OPTIMAL SANCTIONS, UNINFORMED INDIVIDUALS, AND ACQUIRING INFORMATION ABOUT THE LAW

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Discussion Paper No. 62

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Abstract

Individuals sometimes will be uncertain about whether their acts are subject to sanctions, as illustrated by income tax filing and many heavily regulated activities. Some such individuals will be undeterred with regard to illegal acts and others will be deterred from committing legal acts, when sanctions are at the level that would be optimal if all individuals knew whether their acts were legal. In addition to these problems with respect to behavior, the undeterred will bear sanctions, which itself may be socially costly. This paper examines the optimal magnitude of sanctions when some individuals are uninformed about the law, considering both the case in which it is and is not possible to apply different sanctions to the uninformed and to those who knew that their acts were illegal. The difference in achievable welfare in these cases indicates the value of expending resources to differentiate uninformed and informed individuals. All of these issues also are analyzed when it is possible for uninformed individuals, at some cost, to acquire information before they act.

Optimal Sanctions, Uninformed Individuals, and Acquiring Information about the Law

Louis Kaplow*

Individuals sometimes will be uncertain at the time they act about whether their acts are subject to sanctions. Income tax filing and many heavily regulated activities are but the most obvious examples.[1] When individuals are unsure about whether their acts are illegal, some may commit illegal acts and others may be deterred from committing legal acts. For example, individuals uncertain about which income tax deductions are permissible may take many deductions, including some not legally permitted, if their expected sanctions are low. If their expected sanctions instead are high, they may be deterred from these illegal acts but at the same time be induced to forgo legitimate deductions. In addition to these undesirable results, note that undeterred individuals bear sanctions, which themselves may be socially costly.

This paper investigates optimal enforcement when some individuals are uncertain about whether their acts are subject to sanctions. An important aspect of the enforcement problem concerns the question whether the social authority should apply different sanctions depending on whether individuals were informed about the law at the time they act.[2] Section 1 states a model, which is analyzed fully in section 2 for the case when individuals are risk-neutral and sanctions are monetary, and thus (it is assumed) socially costless. If uninformed individuals accurately perceive the likelihood that their acts are harmful, the optimal sanctions for the uninformed and informed are the same. If not, optimal sanctions for the uninformed will be higher or

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[1] Uncertainty may take two forms: uncertainty about sanctioning rules (e.g., is it legal to discharge chemical x?) and uncertainty about the characteristics of one's acts (given that it is legal to discharge chemical x, but illegal to discharge y, does the discharge from my plant contain chemical x or y?).

[2] Also, the model clearly is applicable to the simpler case in which all individuals are uninformed.

lower than for the informed depending on whether the uninformed under- or overestimate the likelihood that their acts are harmful. The optimal sanction when the two groups cannot be distinguished is also determined. The reduction in achievable welfare that arises from the inability to differentiate constitutes the value of information about individuals' types and thus whether it is efficient for the social authority to expend the resources necessary to distinguish the groups.

Section 3 examines the possibility that uninformed individuals obtain information before they act about whether their acts are sanctionable.[3] While such information tends to improve behavior in this model, in some cases the social value of information will not exceed its cost. Moreover, the problem of determining optimal sanctions is affected. When information is available, higher or lower sanctions may be optimal than otherwise. The discussion considers when the availability of information increases achievable welfare and determines the optimal tax or subsidy on information.

Section 4 extends the results to account for socially costly sanctions -- in particular, nonmonetary sanctions (imprisonment) and monetary sanctions when individuals are risk-averse. Sanctioning costs in some cases provide a reason to apply lower sanctions to the uninformed. Section 5 comments on how the analysis bears on the rule that ignorance of the law is not an excuse and related legal issues involving mistake. Section 6 offers brief concluding remarks.

1. The Model

Individuals each decide whether to commit an act. Individuals' benefits from acts, which differ, are not observed by the social authority, which only knows the distribution of individuals' benefits. Only some individuals' acts

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[3] When individuals' uncertainty concerns sanctioning rules (see note 1), for example, information might be obtained from lawyers or through self-study. In an area such as tax compliance, where the cost of information (including time spent reading instructions) is in the billions or tens of billions of dollars annually, this possibility is obviously very important.

are of the type that causes harm. If and only if an act is harmful, there is some probability that the act will be subject to a sanction.

All individuals know the probability of detection and applicable penalty. A portion of the population, however, is uninformed, at the time they decide whether to act, with regard to whether their acts are harmful and thus whether their acts are subject to sanctions. In estimating the likelihood that they will be sanctioned if they commit their acts, decisions of the uninformed are based upon their beliefs concerning the likelihood that their acts are harmful (as well as on their actual knowledge concerning the probability and magnitude of the sanction if their act is indeed harmful).

The social authority determines the magnitude of sanctions, which may consist of monetary sanctions (fines) that are assumed to be socially costless (aside from any risk that may be imposed) or nonmonetary sanctions (e.g., imprisonment) which are socially costly (direct costs of imprisonment and deprivation of liberty). The analysis will consider both the case when the social authority can and that when it cannot determine, after apprehension, whether individuals were informed at the time they acted. For simplicity, it is assumed that the probability of apprehension is given.[4]

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[4] For reasons explored in Shavell (1989), this assumption may be approximately correct for many acts, as when detection resources simultaneously determine the probability of detection for many types of acts. In a simple model, without mistake, if the probability could be set independently for the particular act, the optimum for the cases when individuals are risk-neutral typically involves the maximum feasible sanction and a probability of detection such that the expected sanction is somewhat less than that given by a model with a fixed probability when the sanction is chosen optimally (and is not constrained). This economizes on enforcement expenditures. With mistake, similar analysis would apply, except that when differentiation is feasible a different expected sanction is optimal in some cases, as described below. Because of the benefit of saving enforcement expenditures, the optimum may involve less of a difference in sanctions (including the possibility of no difference) compared to the model examined here. The reason is that one wishes to lower the probability, which, relative to the level yielding the expected sanctions derived below, will result in a lower expected sanction for the group that should receive the higher sanction. (The "high" group will receive the maximum feasible sanction, and the "low" group may receive a lower sanction, but unless it also receives the maximum feasible sanction, the expected sanction for such individuals will be that given by the conditions below.) Finally, when individuals are risk-averse, similar analysis applies except when an optimum involves partial deterrence, in which case a fine lower than the maximum feasible fine and a correspondingly higher probability may be warranted because this combination achieves a given level of deterrence with less risk-bearing costs, and this savings may exceed the additional enforcement cost. See Kaplow (1989a), Polinsky and Shavell (1979).

The following notation is employed:

h = per capita harm of act, if the act is harmful.

θ = portion of population whose acts, if committed, would be harmful.

b = individuals' benefits from acting.

$f(b)$ = continuous distribution on $[0,\bar{b}]$, independent of whether the act is of the harmful type; $F(b)$ is the c.d.f. of $f(b)$.

α = fraction of population that is informed -- i.e., that knows which acts are harmful (independent of whether the act is of the harmful type and of the level of benefits).

q = perceived probability by the uninformed that act is harmful.

p = probability that harmful acts are detected.

s = sanction for detected harmful acts.

σ = social cost (per unit) of nonmonetary sanction.

Harm, benefits, and nonmonetary sanctions are all measured in monetary equivalents.

2. Optimal Monetary Sanctions When Individuals Are Risk-Neutral

2.1. Individuals' optimizing decisions

Regardless of whether they are informed, individuals who do not act receive no benefits from acting and know that they never bear a sanction, so their utility is

(1) $-nh$,

where n denotes the fraction of the population that commits harmful acts.

Individuals who act receive their benefits b and, if and only if their act is harmful, suffer the sanction s with probability p. Informed individuals whose act is not harmful have utility of

(2) $-nh + b$.

As (2) exceeds (1), they will act. If their act is harmful, informed individuals have expected utility from acting of

(3) $-nh + b - ps^i$,

where the superscript "i" refers to the sanction applicable to informed individuals. Informed individuals will commit the harmful act if (3) exceeds (1), which will be true when

(4) $b > ps^i$.

That is, informed individuals whose act is harmful will act when the benefit of the act exceeds the expected sanction. Let b^{*i} denote the type of informed individual who is indifferent -- that is, for whom (4) holds as an equality.

Uninformed individuals do not know whether their act is harmful. If they act, they will be fined if their act is harmful (which they believe has probability q) and their act is detected (which has probability p), so they perceive that their expected utility is

(5) $-nh + b - pqs^u$,

where the superscript "u" refers to the sanctions applicable to uninformed individuals. Uninformed individuals act if (5) exceeds (1), which will be true when

(6) $b > pqs^u$.

Let b^{*u} denote the type of uninformed individual who is indifferent -- that is, for whom (6) holds as an equality. Comparing (4) and (6), note that, if $q < 1$, a higher total sanction will be required to deter the uninformed to the same extent as the informed (whose acts are harmful).

