THE OPTIMAL USE OF NONMONETARY SANCTIONS AS A DETERRENT

Steven Shavell

Discussion Paper No. 10

9/85

Program in Law and Economics

Harvard Law School

Cambridge, MA 02138

The Program in Law and Economics is supported by a grant from the John M. Olin Foundation.

THE OPTIMAL USE OF NONMONETARY SANCTIONS AS A DETERRENT

S. Shavell

Abstract

The optimal use of nonmonetary sanctions as a means of deterring parties from committing socially undesirable acts is studied in a theoretical model that takes explicit account of the information courts possess about parties and their acts.

THE OPTIMAL USE OF NONMONETARY SANCTIONS AS A DETERRENT

S. Shavell*

I. Introduction and summary

This article studies the optimal use of nonmonetary sanctions (imprisonment, the death penalty, probationary restraints on conduct) in a simple model in which the threat of sanctions may deter parties from committing socially undesirable acts. The main assumptions made in the model are that the apprehension of parties requires social expenditures and that the actual imposition of nonmonetary sanctions is socially costly. The motivation for the latter assumption is that the imposition of nonmonetary sanctions often involves direct claims on goods and services (as with the operation of the prison system) and, in contrast to the case with monetary sanctions, results in disutility to punished parties that is not balanced in any automatic way by additions to the utility of other parties.

Social welfare is defined in the model to be the social benefits associated with parties' acts less the harm done and the costs of apprehending parties and of imposing sanctions.[1] The social problem is to choose a set of sanctions and the probability of apprehension in order to maximize social welfare. As will be emphasized, an important aspect of this problem is that because the imposition of sanctions is socially costly, it is best, other things equal, to design the system of sanctions so that sanctions will turn out to be imposed as infrequently as possible.

The social problem is first considered under the hypothetical assumption that the courts[2] can obtain perfect information about parties who have been apprehended. With perfect information, the courts are able to recognize the two situations in which imposing sanctions would not be optimal, namely, where a party's act was socially desirable (speeding in an emergency), and where a party's act was socially undesirable but could not possibly have been deterred given the probability of apprehension (killing in the heat of passion, stealing a large amount when the likelihood of discovery was low). Deterrence might have been impossible given the probability of apprehension because the disutility of sanctions is bounded. With perfect information, the courts will also be able to determine if a party's act was undesirable and could have been deterred. Yet that situation will never arise because it will clearly be best for the courts to set sanctions high enough to deter undesirable acts wherever deterrence can be accomplished.[3] Hence, sanctions will never in fact be imposed. In this case where undesirable acts are deterred, optimal sanctions are not uniquely determined. A sanction could as well be extremely high as barely sufficient to deter, for an extremely high sanction (the death penalty, for instance) is no more costly than a lower one if neither will be imposed.[4] Moreover, optimal sanctions do not depend on the harmfulness of acts (assuming that the harmfulness is great enough to make the acts undesirable).[5] Optimal sanctions are affected, however, by the probability of apprehension and by the benefits parties would derive from their acts, for the expected sanctions must be high enough to offset these benefits.[6] Finally, the optimal probability of apprehending parties reflects a balancing of two factors: the greater is the probability, the more parties who can possibly be deterred, but the larger are the expenses in policing behavior.

The social problem is then reconsidered under the realistic assumption that the courts cannot obtain perfect information about parties. Thus the courts are unable to employ sanctions as just described. They will make various "errors" relative to the situation under perfect information, resulting in the discouragement of some socially desirable acts and in the actual imposition of sanctions (because for instance the courts might apply a positive sanction where deterrence was impossible). In this case, unlike under perfect information, the optimal sanction is uniquely determined -- it represents an appropriate compromise between achieving greater deterrence and the social costs due to the actual imposition of sanctions[7] -- and it does depend on the magnitude of harm done. The optimal probability of apprehension reflects factors similar to those under perfect information.[8]

The article concludes with several remarks.

II. The model

Parties decide whether to commit harmful acts from which they would derive private benefits. Let[9]

b = private benefit to a party from committing a harmful act; $0 \leq b \leq \bar{b}$;

h = harm resulting from an act; $0 \leq h \leq \bar{h}$.

A particular party is identified by b and h, and the distribution of parties by type is described by

$f(b,h)$ = probability density of b and h;

the function f is assumed to be known by the courts. If a party commits an act, he might be apprehended and suffer a sanction. Let

p = probability that a party who commits an act is apprehended and suffers a sanction;

s = sanction; $0 \leq s \leq \bar{s}$.

