is assessed for the harm he imposes on others; he pays for this harm but not to the injured parties. Thus Pigou's asymmetric analysis is an antecedent to the theory of incentive compatibility (an

unwitting antecedent I might add, since Pigou was not addressing the problem of misrepresentation).

The responsibility principle provides a way of explicitly constructing incentive compatible mechanisms in particular situations. The idea is that one takes the costs A imposes on others, as represented by the others (the B's), and internalizes these costs by imposing them back on A (making A responsible). What happens to B (as the recipient) is treated as a separate matter. The result is "almost" efficient.[22]

I have said that the difference between Pigou and Coase is that Pigou used both responsibility and efficiency principles, while Coase used the efficiency principle alone. Since Coase and his followers do not rely on the responsibility principle they must use some other source of asymmetry to assign liabilities, or to conclude it does not matter how liabilities are assigned and to rely on a chance mechanism.

In law and economics it is fairly standard to conclude that it <u>does</u> matter how the liabilities are assigned and to introduce asymmetries, but not by means of the responsibility principle. For example, both Calabresi and Demsetz [23] suggest that liabilities be assigned to the party which is the "least cost avoider." Polinsky [24] suggests that if information is asymmetric in such a way that the court knows B's harm, as a function of A's activity, but not the benefits of A's activity, then efficiency is

improved by assigning liability against A.

Since neither approach is an application of the responsibility principle, we might suspect that these approaches will create perverse incentives to misrepresent. And indeed they do. In each, to obtain the favored assignment of liability, the injurer A has incentives to misrepresent by claiming the prevention costs are higher than they are and their estimation is more highly certain than is actually the case. B has incentives to misrepresent by claiming that the damage costs are more certain and higher than they actually are.

V. <u>Responsibility</u>, <u>Efficiency</u>, <u>and</u> <u>Incentives Compatibility</u>

Under the responsibility principle we think it fair for a firm to pay for the cost it imposes on others, as a cost of doing business. We think it fair for a firm to pay for its labor, and when a firm decreases its labor cost by substituting capital for labor, we think it fair for the firm to pay for its remaining labor (even though it pays "twice" for its remaining labor -- once for the substituting capital and again for the labor itself). We think it fair, as a cost of doing business, for a firm to pay for the pollution it generates, both for its abatement and for its residual damage. We think it fair, as a cost of doing business, when the cost is in the form of a toxicity risk, for the firm to

pay for this cost of risk as well.

In this last case the firm is generating a lottery, with probabilities of harm. A firm can do research to assess the probabilities, but as a practical matter the firm will not be able to assess precisely the likelihood of toxicity associated with a chemical by any finite amount of testing. Even the best tests have error rates.

To put the matter bluntly, when a chemical firm decides to produce a chemical involving some risk of toxicity, it is gambling with the health of its workers, its customers, and/or the public at large. Within constraints we allow firms to take these gambles because there are often large benefits associated with them (and as a practical matter it is not possible to avoid risk altogether). Under the view of responsibility developed in this paper, we do not blame firms for creating such gambles. And when a firm bets on the wrong horse (the chemical turns out to be more toxic than predicted) this outcome is not by itself blameworthy -- the firm simply bet on the wrong horse. Where there is uncertainty, mistakes are inevitable. Nonetheless, when a firm bets on the wrong horse, it pays for the consequences -- partly as a matter of fairness and responsiblity as own cost bearing and partly to provide incentives for efficiency in research and in precautionary behavior, and to avoid incentives to misrepresent [25].

In addition to holding a firm to the consequences of its actions, we may impose constraints in the form of affirmative duties, for example, duties to report test results. (Section 5 of the Toxic Substances Control Act makes it an affirmative duty to report test results for new chemicals.) Some actions, such as lying, failing to follow "good laboratory practices," failing to report test results, and failing to warn of the current hazard assessment may be considered directly blameworthy, calling for liability or other sanctions (possibly including punitive damages or criminal penalties).

The principle of responsibility as own cost bearing says that the initial assignment of liability should be to the risk maker. I have mentioned the excuses of coercion and ignorance. To flesh out the notion of liability corresponding to the responsibility principle we need to address the related issues of reassignment of liability and warnings.