2.2. Social optimization problem

Before proceeding, note with respect to the uninformed that their perceptions determine their behavior but do not directly determine their

contribution to social welfare. For purposes of determining social welfare, their expected utility if they act is given by

$$(5') \quad (1-\theta)(-nh + b) + \theta(-nh + b - ps^u)$$

$$= -nh + b - p\theta s^u.$$

This expression differs from (5) only in the substitution of the actual probability of causing harm, θ, for the perceived probability, q. To illustrate the potential difference, if the uninformed act, anticipating that their acts are unlikely to be harmful, but many in fact are subject to an extreme sanction because most acts actually are harmful, the contribution to social welfare from the expected utility of the uninformed would be lower than indicated by the perceived expected utility given by (5).

The social optimization problem is to choose the sanction to maximize social welfare, defined as the sum of individuals' actual expected utilities. It is assumed that the monetary sanction is socially costless to apply. Thus, because individuals are risk-neutral, sanctions affect social welfare only by their affect on behavior, in determining b^{*i} and b^{*u}.[5] Social welfare can be expressed as

$$(7) \quad W = \alpha(1-\theta)\int_0^{\bar{b}} bf(b)db + \alpha\theta\int_{b^{*i}}^{\bar{b}} (b - h)f(b)db$$

$$+ (1-\alpha)\int_{b^{*u}}^{\bar{b}} (b - \theta h)f(b)db, \text{ or}$$

$$(8) \quad W = \alpha(1-\theta)\int_0^{\bar{b}} bf(b)db + \alpha\theta\int_{b^{*i}}^{\bar{b}} bf(b)db + (1-\alpha)\int_{b^{*u}}^{\bar{b}} bf(b)db$$

$$- \theta h[\alpha(1-F(b^{*i})) + (1-\alpha)(1-F(b^{*u}))]$$

In (7), each term refers, respectively, to acts by the informed whose acts are harmless (these acts produce benefits and have no other effect), acts by the

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[5] Fine revenue, which is assumed to be rebated in a lump-sum manner, will not affect welfare.

informed whose acts are harmful (those not deterred create benefits but cause harm), and acts by the uninformed (same components as the informed whose acts are harmful, but harm is weighted by the probability that the act is harmful). The term for each group is weighted by its portion in the population. (Individuals who do not act do not affect welfare, although they share in the harm produced by those who act.) Expression (8) separates the two types of effects; it states that social welfare is the sum of all benefits from acts minus the harm caused by acts.

2.3. Optimal monetary sanctions when differentiation is feasible

In this case, differentiating (8), the first-order conditions are[6]

$$(9)\quad \frac{dW}{ds^i} = \alpha\theta pf(b^{*i})[h - b^{*i}] = 0, \text{ or}$$

$$(10)\quad s^i = \frac{h}{p}$$

and

$$(11)\quad \frac{dW}{ds^u} = (1-\alpha)qpf(b^{*u})[\theta h - b^{*u}] = 0, \text{ or}$$

$$(12)\quad s^u = \frac{\theta h}{qp}.$$

Equation (9) encompasses the familiar result that optimal deterrence involves an expected sanction equal to the harm of the act, so that individuals whose acts produce more harm than benefit are deterred but those whose acts produce more benefit than harm are not. Equation (11) is an analog, indicating that the expected sanction should equal the expected harm, θh. The interpretation is that, because uninformed individuals do not know in advance whether their act is harmful, the best the social authority can do is to induce them to take into account the probability and magnitude of harm. Because the fraction θ of all acts are harmful, and θ is independent of the level of b, the expected harm when an uninformed individual acts is θh.[7]

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[6] The possibility that $f(b^*) = 0$ at an optimum does not affect the analysis to follow, so it will be ignored.

[7] If the fines given by (10) or (12) are infeasible (as the maximum feasible fine is constrained by individuals' available wealth), the optimal fine would

From (10) and (12), one can see that if $q = \theta$ -- that is, if uninformed individuals accurately estimate the proportion of acts that are harmful -- the optimal fine is the same for both groups. The intuition is that uninformed individuals' acts have expected harm that is weighted by θ (compared to informed individuals whose acts are harmful), but their expected sanction is similarly weighted by q (compared to informed individuals whose acts are harmful) -- recall the discussion comparing (4) and (6). Only if these weights differ is there a reason to apply different sanctions. If $q < \theta$ -- that is, if uninformed individuals believe that their acts are less likely to be harmful than is actually the case -- (10) and (12) imply that the optimal fine on the uninformed exceeds that on the informed.[8] Conversely, if $q > \theta$ -- that is, if uninformed individuals excessively fear that their acts are harmful -- a lower fine is optimal.

2.4. Optimal monetary sanctions when differentiation is infeasible

In (8), assume that the social authority is constrained to apply the same sanction to all who are detected committing the harmful act. The first-order condition is the sum of (9) and (11):

$$(13)\quad \frac{dW}{ds} = \alpha\theta pf(b^{*i})[h - b^{*i}] + (1-\alpha)qpf(b^{*u})[\theta h - b^{*u}] = 0.$$

The bracketed expressions both equal zero if and only if $q = \theta$, in which case the inability to differentiate does not reduce achievable welfare. In other cases, one of the bracketed expressions must be positive and the other negative -- that is, the group for whom the fine ideally would be higher will be underdeterred and the group for whom the fine ideally would be lower will be overdeterred, with the optimal single fine between the levels stated in (10) and (12).

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be the maximum feasible fine, as it is clear from (9) and (11) that welfare is increasing for any lower fine. Similarly, when differentiation is infeasible, the optimal fine would be the maximum feasible fine if the constraint that the fine cannot exceed wealth were binding. (If individuals are risk-averse, the case considered in section 4.2, it need not be the case that a binding constraint on the fine leads to selection of the maximum feasible fine: because the fine is lower, less are deterred, so more bear risk; thus, one must consider whether a further reduction in the fine might be optimal.)

[8] If, however, $q = 0$ -- that is, if uninformed individuals feel certain that their act is not harmful and thus cannot be subject to a sanction -- (11) equals zero for any s^u, which implies that the sanction has no effect on welfare.

2.5. The value of differentiation[9]

One can compute achievable social welfare for each of the two cases, and the difference constitutes the value of information. Obviously, this difference will be greater the greater is the divergence between q and θ. The difference will also depend on the other parameters -- most notably, if α is near zero or one, the optimal single fine will be close to the optimal differentiated fine for the uninformed or informed, respectively, and the loss in welfare from being unable to distinguish the groups will be small.

3. Optimal Sanctions and Ex Ante Information[10]

This section continues to assume that sanctions are monetary and individuals are risk-neutral. It adds the assumption that, at a cost of c, the uninformed can obtain perfect information -- that is, certain knowledge about whether their act is harmful, putting them in the same position as the informed.

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[9] The discussions here and elsewhere of the value of differentiation do not explicitly address or model the cost of differentiation, which would depend, among other things, on the applicability of mechanisms that might induce individuals to reveal information. The form of differentiation costs might itself affect some of the other analysis. For example, if there is a cost per case, this may affect optimal sanctions in a manner analogous to that explored in Kaplow (1989b).

[10] Information may concern the act or legal rules. See note 1. The treatment of information here begins with the first model in Shavell (1988), which examines the decision to acquire information and its affect on behavior when sanctions are given (whereas the focus here is on how the availability of information affects the problem of optimal sanctions and whether information is desirable when sanctions are optimally chosen to take it into account). As explained by Shavell, results suggesting that information has desirable effects on behavior (abstracting from whether the such benefits exceed the cost of information) depend on the assumptions, used here as well, that information is definitive, acts subject to no sanction cause no harm, and information does not reduce expected sanctions for a given act (as when an individual who better understands the law is better able to escape detection). Shavell also assumes that there is no overdeterrence (i.e., that the expected sanctioning cost does not exceed the harm of the act), which holds in the case of monetary sanctions, risk-neutral individuals, and differentiated sanctions (all who purchase information are of type $b \leq \beta$, and (20) indicates that $\beta \leq h$), but overdeterrence may be optimal when sanctions are not differentiated (see the discussion of (24)) and when sanctions are costly (see section 4).

3.1. Individuals' optimizing decisions

Individuals will purchase ex ante information if, given their beliefs q, it increases expected utility. Thus, if they would choose not to act in the absence of information, they will purchase information if

(14) $(1-q)b > c$,

that is, if the perceived likelihood that they will be told that the act is harmless times the gain from the resulting changed decision (the benefit of the act) exceeds the cost of information. (If they are told that the act is harmful, which they believe has probability q, they will not act, resulting in no change in utility since they would not have acted if they did not obtain information.) The group of individuals who would not act without information and would purchase information, therefore, are of type $b \in (c/(1-q), pqs^u]$. (The upper bound, recall from (6), is the uninformed type just indifferent about whether to act, when no information is obtained.)