The level of s is determined by a sanctioning function, that is, a function of the variables that the courts can observe (as discussed below). The utility of a party who commits an act will be b if he is not sanctioned and $b - s$ if he is; if he does not commit an act, his utility will be 0. Therefore, he will commit an act if[10]

$$(1)\ b > ps.$$

Because s is bounded by $\bar{s}$, it may be impossible to deter a party from committing an act. This will be true if

$$(2)\ b > p\bar{s},$$

and such a party will be referred to as undeterrable given p.

Social welfare is defined to be the private benefits, multiplied by a weight, less the harm done and the social costs due to the imposition of sanctions and the apprehension of parties. In particular, suppose that

β = weight for calculating social benefits; βb are the social benefits if a party obtains a private benefit of b from committing an act; $\beta \geqq 0$;11/

σ = weight for calculating social costs from imposition of sanctions; σs is the social cost if the sanction imposed is s; $\sigma > 0$;12/ and

$c(p)$ = social cost of maintaining the probability of apprehension at p; $c(p) > 0$; $c'(p) > 0$; $c''(p) > 0$.

Social welfare thus equals

$$(3)\ \int(\beta b - h - p\sigma s)f(b,h)dbdh - c(p),$$

where the integration is performed over the set of parties who commit the act as determined by (1).

The social problem is to choose the sanctioning function and the probability to maximize social welfare; this choice will be called the optimal system of deterrence and will be denoted s^* and p^*. It will be assumed that $p^* > 0$; otherwise the social problem is without interest.

The first-best behavior of parties -- that which would maximize social welfare if the parties' behavior could be commanded -- is for parties to commit acts if and only if

$$(4)\ \beta b > h.$$

Figure 1 illustrates the regions where it is not and it is best for acts to be committed.[13]