Once assigned, can liability be reallocated through contracting? I would think this should be allowed in many cases where there is voluntary choice. The traditional requisites for voluntary choice are information and lack of coercion (just the reverse of the conditions for involuntary choice used in the excuses from the responsibility principle.) The conditions that employees are as well informed as management as to the nature of the risks and have a baseline of "good" alternative job

opportunities appear to satisfy the requisites. The example of a welder who has other high paying job opportunities but agrees to work on a bridge for extra hazard pay, knowing the extra risk, seems to be a case in point.

It is sometimes argued that when a risk maker provides a warning, he should be "off the hook" to customers and employees, on the grounds that customers and employees could have contracted out, but voluntarily assumed the risk. But for voluntary assumption of risk the warning must correctly conveyed the existing information about risk, it must be correctly interpreted, and there must be no coercion. To some extent these conditions of voluntary agency and voluntary assumption of risk can be checked if there is an actual contract reassigning the risk bearing, but because these conditions of voluntary agency on the part of B the recipient are often only partially met, mere warnings should not be readily assumed to alter the initial assignment of liability to the risk maker. To provide an incentive to warn, where a warning is desirable, a warning can be treated as an affirmative duty with sanctions for failure to warn.

In the airline industry it is generally understood that safety is part of the cost of doing business, and the airline (or manufacturer) should pay for the consequences of accidents without attempting to excuse itself by means of warnings. Other risks, called "ultra-hazardous," are also without excuse from warning.

Traditionally this simple form of strict liability has been reserved for particular risks, such as blasting or keeping wild animals. The risks of toxic chemicals are surely as grave as those from keeping animals; but more generally the simple form of strict liability, without excuse from warning, can be applied where risks are viewed as costs of doing business.

We can compare the simple version of strict liability (without excuse from warning) with the current form of strict liability and two versions of a negligence standard. Consider the following example in which firm X produces a chemical. At the time of its production decision, which is at the time of exposure to $Y_1, Y_2, \ldots, Y_n$ who are employees, customers, and the public at large, the firm assesses the probability of toxicity to be p. Associated with its production of the chemical are net benefits B, which include the sales revenue minus labor costs, etc., and $C_1, C_2, \ldots, C_n$ the "excess" health costs to $Y_1, Y_2, \ldots, Y_n$ if the chemical is toxic (and each $C_i = 0$ if the chemical is not toxic). We suppose that it is later learned, with virtual certainty, that the chemical is toxic (examples of vinyl chloride, asbestos, and BCME come to mind). Y_1 sues the firm.

Under the simple version of strict liability the firm pays C_1 to Y_1, and C_i to each Y_i that can be identified. Under the current version of liability for toxic chemicals, liability is strict but with the important provision that if the harm is to be

an employee or customer, this form is exempt from liability if it "adequately" warned of the risk, (there is no exemption from liability for "strangers," such as third parties affected by an environmentally borne risk). Under the first version of the negligence standard, the Learned Hand test, the court attempts to identify the total harm $C = \sum C_i$, and finds liability if $pC > B$. Schwartz [26] suggests a second version of the Learned Hand test, which is applied to the level of the firm's research. Under this version if the level of research is efficient in the sense that the expected value of further research is less than the cost of undertaking it and if the firm "adequately" warns of the risk, then the firm is not liable to its employees and customers, who (it is assumed) could have responded to the warning by contracting out. An adequate warning would be to report p, the firm's assessment of the risk obtained from the then current efficient level of research. The firm would still be liable for external harms to the public at large, but only up to an aggregate amount of the firm's (ex ante) calculation of the expected harm, pC.

The alternative versions of liability can be distinguished by what information the court must take into account for each, as shown in Table 1.

There are four things to observe from the comparison. First, the fact finding burden for the court is lowest for simple strict liability, higher for the current version of strict

liability, higher for the Hand version, and higher still for the Schwartz version. Second, if there were "perfect markets and perfect courts" all four would lead to an efficient level of research and risk generation by a particular firm [27]. Third, only simple strict liability satisfies the responsibility principle. The responsibility principle is not satisfied for the Hand version of negligence because risks under the negligence standard are free from the firm's point of view, even though they entail real costs, in expectation and on average, to others. Both the current version of strict liability and Schwartz' version of negligence allows exemption to arise from warning. In addition Schwartz would allow the unknowability excuse for risks of toxic chemicals. I will pursue this excuse of ignorance in more detail.

