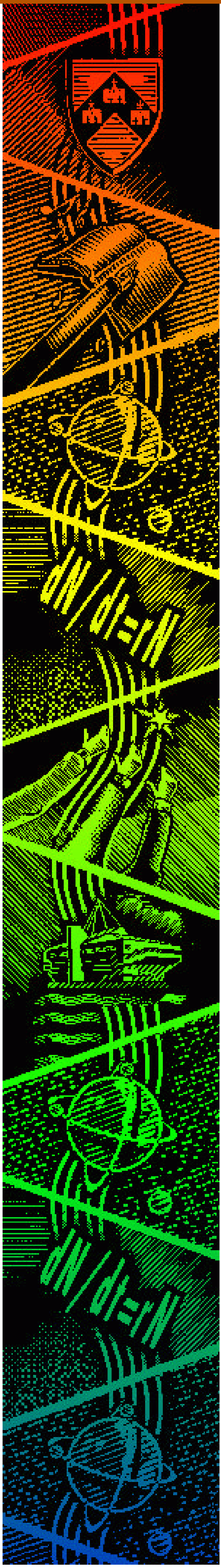

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Optimal Deterrence with Legal Defence Expenditure

by

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Optimal deterrence with legal defence expenditure*

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Abstract

Legal defence expenditure by those accused of a crime reduces their probability of punishment (whether innocent and guilty). We show that there could be more or less crime in a system which permits such expenditure. Because accused may choose a level of defence expenditure which bankrupts them if found guilty, deterrence can decrease when the fine is increased. The unregulated expenditure of innocent and guilty defendants is inefficient. We show that the optimal fine will never bankrupt the dishonest accused but that the honest accused can be bankrupt or left with positive wealth if convicted. We examine policies to regulate defence expenditure including a tax financed public defender system, a tax on legal defence and compensation for acquitted accused.

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1 Introduction

In this paper we consider a justice system which makes both type I errors (sometimes convicting the innocent) and type II errors (sometimes acquitting the guilty) and in which legal defence expenditure on behalf of the accused can reduce their probability of conviction. Such expenditure has a private value but its social value is less clear. We address two sets of issues. First, are decisions by those accused of crimes about their expenditure on legal defence socially optimal, and, if not, what are the implications for public policy in terms of the regulation of defence expenditure or its provision by the state? Second, what are the implications of legal defence expenditure for optimal deterrence policy?

With the standard efficiency orientated welfare function, in which all individuals, including those who choose to be dishonest count equally (Becker, 1968; Polinsky and Shavell, 1979), the socially relevant aspects of legal defence are its effect on deterrence and its cost.

Since defence expenditures reduce the probability of punishment of dishonest individuals, they reduce the expected sanction on dishonest individuals and thus reduce deterrence. However, when there are type I errors, honest individuals face the risk of wrongful arrest and conviction.[1] Defence expenditure by them increases the rewards for honesty. What matters for deterrence are the effects of defence expenditure on the *difference* between the expected utility of honest and dishonest individuals. We show that permitting defence expenditures may increase deterrence as compared with a system in which no such expenditure is permitted.

We also show that the level of defence expenditure chosen by accuseds is not socially efficient. The private value of legal defence expenditure is the reduction in the probability of conviction. Both honest and dishonest individuals choose their expenditure, when accused, to maximise their expected utility. The marginal effect of defence expenditure on the expected utility of honest and dishonest individuals at the privately optimal levels is zero. Consequently marginal changes in defence expenditure at the private optimum have no effect on deterrence because they do not change the difference between the expected utilities of honest and dishonest individuals. But defence expenditures do have a positive marginal social cost, so that the marginal private and social values of defence expenditure are different and there is scope for regulation to improve on the market equilibrium.

The canonical result in optimal deterrence policy is the Becker (1968)

[1]Through out the paper we use the terms honest and dishonest as synonyms for innocent and guilty respectively.

demonstration that, since fines have a positive deterrent effect but a zero marginal social cost, the optimal policy is to increase them to a level which leaves convicted accused with zero wealth. There are few examples of deterrence regimes which use maximal fines and the Becker result has generated a large literature which suggest reasons why the optimal fine should not bankrupt convicted accused (Garoupa, 1997; Polinsky and Shavell, 2000).

The effective fine is limited by the wealth, net of defence expenditure, of those convicted. We show, that if the nominal fine is large enough, accuseds will choose a high level of defence expenditure which bankrupts them if they are found guilty but leaves them with positive wealth if acquitted. With a lower nominal fine they spend less on defence and are not bankrupt even if convicted. There is critical level of the fine such that they are indifferent between the high level of defence expenditure which bankrupts them if found guilty and a lower level which does not.

Suppose that the critical fine is smaller for the dishonest than the honest. Then it can never be efficient to set the fine above the level which is critical for the dishonest. Raising the fine above this level would have no effect on the dishonest, since they cannot pay it in full. Their defence expenditure will however jump upwards. The honest do pay the fine in full if convicted. They are made worse off and their defence expenditure is increased. Hence the increase in the fine above the critical level for the dishonest simultaneously reduces deterrence and increases socially costly defence expenditure. The optimal fine cannot exceed this critical level and both dishonest and honest types are left with positive wealth if convicted. Note that it is the fact that defence expenditures are chosen by the accused which drives the conclusion that the optimal fine leave those convicted with positive wealth, not the presence of type I errors.

Alternatively, if less plausibly, suppose the critical fine for the honest is smaller than for the dishonest, so that they are induced to choose bankruptcy before the honest. The fine again should not be greater than the critical level which induces the dishonest to choose bankruptcy. At higher levels there is no effect on deterrence because neither type of individual pays the fine in full but the expenditure of the dishonest jumps upward. Hence the fine should not exceed a level which leaves the dishonest with positive wealth but which induces the honest to prefer bankruptcy if convicted. We show that if defence expenditures are sufficiently responsive to the fine it will be optimal to set the fine below the critical level for the dishonest. Thus even in this case where the honest are induced to choose bankruptcy before the dishonest, the optimal deterrence policy can leave both the honest and the dishonest with positive wealth if convicted.

We outline the model and consider the implications of defence expenditure for deterrence in section 2. In section 3 we consider the choice of the fine in the presence of type I and type II error and defence expenditure by accused individuals and show that it is never optimal to have fine which bankrupts all those convicted. We also show that the market equilibrium level of legal defence expenditure is not optimal. Section 4 examines policies to regulate legal defence: a upper limit on individuals' legal defence expenditures, a tax financed public defender system in which all accused receive the same amount of defence, a tax on the privately chosen defence expenditures, and compensation for acquitted individuals. Section 5 extends the analysis by considers a welfare function which reflects direct concern about type I and II errors. Section 6 concludes.

In the remainder of this introduction we relate our analysis to the previous literature. Type I and II errors are considered by Ehrlich (1982) and Miceli (1991) who show that such errors can lead to a less than maximal sanction if there is direct social concern with the wrongful punishment of the honest and the mistaken acquittal of the dishonest. In Png (1986) individuals can decide to take part in an activity which may produce more social benefit than harm if they exercise sufficient care. Because those who do not exercise sufficient care may escape punishment, the fine should exceed the harm caused to ensure that expected punishment equals the harm. Such a fine reduces participation in the activity below its efficient level because some of those who do take sufficient care are wrongly punished. Thus there should also be a subsidy for participation in the activity. In none of these papers are individuals able to reduce their probability of punishment by legal defence expenditure.