First-best Behavior

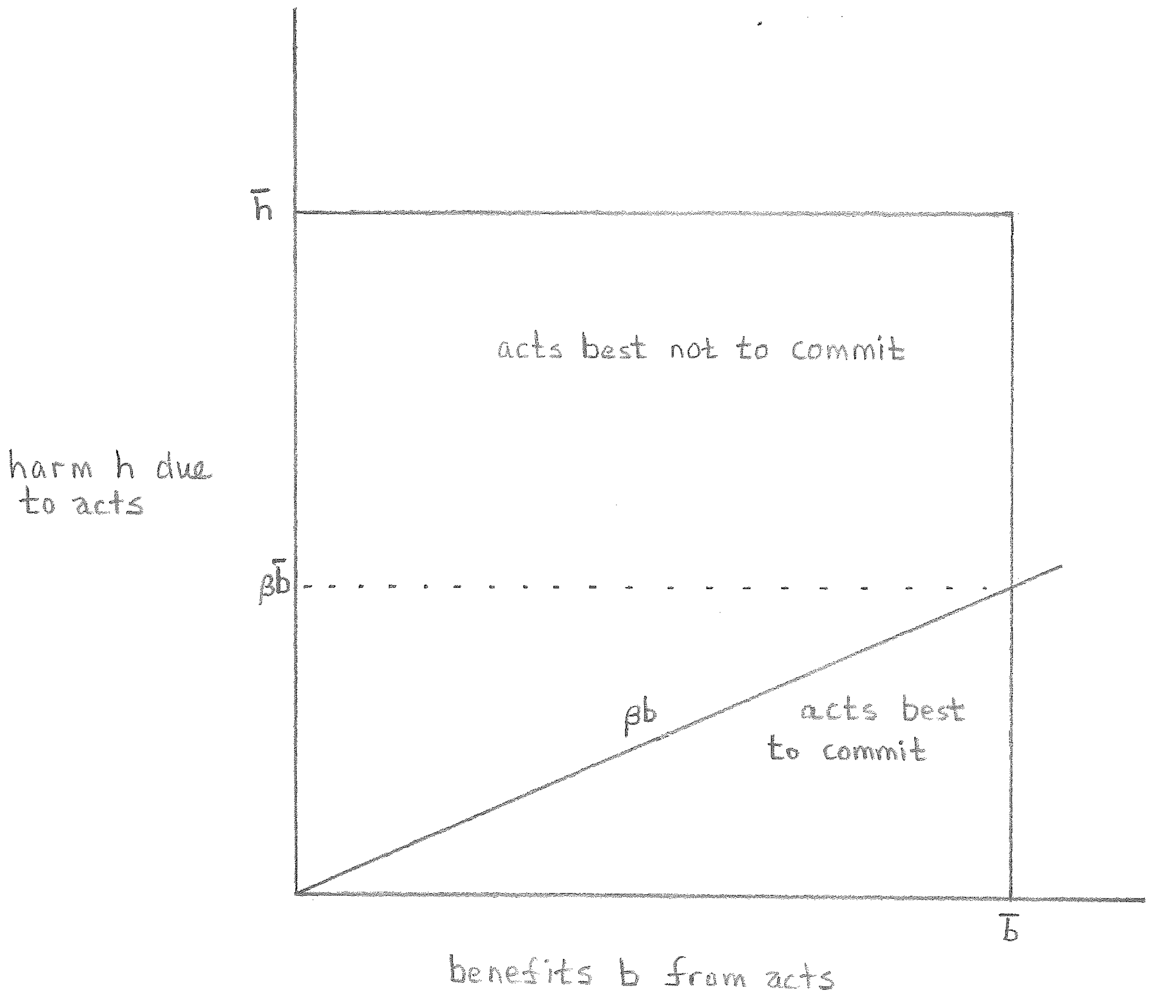

figure 1

III. The optimal system of deterrence where the courts possess perfect information

In this case, the courts can determine the benefits b and the harm h, so the sanction s may be a direct function of b and h. Thus, we have

Proposition 1. If the courts are able to obtain perfect information about parties who are apprehended, then under the optimal system of deterrence,

(a) parties whose acts are undesirable and who can be deterred (given the probability of apprehension) will be deterred by the threat of a positive sanction -- of at least b/p^*;

(b) parties whose acts are undesirable and who cannot be deterred, and also parties whose acts are desirable, will face no sanction and will commit their acts.

(c) Sanctions will therefore never actually be imposed.

(d) The optimal probability of apprehension is such that the marginal cost of raising the probability equals the reduction in harm net of social benefits of additionally deterred parties.

Proof. (a) The claim here is that under the optimal system of deterrence, parties in area A of Figure 2 will be deterred; that is, if $\beta b \leqq h$ and $b \leqq p\bar{s}$, then s^* is any s satisfying $b \leqq ps$. The reason is that this will prevent a decline in social welfare (see (3)) of h per party in A yet not involve the actual imposition of sanctions since parties will be deterred.

(b) The first claim here is that parties in area B will face no sanctions: if $\beta b \leqq h$ but $b > p\bar{s}$, then $s^* = 0$. The reason is that imposing a positive sanction would not deter parties in area B, so its only effect would be to lower social welfare by $p\sigma s$ per party. The other claim of (b) is