I have already briefly discussed how in some situations lack of information could be an excuse from the responsibility principle. Fletcher gives the example of Smith v. Lampe, which illustrates the appeal of the excuse. The defendant, seeing from the shore a tugboat looming out of a dense fog toward him, honked his horn to warn the boat away. Unknown to the defendant, his warning interfered with a prearranged signal, which was to lead the tug to harbor, and consequently the tug ran aground. We might well agree that it was not "reasonably foreseeable" for the defendant to know about the signal and he should not have been reasonably expected to have found out about it. (In Bayesian

terms, the defendant's state space reasonably does not include the eventuality which occurred.)

The situation is different for a chemical firm. In designing, producing, and marketing a chemical, the firm is creating a lottery of known structure. Further the firm knows a lot about B, C and p. The possible eventuality of toxicity is clearly foreseeable, given the long history and study of toxic properties of chemicals. Indeed the possible eventuality of toxicity is one of the first things a firm thinks about in deciding whether, and under what conditions, to produce a chemical. From the tens of thousands of chemicals already tested, a firm can estimate that roughly 4 percent of the universe of commercial chemicals is carcinogenic and 15 percent toxic in some form [28]. Thus if a firm did no testing and knew "nothing" about a new chemical, and it was "randomly" drawn from the universe of potentially commercial chemicals, it would still be readily foreseeable that the chemical had roughly a 4 percent chance of being carcinogenic and a 15 percent chance of being toxic in some form.

Of course a firm typically knows much more about the chemical -- it knows the geometric structure of the molecule, the properties of closely related chemicals, and probably the results of at least some tests. Stopping at its efficient level of research, the firm's current probability p is (or should be) an

unbiased estimate of the posterior probability which would arise from further research. (In Bayesian terms, the possible eventuality of toxicity is reasonably an element of the firm's state space, and the firm has a reasonable basis upon which to construct its prior and posterior probabilities.) Along with this information, a firm typically has some information on production and exposure, and hence $B, C_1, \ldots, C_n$. Taking all this information into account, the firm makes many complicated choices, concerning the design of the molecule, the amount of testing, manufacturing and use restrictions, production volume, and so on. True, these choices are choices under uncertainty, but this is how we make almost all of our choices.

The firm voluntarily chooses to make the lottery, and in fact tailors the branches of the lottery by its design, testing, production and marketing decisions. Typically the chemical manufacturing firm has better information on the lottery than anyone else. The fact that the firm does not know precisely the probabilities of the lotteries it creates does not make, by itself, its choice involuntary or the excuse of ignorance applicable. On the contrary, as long as the potential consequences are foreseeable, one might conclude that it is more important to make a firm responsible for partially known risks than for fully known risks, because the former interfere more with the recipients' autonomy, being more difficult to defend against.

In short, the ignorance excuse, as I have interpreted it, would apply to Smith v. Lampe, but rarely for toxic chemicals. In contrast, Schwartz' ignorance excuse would apply virtually all the time. In virtually every case, the full extent of a chemical risk is not fully known with any finite level of research, let alone an efficient amount.

The fourth observation to make from the comparison in Table 1 is that because the last three versions of liability do not incorporate the responsibility principle, they will generate incentives to misrepresent. Referring to Table 1, we see that under simple strict liability, the only opportunity for a firm to misrepresent is to argue that the cost of the toxic harm, C_1, is lower than it actually is. However, the firm has no special private information on the plaintiff's harm, which is there for the court to assess directly. Under the current version of strict liability, the court must also assess the adequacy of the warnings. The firm has an incentive to represent the state of information, at the time of the warning, as indicating a low risk and the harm as "totally unexpected," perhaps "unknowable." Part of the court's difficulty is that information on this firm's judgement of p is private to the firm, and thus easier to misrepresent. Under Hand's negligence standard the incentives to misrepresent are larger. It is to the advantage of the firm to argue that B is larger than it actually is, and p and C smaller.

Representations about B in addition to p, involve private information to the firm.