For those who would choose to act in the absence of information, they will purchase information if

(15) $q(ps^u - b) > c$,

that is, if the perceived likelihood that they will be told that the act is harmful times the gain from the resulting changed decision (the gain from avoiding the sanction minus the loss from forgoing the benefit of the act) exceeds the cost of information. (If they are told that the act is harmless, with probability q, they will act, resulting in no change in utility.) The group of individuals who would act without information and would purchase information, therefore, are of type $b \in (pqs^u, (pqs^u - c)/q)$.

3.2. Social optimization problem

The social optimization problem is to choose the optimal sanction taking into account that some individuals, depending on the level of the sanction, will purchase information and act based on the information they purchase. As a preliminary matter, it is useful to indicate the range of sanctions for

which some individuals will acquire information. Both for individuals purchasing information who would act if advice were unavailable and for those who would not, the critical value of s^u at which the interval vanishes (that is, the value of s^u for which the endpoints are equal) is the same, and is given by

$$(16)\quad \hat{s} = \frac{c}{pq(1-q)}.$$

That is, for any $s^u < \hat{s}$, no individuals acquire information. For such values of s^u, social welfare is given by (7) and (8), and marginal welfare is given by (9) and (11) if sanctions are differentiated and by (13) if not. And, for any $s^u > \hat{s}$, some individuals would purchase information, and these individuals would consist in part of those who otherwise would have acted and in part of those who otherwise would not. For sanctions in this range, social welfare can be expressed, analogously to the statements in (7) and (8), as

$$(17)\quad W = \alpha(1-\theta)\int_0^{\bar{b}} bf(b)db + \alpha\theta\int_{b^{*i}}^{\bar{b}} (b - h)f(b)db$$

$$+ (1-\alpha)\int_{\frac{c}{1-q}}^{pqs^u} [(1-\theta)b - c]f(b)db + (1-\alpha)\int_{pqs^u}^{\frac{pqs^u-c}{q}} [(1-\theta)b - c]f(b)db$$

$$+ (1-\alpha)\int_{\frac{pqs^u-c}{q}}^{\bar{b}} (b-\theta h)f(b)db, \text{ or}$$

$$(18)\quad W = \alpha(1-\theta)\int_0^{\bar{b}} bf(b)db + \alpha\theta\int_{b^{*i}}^{\bar{b}} bf(b)db + (1-\alpha)\int_{\frac{c}{1-q}}^{\frac{pqs^u-c}{q}} (1-\theta)bf(b)db$$

$$+ (1-\alpha)\int_{\frac{pqs^u-c}{q}}^{\bar{b}} bf(b)db - \theta h[\alpha(1-F(ps^i)) + (1-\alpha)(1-F(\tfrac{pqs^u-c}{q}))]$$

$$- (1-\alpha)c[F(\tfrac{pqs^u-c}{q}) - F(\tfrac{c}{1-q})].$$

The effect of the availability of costly information can be seen by comparing (18) and (8). The third term in (18) indicates that those who buy information receive the benefits of the act if and only if it is not harmful (the term is weighted by $1-\theta$). This group includes some individuals who would not have acted but for the availability of information and some who would have acted in any event. (For the latter group, but for obtaining information, all would have acted, rather than only the portion whose acts are not harmful.) In the fifth term, the harm caused by the uninformed involves only those with benefits exceeding $(pqs^u-c)/q$, that is those with benefits so high that information is not worth purchasing. All individuals with lower benefits either act after becoming informed that their act is not harmful or do not act. The sixth term simply measures total expenditures on information.

3.3. Optimal sanctions when differentiation is feasible[11]

Comparing (18) and (8), it is clear that the optimal sanction for the informed, s^i, is unchanged. For the uninformed, the first-order condition in the range $s^u > \hat{s}$, after some manipulation, can be expressed as

$$(19)\quad \frac{dW}{ds^u} = (1-\alpha)pf(\beta)[\theta h - \theta\beta - c] = 0,$$

where $\beta = (pqs^u-c)/q$ -- the type just indifferent between acting without obtaining information and purchasing information (and then acting if and only if the act is harmless). Note that the other marginal type, $c/(1-q)$ -- who is just indifferent between not acting without obtaining information and purchasing information -- does not enter in (19) because this type is fixed by the parameters c and q.

The optimal sanction implied by (19) is that for which

$$(20)\quad \beta = h - \frac{c}{\theta}.$$

This, in turn, implies that

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[11] One could also consider the possibility of applying a different sanction depending on whether individuals acquired information ex ante, if this was feasible.

$$(21)\quad s^u = \frac{h}{p} + \frac{c}{p}\left(\frac{1}{q} - \frac{1}{\theta}\right).$$

When $q = \theta$, the second term on the right side of (21) is zero, and one has the familiar result that the expected sanction, ps^u, should equal the harm. The availability of information, which itself is costly when obtained and which may favorably change behavior, does not alter this result. The reason is that, when the expected sanction equals the actual harm and individuals accurately perceive the probability that their acts are harmful, the only externality is effectively internalized. In this case, the private and social value of information are the same, so individuals will be led to make socially optimal decisions both with regard to acquiring information and with regard to whether to act -- that is, socially optimal given that individuals are uninformed and that information is costly.[12]

This simple result holds only if $q = \theta$. If $q < \theta$ -- that is, if individuals underestimate the likelihood that their acts are harmful -- a higher sanction is optimal. Note that, in this version of the model, the higher sanction does not directly deter more individuals. Rather, it induces individuals who would have acted without obtaining information to purchase information and then decide whether to act. The interpretation is that, when high-benefit individuals -- those who would act if information is unavailable -- underestimate the likelihood that their act is harmful, they similarly underestimate the value of information. A higher sanction than h/p compensates for this by making the *perceived* expected sanction, taking into account their excessive discount q, accurately reflect the actual expected harm. From (21), the greater is the cost of information, the greater is the additional increment in the actual sanction that is necessary to accomplish this. (Conversely, if $q > \theta$, individuals overestimate the harm and thus the value of information at a sanction of $s^u = h/p$. Thus, a sanction lower than h/p is optimal to compensate for this effect.)[13]

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[12] As one would expect, this does not generally involve all acquiring information, because of the cost involved. Those with very high benefits act without obtaining information, as, even if their act is net harmful, the probability is sufficiently small that this is the case and the net harm is sufficiently small that it is not worth expending resources to avoid this. For those with very low benefits, their act may be beneficial, but not sufficiently so to justify the cost of determining whether this is the case.

Condition (21) states a local optimum in the range $s^u > \hat{s}$. There is, however, no guarantee that the optimal sanction defined by (21) is in this range and, even if it is, one must determine whether there exist other local optima in the range $s^u \leq \hat{s}$. To examine these issues, first note that the necessary and sufficient condition for the solution to (21) to equal or exceed $\hat{s}$ is

$$(22)\quad c \leq \frac{\theta h(1 - q)}{1 + \theta - q}.$$

In addition, the necessary and sufficient condition for the optimal differentiated sanction defined by (12) -- the condition when information is unavailable (or too expensive for anyone to purchase) -- to equal or exceed $\hat{s}$ is

$$(23)\quad c \leq \theta h(1 - q).$$

Based on these two conditions, there are four cases to consider.

1. Conditions (22) and (23) both hold: From (11), it is clear that, for any sanction less than that defined by (12), $dW/ds^u > 0$. When (23) holds, this result applies to all sanctions in the range $s^u < \hat{s}$. At

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[13] Further illumination of these points can be obtained by substituting the definition of β in the bracketed expression in (19) and rewriting it as follows:

$$\theta(h - ps^u) + c(\frac{\theta}{q} - 1) = 0.$$

The first term indicates the direct tendency to have the actual expected sanction equal to the expected harm. The second term is a compensation concerning the acquisition of information. When, for example, $q < \theta$, the second term is positive, indicating that welfare is still increasing in the sanction when $s^u = h/p$.

It is also interesting to note that, when $q < \theta$, the optimal sanction for the uninformed is lower when information is available than when not (and conversely for the case in which $q > \theta$). Although in both cases a divergence between q and θ motivated an adjustment in the sanction to compensate for misperceptions, it calls for a greater adjustment when individuals cannot obtain information. (Consider, for concreteness, the case in which $q < \theta$: when information is available, individuals must be induced to overcome their underestimation of the benefits from incurring the cost c, which for the marginal individual just equal c. When information is unavailable, the underestimation pertains to the actual expected harm, θh. Whenever c is sufficiently low that individuals will purchase information at the optimum, it is clear that $c < \theta h$ -- see (19) -- so less of an adjustment is required in the case when information is available.)