The relationship between punishment and legal defence is considered in Lott (1987) where it is assumed there are only type II errors, that punishment is fixed and that potential criminals have different opportunity costs of imprisonment. Lott (1987) argues that if punishment does not vary by opportunity cost, those with high opportunity costs will be overdeterred. Allowing individuals to choose their defence expenditure leads to those with greater opportunity costs spending more on defence and having lower probability of punishment, thus reducing the extent of overdeterrence.

Kaplow and Shavell (1990) show that legal advice to those contemplating potentially harmful acts may either raise or lower welfare, though they do not consider the costs of providing the advice. In Malik (1990) there are only type II errors and individuals who decide to commit a crime can engage in a costly "avoidance" activity which reduces their probability of punishment. Consequently it is argued that the fine may be less than the wealth of the accused because its beneficial deterrent effect is partially offset by its inducement of costly avoidance activity. Any policy which reduced avoidance activity would therefore be socially beneficial. Our model allows for type I errors and thus avoidance activity (legal defence expenditure) by honest individuals. In these circumstances the issue of whether avoidance activities which raise the expected utilities of both honest and dishonest individuals are socially beneficial is non trivial. Further, by correctly specifying the bankruptcy constraint on policy, we show that the optimal fine *always* leaves the convicted dishonest individuals with positive wealth.

2 The model

The basic model is standard (Polinsky and Shavell, 1979; 2000). All individuals are risk neutral and endowed with an income of y.[2] Each considers the possibility of committing a harmful act with a benefit of b and a social cost of h. Individuals are identical except for their benefit $b \in [0, \infty)$ which has a distribution function $G(b)$ over individuals. Because $h > 0$ is finite and fixed, some crimes have a positive net social benefit. This is not essential, though it is of interest to show that an optimal deterrence policy will in general not seek to deter all crimes with a negative net social value. One example might be firms which can choose to abide by pollution control standards or violate them and risk a fine. The social harm from additional pollution may exceed or be less than the costs incurred by the firm in reducing its emissions.

2.1 Choice of defence expenditure by accused

Every individual, whether honest or dishonest, has a probability of being arrested and tried for the offence. The arrest probability of the dishonest q_1 exceeds that of the honest q_0:

$$1 > q_1 > q_0 > 0 \tag{A1}$$

The probability of conviction p_i for an accused individual of type i is a decreasing convex function $p_i(c_i)$ of legal defence costs c_i: $p_i' < 0$, $p_i'' > 0$ and satisfies $p_i(0) < 1, p_i(\infty) > 0$. There are both type I errors, since the honest have a positive probability of conviction: $q_0 p_0(\infty) > 0$, and type II errors, since the dishonest have a positive probability of escaping punishment: $q_1[1 - p_1(0)] > 0$.

The nominal fine for the offence is f. If the fine is less than $y - c_0$ it is paid in full by a wrongfully convicted honest individual, who is left with y −

[2] The assumption that individuals have the same income and that all count equally in our welfare function means that we are not concerned with distributional issues, such the optimal means of providing subsidies for legal defence expenditure to the poor (Dnes and Rickman, 1998).

h	social harm from a crime
b	private benefit from a crime
$G(b)$	distribution function of benefits from crime
y	endowed income
q_0	probability that honest individual is charged
q_1	probability that dishonest individual is charged
$p_0(c_0)$	probability of conviction of honest accused
$p_1(c_1)$	probability of conviction of dishonest accused
c_i	legal defence expenditure of type $i = 0, 1$ accused
f	fine
F_i	fine which just induces type i accused to choose c_i which bankrupts him if convicted
m	policing costs
t	tax rate on defence expenditure
θ	compensation for acquitted accused
k_0	social cost per convicted honest person
k_1	social cost per acquitted dishonest person
λ	social value of relaxing bankruptcy constraint on effective fine
T	lump sum tax

Table 1: Notation

$c_0 - f$. If the fine exceeds $y - c_0$ he is left with nothing. The honest accused chooses c_0 to maximise

$$u_0(c_0) = [1 - p_0(c_0)](y - c_0) + p_0(c_0)\max\{y - c_0 - f, 0\}$$

The dishonest accused's problem is very similar. We assume that the benefit b from the crime is not recoverable by a fine.[3] If the nominal fine is less than $(y - c_1)$ it is paid in full and the convicted dishonest individual is left with $y + b - c_1 - f$. If the fine exceeds $y - c_1$ he is left with b. The dishonest accused will choose c_1 to maximise

$$\begin{aligned} u_1(c_1) + b &= [1 - p_1(c_1)](y - c_1) + p_1(c_1)\max\{y - c_1 - f, 0\} + b \\ &= [1 - p_1(c_1)](y + b - c_1) + p_1(c_1)\max\{y + b - c_1 - f, b\} \end{aligned}$$

We assume that $p_i'(0) > -\infty$ so that there is a small enough fine f_i^o such that the accused only chooses to spend on defence if $f > f_i^o$. There are two

[3]The offence may yields purely non-monetary benefits. Alternative it may yield monetary benefits which have been spent or distributed to shareholders by the time the accused is convicted. A similar assumption is made in Malik (1990) and Polinsky and Shavell (2000).

possible solutions with positive defence expenditure: c_i^* and c_i^{**}, $i = 0, 1$. The first holds when the accused chooses a level of expenditure which leaves positive wealth if convicted:

$$c_i(f) = c_i^*(f) = \arg\max\{y - c_i - p_i f_i\}$$

The second holds when the fine is so large that the individual chooses a level of expenditure which leads to bankruptcy if convicted:

$$c_i(f) = c_i^{**} = \arg\max\{(y - c_i)(1 - p_i)\}$$

The two solutions are characterised by

$$-[p_i'(c_i^*)f + 1] = 0 \quad (1)$$
$$-p_i'(c_i^{**})[y - c_i^{**}] - [1 - p_i(c_i^{**})] = 0 \quad (2)$$

and are shown in Figure 1.

When the individual is bankrupted if convicted both the expected marginal cost and the expected marginal gain from defence expenditure are reduced. As we show in the appendix, the former effect outweighs the latter, so that expenditure when the individual chooses to be bankrupt if convicted is greater than if he does not: $c_i^{**} > c_i^*$.

For low enough fines the accused chooses a level of defence expenditure c_i^* which leaves positive income even if convicted. His maximized expected utility conditional on being accused is then $v_i^n(f) = y - c_i^*(f) - p_i(c_i^*(f))f$ and is decreasing with the fine. For a large enough fine the accused will prefer to choose a level of defence expenditure c_i^{**} which bankrupts him if convicted. His maximized expected utility in this case is $v_i^b = [1 - p_i(c_i^{**})](y - c_i^{**})$ which does not vary with the fine. As we show in the appendix, there is a level of the fine F_i at which the accused is indifferent between $c_i^*(F_i)$ and c_i^{**}. To avoid needless complications we assume that indifferent individuals choose $c_i^*(F_i)$. Defence expenditure is at first increasing in f, jumps upwards at F_i, and is constant thereafter. Expected utility is continuous in the fine, though defence expenditure is not.