Behavior When the Courts Can Obtain Perfect Information

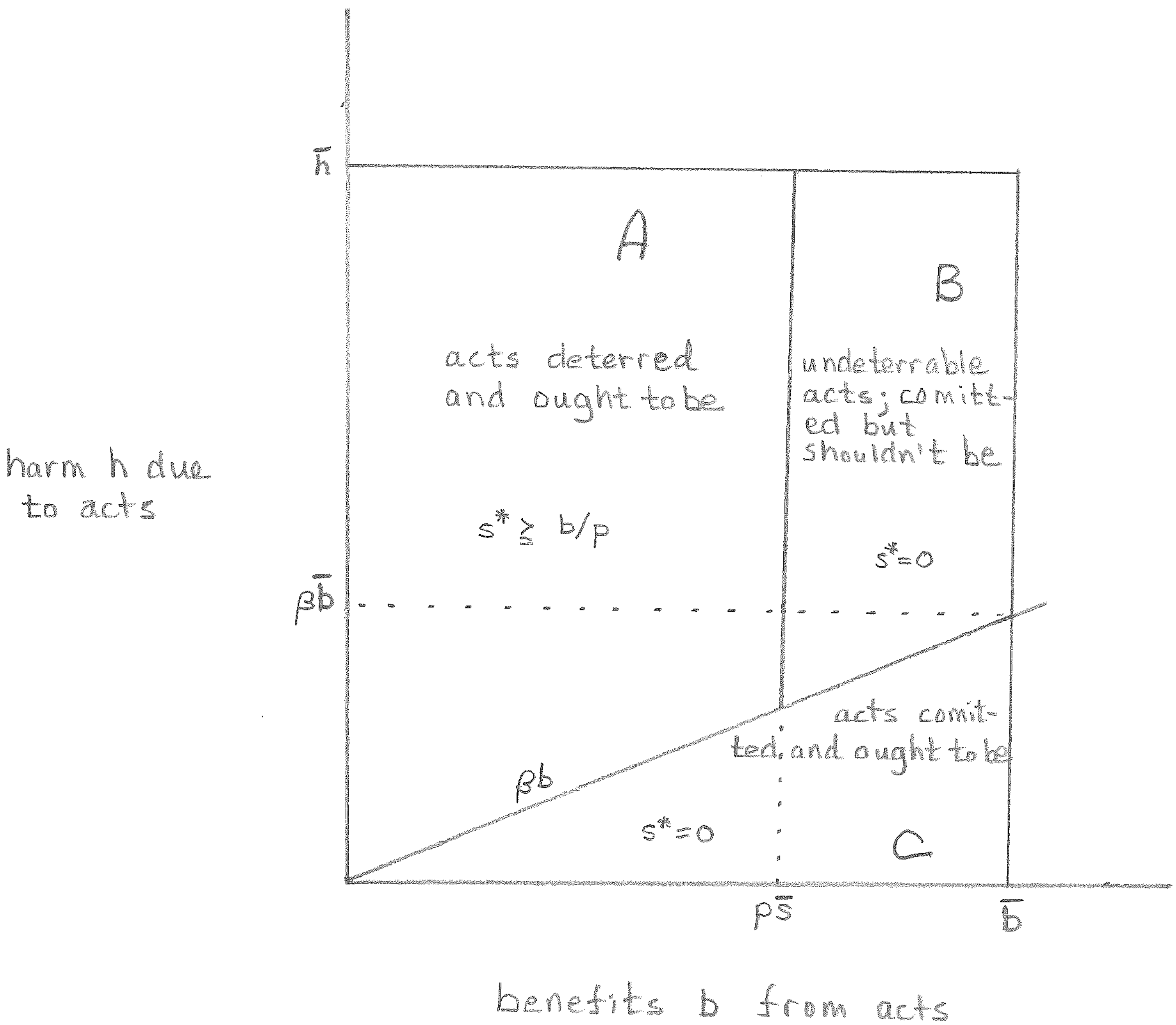

Figure 2

that parties in area C will face no sanctions: if $\beta b > h$, then $s^* = 0$. This is true because with $s^* = 0$, there is an increase in welfare of $\beta b - h$ per party in C, whereas with a positive sanction, welfare will decline by $p\sigma s$ per party not deterred and by $\beta b - h$ per party deterred.

(c) This is immediate from (a) and (b).

(d) From (a) and (b), we know that social welfare can be written

$$(5) \quad \int_0^{\beta\bar{b}} \int_{h/\beta}^{\bar{b}} (\beta b - h) f(b,h)\,db\,dh - \int_{\beta p\bar{s}}^{\bar{h}} \int_{p\bar{s}}^{\min(h/\beta,\bar{b})} (h - \beta b) f(b,h)\,db\,dh - c(p).$$

The first term corresponds to the area C of Figure 2, and the second to the area B. The derivative of (5) with respect to p is

$$(6) \quad \bar{s}\int_{\beta p\bar{s}}^{\bar{h}} (h - \beta p\bar{s}) f(p\bar{s},h)\,dh + \bar{s}\beta\int_{p\bar{s}}^{p\bar{s}} (\beta p\bar{s} - \beta b) f(b,\beta p\bar{s})\,db - c'(p)$$

$$= \bar{s}\int_{\beta p\bar{s}}^{\bar{h}} (h - \beta p\bar{s}) f(p\bar{s},h)\,dh - c'(p),$$

from which it follows that p^* is determined by

$$(7) \quad c'(p) = \bar{s}\int_{\beta p\bar{s}}^{\bar{h}} (h - \beta p\bar{s}) f(p\bar{s},h)\,dh.$$

The left hand side here is the marginal cost of raising p -- of moving to the right the dividing line between areas A and B -- and the right hand side is the marginal benefit of so doing -- the gain due to shrinking B slightly, that is, of deterring those on the dividing line. Q.E.D.

Several characteristics of the optimal system of deterrence may now be noted.

(i) <u>relation of the optimal sanction to h,b,p*, β, and σ</u>. An increase in h has no necessary effect on s* within area A since s* need only satisfy $b \leqq p^*s^*$ there; an increase in h could, however, move an act from area C to A and thus raise s* from 0 to a positive level. An increase in b increases the minimum s* needed to deter within area A, namely, b/p*; but an increase in b could move an act from area A to B and thus reduce s* from a positive level to 0. An increase in p* reduces the minimum s* needed to deter in area A, but because it enlarges area A, it can result in an increase in s* from 0 to a positive level. An increase in β can only reduce s*, for it enlarges area C by rotating the line βb upward and to the left. An increase in σ has no effect on s*. (This is of course due to the fact that sanctions are never actually imposed.)

(ii) <u>relation of the optimal probability to β and σ</u>. An increase in β reduces p*, for the right hand side of (6) decreases with β and the left hand side is unaffected. An increase in σ does not affect p* (again because sanctions are never imposed).

(iii) <u>perfect information about b and h is socially valuable</u>. This is clear since s* depends on both b and h in a non-trivial way.

(iv) comparison to the first-best situation. The situation here is inferior to the first-best situation because here parties in area B are not deterred and because the expense $c(p^*)$ is incurred.