$s^u = \hat{s}$, dW/ds^u is not well defined, because (11) and (19) are not equal. But, because both are finite,[14] this presents no problem for determining the optimum, which will be at the level of sanction defined by (21), because (22) guarantees that, at $s^u = \hat{s}$, $dW/ds^u \geq 0$ (and strictly greater if (22) holds as an inequality). The intuition is that as the sanction is raised from 0 to $\hat{s}$, welfare is increasing due to pure deterrence benefits, and, as the sanction is raised from $\hat{s}$ to the s^u defined by (21), welfare is increasing because more individuals who otherwise would have acted purchase information and thus refrain from acting if their act is harmful. The discussion of (21) indicates why the benefit to those who acquire information, rather than being undeterred altogether, exceeds the cost of information. Thus, when the cost of information is "low," the optimal sanction is sufficiently high to induce some individuals to purchase information.

2. Neither (22) nor (23) holds: When (22) does not hold, one can see from (19) that, for $s^u > \hat{s}$, $dW/ds^u < 0$. Thus, the optimal sanction cannot exceed $\hat{s}$. When (23) does not hold, the optimal sanction when individuals purchase no information, given by (12), is less than $\hat{s}$, so it is the optimum. The intuition is that, when the cost of information is sufficiently "high," the optimal sanction is not so large as to induce any individuals to purchase information. And, when this is so, the social welfare problem is no different than if information were unavailable, and thus involves solving (7) or (8).

3. Condition (23) holds, but (22) does not: As just stated, when (22) does not hold, $dW/ds^u < 0$ for $s^u > \hat{s}$. And, when (23) does hold, $dW/ds^u > 0$ for $s^u < \hat{s}$. Thus, the optimum involves a sanction of $\hat{s}$. The intuition is that, up to $\hat{s}$, welfare is increasing due to a pure deterrence effect. Above $\hat{s}$, a higher sanction induces more individuals to purchase information that has a social value less than its cost. Thus, the availability of information leads one to choose a lower sanction than

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[14] As it turns out, both are positive, with the derivative given by (19) exceeding that given by (11).

otherwise[15] in order to avoid inducing individuals to purchase information.

4. Condition (22) holds but (23) does not: When condition (22) holds (as an inequality), there is a local optimum with $s^u > \hat{s}$, defined by (21), that involves some individuals purchasing information. When (23) fails, there is a local optimum with $s^u < \hat{s}$, defined by (12), that involves no one purchasing information. One would have to compare the welfare for each local optimum to determine which was the global optimum. At the higher sanction, defined by (21), there are two differences in behavior compared to the lower sanction, defined by (12). First, some individuals whose benefit exceeds the expected harm are deterred: this adverse result is due to raising the sanction from that defined by (12) to $\hat{s}$. Second, some individuals who would act regardless of whether their act is harmful are induced to purchase information and thus not act when their act is harmful (and this net benefit exceeds the cost of information): this is the desirable effect of raising the sanction from $\hat{s}$ to that defined by (21). Clearly, depending on the parameters, either effect could be greater. Thus, the optimum may involve the social authority choosing a higher sanction than when information is unavailable, because of the benefits of inducing individuals to purchase information before they act, or keeping a low sanction, because of the overdeterrence that otherwise results.

Note that, if $q = \theta$, only the first two cases can arise because conditions (22) and (23) are identical. If $q < \theta$ -- that is, uninformed individuals underestimate the likelihood that their acts are harmful -- (22) is more restrictive, so there exists an intermediate range of costs that corresponds to case 3; if $q > \theta$, (23) is more restrictive, so case 4 may apply. For simplicity, attention for the remainder of this paper largely will ignore cases 3 and 4, although the analysis will be suggestive for these cases. Case 2 is simply that analyzed in section 2: information is so expensive that the optimum is unaffected by its availability. Thus, the discussion to follow

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[15] The sanction would be equivalent if (23) holds as an equality.

considers only case 1. One should note, however, that some of the elements below might affect whether case 1 continues to apply; such complications will be ignored without further comment.

3.4. Optimal sanctions when differentiation is infeasible

Assume that the social authority is constrained to apply the same sanction to all who are detected committing the harmful act. The first-order condition for maximizing welfare is the sum of (9) and (19):

$$(24)\ \frac{dW}{ds} = \alpha\theta pf(b^{*i})[h - b^{*i}] + (1-\alpha)pf(\beta)[\theta h - \theta\beta - c] = 0.$$

As with the case in which information was unavailable (13), the bracketed expressions both equal zero if and only if $q = \theta$, in which case the inability to differentiate does not reduce achievable welfare. In other cases, one of the bracketed expressions must be positive and the other negative -- that is, the group for whom the fine ideally would be higher will be underdeterred and the group for whom the fine ideally would be lower will be overdeterred, with the optimal single fine between the levels stated in (10) and (21). Thus, when $q < \theta$, one will want $s > h/p$ (and conversely for when $q > \theta$), but to a lesser extent than indicated in (21). The value of differentiation would be the difference between welfare at this optimum and that when differentiation was feasible.[16]

3.5. Whether the availability of information increases welfare

Consider the case when differentiation is feasible.[17] To determine

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[16] One might suspect that the value of differentiation will be less when information is available at low cost because, as discussed in note 13, the difference in sanctions between the uninformed and informed when $q \neq \theta$ is less when information is available than when it is not.

[17] When differentiation is infeasible, each problem, as seen in (13) and (24), involves a sanction that compromises between the optimal sanction for each group considered separately. The analysis to follow is suggestive for this case. An additional consideration would arise because, when differentiation is infeasible, the sanction will not be optimal for the uninformed if $q \neq \theta$, as (24) indicates. Thus, those who would have acted if information was unavailable will value information to an extent that diverges from its social value. When differentiation is feasible, this problem can only arise with respect to those who would not act if information were unavailable, as explained in the discussion of (25), to follow. Finally, because less of a difference in sanctions is optimal when information is available, see note 13, one might expect that the loss in welfare resulting

whether the availability of information improves welfare in case 1, one can subtract (8) -- welfare when information is unavailable -- from (18) -- welfare when information is available, evaluating each at the relevant optimal sanction. There are two subcases to examine. First, assuming that, at the relevant optima, $c/(1-q) \leq b^{*u} \leq \beta$,[18] the difference in achievable welfare can be expressed as

$$(25)\quad (1-\alpha)\int_{\frac{c}{1-q}}^{b^{*u}} [(1-\theta)b - c]f(b)db + (1-\alpha)\int_{b^{*u}}^{\beta} [\theta h - \theta b - c]f(b)db.$$

(Note: b^{*u} and β refer to the optima defined by (11) and (20), respectively.)

The first term in (25) reflects the effect on individuals who would not have acted if information were unavailable but who obtain information when information is available. All such individuals spend c and, with probability $1-\theta$ (that is, if they learn that their act is not harmful), act, obtaining benefit b. Recall from (14) that individuals who would not act without information purchase information if and only if $(1-q)b > c$. Thus, if $q \geq \theta$, all individuals in this group produce a gain in welfare when information is available (except the marginal type when $q = \theta$, for whom there is no effect). If $q < \theta$ -- which, recall, implies that such individuals overvalue information -- some individuals have a lower *actual* expected value of information than its cost, so the availability of information would reduce welfare with respect to such individuals.[19]

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from the forced compromise in setting the single, undifferentiated sanction to be less when information is available.

[18] Case 1 assumes that conditions (22) and (23) hold, and each condition implies, respectively, that $\beta \geq c/(1-q)$ and $b^{*u} \geq c/(1-q)$ at the relevant optima. Thus, the only question is whether $\theta h = b^{*u} \leq \beta = h - c/\theta$ -- that is, whether $c \leq \theta h(1-\theta)$. A sufficient condition is $q \geq \theta$, as is clear from (23). If $q < \theta$, (22) is more restrictive than (23) and it can be demonstrated that $\theta h(1-\theta)$ is necessarily less than the right side of (22), so there will exist intermediate levels of c such that, in case 1, $\beta < b^{*u}$.

[19] Note that if $c = 0$, all the uninformed purchase information and there can be no individuals for whom the actual expected value of information is less than the cost of information. In this case, it is as if all individuals are informed, so there will be a single optimal sanction, given by (10), equal to h/p. Better control is possible when individuals are informed, because the problem of deterring harmless acts is eliminated and that of imposing sanctions (which may be costly) on undeterred individuals may be diminished. (With respect to the latter, whatever level of deterrence, b^{*u}, is achieved when information is unavailable can be achieved if all individuals are informed with a lower sanction, because it will be discounted by p rather than

The second term in (25) reflects the effect on individuals who would have acted if information were unavailable but who obtain information when information is available. The bracketed term is zero for the marginal type, β, according to the first-order condition (19), so the integrand is zero when evaluated at the upper limit of integration stated in (25). Thus, the integrand is positive (for all but this marginal type), so the second term is positive. That is, all who purchase information have an actual (as well as a perceived) value of information greater than (or equal to) its cost. Unlike with the first term in (25), this result is unambiguous and is independent of the relative magnitude of q and θ. The reason, recall from the discussion of (19), is that the margin reflected by the upper limit of integration (whether to act without acquiring information or to acquire information to decide whether to act) is optimized through the selection of the sanction, s^u. That is, when individuals over- or underestimate the value of information, the optimal sanction compensates completely, resulting in an undistorted decision concerning whether to acquire information.