Although the accused is indifferent between $c_i^*(F)$ and c_i^{**} when $f = F_i$ and he would be bankrupt if convicted if he chose c_i^{**}, the accused is not bankrupt if he chooses $c_i^*(F)$. Let $\hat{c}_i$ be the defence expenditure which just bankrupts him: $\hat{c}_i = y - F_i$. Substituting $F_i = p_i(\hat{c}_i)F_i + [1 - p_i(\hat{c}_i)]F_i$ and rearranging, we see that if he chose this level of expenditure he would have $y - \hat{c}_i - p_i(\hat{c}_i)F_i = [1 - p_i(\hat{c}_i)](y - \hat{c}_i)$. As inspection of Figure 1 shows this must occur where $\hat{c}_i > c_i^*(F_i)$. Hence he must have strictly positive wealth at $c_i^*(F_i)$: $y - c_i^*(F_i) - F_i > 0$.

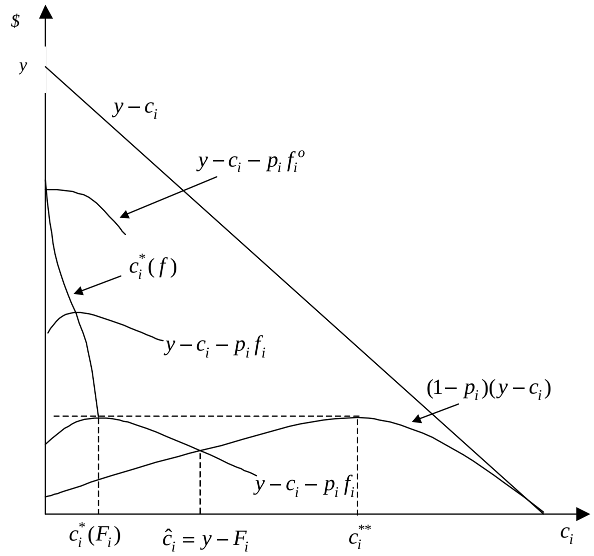

Figure 1: Effect on legal defence expenditure of an increase in the fine.

Summarising we have[4]

Proposition 1 *There is a level of the fine F_i for each type of individual such that if $f \leq F_i$ the accused chooses a level of defence expenditure $c_i^*(f)$ which does not lead to bankruptcy if convicted and if $f > F_i$ the accused chooses a level of defence expenditure c_i^{**} which does lead to bankruptcy if convicted. Privately optimal defence expenditure $c_i(f)$ is increasing in the fine in the non-bankruptcy case, discontinuous upwards in the fine at F_i, and unaffected by the fine in the bankruptcy case:*

$$\begin{aligned}
c_i(f) &= 0, & f &\in [0, f_i^o], \\
&= c_i^*(f), & f &\in (f_i^o, F_i] \\
&= c_i^{**} > c_i^*(F_i), & f &\in (F_i, \infty). \\
c_{if} &= c_{if}^*(f) > 0, & f &\in (f_i^o, F_i) \\
&= 0, & f &\in (F_i, \infty)
\end{aligned}$$

We assume that the legal system is not perverse in the sense that the honest are more likely to be convicted than the dishonest when they spend

[4]Proofs of propositions not given in the text are in the appendix.

the same amount on defence. The *non-perversity* assumption is

$$p_1(c) > p_0(c) \tag{A2}$$

It is less obvious whether defence expenditure has a larger or smaller marginal effect for the honest or the dishonest. We could argue that a good quality (high cost) lawyer will make more difference when the evidence against the accused is stronger (because he is guilty) so that

$$p_1'(c) < p_0'(c) < 0 \tag{A3}$$

However, defence expenditure could have a greater marginal effect for the innocent:

$$p_0'(c) < p_1'(c) < 0.$$

For example, searching for witnesses who will testify that the accused was elsewhere when the crime was committed may be less costly if he is innocent than if he is guilty.

Using the first order conditions it is straightforward to establish

Proposition 2 *For $f > f_1^o$ dishonest accuseds spend more on legal defence than honest accused if their defence expenditure has a greater marginal effect (A3 holds). For $f \in (f_0^o, F_1)$ and for $f \geq F_0$ dishonest accuseds spend less on legal defence than honest accused if their defence expenditure has a smaller marginal effect*

Part (a) of Figure 2 illustrates for the case in which defence expenditure is more productive for the dishonest than the honest. In part (b) defence expenditure is more productive for the honest.

If the marginal effect of defence expenditure is larger for honest accused, Proposition 2 and the non-perversity assumption A2 imply that they have a smaller probability of conviction than the dishonest. However, if the marginal effect of defence expenditure is greater for the dishonest, they could spend sufficiently more on defence to offset their disadvantage in having a higher conviction probability at given levels of defence expenditure. Hence there could be a *p probability reversal*: $p_1(c_1(f)) < p_0(c_0(f))$.

If the dishonest accused have a smaller conviction probability than the honest it is also possible that they have a smaller unconditional probability of being convicted: $q_1 p_1(c_1(f)) < q_0 p_0(c_0(f))$. As we will see shortly, such a *qp probability reversal* implies that, when both honest and dishonest prefer a level of defence expenditure which enables them to pay the fine if convicted,

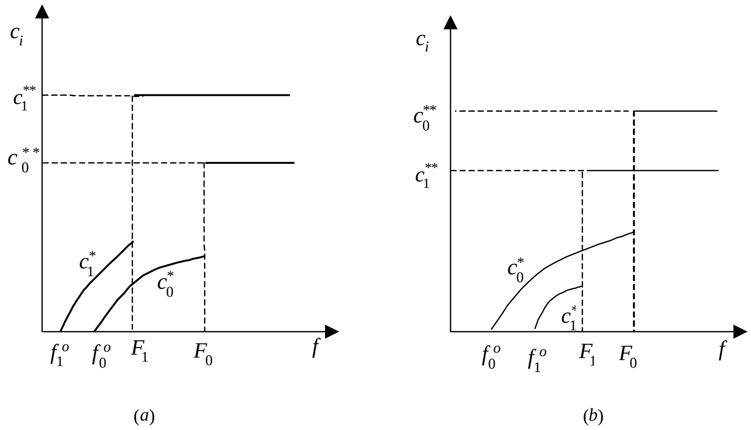

Figure 2: Legal defence expenditure when expenditure is more productive for (a) the dishonest and (b) the honest

increases in the fine will increase the amount of crime. We will restrict attention to the more plausible case in which there is no qp probability reversal and the dishonest have a greater unconditional conviction probability than the honest:

$$1 > q_1 p_1(c_1(f)) > q_0 p_0(c_0(f)) > 0 \tag{A4}$$

Deterrence policy is considerably affected by whether the honest or the dishonest are the first to choose bankruptcy as the fine increases. Accuseds prefer the optimal non-bankrupting expenditure as long as $v_i^n(f)$ exceeds v_i^b. Increases in the fine reduce v_i^n at the rate $p_i\left(c_i^*(f)\right)$ and have no effect on v_i^b. Honest and dishonest have the same expected utility from non-bankruptcy with a zero fine. With no probability reversal v_1^n will fall faster than v_0^n as f increases. However, this does not imply that the dishonest will be the first to choose bankruptcy as f increases: their expected utility from bankruptcy is smaller than that of honest accuseds. Although v_1^n falls faster than v_0^n it must fall further before the dishonest prefer bankruptcy.

If there is probability reversal, so that v_1^n falls more slowly than v_0^n as f increases, the honest will choose bankruptcy before the dishonest: $F_0 < F_1$. The converse does not hold, so that if there is no probability reversal we cannot conclude that the dishonest will choose bankruptcy before the honest.