IV. The optimal system of deterrence where the courts' information is imperfect

Now assume that while the courts can determine h, they cannot determine b; in particular, let

r = imperfect indicator of b observed by the courts; $0 \leq r \leq \bar{r}$.14/

Then social welfare may be written as

$$(8)\quad \int_0^{\bar{h}} \int_0^{\bar{r}} \int_{ps}^{\bar{b}} (\beta b - h - p\sigma s) f(b|r,h) f(r|h) f(h)\,db\,dr\,dh - c(p),$$

where $f(b|r,h)$ and $f(r|h)$ are conditional probability densities,[15] $f(h)$ is the unconditional density of h, and s is understood to be a function $s(r,h)$.[16] The support of $f(b|r,h)$ is for simplicity assumed to be $[0,\bar{b}]$; that is, there is a positive probability of any b given any r and h. The solution to the social problem of maximization of (8) over sanctioning functions s and over p is described by

Proposition 2. If the courts cannot obtain perfect information about apprehended parties, then under the optimal system of deterrence,

(a) there may be parties who commit acts and who are sanctioned. These parties may include both those whose acts are and are not desirable, and both those who are and are not deterrable.

(b) Also, some parties may be discouraged from committing desirable acts.

(c) If the optimal sanction is not 0 or $\bar{s}$, it is such that the marginal social cost of raising sanctions, in terms of sanctions actually imposed, equals the net marginal social benefits due to deterrence of additional parties.

(d) The optimal probability of apprehension is such that the marginal social cost of raising the probability plus the cost of imposing sanctions more frequently equals the reduction in harm net of social benefits of additionally deterred parties.

<u>Proof</u>. (a) - (b) are obviously true since the sanction $s^*(r,h)$ does not depend on b.

(c) To derive the condition determining $s^*(r,h)$, note from (8) that $s^*(r,h)$ must maximize

$$(9)\quad \int_{ps}^{\bar{b}}(\beta b - h - p\sigma s)f(b|r,h)db$$

over s. The derivative with respect to s of this equals

$$(10)\quad -\sigma p\text{Prob}[b \geqq ps|r,h] + (h + p\sigma s - \beta ps)f(ps|r,h),$$

so that if s^* is interior to $[0,\bar{s}]$, it is determined by the first-order condition

$$(11)\quad \sigma p\text{Prob}[b \geqq ps|r,h] = (h + p\sigma s - \beta ps)f(ps|r,h).$$

The left-hand side of (11) is the marginal cost of increasing s -- the expected marginal social cost σp of increasing the sanction per party who commits an act times the conditional likelihood $\text{Prob}[b \geqq ps|r,h]$ that a party will do this; and the right-hand side is the marginal benefit of increasing s -- the expected benefit per individual just deterred times the density of these individuals.

(d) For a given r and h, let $w(s,p)$ denote the value of (9) given s and p, and write $s^*=s^*(p)$ to show the dependence of s^* on p. We claim first that if s^* is determined by (11), then $dw(s^*(p),p)/dp=0$. To see this, observe that

$dw(s^*(p),p)/dp = w_s s^{*\prime}(p) + w_p = w_p$ since $w_s = 0$ (this is (11)); and w_p is easily verified to be a positive multiple of w_s, so that $w_p = 0$. If s^* is not determined by (11), one possibility is that $s^* = 0$ and that the non-negativity constraint is binding. In this case as $s^{*\prime}(p) = 0$, $dw(s^*(p),p)/dp = w_p$; but as w equals $\int_0^{\bar{b}} (\beta b - h) f(b\ r,h)\,db$, $w_p = 0$, so that the derivative is again 0. The remaining possibility is that $s^* = \bar{s}$ and the constraint $s \leqq \bar{s}$ is binding. In this case, as $s^{*\prime}(p) = 0$, $dw(s^*(p),p)/dp = w_p$; and as $w = \int_{p\bar{s}}^{\bar{b}} (\beta b - h - p\sigma\bar{s}) f(b\ r,h)\,db$, $w_p = \sigma\bar{s}\,\mathrm{Prob}[b \geqq p\bar{s} | r,h] + (h + p\sigma\bar{s} - \beta p\bar{s}) f(p\bar{s} | r,h)$. It follows from this, the fact that the integral in (8) may be rewritten as $\int_0^{\bar{h}}\int_0^{\bar{r}} w(p, s^*(p,r,h), r,h) f(r|h) f(h)\,dr\,dh$, and the fact that $w_p = 0$ on the boundary of the set $Z(p)$ -- the set of r and h where $s \leqq \bar{s}$ is binding -- that p^* is determined by

$$(12)\quad \sigma\bar{s}\,\mathrm{Prob}[b \geqq p\bar{s} \,|\, (r,h) \varepsilon Z(p)] + c'(p) = \iint_{(r,h)\varepsilon Z(p)} (h + \sigma p\bar{s} - \beta p\bar{s}) f(p\bar{s}|r,h) f(r|h) f(h)\,dr\,dh.$$

The left-hand side of (12) is the marginal social cost of increasing p, comprising both additional sanctions suffered (since more parties are apprehended) and the direct expense of raising p. (By comparison, in (7) the marginal cost equaled only c'(p), for no parties actually suffered sanctions.) The right hand side is the marginal benefits in terms of increased deterrence. Q.E.D.