Combining these effects, the availability of information will be desirable in this subcase, taking into account its real cost, unless individuals underestimate θ by a sufficient amount that a large enough number of individuals with low benefits purchase information unnecessarily so that the waste of resources on information exceeds all the benefits that result when it is available. How large this underestimate would have to be depends, most notably, on the fraction of the population whose benefits are in the range that results in a negative contribution to welfare.

Now, consider the second subcase: $c/(1-q) \leq \beta < b^{*u}$ at the relevant optima. As discussed in note 18, this may (but need not) be the case only if $q < \theta$. (In particular, it requires that c exceed $\theta h(1-\theta)$ but not be so high

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by pq. Thus, a lower actual sanction is imposed on those who are undeterred. The possibility that a different sanction might then be optimal can only improve welfare further.)

that condition (22) or (23) fails.) In this instance, the difference in welfare can be expressed as

$$(26)\quad (1-\alpha)\int_{\frac{c}{1-q}}^{\beta}[(1-\theta)b - c]f(b)db + (1-\alpha)\int_{\beta}^{b^{*u}}[b - \theta h]f(b)db.$$

(As with (25), b^{*u} and β refer to the relevant optima.) The first term is similar to that in (25); it indicates those who would be deterred at the optimum if information were unavailable but who would acquire information (and act if the act is harmless) if information is available. From (19), the upper limit of integration, β, equals $h-c/\theta$ at the optimum. Substituting this for b, one can demonstrate that $(1-\theta)\beta - c$ is negative in this case with $\beta < b^{*u}$. As a result, all individuals in this group incur a cost for information that exceeds its social benefit. (Recall that in this special case, $q < \theta$, so, as explained in the discussion of (25), individuals' private value of information for those who would not act if information is unavailable exceeds the social value of information.)

The second term in (26), which has a different character than that in (25), refers to those who would be deterred at the optimum when information is unavailable but who would be undeterred (and not even induced to acquire information before acting) when information is available. Because $b^{*u} = \theta h$ at the relevant optimum, this term also indicates a negative contribution to welfare. The reason that $\beta < b^{*u}$ when these conditions hold is that, although it would be desirable to deter individuals of types $b \in (\beta, b^{*u})$, a sanction sufficiently high to do so would result in their purchasing information that has a social value less than its cost.

Combining these two effects, the result is that, in this subcase, the availability of information unambiguously reduces achievable welfare. Thus, in case 1 as a whole, the availability of information increases welfare if $q \geq \theta$ and may increase or reduce welfare if $q < \theta$. The effect of information on welfare in the other cases is straightforward. In case 2, the problem was unaffected by the availability of information. In case 3, the availability of information reduces welfare, because a lower sanction (forgoing desirable

deterrence) is required in order to avoid inducing the inefficient purchase of information. In case 4, the availability of information could only improve welfare, as the optimum when information is unavailable remains feasible and an additional local optimum, involving a higher sanction, is also feasible.

3.6. Optimal tax or subsidy on information

Finally, it is interesting to inquire whether a price equal to the cost of information is optimal (in case 1). That is, what tax or subsidy maximizes welfare? Let the tax on information equal t. (A negative value corresponds to a subsidy.) The expression for welfare is unchanged, except that, when examining the limits of integration in (17) and the analogous components in (18), the assumed price c is replaced by c+t. (Tax *revenue* does not affect welfare, as it is assumed to be rebated in a lump-sum manner.) The first-order condition when differentiation is feasible, after some manipulation, is

$$(26)\ \frac{dW}{dt} = -(1-\alpha)\left[\frac{f(\beta)}{q}(\theta h - \theta\beta h - c) + \frac{f(\frac{c+t}{1-q})}{(1-q)}(c - \frac{1-\theta}{1-q}(c+t))\right] = 0.$$

The first term within the brackets, from the first-order condition for the optimal sanction (19), equals zero. The intuition is that the sanction, as discussed above, affects (only) the margin between individuals who act without information and individuals who purchase information. The marginal type, β, can be selected without constraint by adjusting the sanction, so the tax is irrelevant to welfare with respect to this margin.

Thus, the second term in (27) must equal zero, which implies that

$$(28)\ t = \frac{\theta-q}{1-\theta}c.$$

If $q = \theta$, the optimum involves no tax or subsidy. That is, when uninformed individuals accurately perceive the likelihood that their act is harmful, their value for information equals its social value. When $q \neq \theta$, the effective price with the optimal tax (subsidy), c+t, will equal $c(1-q)/(1-\theta)$. This effective price corrects for the inefficiency noted when discussing the first term of (25). Because the sanction has no affect on this margin -- between individuals who do not act and whose who purchase information to decide whether to act -- an additional instrument is needed to correct for any

misperception. With this optimal correction, the marginal individual, who is of type $(c+t)/(1-q)$, will be of type $c/(1-\theta)$ -- which is the type for whom $(1-\theta)b = c$. The intuition is that this is the type for whom the actual (rather than the perceived) value of information just equals its actual cost. This correction involves a tax if $q < \theta$ and a subsidy if $q > \theta$. The tax corrects for individuals who underestimate the likelihood that their act is harmful and thus overestimate the benefit of information (which, for this group of individuals, who would not act if information is not acquired, is the benefit of the act weighted by the likelihood that it is not harmful). Conversely, the subsidy corrects for overestimation of the likelihood of harm and thus underestimation of the value of information.

Finally, reconsider the question whether the availability of information raises or lowers achievable welfare in the presence of the optimal tax (or subsidy). When $q \neq \theta$ (which is necessary for the optimal tax not to equal zero), one must redefine the sanction $\hat{s}$ that indicates whether any individuals will purchase information. Following the previous derivation,

$$(29)\quad \hat{s}_t = \frac{c}{pq(1-\theta)},$$

where $\hat{s}_t$ refers to the critical sanction when the optimal tax is employed. Continuing with the previous derivation for this case, one can compute that the critical value of c for which the problem when information is available and that when it is not have an optimal sanction for the uninformed greater than or equal to $\hat{s}_t$ is

$$(30)\quad c \leq \theta h(1-\theta).$$

(Observe that (30) is equivalent to both (22) and (23) in the case in which $q = \theta$.) The intuition is that, as described previously, the tax (or subsidy) corrects for any overvaluation (or undervaluation) of information. Because (30) applies to the problems with and without information, one has only cases 1 and 2. In case 2, no one would purchase information (with the optimal tax or subsidy employed), so the availability of information does not affect achievable welfare. In case one, only the first subcase, represented by (25) can arise,[20] and the availability of information will unambiguously improve

welfare. Recall that the only individuals with respect to whom information might result in a negative contribution to welfare were those who (when $q < \theta$) overvalued information and thus might inefficiently purchase it, rather than simply refraining from acting. When the optimal tax is employed, the integrand in the first term in (25) evaluated at the lower limit of integration -- which now will equal $c/(1-\theta)$ -- equals zero, and the integrand will be positive for all other b in the stated range. In summary, while the availability of information generally may raise or lower achievable welfare, it can only raise welfare if the optimal tax or subsidy is employed. This is as one should expect, for when the optimal tax or subsidy is combined with the optimal differentiated sanction for the uninformed, individuals private value of information equals its social value, so it is purchased only when welfare would be increased.

4. Costly Sanctions

Optimal sanctions are affected not only by considerations of deterrence, but also by sanctioning costs. The two most studied forms of sanctioning costs involve nonmonetary sanctions (imprisonment), which are costly in themselves, and monetary sanctions when individuals are risk-averse, which involve risk-bearing costs when not all individuals are deterred from committing harmful acts. Unfortunately, both cases may be intractable even without considering the problem of uninformed individuals, because there need not exist nonextreme solutions and, when nonextreme solutions exist, they need not be unique and may involve interior minima rather than maxima.[21] As a result, the analysis here will focus on special cases in which the solutions are relatively simple to characterize. For this purpose, the assumption that $f(\cdot)$ is uniform is added. In addition, to focus on the issues presented by costly sanctions, it will be assumed in this section that $q = \theta$.[22]

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[20] As indicated in note 18, the second subcase, represented by (26), can arise only if $c > \theta h(1-\theta)$, which is now ruled out because case 1 is defined by the assumption that (30) holds.

[21] For monetary sanctions, see Kaplow (1989a), and for nonmonetary sanctions, see Kaplow (1989c).