Under Schwartz' version of negligence, the incentives are again larger. In addition to the incentives of the first negligence standard, the firm has incentives to misrepresent on both the cost of his research activity and its expected value of information. One of the most difficult tasks in implementing the excuse of ignorance is reconstructing the firm's judgmental probabilities at the time of testing (and its decision not to test further). These probabilities include the then current (subjective) probability of toxicity (at various potency levels) and what the probabilities would be if further testing had been done (each conditional on a possible outcome of a candidate test). By definition proper scoring rules are the only mechanisms with dominant strategies not to misrepresent probability assessments (assuming risk neutrality). But proper scoring rules can be shown equivalent to simple strict liability rules [29].

The enormous difficulty of reconstructing what a firm knew and how it assessed the probabilities, years before the injury became apparent, is illustrated in the example of Rohm and Haas. In Senate testimony [30] representatives of Rohm and Haas argued that it knew little about the risk until about 1972. Representatives for the workers found in a questionnaire that a company doctor had written that BCME had been observed by 1967 to

be linked with increased lung cancer. There followed an acrimonious debate as to whether the doctor who signed the questionaire was the plant physician or the Corporate Medical Director who might have signed for the plant physician, and whether the questionaire was misleading, as the Corporate Medical Director claimed. Ascertaining these "facts" is just the beginning in an evaluation of an ignorance excuse.

If the unknowability excuse is not allowed, but the risk imposer is held strictly liable whether or not the expected value of information exceeded the costs of gathering it, the risk maker has an incentive to undertake an efficient amount of research without an incentive to misrepresent research cost, the probabilities or the ex ante expected value of information. There is no incentive to misrepresent these assessments because liability does not depend upon these representations.

Compared with negligence standards and the unknowability excuse, strict liability, as an application of the responsibility principle, decreases but does not eliminate all the incentives for misrepresentation. In toxics cases, it is often uncertain whether a chemical has caused an injury. Thus, even with simple strict liability there are incentives for the risk imposer and the injured parties to misrepresent on the issues of causality and the extent of the harm. The point here is not that strict liability eliminates incentives to misrepresent, but that negligence has the

same incentives to misrepresent plus additional ones [31].

VI Conclusion

In this paper I have tried to show the close connection between (i) the partial principle of responsibility as own cost bearing, (ii) incentives compatibility, and (iii) efficiency.

Utilitarianism, and efficiency, are usually viewed as being outcome-oriented. Responsibility, as discussed in this paper, is action-oriented. But in the vocabulary of game forms, which I have used as a common language in the paper, actions and outcomes are closely related. Individuals take actions by choosing strategies. Jointly, as a result of all the strategy choices (including nature's when there is uncertainty), an outcome affecting all the individuals is determined. By taking into account how one individual's action affects others' well-being, institutions can be designed with greater incentive compatibility.

Responsibility is justified primarily on the grounds of fairness in the assignment of cost. That the responsiblity principle also has efficient incentive properties adds to its normative appeal. We do not have to choose between the responsibility and efficiency principles, we can choose both.

NOTES

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1. When "unknowability" is allowed as a legal excuse, a firm can avoid liability by successfully arguing that a risk it imposed was "unknowable" or would have been inefficient to discover. I discuss the excuse in Section V.

2. Ronald Coase, "The Problem of Social Cost," Journal of Law and Economics," 3 (1960), 1-44.

3. Arthur C. Pigou, The Economics of Welfare (London: Macmillan and Co., 1932).

4. George Fletcher, "Fairness and Utility in Tort Theory," Harvard Law Review, 85 (1985), 537-573.

5. Richard Epstein, "A Theory of Strict Liability." Journal of Legal Studies, 2, (1973), 151-221.

6. Jules Coleman, "Moral Theories of Tort: Their Scope and Limits." Parts I and II in Law and Philosophy, 1 and 2, (1982-83), 371-90 and 5-36.

7. See for a short but classic discussion of causality in epidemiology Bradford Hill, "The Environment and Disease: Association or Causation?" Proceedings of the Royal Society of Medicine, 58 (1985) No. 5.

8. Environment Directorate (1974). "The Polluter-Pays Principle: Note on the Implementation of the Polluter-Pays Principle." Mimeo: Organization of Economic Co-operation and Development.

9. See Ronald Ridker, Economic Costs of Air Pollution: Studies in Measurement (New York: Praeger, 1967), 90-114 and 201-6. The question was phrased: "What would you have been willing to pay to have kept this incident from affecting you? ____. (Had I been here that Friday evening before the soot and ash episode and told you what was about to happen, what would you have paid me to have kept your property from being affected?)" Twenty years after the study was designed Ridker and his colleague, William Watson, remember that many were upset by this implicit allocation of rights.