The case in which the dishonest choose bankruptcy before the honest seems more plausible and we will often make this assumption:

$$F_1 < F_0 \tag{A5}$$

2.2 Honesty versus dishonesty

If honest, an individual has expected utility:

$$V_0(c_0) = (1 - q_0)y + q_0 u_0(c_0)$$

whereas a dishonest individual has expected utility

$$V_1(c_1) = (1 - q_1)y + q_1 u_1(c_1) + b$$

The individual commits a crime if and only if $V_1 > V_0$ or equivalently

$$b > z(c_0, c_1, f, y) = (1 - q_0)y + q_0 u_0(c_0) - (1 - q_1)y - q_1 u_1(c_1) \qquad (3)$$

Since the proportion of individuals choosing honesty is $G(z)$ we can define z as the amount of deterrence produced by the criminal justice system.

When the dishonest choose bankruptcy if convicted at a lower fine than the honest ($F_1 < F_0$), we have

$$\begin{aligned} z &= q_1[p_1 f + c_1^*] - q_0[p_0 f + c_0^*], && f \le F_1 && (4) \\ &= q_1[p_1 y + (1 - p_1)c_1^{**}] - q_0[p_0 f + c_0^*], && F_1 < f \le F_0 && (5) \\ &= q_1[p_1 y + (1 - p_1)c_1^{**}] - q_0[p_0 y + (1 - p_1)c_0^{**}], && F_0 < f && (6) \end{aligned}$$

When $F_0 < F_1$ the deterrence function has the same form as (4) for $f \in (0, F_0]$ and as (6) for $f \in (F_1, \infty)$, but

$$z = q_1[p_1 f + c_1^*] - q_0[p_0 y + (1 - p_0)c_0^{**}], \qquad F_0 < f \le F_1 \qquad (7)$$

Examination of the deterrence function establishes

Proposition 3 *Deterrence is a continuous function of the fine. If A4 holds, then (a) if $F_1 < F_0$, deterrence is increasing in the fine up to F_1: $dz/df = q_1 p_1 - q_0 p_0 > 0$, decreasing over the range (F_1, F_0): $dz/df = -q_0 p_0 < 0$, and constant thereafter; (b) if $F_0 < F_1$, deterrence is increasing in the fine up to F_1 and constant thereafter.*

Figure 3 illustrates. In part (a), where $F_1 < F_0$, increases in the fine to F_1 make crooks and honest individuals worse off, even though they respond by increasing their defence expenditure. The crooks suffer a larger fall in expected utility and so more individuals choose to be honest. Over the range $[F_1, F_0]$, crooks are unaffected by increases in the fine since they are bankrupted if found guilty, whereas honest individuals are made worse off. Hence the gain from crime compared to honesty increases. With a fine large

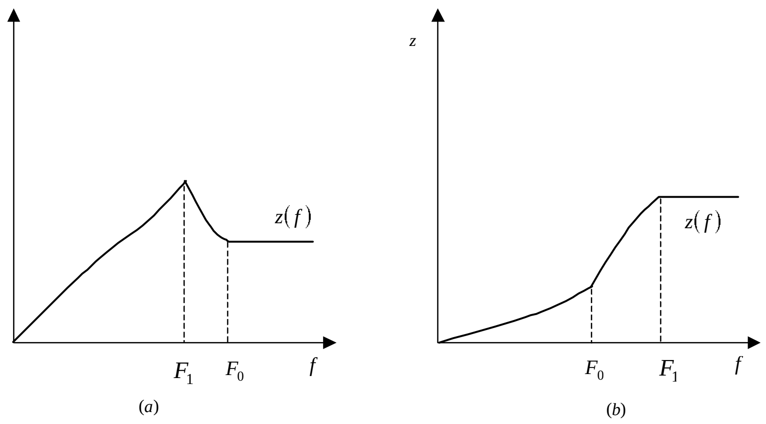

Figure 3: Effect of fine on deterrence $z(f)$ when (a) the dishonest choose bankruptcy before the honest and (b) the honest choose bankruptcy before the dishonest.

enough to make all types of convicted accused prefer bankruptcy if convicted, further increases in the fine have no effect on the expected utility of either crooks or honest individuals.

Figure 3(b) shows the case where $F_0 < F_1$. The expected utility of the dishonest falls faster than that of the honest up to F_0, so deterrence increases. Once the honest have chosen to be bankrupt if convicted, increases in the fine only affect the dishonest, so that the fine has a greater marginal deterrence effect and the deterrence function is kinked upwards at F_0. Once both groups prefer bankruptcy when convicted, further increases in fine have no additional deterrent effect.

2.3 Type 1 and II errors and deterrence

It is well known (Miceli, 1990) that the existence of type I and type II legal errors weakens deterrence because the possibility of wrongful arrest and conviction reduces the expected utility from being honest and the possibility of escaping punishment increases the expected utility from dishonesty. The implications of type I and type II errors are less straightforward once legal defence expenditure is allowed for.

The accuseds' ability to spend money to reduce their conviction probability when arrested increases their expected utility compared with no expenditure: $V_i(c_i(f)) > V_i(0)$. What matters for deterrence is the difference between the expected utilities of honest and dishonest individuals. The fact that $V_i(c_i(f)) > V_i(0)$ implies nothing about whether $V_0(c_0(f)) - V_1(c_1(f))$ is greater or less than $V_0(0) - V_1(0)$. However if there are no type I errors, so that only the dishonest engage in defence expenditure which increases their expected utility, defence expenditure must reduce deterrence. We have

Proposition 4 *In the presence of type I and type II errors, permitting defence expenditure by accused individuals may increase or reduce the amount of crime: $z(c_0(f), c_1(f), f)$ may be less than or greater than $z(0, 0, f)$. If there are no type I errors ($q_0 p_0 = 0$) permitting legal defence expenditure reduces deterrence.*

3 Welfare maximising deterrence

3.1 Optimal fine policy

Deterrence activities generate an increase in public sector expenditure, equal to the cost of policing less the expected receipts from fines, which is covered by lump sum taxes T imposed elsewhere in the economy. We assume in effect that we are concerned with deterrence in a small area or sector whose potentially dishonest population is small in relation to the total population of the economy. Hence changes in T resulting from changes in this sector have a negligible effect on the tax bills of the population in the sector. The assumption enables us to ignore the potential complications which would result from changes T leading to changes in the critical levels F_i at which accused would prefer bankruptcy if convicted.

Welfare is the unweighted sum of the expected utilities of honest and dishonest individuals and the taxpayers and can be written as

$$W = W(c_0(f), c_1(f), z(c_0(f), c_1(f), f), f) = \int_0^z V_0 dG + \int_z^\infty [V_1 - h] dG - T$$
$$= y + \int_z^\infty (b - h) dG - m - G(z) q_0 c_0 - [1 - G(z)] q_1 c_1 \quad (8)$$

where $z(\cdot)$ is defined by (3) and m is the fixed level of policing expenditures. Notice that the social consequences of legal defence, as opposed to its private consequences, are solely determined by its impact on deterrence and by its cost.