Characteristics of the optimal system of deterrence may now be discussed.

(i) <u>relation of the optimal sanction to h, r, p*, β, and σ.</u>[17] An increase in h causes s* to rise, other things equal. To show this, note that (11) is of the form $g(s^*,h)=0$. Implicitly differentiating this with respect to h, we obtain $g_s(s^*,h)s^{*\prime}(h)+ g_h(s^*,h)=0$, or $s^{*\prime}(h)= -g_h(s^*,h)/g_s(s^*,h)$. Now $g_s(s^*,h)<0$ (this is the second order condition for optimality of s*), and assuming that the conditional density f does not change with h (to isolate the effect of a change in h), we have $g_h(s^*,h)=f(ps|r,h)>0$, so that $s^{*\prime}(h)>0$ as claimed. The explanation for this is that if h increases, the marginal social cost of imposing sanctions is unaffected, but the marginal benefits of deterrence are increased.

Suppose that an increase in r indicates a rightward shift in the distribution of b; that is, suppose that where $\mathrm{Prob}[b \geq x|r,h]<1$, this probability rises with r for any x. Then writing (11) in the form $g(s^*,r)=0$ and proceeding analogously to the previous paragraph, we see that the sign of $s^{*\prime}(r)$ equals the sign of $g_r(s^*,r)$. Now $g_r(s^*,r)=$ $-\sigma p^*d[\mathrm{Prob}[b\geq p^*s^*|r,h]]/dr+(h+p^*\sigma s^*-\beta p^*s^*)f_r(p^*s^*|r,h)$. By assumption, the derivative of the probability is positive, so the first term is negative; and from (11), $(h+p^*\sigma s^*-\beta p^*s^*)>0$. Hence, certainly if $f_r(p^*s^*|r,h)<0$, g and thus s* decrease with r; but if $f_r(p^*s^*|r,h)$ is sufficiently high, g and s* could increase. The explanation for the ambiguity of the effect of an increase in r is straightforward: when the probability distribution of b shifts to the right, the marginal social cost of sanctions increase (since more parties commit acts, more suffer sanctions); but the marginal social benefits may increase or decrease (because the density of parties just deterred may increase or decrease).

The effect of an increase in p^* or s^* is also ambiguous. Writing (11) in the form $g(s^*,p^*)=0$, we see as before that the sign of $s^{*\prime}(p^*)$ equals the sign of $g_{p^*}(s^*,p^*)=-\sigma\mathrm{Prob}[b\geqq p^*s^*|r,h]+\sigma p^*s^*f(p^*s^*|r,h)+(\sigma s^*-\beta s^*)f(p^*s^*|r,h)+(h+p^*\sigma s^*-\beta p^*s^*)s^*f_b(p^*s^*|r,h)$, which may be positive or negative. The explanation for the ambiguity here is that if p^* rises, the marginal social cost of sanctions may either rise or fall (the probability of imposing sanctions rises per party who commits an act, but the number so doing falls), and the marginal social benefits may also rise or fall (at least because the density of parties just deterred may rise or fall).

If β rises, then s^* falls;[18] for writing (11) in the form $g(s^*,\beta)=0$, we see that the sign of $s^{*\prime}(\beta)$ equals the sign of $g_\beta(s^*,\beta)$, which is $-p^*s^*f(p^*s^*|r,h)<0$. The explanation is that when β rises, the marginal social cost of sanctions is unaffected, while the marginal social benefits fall.

If σ rises, then s^* could rise or fall; for writing (11) in the form $g(s^*,\sigma)=0$, we see that the sign of $s^{*\prime}(\sigma)$ equals the sign of $g_\sigma(s^*,\sigma)$, which equals $-p^*\mathrm{Prob}[b\geqq p^*s^*|r,h]+ p^*s^*f(p^*s^*|r,h)$, which could be positive or negative. The reason for the indeterminacy is that if σ rises, while the marginal social cost of sanctions rises, so do the marginal social benefits (for when a party is deterred, society avoids not only the harm he would do but also the expected social cost of punishing him).