10. To interpret every involuntarily borne harm and every involuntarily borne risk as blameworthy would be to spread the concept very thinly, covering perhaps the vast majority of human actions. Peter Railton ("Locke, Stock, and Peril: Natural Property Rights, Pollution, and Risk" in To Breathe Freely, Mary Gibson, ed. [Totowa, N.J.: Rowman and Allanheld, 1985] pp. 89-123) discusses the problems of liberation and natural rights theories in dealing with pollution and risk.

11. George J. Stigler, The Theory of Price (New York:

The Macmillan Co., 1966), p. 113.

12. As Hurwicz has pointed out, the Coase "theorem," simple as it is, is problematical because Coase did not define the bargaining process. If Coase implicitly meant the parties are to bargain until the core is reached, there is a problem because examples can be constructed where there is no core. See Varouj Aivazian and Jeffrey Callen in "The Coase Theorem and the Empty Core," Journal of Law and Economics, 24, No.1, (1981), 175-81 and responses. William Samuelson in "A Comment on the Coase Theory" (forthcoming in Game-Theoretic Models of Bargaining, A. Roth, ed., [Cambridge: Cambridge Univ. Press]) provides several examples where bargaining is inefficient. Elizabeth Hoffman and Matthew Spitzer in "The Coase Theorem: Some Experimental Tests," Journal of Law and Economics, 25, (1982), 73-98 have constructed a simple experiment where there is a core and where the parties typically bargain to it.

13. Harold Demsetz, "Some Aspects of Property Rights," Journal of Law and Economics, 9, (1966), 61-70.

14. Stigler, p. 113.

15. A (technological) external cost is a direct non-market transferred harm which cannot be costlessly prevented by the recipient (no "refusability"). A pecuniary external cost is a market transferred harm (e.g. a firm is harmed by competitor's lowered prices). In a market equilibrium technological

externalities lead to inefficiency, while pecuniary externalities do not. Pecuniary externalities (see note 15) are often excluded from regulatory attention on the grounds they are temporary. De minimus harm are often excluded as well.

16. W. Prosser, Handbook of the Law of Torts, Section 86 at 571. Fourth edition, St. Paul: West Pub. Co., 1971.

17. Mitchell A. Polinsky, An Introduction To Law and Economics, (Boston and Toronto: Little, Brown and Co., 1983).

18. Coase considers the case of a factory polluting the air and a Pigovian tax, equal to the sum of the marginal damages of per unit of smoke emission and levied as a per unit emission basis (p. 42). According to Coase, as people move next to the factory (perhaps because of the emissions abated, in reaction to the tax, Coase does not say why) the marginal damage, per unit emission increases. This increase, translated back into higher per unit emissions taxes, represents higher costs imposed on the factory. Because the homeowners do not take that cost into account in their decisions to locate near the factory, the Pigovian tax is inefficient, so Coase claims.

This argument is clearly fallacious. The increased cost borne by the factory due to increased per unit effluent taxes is a pecuniary externality. As is well known pecuniary externalities do not prevent Pareto optimality.

In another instance Coase argues that the Pigovian

solution of imposing costs on the railroad train for its damaging sparks may be inefficient (p. 32). According to Coase, by making the railroad liable the farmer becomes indifferent to planting too close to the tracks since Coase assumes the farmer is reimbursed for the damages. Thus he will plant too close. In making this argument Coase forgets what he notes elsewhere (p. 41) -- that the Pigovian tax (here in the form of liability damage paid by the railroad) is usually not paid to B, here the farmer. When the damages are not returned to B, there is no incentive for B to snuggle up too close to the track, he would just get more fire damage that way. It is easy to check that this arrangement -- A pays the government at a rate agreed as the marginal damage of his activity, B bears the fire damage -- leads to Pareto optimality. Sometimes in the Pigovian framework it is suggested that B should be compensated at a rate of damage that would occur if he had taken his best defensive action. This too leads to Pareto optimality, as do other compensations of B which are not conditioned on his actual behavior (they can be conditioned on his best defensive actions). Such compensation systems correspond to adjustments for contributory negligence.