We assume that the planner cannot observe whether an individual is honest or not, nor can she observe the level of any individual's defence expenditure. We suppose initially that her only policy instrument is the fine.[5]

[5] Increasing policing expenditures m will increase the arrest rates q_i. Since type I

We noted above that deterrence is a kinked function of the fine at F_1 and F_0 and that defence expenditure jumps at these points. A more laborious approach than the calculus is required to derive

Proposition 5 *Assume that A4 holds. The optimal fine always leaves dishonest individuals with positive wealth if convicted:* $f^* \leq F_1$. *If* $F_1 < F_0$ *both honest individuals and dishonest individuals have positive wealth if convicted.*

The derivative of welfare with respect to the fine exists and is continuous except at F_0 and F_1 and we can obtain some intuition about the result by examining

$$\begin{aligned}\frac{dW}{df} &= W_z z_f + \sum W_{c_i} c_{if} \\ &= \left[(h - z) + (q_1 c_1 - q_0 c_0)\right] g(z) z_f - q_0 G c_{0f} - q_1(1 - G) c_{1f} \qquad (9)\end{aligned}$$

Suppose that the dishonest choose bankruptcy before the honest ($F_0 > F_1$). Increases in the fine have no effect on defence expenditures for an individual of type i if the fine exceeds F_i (see Proposition 1). Hence for $f > F_0 > F_1$ the last two terms in (9) are zero and so is the first term, since deterrence is not affected. Consequently, the marginal value of the fine is zero for $f > F_0 > F_1$.

For $F_0 > f > F_1$ the first term in (9) is negative because deterrence is reduced in this range (Proposition 3). Since c_{0f} is positive and c_{1f} is zero, the marginal value of the fine is negative for this range.

For $F_0 > F_1 > f$ increases in the fine do increase deterrence so that the first term in (9) is positive. The second and third terms are negative so that an interior optimal fine is possible in this range.

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and II errors and defence expenditures have no new implications for optimal policing expenditure, we simplify by assuming that m is fixed. The standard maximal fine result is driven by the fact that the fine is a costless instrument which can be substituted for costly policing expenditure. However, our demonstration that the optimal fine does not bankrupt dishonest accused does not depend on the fixity of m. If m was a policy variable it would be optimally chosen when

$$\left[(h - z) + (q_1 c_1 - q_0 c_0)\right] g(z) z_m - 1 = 0$$

implying

$$\frac{dW}{df} = -\left.\frac{dm}{df}\right|_z - q_0 G c_{0f} - q_1(1 - G) c_{1f}$$

so that dW/df need not be positive even though increases in the fine permit reductions in costly policing.

In the perhaps less plausible case in which the honest are bankrupt before the dishonest ($F_0 < F_1$) deterrence is increasing with the fine up to $f = F_1$ and constant thereafter. Since defence costs increase with f it is again possible that the optimal fine does not maximise deterrence and leaves either the dishonest, or both the honest and dishonest with positive wealth if convicted.

These arguments suggest that the welfare maximising fine cannot exceed F_1 and that there are two types of optimal fine depending on the relative marginal importance of the fine's impact on deterrence and in reducing defence expenditure:[6]

critical fine: $f^* = F_1$. If deterrence has a high marginal value relative to the marginal cost of defence expenditure, then our assumption that all dishonest individuals choose $c_1^*(F_1)$ at F_1 means deterrence can be increased to its maximal extent without triggering a jump in defence expenditure. Dishonest accused are not bankrupted if not convicted. Honest individuals are also left with positive wealth or bankrupt if convicted depending on whether $F_1 < F_0$ or $F_1 > F_0$.

interior fine: $f^* < F_1$. If increases in the fine lead to an increase in defence expenditure which is large relative to the change in deterrence there will be a interior solution in which the optimal fine is less than the critical F_1 and the dishonest are not bankrupted by the fine. If $F_1 < F_0$ the honest will have positive wealth if convicted but may be bankrupt if $F_1 > F_0$.

In models with type I and II errors but no defence expenditures the bankruptcy constraint is just $y \leq f$ for both honest and dishonest accused. Since there is no qp probability reversal in such models, increases in the fine always increase deterrence and do not increase socially costly defence expenditures. Hence the optimal fine is as large as possible: $f^* = y$. Thus it is defence costs, rather than the presence of type I and type II which potentially overturn the Becker (1968) maximal fine result when individuals are risk neutral. Although the fine is a deterrent it is also a stimulus to socially wasteful expenditure by the accused.

Does "punishment fit the crime" in the sense that the dishonest face an expected penalty equal to the direct social harm they impose: $z = h$? In the standard Becker (1968) model the punishment is less than the harm because policing has a positive marginal cost. The marginal value of deterrence is positive at the optimum because deterrence has a positive marginal cost. In our model where there are defence costs and legal error the marginal

[6]If *any* of the dishonest accused choose c_1^{**} rather than $c_1^*(F_1)$ when $f = F_1$ the welfare problem may have no solution. Welfare would be always be greater at some fine slightly less than F_1 than at F_1 because of the upward jump in defence expenditure by accuseds who choose c_1^{**} at F_1.

social benefit from deterring an additional criminal will also be positive at the optimum. The marginal social benefit from deterrence is the net social cost of the marginal crime $(h - b) = (h - z)$ plus the expected increase in expenditure of criminals compared to honest individuals $(q_1c_1 - q_0c_0)$. When A3 holds, so that criminals spend more on defence than honest accused, the latter term is positive. Hence a positive marginal social value of deterrence does not necessarily imply that the benefit to the marginal criminal (z) is less than the social harm from his crime. Criminals may face expected penalties which exceed the direct harm they inflict.

3.2 Social value of legal defence expenditure

We now temporarily assume that it is possible to identify crooks and honest individuals and to control their defence expenditure. The aim of the assumption is to further investigate the welfare implications of defence expenditure, rather than to suggest realistic policy prescriptions.

When defence expenditure is directly controlled it can be used to alter deterrence and the welfare function is written as $W(c_{0,}\, c_{1,}\, z(c_0, c_1, f),\ f)$. The effect on welfare of a marginal increases in defence expenditure by the type i accused is

$$W_z z_{c_i} + W_{c_i} \tag{10}$$

At the privately chosen defence expenditures $c_i(f)$ the first term is zero since z is the difference between expected utilities which are maximised by private choice of defence expenditures. The second term is always negative.

Proposition 6 *The choices of defence expenditure by honest and dishonest accused are not first best socially optimal. The first best expenditure by honest accuseds is less than the privately optimal level and may be zero. The first best expenditure by dishonest accuseds is either zero or greater than the privately optimal level.*

At $c_i = 0$ defence expenditure increases the expected utility of both types of individual and so $z_{c_0} > 0$ and $z_{c_1} < 0$. Hence the first term in (10) is positive for honest individuals and the marginal social value of c_0 can be positive.

The marginal social value of c_1 at $c_1 = 0$ is negative. This does not, however, mean that the first best socially optimal value of c_1 is zero. It may be possible to set it at such a high level, which must exceed $c_1^*(f)$, that the dishonest individual has a lower expected utility than if c_1 was zero. For example, setting $c_1 = y$ leaves the dishonest individual with zero wealth whether convicted or acquitted and a lower expected utility than if $c_1 = 0$. The resulting increase in deterrence may be worth the additional defence costs.

4 Regulating defence costs

We now consider various policies which can be adopted to affect the defence expenditure of accused. The regulator's information is limited: she observes the results of the trial, but she does not observe b, nor individual defence expenditures, nor whether an individual committed a crime. The regulator's feasible policies, in addition to the fine, include a limit on private defence expenditure by accused, a ban on private defence expenditures and provision of the same level of defence expenditure to all accused (a public defender system), a tax or subsidy on defence expenditure, and compensation for accuseds who are acquitted.