4.1. Nonmonetary Sanctions[23]

4.1.1. Social optimization problem

The only affect of introducing nonmonetary sanctions is that, for a given set of sanctions and the individual behavior that results, welfare will be reduced by the total sanctions imposed weighted by the sanctioning cost, σ. One can thus modify the expressions for social welfare, (7) and (8):

$$(7') \quad W = \alpha(1-\theta)\int_0^{\bar{b}} bf(b)db + \alpha\theta\int_{b^{*i}}^{\bar{b}} (b - h - p\sigma s^i)f(b)db$$

$$+ (1-\alpha)\int_{b^{*u}}^{\bar{b}} (b - \theta h - p\theta\sigma s^u)f(b)db, \text{ or}$$

$$(8') \quad W = \alpha(1-\theta)\int_0^{\bar{b}} bf(b)db + \alpha\theta\int_{b^{*i}}^{\bar{b}} bf(b)db + (1-\alpha)\int_{b^{*u}}^{\bar{b}} bf(b)db$$

$$- \theta h[\alpha(1-F(b^{*i})) + (1-\alpha)(1-F(b^{*u}))]$$

$$- \theta p\sigma[\alpha s^i(1-F(b^{*i})) + (1-\alpha)s^u(1-F(b^{*u}))].$$

The first-order condition for informed individuals is

$$(9') \quad \frac{dW}{ds^i} = \alpha\theta pf(b^{*i})(h + p\sigma s^i - ps^i) - \alpha\theta p\sigma(1 - F(b^{*i})) = 0,$$

and that for uninformed individuals is

$$(11') \quad \frac{dW}{ds^u} = (1-\alpha)pqf(b^{*u})(\theta h + \theta p\sigma s^u - pqs^u) - (1-\alpha)\theta p\sigma(1 - F(b^{*u})) = 0.$$

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[22] If $q \neq \theta$, there are the additional effects described in sections 2 and 3. If $q = 0$ -- that is, if uninformed individuals believed with certainty that their act was not subject to sanctions -- the optimal sanction for the uninformed would be zero, as positive sanctions do not affect behavior but do result in sanctioning costs.

[23] When wealth substantially limits the maximum feasible fine, nonmonetary sanctions will primarily be relevant. It generally is optimal first to use fines to the maximum possible extent and then to impose additional increments of punishment through nonmonetary sanctions. See Polinsky and Shavell (1984). The combined case is not separately examined, as it does not affect the character of the results.

The first term in each equation is analogous to those in (9) and (11). The only difference in this regard is that the total social harm per individual who commits a harmful act in this case is $h + p\sigma s$, the latter effect representing the expected sanctioning cost for each individual who acts and causes harm. The first term indicates the marginal effect of a change in sanctions on welfare. The second term denotes the inframarginal effect: $1-F(b^*)$ is the portion who are not deterred; a marginal increase in the sanction increases the expected social sanctioning cost per individual not deterred from committing a harmful act by $p\sigma$.

Before proceeding, one should note that the solutions indicated in (9′) and (11′), assuming they exist, will be a maximum if $\sigma < .5$ but will be a minimum if $\sigma > .5$.[24] These cases must be distinguished for the remainder of the analysis.[25]

4.1.2. Analysis for the case in which $\sigma < .5$

In this case, by comparing (9′) and (11′) with (9) and (11), one can see that there are two effects of costly sanctions. The marginal effect of

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[24] To illustrate, the second-order condition for the informed (recalling the assumption that the distribution is uniform, so $f' = 0$) is

$$\frac{d^2W}{ds^{i2}} = \alpha\theta p^2 f(b^{*i})(\sigma - 1) + \alpha\theta p^2 \sigma f(b^{*i}) = \alpha\theta p^2 f(b^{*i})(2\sigma - 1).$$

Thus, the first derivative is everywhere increasing if $\sigma > .5$ and is everywhere decreasing if $\sigma < .5$. (If $\sigma = .5$, the first derivative is constant: the level of sanctions has no affect on welfare.) The intuition with respect to the first term is that, as the sanction is increased, the marginal benefit of deterring the marginal individual is increasing because a greater sanction is avoided with respect to that individual. It is also true that a greater benefit is forgone: the benefit for the marginal individual just equals the expected sanction. Which effect dominates depends on whether the social cost of the expected sanction, σ, is greater than one per unit of the sanction. For the second term, the greater the sanction the less is the undeterred portion of the population, and thus the less the inframarginal sanctioning cost as the sanction is increased further. For further discussion (including comment on the significance of the assumption that the distribution is uniform), see Kaplow (1989c).

[25] One might think it sensible to assume that $\sigma > 1$: if the private cost of imprisonment (loss of liberty) is counted as a social cost and there are additional social costs (running the prison), this would be the case. On the other hand, if the private cost were deemed not to be a social cost or if there are benefits to imprisonment other than deterrence (retribution, incapacitation), it might be appropriate to assume $\sigma < 1$, and, in particular, $\sigma < .5$.

sanctioning costs indicates a higher sanction, because as more individuals are deterred, fewer bear costly sanctions. The inframarginal effect favors a lower sanction, because less sanctioning costs are thereby borne by undeterred individuals. Either effect could be greater, so the optimal sanction may be higher or lower than with monetary sanctions and risk-neutral individuals.[26]

Of particular interest is that, when $q = \theta$ and differentiation is feasible, it can be demonstrated that the optimal sanction for the uninformed is less than that for the informed (whereas, in all prior cases, the optimal sanctions were the same when $q = \theta$).[27] First, for a given sanction, the cost of an increase is relatively greater for the uninformed because more are (and remain) undeterred. Second, a given increase in the sanction causes relatively less marginal benefits (corresponding to the first terms in (9′) and (11′)) for the uninformed, because the marginal effect is weighted by pq for this group rather than by p;[28] the inframarginal effect applies to all who commit the harmful act, and thus is weighted by θ for both groups. Because the marginal effect is positive in the relevant range and the inframarginal effect is negative, weighting the marginal effect relatively less implies that a lower sanction is optimal.[29] Finally, if differentiated sanctions could not be applied, the optimum would, as before, involve a compromise between the sanctions that were optimal for each group separately.

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[26] See Polinsky and Shavell (1984). Additional restrictions have been imposed in the model here, but the result is still indeterminate, depending on the relative magnitudes of h, $\bar{b}$, and σ.

[27] In solving (9′) and (11′) for s^i and s^u, one finds that, at the optimum, $s^u < s^i$ if and only if $q(1-G(b^{*i})) < 1-G(b^{*u})$. Moreover, comparing these first-order conditions with each other makes it clear that, at the optimum, $b^{*i} > b^{*u}$. (Evaluated at the same b* when $q = \theta$, all components are identical, except the weights α and $1-\alpha$, which do not affect the sign, and the fact that the first component of the first term in (11′), h, is weighted by θ, while this is not the case in (9′). Thus, at the b* for which (9′) equals zero, (11′) is negative. Finally, under the stated assumptions, the solutions for these first-order conditions will be unique.) Thus, the result holds.

[28] That the marginal effect is less for the uninformed at a given sanction depends, of course, on the assumption that the distribution of benefits, $f(\cdot)$, is uniform. If the distribution were declining, the marginal effect for the uninformed could be greater -- and, if it were greater by a sufficient amount, a higher sanction for the uninformed could be optimal.

[29] As in the case of monetary sanctions, each uninformed individual who is deterred avoids causing only the fraction θ of the total expected harm and sacrifices only θ of the benefits, because the marginal type is lower; there were no inframarginal effects in the prior cases.

Consider now how the availability of ex ante information affects the results. That sanctions are nonmonetary again affects only the social costs of harmful acts, not behavior for a given sanction. When $q = \theta$, recall, only cases 1 and 2 could arise; case 2, in which individuals do not purchase information because it is too expensive, again needs no further consideration. For case 1, the first-order condition for the uninformed becomes

$$(19') \quad \frac{dW}{ds^u} = (1-\alpha)pqf(\beta)[\theta h + \theta p\sigma s^u - \theta\beta - c] - (1-\alpha)\theta p\sigma(1 - F(\beta)) = 0.$$

Comparing this condition to (11'), it can be demonstrated that the availability of information makes it optimal to apply a higher sanction. The reason is that the marginal effect of raising the sanction is equal in both cases (although composed of different components) but the inframarginal effect is less unfavorable when information is available because $\beta > b^{*u}$, so a smaller portion of the population commits the harmful act, thereby incurring the costly sanction.[30] Moreover, the availability of information will have a more positive effect on social welfare when sanctions are costly. Individuals whose acts are harmful and who purchase information but, in its absence, would have acted, avoid not only causing the harmful acts themselves but also incurring costly sanctions.

4.1.3. Analysis for the case in which $\sigma > .5$

As noted previously, no intermediate sanction is optimal. Thus, the optimum involves either a sanction of zero or a maximal sanction (one sufficiently high to deter all individuals or, if there is a constraint on the level of sanctions, the maximum feasible sanction). A complete description of the results would be more involved, but basically the same effects arise.