19. William J. Baumol and Wallace E. Oates (1975). The Theory of Environmental Policy. (Englewood Cliffs, N. J.: Prentice Hall, Inc. 1975).

20. In introducing his view of symmetry and rejection of

the responsibility principle, Coase discusses two other examples, one of cattle straying and the other of sparks in a field. The first is the same as the verse I cited from Exodus in Section I, and by a surprising coincidence the second is the same as the following verse. The difference of course is that the two successive verses are affirming the responsibility principle, and thus Coase is taking on the biblical tradition in addition to the "Pigovian tradition." I thank Brian Barry for pointing out this coincidence to me.

21. Epstein, pp. 151-221.

22. More technically the situation is "satisfactory," and there is also an assumption of linear separable utility. Jerry Green and Jean-Jacques Laffont, Incentives in Public Decision Making (New York: North Holland Publishing Co., 1979).

23. Harold Demsetz, "When Does a Rule of Liability Matter?," Journal Legal Studies, 1, (1972), 13-28; Guido Calabresi, The Costs of Accidents: A Legal and Economic Analysis (New Haven: Yale University Press, 1970).

24. Polinsky, p. 22.

25. An alternative to paying for the consequences of a lottery is paying for the expectation of the lottery, for example by requirements to purchase insurance or regulations on the use and production of chemicals.

26. Alan Schwartz, "Products Liability, Corporate

Structure and Bankruptcy: The Remote Risk Relationship," Journal of Legal Studies (forthcoming).

27. The assumption of perfect courts is that courts have zero costs of fact finding and find facts with perfect accuracy. In practice of course, neither assumption obtains. Court costs, primarily including lawyers' fees, are about half of the settlement in an average case. See Peter Rydell, How Trial Fees Would Affect Civil Justice. Rand Paper Series, Santa Monica, California, (1984). Decreasing the fact finding burden of the courts is an important way of decreasing their administrative costs.

28. See Toxicity Testing: Strategies to Determine Needs and Priorities, National Academy Press, Washington D. C. 1984. These rough estimates take into account selection bias which arise from the tendency to test the most suspicious chemicals first.

29. Talbot Page and John Ferejohn, "Improving Risk Analysis" in Contemporary Issues in Risk Analysis, New York: Plenum Press (forthcoming).

30. See United States Senate, Hearings before the Subcommittee on the Environment, Committee on Commerce, March 3, 5, 10 and April 15, 1975.

31. When the causal link is in dispute there are several alternatives. The usual procedure is to require B to show, by a preponderance of the evidence, that there is a link (i.e. the

chemical is toxic). In other words, for A to be liable, B, must convince the court that $p > 0.5$. This standard of proof is generally inefficient (see Talbot Page, "On the Meaning of the Preponderance Test in Judicial Regulation of Chemical Hazards", Law and Contemporary Problems, 46, No. 3,(1983) 267-83). The standard "A is liable if the court finds it is more likely than not that $p > B/C$" is more efficient; it is also close to the Hand test. Typically liability is "winner take all" - - if B can meet the burden of proof in establishing the causal link he recovers, otherwise not. A pays in the event-- A pays for the full harm C_1 when B meets the burden of proof. Another alternative, which may be fairer and have better incentive properties, is for A to pay in the expectation. In this procedure, both A and B present evidence on the causal link or its lack. The court assesses p, the probability of this link, and A pays pC_1. Thus, if the court finds only a 20 percent chance of toxicity, B still gets something, though not as much as had the evidence been stronger. A requirement for A to buy insurance before the harm is another example for A paying in the expectation.

Table 1

	Court must take into account
Strict liability (simple)	C_1
Strict liability (current)	C_1, p
Negligence (Hand)	$C_1, C_2, \ldots, C_n$, B, p
Negligence (Schwartz)	$C_1, C_2, \ldots, C_n, B, p, C_e, p_1, p_2, \ldots, p_K$ $\Delta C_1^1, \ldots, \Delta C_n^1, \ldots, \Delta C_n^K, \Delta B^1, \ldots, \Delta B^K$

Notes: C_e cost of test; p_k revised probability of toxicity if the test outcome is k; ΔB^k optimal change in benefits if the test leads to p_k; ΔC_i^k expected change in harm to i if the firm reacts optimally to possible test result k; K the number of possible test results; n the number at risk.