4.1 Limit on private legal defence expenditure

Suppose that A3 and A5 hold so that the honest spend less on defence and choose bankruptcy at a higher fine than the dishonest. When the regulator can fix the maximum amount $\bar{c}$ which accuseds can spend on their defence it cannot be optimal to set $\bar{c} > c_0^*(f)$. Setting $\bar{c} \geq c_1^{**}$ does not constrain the choices of either type of accused. If $\bar{c} \in (c_1^*(f), c_1^{**})$ reducing $\bar{c}$ to $c_0^*(f)$ reduces the defence expenditure of the dishonest and makes them worse off. The reduction in $\bar{c}$ in this range does not affect the expected utility of the honest or their defence expenditure. Hence deterrence increases and defence expenditure falls, so that welfare must increase. The regulator can therefore restrict attention to $\bar{c} \leq c_0^*(f)$ and honest and dishonest accused will choose $c_0 = c_1 = \bar{c}$.

The regulator's problem is to chose f and $\bar{c}$ to maximize welfare (8) and, since fines which bankrupt the accused have no marginal welfare impact, we constrain policy by $y - c - f \geq 0$. Deterrence is

$$z = q_1[p_1(\bar{c})f + \bar{c}] - q_0[p_0(\bar{c})f + \bar{c}] \tag{11}$$

which is increasing in f: $z_f = q_1 p_1(\bar{c}) - q_0 p_0(\bar{c}) > 0$ by A1 and A2. We have assumed (A3) that the defence expenditure of the dishonest has a greater marginal product, so deterrence is decreasing in $\bar{c}$:

$$z_{\bar{c}} = q_1[p_1'(\bar{c})f + 1] - q_0[p_0'(\bar{c})f + 1] < 0 \tag{12}$$

by A1 and the fact that $\bar{c} \leq c_0^*(f) < c_1^*(f)$.

The policy Lagrangean is $L = W + \lambda(y - \bar{c} - f)$ and the optimal policy satisfies

$$L_f = W_z z_f - \lambda = 0 \tag{13}$$

$$L_{\bar{c}} = W_z z_{\bar{c}} + \sum W_{c_i} - \lambda \leq 0, \quad \bar{c} \geq 0, \quad L_{\bar{c}}\bar{c} = 0 \tag{14}$$

Since greater deterrence is welfare increasing, and deterrence is decreasing in $\bar{c}$ and increasing in the fine, and welfare is decreasing in defence expenditure, we have

Proposition 7 *If A3 and A5 hold, the optimal limit on defence expenditure is zero:* $\bar{c}^* = 0$ *and the optimal fine is maximal:* $f^* = y$.

We saw in section 3 that the privately optimal defence expenditure was not first best optimal. We have now established that the private, unregulated equilibrium expenditure is also not second best optimal: a complete ban on private defence expenditure yields a higher welfare than the unregulated market equilibrium. Indeed any binding restriction on private legal defence expenditure increases welfare compared with the market equilibrium.

4.2 Public defender system

Under a public defender system all accused are provided with the same amount of legal defence $c_0 = c_1 = c$ which is paid for by taxation rather than by the accused. Accordingly we now constrain policy by $y - f \geq 0$. Deterrence is

$$z = [q_1 p_1(c) - q_0 p_0(c)]f \tag{15}$$

and increases in c reduce deterrence: $z_c < 0$. The policy Lagrangean is very similar to case where the regulator limits private defence expenditure and the first order conditions on f and c are identical to those on f and $\bar{c}$. The solution is identical:

Proposition 8 *The optimal amount of publicly funded legal defence expenditure is zero. The optimal fine is maximal:* $f^* = y$.

4.3 Taxes on defence costs

If the regulator can impose a proportional tax t on defence costs paid by each defendant to their lawyers,[7] the privately optimal decisions on defence expenditure are $c_i(f,t)$ and are defined in the interior solution cases where $f > f_i^o - t/p_i'(0)$ by

$$-[p_i'(c_i^*)f + 1 + t] = 0$$

$$-p_i'(c_i^{**})[y - (1+t)c_i^{**}] - [1 - p_i(c_i^{**})](1+t) = 0$$

Policy is now complicated by the fact that the critical fines F_i are now functions of the tax rate. The deterrence function is identical to (4) to (7), except that the c_i terms are replaced by $(1+t)c_i$. Deterrence is increasing in the tax rate for $f < \min\{F_1, F_0\}$:

$$z_t = q_1 c_1^* - q_0 c_0^* > 0, \qquad f < F_1$$

but ambiguously signed otherwise. The argument used for Proposition 5 ensures that, for given t the optimal fine does not exceed F_1. We can therefore model the regulators' problem as maximising welfare subject to constraint that the dishonest choose not to be bankrupt when convicted:

$$y - (1+t)c_1^* - p_1(c_1^*)f \geq [1 - p_1(c_1^{**})][y - (1+t)c_1^{**}]$$

The partial derivatives of the policy Lagrangean with respect to the fine and the tax are

$$L_f = W_z z_f + \sum W_{c_i} c_{if} - \lambda p_1(c_1^*(f)) \tag{16}$$

$$L_t = W_z z_t + \sum W_{c_i} c_{it} + \lambda \{[1 - p_1(c_1^{**})]c_1^{**} - c_1^*(f)\} \tag{17}$$

with suitable left and right derivatives at $f = F_0$ if $F_0 < F_1$

Suppose the solution has an interior fine $f^* < F_1$ and $\lambda = 0$, so that (17) is positive as long as there is positive defence expenditure. Hence the tax should be raised until defence expenditure is zero. But this will reduce (16) to $W_z z_f$ which is positive. Hence the optimal fine must be critical and the constraint will bind. If the constraint binds then it is possible that there is a solution in which the last term in (17) is negative and so the tax is not set at a level which drives defence expenditure to zero.

[7] We assume that the tax is actually collected from lawyers, rather than individual defendants, otherwise the regulator can infer the defendant's type from his expenditure.

Proposition 9 *If A3 and A5 hold and it is possible to tax defence expenditure, the optimal fine is critical:* $f^* = F_1(t^*)$. *The optimal tax* t^* *may be set so high that defence expenditure is zero, be positive but leave positive defence expenditure or be negative increasing defence expenditure above the unregulated equilibrium level.*

A solution with positive defence expenditure will occur only if increasing the tax tightens the constraint on the fine by reducing the expected utility of the dishonest by less if they choose c_1^{**} than if they choose $c_1^*(F_1)$. It is possible that defence expenditure should be subsidised to relax the constraint on the effective fine.

Although direct regulation of defence costs and the tax are both effective policies for controlling defence expenditure, the solutions they yield may not be the same: the optimal tax on defence expenditure need not drive it to zero, whereas the optimal regulated level is zero. The difference between the two solutions arises because of the different implications of bankruptcy in the two policy regimes. When defence expenditure is constrained the bankruptcy constraint on the fine arises solely because the fine has no marginal deterrence value when it bankrupts the accused. With individuals having an unconstrained choice of defence expenditure bankruptcy causes an upward jump in socially costly defence expenditure.

4.4 Compensation for acquitted individuals.

Although honest and dishonest individuals are not distinguishable by the regulator, the outcome of the trial of each accused is observed. It is possible to pay a compensation θ to an individual who is acquitted, so that expected income conditional on being tried is $y - p_i f + (1 - p_i)\theta - c_i$ or $(y - c_i + \theta)(1 - p_i)$ depending on whether individual chooses to be bankrupt if convicted.