(ii) <u>relation of the optimal probability to β and σ</u>: If β rises, then p^* could rise or fall. To see this, write (12) in the form $g(p^*,\beta)=0$, and note that the sign of $p^{*\prime}(\beta)$ is that of $g_\beta(p^*,\beta)$. But the latter is of indeterminate sign; for the set $Z(p)$ shrinks as β rises,[19] making the derivative of the first term positive and that of the second term negative. Similarly, if σ rises, then p^* could rise or fall; for writing (12) in the form $g(p^*,\sigma)=0$, we see that the sign of $p^{*\prime}(\sigma)$ is that of $g_\sigma(p^*,\sigma)$, which is clearly indeterminate. The explanation for the indeterminacy with respect to β is that both the marginal social costs and benefits of raising p fall with increases in β; and in respect to σ, the explanation is that the marginal social costs and benefits each could either rise or fall.

(iii) <u>imperfect information about individuals' benefits is socially valuable</u>: The imperfect information r is socially valuable because given any h, $s^*(r,h)$ depends on the conditional density function $f(\cdot|r,h)$ in a non-trivial way.

(iv) <u>comparison to the situation where the courts possess perfect information</u>. The situation here differs because some parties suffer sanctions and because some parties whose acts are desirable may be discouraged from committing them.

V. <u>Concluding comments</u>

(a) The model could be extended in the following ways.[20] (i) An act could be associated with a probability distribution of harm (rather than with a single and certain level of harm). And if so, it would be natural to assume that the courts are unable to obtain perfect information about the probability distribution, for in fact all the courts can usually determine directly is the harm actually done, not the harm that might have been done. (ii) A particular issue that could be studied given the previous assumption is the punishment of attempts, that is, acts that happen not to result in harm even though they might be very harmful in an expected sense. (iii) A party's benefits could be allowed to depend on harm done. This assumption is often realistic, for a party's object may be to do harm (as in murder or theft). Moreover, analysis of the assumption would furnish an indirect reason why the sanction should rise with harm, namely, the higher the harm, the higher the party's benefits, and thus the higher the sanction probably needed to deter him. (iv) A party could be allowed to choose among a set of harmful acts. This would allow study of the issue of "marginal deterrence": discouraging a party who is <u>not</u> deterred from committing an undesirable type of act (kidnapping) from doing greater harm (killing his victim) by making the level of the sanction depend on the level of harm done.

(b) The main points regarding the optimal sanction shed light on the principles and doctrines of criminal law.[21]

For instance, the importance given to "intent" in the criminal law may further the purposes of deterrence, for intent can be argued to be a rough proxy for a variety of factors (including the magnitude of the private benefits from committing an act and the expected harmfulness of an act) that raise the optimal sanction. The results concerning the optimal sanction also obviously suggest the rationality of not punishing those who probably cannot be deterred (the insane or the coerced) or those whose acts were not undesirable (those who kill in self defense).

(c) The optimal use of nonmonetary sanctions may be contrasted with the optimal use of monetary sanctions in the usual model of externalities. In that model, of course, if parties pay for harm done, a first-best outcome results, and the only information required by the social authority is the magnitude of the harm. The chief reason that the first-best outcome results without the authority's needing more information is that imposition of the monetary sanctions is implicitly assumed to be costless.[22]

(d) While in the present article, it was assumed that the form of sanctions was nonmonetary, the social decision to employ such sanctions rather than only monetary sanctions could also have been studied. Were this done, the presumed conclusion would be that nonmonetary sanctions would not be optimal to use unless the socially costless (or at any rate less costly) monetary sanctions could not adequately deter parties. That in turn would be more likely to be the case where the harm parties might do is great in relation to their assets and where it would be difficult to identify or apprehend parties who do harm.[23]

Footnotes

* Professor of Law and Economics, Harvard Law School. I wish to thank L. Bebchuk and A.M. Polinsky for comments and the National Science Foundation (grant no. SES-8420226) for research support.

1. Here and below, the word "sanctions" will be understood to mean nonmonetary sanctions.

2. The term "courts" will be understood to refer to the social authority responsible for deciding upon sanctions.

3. Suppose a party would obtain a benefit of 50 from committing an undesirable act, that the probability of apprehension is 10%, and that the maximal disutility of sanctions is 1,000. Then the party could and would be deterred; the threat of any sanction exceeding 500 would do this.

4. In the previous example, whether the sanction used to deter would be just 500 or as high as 1,000 makes no difference, because the party would not commit the act and thus would not be punished.

5. From the example, one can see that the harm that would be done by an undesirable act is irrelevant to the setting of the sanction.

6. In the example, the sanction must be at least 500 so that the expected sanction offsets the benefits of 50.

7. To illustrate, suppose the example is modified as follows. There is an another party who would obtain benefits of 150 from committing the undesirable act and thus who could not be deterred even by the maximal sanction of 1,000

(since the maximum _expected_ sanction is only 100). Suppose also that this second party cannot be distinguished from the first by the courts (the sense in which their information is imperfect). Hence, the courts must apply the same sanction to each party. In this case, a sanction of 500, but not one above 500, would be optimal: a sanction of just 500 would deter the first party; raising the sanction above 500 would not deter the second party but would lower social welfare because it would increase the expected social cost of imposing sanctions on the second party.