Whether a sanction of zero or a maximal sanction is optimal depends on whether the average harm avoided exceeds the average benefit forgone.[31] For

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[30] For the first terms of (11') and (19'), $\theta\beta + c = p\theta s^u = b^{*u}$. Thus, when sanctions are equal, the only difference between these first-order conditions is in the second terms. And in case 1 with $q = \theta$, it must be that $\beta > b^{*u}$ (or equal if (22) holds as an equality), which demonstrates the result.

[31] If there is no binding constraint on the sanction, neither the maximal sanction nor zero sanction involve any sanctioning costs being borne, so the harm and benefit avoided with full deterrence would completely determine which

the case of differentiated sanctions, a sanction of zero is more likely to be optimal for the uninformed, simply because a maximal sanction deters harmless acts as well as harmful acts (or, equivalently, for an act with a given benefit, the expected harm for the uninformed is only θh rather than h).[32] This result is analogous to the result for $\sigma < .5$ that the optimal intermediate sanction is lower for the uninformed.[33]

If information is available, optimal sanctions for the uninformed are more likely to be maximal[34] (and, if this is the case, welfare will be increased), because some uninformed individuals, rather than forgoing acts that may be beneficial, will acquire information.[35] This result also is analogous to that when an intermediate sanction is optimal.

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is optimal. If there is a binding constraint, one would also have to account for the sanctioning costs at the maximal sanction, which would make a sanction of zero more likely to be optimal.

[32] With no binding constraint, complete deterrence is optimal for the informed when $h > \bar{b}/2$ and for the uninformed when $\theta h > \bar{b}/2$. If a constraint is binding, so complete deterrence is not possible, a lower fraction of the uninformed than the informed would be deterred at the maximal sanction, so greater sanctioning costs would be borne. An additional implication of this reasoning is that the constraint may be binding for the uninformed but not for the informed. These considerations further suggest that a maximal sanction may be optimal for the informed while a zero sanction is optimal for the uninformed. (When a maximal sanction is optimal for the uninformed, a higher sanction will be required than for the informed since the sanction is discounted by pq rather than by p, although in the simple case considered here the higher sanction could be applied to the informed, as all are deterred in any event.)

[33] If differential sanctions are infeasible, welfare is only affected if the optimal sanction for the informed is maximal and that for the uninformed is zero. A maximal undifferentiated sanction will be optimal if the weighted average expected harm exceeds the average benefit -- that is, if $\alpha h + (1-\alpha)\theta h \geq \bar{b}/2$. (The only other possible optimum involves a sanction of $\bar{b}/p$, just sufficient to deter all the informed; at this sanction, the first-order condition, as one might expect, is not continuous.)

[34] Note that the interpretation of a maximal sanction when information is available is that the sanction is sufficient to induce the individual of type $\bar{b}$ to acquire information. All harmful acts of the uninformed are deterred, but not all acts.

[35] Also, if there is a binding constraint, some uninformed individuals who otherwise would bear a costly sanction will acquire information and thereby not commit harmful acts.

4.2. Monetary Sanctions and Risk-Averse Individuals

Even with the stated additional assumptions, this case is difficult to analyze, as there may be extreme or interior optima for each group. Thus, the discussion here merely will be suggestive of the optima that may arise.

The basic intuitions with monetary sanctions and risk-averse individuals are similar to the case in which nonmonetary sanctions give rise to sanctioning costs. If all are deterred or none are deterred, there are no risk-bearing costs, so one simply can compare the average harm and benefits of those deterred to choose among these extremes, and, if all are to be deterred, choose sanctions sufficiently high to accomplish this.[36]

Intermediate optima are also possible. In this case, the marginal condition for the optimal fine reflects the deterrence effects and risk-bearing costs, the latter having two components: a higher fine raises risk-bearing costs for undeterred individuals but decreases the fraction of the population that bears risk. In this case, the primary effects seem to indicate that a lower sanction would be optimal for the uninformed, for the same reasons that arose in the case of nonmonetary sanctions when an intermediate sanction was optimal.[37] First, there is the effect noted previously in the case of nonmonetary sanctions: with an equal sanction for each group, more of the uninformed bear the sanctioning cost because less are deterred. Thus, an increase in the fine, while having the same marginal effect on each individual who bears the sanctioning cost, would cause a greater relative increase in risk-bearing costs on the uninformed. Another

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[36] As before, if there is a constraint on the maximum feasible sanction, it is more likely to be binding for the uninformed because they discount the sanction s by pq rather than by p. Also as before, if one considers the subcase in which all the informed but not all the uninformed are deterred, there will be the added sanctioning cost for the latter, here due to risk-bearing costs, which may make a lower sanction more attractive.

[37] The argument to follow in the text is heuristic. Sufficient conditions (none necessary) for $dW/ds^u < 0$ when $dW/ds^i = 0$ at $s^u = s^i$, in addition to those already stated, in a model in which the harm and benefit are monetizable, are: (1) a constant absolute risk aversion utility function, and (2) $pf < h$. The demonstration, which is tedious, is omitted. A complete analysis is complex in part because any interior optimum need not be unique, and, in particular, the global optimum for either group may involve complete deterrence. See Kaplow (1989a).

factor is that a given increase in the fine will cause a greater marginal deterrent effect for the informed because they expect to be sanctioned with probability p rather than pq. So long as the interior optimum involves $b^{*i} < h$, this effect implies that the marginal benefits from increasing the sanction are greater for the informed than for the uninformed.[38] Thus, two factors tend to suggest that, if the optimal sanction for both groups are intermediate, that for the uninformed will be lower.

Finally, consider briefly how these results are affected by the availability of ex ante information. Sanctions applied to the uninformed have less social cost to the extent some individuals are induced to purchase information. First, fewer beneficial acts are deterred by high sanctions, because individuals who would not have acted may acquire information and, if their act is not harmful, they then will act. Second, if an intermediate sanction is employed, sanctioning costs will be borne by fewer individuals, because some individuals who otherwise would not be deterred at an intermediate sanction will acquire information and, if they learn that their act is harmful, will not act. Both these factors tend to make higher sanctions on the uninformed more desirable than when information is unavailable.

5. Comments on the Law

The issues examined in this investigation tend to be addressed in legal commentary primarily when discussing the rule that ignorance of the law is no excuse -- that is, to have been unaware (or uncertain) that one's act violated the law is not a defense.[39] The rule is typically justified on the grounds

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[38] As discussed in note 28, this relies directly on the assumption that the distribution of benefits is uniform.

[39] See Fletcher (1978), LaFave and Scott (1972), and Model Penal Code and Commentaries (1985) for statements of the legal principles and discussion of their rationale. For brief discussions of the economics of this and closely related issues in the criminal law, see Posner (1985) and Shavell (1985). The analysis here also is relevant to other legal issues, such as the costs of complexity and the value of providing notice about legal rules, which concern the extent to which the population will be uninformed in the first instance,

that it would be difficult to allow the defense, as individuals would attempt to feign ignorance, and that the rule gives individuals an incentive to learn the law and thus abide by it.

An initial difficulty in evaluating this legal principle is that "ignorance" is not defined precisely. If individuals are completely ignorant ($q = 0$ in this model) it typically would be optimal to apply no sanction, if individuals could be differentiated. The reason is that sanctions have no affect on behavior but may entail sanctioning costs. In particular, sanctions provide no incentive to learn of the law when individuals are completely ignorant. (The type just indifferent between acting and purchasing information is of type $\beta = ps^u - c/q$; if $q = 0$, no individuals acquire information.) There remains the rationale that it may be infeasible to differentiate the ignorant from the informed. If this is the case, however, the optimal sanction might be quite different if a large portion of violators were ignorant; in particular, a lower sanction, while forgoing some deterrence of willful violators, would reduce sanctioning costs with respect to the ignorant, who are undeterrable.

One suspects, however, that in many instances the "ignorant" will have some idea that their harmful acts might be illegal, and this must be the case if the fear of sanctions is to induce individuals to acquire information, as is commonly suggested. In these circumstances, as sections 2 and 3 demonstrate, considerations of deterrence and incentives to acquire information favor higher, lower, or equal sanctions for the uninformed than for the informed, depending on whether the uninformed underestimate, overestimate, or accurately estimate the likelihood that their acts are harmful,[40] and, as section 4 suggests, sanctioning costs may warrant lower

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the nature of misperceptions that individuals are likely to have, and how costly information that clarifies the rules will be.

[40] Discussions of ignorance of the law often implicitly assume that $\theta = 1$ -- that is, that one is examining only harmful acts and inquiring into whether it is appropriate to apply a sanction -- in which case underestimation is necessarily assumed and thus an individual's uncertainty about the legality of an act might appropriately be viewed as an aggravating factor rather than as a mitigating factor, with regard to behavioral effects. (In this case, $q < 1$ could be viewed simply as individuals' underestimating the probability of apprehension.) Many of the effects considered in sections 2-4 arise precisely

sanctions than would be optimal considering behavioral effects alone.