For given θ the optimal fine does not exceed F_1 for the usual reasons and we derive the optimal compensation policy as

Proposition 10 *If the optimal fine is interior then the optimal compensation is zero and if the optimal compensation is positive the optimal fine is critical:* $f^* = F_1$.

The intuition is straightforward in the case in which the dishonest are bankrupt before the honest ($F_1 < F_0$) so that the privately optimal defence expenditures satisfy

$$-[p_i'(c_i^*)(f + \theta) + 1] = 0 \tag{18}$$

Deterrence is

$$z = q_1[p_1 f + c_1^* - (1 - p_1)\theta] - q_0[p_0 f + c_0^* - (1 - p_0)\theta] \tag{19}$$

and

$$z_\theta = q_0(1 - p_0) - q_1(1 - p_1) = q_0 - q_1 + z_f < z_f \tag{20}$$

so that deterrence may increase or fall when compensation is paid to acquitted accused. A \$1 increase in f and in compensation have identical effects on defence expenditures. However, the fine has a more powerful effect on deterrence. Suppose that $f < F_1$ and that $\theta > 0$. Then an increase in the fine and an equal reduction in compensation leave defence expenditure unchanged but increases deterrence. Hence it cannot be optimal to have an interior fine and positive compensation. When the fine is critical it may be worthwhile to introduce compensation for acquitted accuseds if the rate at which deterrence is reduced is small relative to the rate at which the constraint on the fine is relaxed.

We constrained the compensation paid to acquitted individuals to be non-negative. It could be welfare increasing to permit negative compensation i.e. to penalise the acquitted as well as the convicted. If the social value of deterrence is great enough, increasing deterrence by punishing all those arrested could raise welfare. Such a conclusion seems repugnant, suggesting that the welfare criteria adopted so far in the analysis may be flawed in that it neglects what many people would consider to be important aspects of a justice system.

5 Justice orientated welfare function

The unweighted utilitarian welfare function (8) is standard but does not reflect the common view that there are additional social costs from a justice system which fails to convict some dishonest accused and convicts some honest individuals. On occasion the welfare function yields somewhat distasteful policy conclusions and it provides no support for the frequently observed policy of providing tax financed legal defence expenditure to those accused of a crime.

Suppose that each case of wrongful conviction has a social cost of $k_0(f)$, where $k_0'(f) > 0$ reflects the judgement that the social harm from wrongful conviction is greater the greater the punishment imposed (Ehrlich, 1982; Miceli, 1991). Each dishonest person who is not punished, either because not tried or because wrongful acquitted, has a social cost of k_1.[8] The justice orientated social welfare function is:

$$\hat{W} = W - Gq_0p_0k_0 - (1-G)\left[(1-q_1) + q_1(1-p_1)\right]k_1 \tag{21}$$

and the effect of a marginal increase in deterrence on welfare is

$$\hat{W}_z = W_z - \{p_0q_0k_0 - \left[(1-q_1) + q_1(1-p_1)\right]k_1\}\,g(z) = W_z - Kg(z)$$

The term K is the marginal injustice cost of increasing deterrence and could be positive or negative. With increased deference more individuals choose to be honest, so that the number of mistaken convictions of the honest increases, thereby increasing the cost of injustice. However, the number of dishonest individuals decreases, so that there are fewer who escape punishment, thereby reducing injustice costs.

The marginal social effect of an increase in the fine is

$$\frac{d\hat{W}}{df} = \frac{dW}{df} - Kgz_f - Gq_0p_0k_0' - Gq_0p_0'c_{0f}k_0 + (1-G)q_1p_1'c_{1f}k_1 \tag{22}$$

A concern for injustice may tend to increase or decrease the optimal fine. The second term in (22) is negative if the marginal injustice cost of deterrence K is positive. The third effect tends to reduce the optimal fine (Ehrlich, 1982; Miceli, 1991), since increases in the fine raise the social cost of type I errors. The last two terms reflect the impact of the fine in increasing accuseds' defence expenditures and hence reducing their probability of conviction. The fourth term is the social benefit from reduction in the probability of conviction of the honest is a social benefit and works to increase the optimal fine. The last term is the social cost from increasing the probability of acquittal of the dishonest and works to reduce the optimal fine.

A concern for injustice has an ambiguous effect on the optimal fine in general. It is even possible that it may lead to the fine being set above the critical level F_1. Thus, when $F_0 > f > F_1$ the first term in (22) is negative, since increases in the fine reduce deterrence, and the last term is zero (recall the discussion in section 3.1). The marginal value of the fine can be written as

$$\frac{d\hat{W}}{df} = \left[(h-z) + (q_1c_1 - q_0c_0) - K\right]gz_f - Gq_0p_0k_0' - Gq_0(p_0'c_{0f}k_0 + 1) \tag{23}$$

[8]The social harm from failure to punish the dishonest could plausibly depend on the cost of their crime, as in Miceli (1991) but this is not relevant in the current model where we assume that all crimes impose the same direct social cost h.

With a sufficiently high cost of type I errors the last term is positive: the gain from reduced probability of conviction of honest individuals exceeds the social cost of the addition defence expenditure. Further, K will be positive and the first term could be also be positive. Hence a concern for the cost of injustice can lead to a fine which bankrupts the dishonest.

The marginal social values of defence expenditure are

$$\frac{d\hat{W}}{dc_0} = W_z z_{c_0} + W_{c_0} - Kg z_{c_0} - G q_0 p_0' k_0 \tag{24}$$

$$\frac{d\hat{W}}{dc_1} = W_z z_{c_1} + W_{c_1} - Kg z_{c_1} + (1 - G) q_1 p_1' k_1 \tag{25}$$

At the privately optimal defence expenditures both (25) and (24) reduce to their second and fourth terms which are negative in the case of (25). However, (24) could be positive since the last term is positive. If $f \leq F_0$, the first order condition (1) on $c_i^*(f)$ implies that (24) is $(f - k_0)Gq_0p_0'$. Hence the private choice of legal expenditure when innocent will now be too small from a social point of view if the marginal social cost of convicting an innocent person is greater than the marginal gain from the reduction in taxation implied by the increased fine revenue: $k_0 > f$.

Proposition 11 *If $f \leq F_0$ and there is a social cost of mistaken convictions the honest individual's choice of legal defence expenditure is too small if and only if $k_0 > f$.*

When the welfare function reflects justice considerations the marginal welfare from public expenditure on legal defence is

$$\frac{d\hat{W}}{dc} = \frac{dW}{dc} - gKz_c - Gq_0p_0'k_0 + (1 - G)q_1p_1'k_1 \tag{26}$$

Because an increase in defence cost reduces the number of accuseds who are convicted, the third term is positive (fewer innocents convicted), but the fourth is negative (more guilty are acquitted). The second term reflects the change in the relative numbers of honest and dishonest individuals and could be negative or positive. Thus when we are directly concerned about mistakes made by the justice system the implications for the level of public defence expenditure are ambiguous. Although increasing defence expenditure reduces the number of convicted innocents, it is not necessarily the case that attaching a higher cost to wrongful convictions than to wrongful acquittals leads to more public defence.