8. To my knowledge, the results described in this and the previous paragraph have not been discussed in the literature on deterrence; see Becker [1968], Carr-Hill and Stern [1979], Polinsky and Shavell [1984], and references cited therein. In that literature the analysis has sometimes been carried out mainly at the level of the aggregate number of offenses (as in Becker); and where the analysis has been conducted at the level of the individual (as in Polinsky and Shavell), it has not focused on the information the courts are able to obtain about an apprehended individual's benefits and the harmfulness of his act, or else it has been concerned with monetary sanctions and has implicitly assumed that such sanctions are socially costless to impose.

9. The benefits and (see below) the sanction are assumed to be bounded because, as is well known, the usual axioms of expected utility theory imply the boundedness of utility; see for instance Arrow [1971].

10. Of course, if $b = ps$, the party will be indifferent between committing the act and not; but in order to avoid having to make tedious qualifications, we adopt the convention that the individual will not commit the act in this case, and we adopt similar conventions below without further comment.

11. A weight β less than 1 would correspond to a social discounting of private benefits. Some might find the assumption of such discounting appealing where the source of a party's utility is the disutility experienced by a victim (as in rape). But it will be seen that the qualitative nature of the conclusions below do not depend on whether β is less than 1.

12. The weight σ may be interpreted as measuring both the resource costs involved in imposing nonmonetary sanctions and the disutility of the sanctioned parties.

13. While Figure 1 illustrates the case that seems most interesting, it would be straightforward to examine the cases where for all h there are some b such that acts are best to commit, and the case where $\beta = 0$, so for each h there are no b such that acts are best to commit.

14. We can imagine that $r = r(b,h,\theta)$, where θ is a random variable with density $g(\theta)$; but we will not need to take the generation of r into explicit account.

15. The conditional densities can of course be derived from underlying distributions. For instance, for any b_o, r_o, and h_o, $f(b_o|r_o,h_o) = f(b_o|h_o)g(\theta((r_o,h_o,b_o))/\int f(b|h_o)g(\theta$

$(r_o, h_o, b))db$, where $\theta(r_o, h_o, b)$ denotes the (let us suppose) unique θ such that $r_o = r(b, h_o, \theta)$.

16. The fact that the lower limit of integration in (8) is ps means that the assumption is that parties commit acts if $b > ps = ps(r,h)$. This means that it has been implicitly assumed that parties can predict what the court's observation r will be. It would be more realistic to assume that parties can only imperfectly predict what the courts' observations will be, but assuming this would lead to more complicated expressions without changing the qualitative nature of the results.

17. We assume here that s* is determined by (11); otherwise, as s* will be a corner solution, it will not change with small variations in the parameters (and the way it will change with large variations is similar to what was described in (i) following Proposition 1).

18. Here and in the next paragraph, we look only at the direct effect of a change in the parameter on s*; we do not consider the indirect effect arising because p* will change if β or σ changes.

19. For (r,h) to be in Z(p), (10) must be positive when evaluated at $\bar{s}$. Since the partial derivative of (10) with respect to β is negative, the set of (r,h) in Z(p) must therefore become smaller as β rises.

20. The extensions are discussed informally in Shavell [1985].

21. See generally Posner [1985] and Shavell [1985].

22. Another reason, obviously, is that in the usual model of externalities, parties pay for harm done with certainty. But even where that is not true and parties who are not apprehended escape monetary sanctions, one supposes that the value of information about apprehended parties to the social authority is not as great as it would be were sanctions nonmonetary.

23. This is a theme discussed informally in Posner [1985] and Shavell [1985], and closely related points are made in Becker [1968] at 190-193 and Polinsky and Shavell [1984] at 95.

References

Arrow, Kenneth J., Essays in the Theory of Risk Bearing, Markham Press, Chicago, 1971, 63-69.

Becker, Gary S., "Crime and Punishment: An economic approach," Journal of Political Economy, 1968, 76, 169-217.

Carr-Hill, R. A. and Nicholas Stern, Crime, the Police, and Criminal Statistics, Academic Press, London, 1979, 280-309.

Polinsky, A. Mitchell and Steven Shavell, "The Optimal Use of Fines and Imprisonment," Journal of Public Economics, 1984, 24, 89-99.

Posner, Richard A., "An Economic Theory of the Criminal Law," forthcoming in Columbia Law Review, 1985.

Shavell, Steven, "Criminal Law and The Optimal Use of Non-Monetary Sanctions as a Deterrent," forthcoming in Columbia Law Review, 1985.