In addition, the idea that sanctioning the uninformed desirably encourages them to become informed is substantially incomplete. Although imposing a sanction on the uninformed does encourage individuals to acquire information, some will act and others will refrain from acting without first acquiring information because information is costly. Even if the cost is low, if individuals' estimates of the likelihood of harm are low, many individuals may act without purchasing information (the marginal type, again, is $\beta = ps^u - c/q$). And, if individuals' estimates of the likelihood of harm are high, there will tend to be more individuals who refrain from acting (and thus may be deterred from committing desirable acts) rather than purchasing information (the marginal type in this instance is $c/(1-q)$). One could subsidize the purchase of information, but as previously explored this need not be efficient.[41] Finally, note that it may be efficient for many individuals to act without first acquiring information, as will be true when the actual likelihood that any individual's act is illegal is low relative to the cost of information.[42]

It also is useful to examine the many important instances in which ignorance is indeed an excuse. First, ignorance of the law excuses conduct when knowledge of the law is an element of the offense. For example, criminal tax evasion requires proof that one intentionally violated a known legal duty.[43] This is quite difficult to prove, as it often is easy to feign ignorance of the tax laws (particularly given the requirement that willfulness be proven beyond a reasonable doubt). Penalties applicable to "uninformed"

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because it often is plausible that $\theta < 1$ -- that is, that individuals cannot distinguish between some legal and some illegal acts.

[41] For example, in the typically imagined case in which individuals underestimate the likelihood of harm, a tax rather than a subsidy was optimal if it was possible to apply higher sanctions to the uninformed. If differentiation is not feasible, some subsidy may increase welfare with respect to those who would have acted without information, but the subsidy will diminish welfare by exacerbating the excessive tendency of individuals who otherwise would not act to acquire information.

[42] But, as the analysis indicates, it need not follow that sanctions for the uninformed should be lower on this account.

[43] See, e.g., United States v. Bishop, 412 U.S. 346 (1973).

violators are quite small by comparison. To some extent, this approach may be justified by the combination of costly sanctions (imprisonment) and a large portion of the population being uninformed and thus likely to violate the tax laws by mistake.[44]

Second, even when ignorance of the law is no excuse, knowledge of certain facts may be essential to proving an element of an offense. For example, the individual who mistakenly takes another's umbrella is not guilty of theft. As noted previously,[45] the model here is equally applicable to uncertainty concerning the nature of one's act and to uncertainty concerning the legal rule. Thus, it is interesting to consider why ignorance of fact is often an excuse when ignorance of the law is not. As with the law, one often can feign ignorance of facts. And if sanctions induce individuals to learn about the law, they presumably will have a similar effect with regard to facts. [46] A significant difference, however, is that a legal rule, such as that against theft, can be learned once and applied in countless situations, whereas one must determine whether one has taken the correct umbrella on each occasion. Also, the likelihood that one actually has taken the wrong umbrella (θ) and the likelihood that one thinks this is the case (q) may be quite low. As a result, the benefits of avoiding sanctioning costs on the undeterred may justify a low (or no) penalty. And, even if many umbrella thieves are exonerated as a result,[47] the lenient treatment of apparently innocent acts may be appropriate if a significant percentage of all wrongful takings of umbrellas are by accident.

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[44] That the penalty for most violations, even in the presence of clear negligence and likely but uncertain fraud, is typically trivial (0-75% plus interest, usually nearer to zero, with a probability of detection usually under a few percent) is harder to explain in this manner, particularly since the civil penalties are monetary.

[45] See note 1

[46] It is easier to learn whether an umbrella is one's own than to learn most legal rules, although it may be more difficult to learn whether goods one purchases at an ordinary store are in fact stolen.

[47] Note that if those who knowingly take another's umbrella believe that their is some probability that they can establish a defense of mistake, a corresponding higher sanction can be applied to intentional violations so that the expected sanction is as high as if no defense of mistake were allowed.

In summary, the rule that ignorance of the law is no defense, as well as related issues concerning knowledge of the law or of facts as an element of an offense, can be understood in the terms of this model. Whether the same penalty, a lower penalty (or exoneration), or even a higher penalty is optimal for those who are "ignorant" is likely to vary greatly by context -- much more than indicated by the frequent invocation of the general maxim accompanied by the frequent definition of offenses to require actual knowledge, with little attention given to the applicability of the competing rationale. The analysis here suggests that, so long as ignorance is not complete, there is no consistent a priori basis for assuming that "ignorance" should be a mitigating, much less exonerating factor, as is implicitly suggested in many discussions of the issue. Note that this result arose even in the models where ex ante information was assumed to be unavailable and where perfect differentiation was feasible (thus negating both traditional justifications for penalizing the ignorant). In addition, the notion that penalizing the ignorant induces them to acquire information is correct -- again, so long as ignorance is not complete -- but it is insufficient to demonstrate that differential penalties are inappropriate. Finally, while differentiation often will be difficult or impossible, one still must determine the appropriate undifferentiated sanction. The model here indicates that the optimal sanction may be unaffected by the presence of an uninformed segment of the population, or that it may be higher or lower, depending most notably on the nature of individuals' ignorance, sanctioning costs, and the availability of information.

6. Concluding Remarks

When some individuals are uncertain about whether their acts are subject to legal sanctions, they commit acts even when the probability and magnitude of sanctions is sufficient to deter harmful acts of those who are informed. For such uninformed individuals, the benefits of deterrence are not achieved and sanctioning costs are imposed. In addition, unless sanctions are negligible, other uninformed individuals will be deterred from committing

desirable acts. If different sanctions can be applied to the uninformed, it may be optimal to impose a lower sanction to reduce sanctioning costs and deterrence of desirable acts, or, in some cases, a higher sanction to reduce underdeterrence of undesirable acts. In other cases, it would not be optimal to apply different sanctions even if this were feasible. When it is infeasible (or too costly, in light of the benefit) to apply different sanctions to the uninformed than to individuals who were informed at the time they act, the optimal sanction reflects a compromise between the optimal sanction for each group considered separately.

Uninformed individuals may be able to acquire information about whether their act is subject to sanctions before deciding whether to act. For a given enforcement policy, such information may but need not produce social benefits in excess of its cost. In addition, the optimal enforcement policy is affected by the availability of information, because the primary effect of a marginal change in sanctions in this case is to affect who acquires information (which in turn determines behavior) rather than to affect behavior directly. The optimal enforcement policy when information is available may involve higher or lower sanctions than otherwise and higher or lower achievable welfare. In some instances, a tax or subsidy on the purchase of information can increase welfare, and, if the optimal tax or subsidy is employed, the availability of information can only increase welfare in this model.

A variety of policies may be optimal, depending on the distribution of individuals' benefits from acting, the level of harm, uninformed individuals' perceptions concerning the likelihood that their acts are harmful, the ability to apply different sanctions to informed and uninformed individuals, the nature of sanctioning costs, and the cost of information. Some of these optima are consistent with observed practice that may be explained, in part, by the considerations noted here. To illustrate, suppose that many individuals (both informed and uninformed) derive small, but positive benefits from their acts, while a few derive substantial benefits (although slightly less than the harm of the act). Optimal sanctions for the case when the two groups are distinguished may involve a small sanction for the uninformed and a

high sanction for the informed. Although the low sanction for the uninformed imposes some sanctioning cost (on high-benefit individuals, who are not deterred) and deters some moderately desirable activity (acts with small positive benefits that are in fact harmless), there may be substantial gain from deterring many acts that produce little benefit but great harm. A high sanction for the uninformed, although avoiding the sanctioning cost and deterring some slightly harmful acts, would deter some very desirable acts. For the informed, there is no sanctioning cost or deterrence of desirable activity with a high sanction, which has the virtue of deterring all of their undesirable acts. If, however, the two groups could not be distinguished, it may be optimal to use a low sanction, thus deterring only acts with low benefits. This option forgoes deterrence of some slightly undesirable acts by the informed, but a high sanction for both groups would deter many desirable acts of the uninformed or, if insufficient to deter them, impose substantial sanctioning costs. This result is consistent with the practice of employing sanctions too low to deter all harmful acts, as well as that of expending resources to differentiate individuals in order to apply higher sanctions to individuals who knowingly violate the law, as is the case with tax evasion.

One could extend this analysis in a number of ways. For example, in practice, any differentiation between individuals depending on their knowledge of the law at the time they acted will be imperfect. Mistakes in categorizing individuals may result in too low a sanction for the some of the informed, producing underdeterrence or requiring additional detection expenditures, and too high a sanction for some of the uninformed, which may involve sanctioning costs for some and which may deter the desirable activity of others. Determining the magnitude of each of these effects would indicate the marginal value of greater precision and, for a given level of precision, the optimal trade-off between type I and type II errors.[48] Other important extensions would allow greater heterogeneity among individuals, such as in the accuracy of their knowledge. This would be important if applying differentiated sanctions were costly or impossible, as is often the case.

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[48] In legal terms, the latter corresponds to setting the burden of proof on the issue.

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