6 Conclusions

When legal defence expenditure reduces the probability of conviction and there is no direct concern with the cost of legal errors, policies are influenced by their implications for deterrence and the level of defence costs. If the only policy variable is the fine, its impact on defence expenditure means that it is never optimal to set it high enough that convicted dishonest accused are bankrupt. If defence expenditures can be directly regulated the optimal regime has no defence expenditure and a fine which is maximal, just bankrupting all accused, both the honest and the dishonest.

Our analysis of policy interventions has been concerned with limiting defence expenditure (either through a cap, an outright ban or a tax). Some of these policies would likely be challenged as unconstitutional or grossly unfair to the accused. One wasy of reflecting such concerns is to suppose that there is a direct social cost of legal errors. Because defence expenditure by the honest reduces the probability that the innocent are wrongly convicted and punished, we show that it can be optimal to permit such expenditure. Direct error costs can also justify the provision of defence from public funds.

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Appendix

Proof of Proposition 1

We assume that the productivity of defence expenditure ensures that there is an f_i^o such that when $f > f_i^o$, the optimal level of defence expenditure is positive and characterised by the first order conditions (1) and (2), depending on whether the accused is bankrupted by his optimal defence expenditure or not.

(a) Denote the maximised value of $y - c_i - p_i(c_i)f$ by $v_i^n(f)$ and of $[1 - p_i(c_i)](y - c_i)$ by v_i^b. $v_i^n(f)$ is monotonically decreasing in f and satisfies $v_i^n(0) > v_i^b > v_i^n(\infty)$. Hence there exists a unique F_i satisfying:

$$v_i^n(F_i) = y - c_i^*(F_i) - p_i(c_i^*(F_i))F_i = (1 - p(c_i^{**}))(y - c_i^{**}) = v_i^b$$

(b) Since (1) characterises the choice of defence expenditure if and only if the individual is not bankrupt at c_i^* we have

$$\begin{aligned} -1 + p_i(c_i^{**}) - p_i'(c_i^{**})[y - c_i^{**}] &= 0 = -1 - p_i'(c_i^*)f \\ &\leq -1 - p_i'(c_i^*)[y - c_i^*] \end{aligned}$$

which implies

$$0 < -p_i'(c_i^{**})[y - c_i^{**}] < -p_i'(c_i^*)[y - c_i^*]$$

Suppose that $c_i^{**} \leq c_i^*$. Then $-p_i'(c_i^{**}) \geq -p_i'(c^*)$ from the convexity of $p_i(c)$ and $y - c_i^{**} \geq y - c_i^*$. Since $y - c_i^{**} \geq 0$ we have a contradiction and have established that $c_i^*(f) < c_i^{**}$for all $f \in (0, F_i]$.

(c) From the implicit function theorem, we know that the sign of $c^*_{if}(f)$ and $c^{**}_{if}(f)$ are given by $\partial^2 u_i/\partial c_i \partial f$. The comparative static results are immediate from (1) and (2).

(d) From the definition of F_i and the fact that $[1 - p_i(c_i)](y - c_i)$ is maximised at c^{**}_i

$$y - c^*_i - p_i(c^*_i)F_i = [1 - p_i(c^{**}_i)](y - c^{**}_i) > [1 - p_i(c^*_i)](y - c^*_i)$$

and subtracting the right hand expression from the left hand expression we get $p_i(c^*_i(F_i))[y - c^*_i(F_i) - F_i] > 0$ and so $y - c^*_i(F_i) > F_i$. The accused is not bankrupt if convicted when he chooses $c^*_i(F_i)$.

(e) Similarly,

$$[1 - p_i(c^{**}_i)](y - c^{**}_i) = y - c^*_i - p_i(c^*_i)F_i > y - p_i(c^{**}_i)F_i - c^{**}_i)$$

implies $p_i(c^*_i)F_i > p_i(c^{**}_i)F_i > p_i(c^*_i)(y - c^{**}_i)$ and so $F_i > y - c^{**}_i$. The dishonest accused is bankrupt when convicted at $f \geq F_i$ when he chooses c^{**}_i.

Proof of Proposition 3

Deterrence is continuous since, up to a positive constant, it is equal to the difference between the value of two maximized functions $V_0(c_0)$, $V_1(c_1)$ each of which are continuous in the fine. Using the envelope theorem, the expression z_f is immediate.

Proof of Proposition 5. The welfare function $W(f) = W(c_0(f), c_1(f), Z(f)) = W(c_0(f), c_1(f), z(c_0(f), c_1(f), f)$ has a continuous total derivative with respect to f everywhere except at F_1 and F_0. The sign of dW/df is discussed in the text.

(a) Consider the case in which $F_1 < F_0$. Then for $\varepsilon > 0$

$$W(F_0) - W(F_0 + \varepsilon) = [1 - G(Z(F_0))][c^{**}_0 - c^*_0(F_0)] > 0$$

since $Z(F_0 + \varepsilon) = Z(F_0)$, $c_1(F_0 + \varepsilon) = c_1(F_0)$, and $c_0(F_0 + \varepsilon) = c^{**}_0 > c_0(F_0) = c^*_0(F_0)$. For $f \in (F_1, F_0)$, $W(f)$ is decreasing in f since deterrence is decreasing, honest individuals' defence costs are increasing, and dishonest individuals' defence costs are constant. Since

$$W(F_1) - \lim_{\varepsilon \to 0} W(F_1 + \varepsilon) = G(Z(F_1))[c^{**}_1 - c^*_1(F_1)] > 0$$

the optimal fine cannot exceed F_1.

(b) When $F_1 > F_0$ and $\varepsilon > 0$

$$W(F_1) - W(F_1 + \varepsilon) = G(Z(F_1))[c^{**}_1 - c^*_1(F_1)] > 0$$

since $Z(F_1+\varepsilon)=Z(F_1)$, $c_1(F_1+\varepsilon)=c_1^{**}>c_1(F_1)=c_1^*(F_1)$, and $c_0(F_0+\varepsilon)$ $=c_0^{**}$. Again the optimal fine cannot exceed F_1.

Proof of Proposition 10 For given θ, Proposition 5 implies that the optimal fine cannot exceed F_1. The regulator's problem can be modelled as choosing f and θ to maximise welfare subject to

$$y-c_1^*-p_1(c_1^*)f+[1-p_1(c_1^*)]\theta \geq [1-p_1(c_1^{**})][y-c_1^{**}+\theta]$$

The first order condition include

$$L_f = W_z z_f+\sum W_{c_i}c_{if}-\lambda p_1(c_1^*)=0$$
$$L_\theta = W_z z_\theta+\sum W_{c_i}c_{i\theta}+\lambda\left[p_1(c_1^{**})-p_1(c_1^*)\right]\leq 0, \theta\geq, L_\theta\theta=0$$

In the case where $F_1<F_0$ we can use (20) and the fact that $c_{if}^*=c_{i\theta}^*$ to get

$$L_\theta = W_z(q_0-q_1)+\lambda p_1(c_1^{**})$$

Since the first term is negative, the optimal compensation is positive only if $\lambda>0$.

When $F_1>F_0$ the deterrence function differs from (19) for $f\in(F_0,F_1)$ and is

$$z=q_1[p_1f+c_1-(1-p_1)\theta]-q_0[p_0y+(1-p_0)\theta-c(1-p_0)] \qquad (27)$$

which is decreasing in θ and increasing in f. Hence in this case the first and second terms in L_θ are negative and so the optimal compensation is positive only if $\lambda>0$.