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Abstract

Marginal deterrence concerns the incentives created by criminal penalties for offenders to refrain from committing more harmful acts. We show that when offenders act sequentially, it is often optimal for the level of the sanction, not just the expected sanction, to rise with the severity of the act, even when enforcement is specific.

Keywords: crime, deterrence, marginal deterrence, optimal sanctions

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1   Introduction

Marginal deterrence was first discussed in the context of the economic model of crime by Stigler (1970), though as Shavell (1992) notes, the idea was understood by earlier writers such as Bentham and Beccaria. The fundamental point is that if sanctions are set too high for minor acts, then offenders will have no incentive to refrain from committing more harmful acts. This suggests that the sanction should rise with the severity of the act, but that conclusion is not easily demonstrated in the economic model of crime because marginal deterrence can be achieved by varying the likelihood of detection as well as the sanction.

The specific context in which marginal deterrence is examined turns out to be important in deriving the optimal policy. Two scenarios are possible. In the first, an offender chooses between two distinct acts involving different levels of harm. For example, a polluter can discharge a small or a large amount of waste into a river. Alternatively, the offender can act sequentially. For example, a kidnapper may choose to kill his victim if that proves beneficial (e.g., Polinsky and Shavell 2007). In the first example, the offender decides between two acts and commits only one of them, whereas in the second, he commits an initial act (kidnapping) and then later decides whether or not to commit the second (murder). The literature on marginal deterrence has established that, if enforcement efforts can be individualized to the two crimes (i.e., specific deterrence), then the optimal sanctions for *both* acts are maximal (Shavell 1992, Wilde 1992).[1] This paper, by contrast, establishes that marginal deterrence in the second scenario often entails a less-than-maximal sanction for the initial act, even when deterrence is specific.

2   The model

Risk-neutral offenders with wealth w consider whether or not to undertake act 1 that promises gross benefit b, where $b \in [0, B]$ according to $F(b)$. Act 1 causes social harm $h_1 > 0$. The probability of detecting act 1 is p_L with probability $\lambda(r_1)$ and p_H with probability $(1 - \lambda(r_1))$, where $\lambda' < 0 < \lambda''$ and $p_H > p_L \geq 0$, such that the expected detection probability is given by

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[1]Friedman and Sjostrom (1993) and Mookherjee and Png (1994) also contribute on marginal deterrence, albeit using very different assumptions.

$p_1(r_1) = \lambda(r_1)p_L + (1 - \lambda(r_1))p_H$, with $p_1' > 0 > p_1''$.[2] The interpretation is that the commission of act 1 creates some kind of evidence out of the set of possible kinds of evidence, and that law enforcement agencies can make more of a given kind of evidence by expending more resources (e.g., by carefully analyzing the crime scene and interviewing available witnesses). A detected act 1 is punished by the fine s_1. After the commission of act 1, offenders observe the evidence created (i.e., whether p_L or p_H applies). Committing act 2 after act 1 does not generate an additional gross benefit but imposes social harm $h_2 > 0$.[3] Act 2 does, however, change the expected sanction for the composite act to $\theta p_2(r_2)s_2$, where r_2 denotes resources invested in the detection of the composite act, $p_2' > 0 > p_2''$, and s_2 is the fine used to punish perpetrators of the composite act. The level of the detection probability is influenced by θ, a random variable that the offender observes after committing act 1, where $\theta \in [0, \Theta]$ according to $G(\theta)$.[4] The offender commits act 2 only if it lowers his expected punishment; that is, if $\theta \leq \theta_i^*$, $i = L, H$, where

$$\theta_i^* = \frac{p_i s_1}{p_2 s_2}. \tag{1}$$

Note that $\theta_L^* < \theta_H^*$, so offenders who observe p_L are less likely to commit act 2. Both thresholds are influenced by the law enforcement parameters as follows

$$\frac{\partial \theta_i^*}{\partial s_1} = \frac{p_i}{p_2 s_2} > 0 > \frac{\partial \theta_i^*}{\partial s_2} = -\frac{p_i s_1}{p_2 s_2^2} \tag{2}$$

$$\frac{\partial \theta_i^*}{\partial r_1} = 0 > \frac{\partial \theta_i^*}{\partial r_2} = -p_2' \frac{p_i s_1}{p_2^2 s_2}. \tag{3}$$

Individuals commit act 1 when their gross benefit b exceeds the total expected sanction, which incorporates the offender's later opportunity to commit act 2. Specifically, those offenders for whom $b \geq D$ will commit act 1, where,

$$D = \lambda \left[(1 - G_L^*)p_L s_1 + p_2(r_2)s_2 \int_0^{\theta_L^*} \theta dG \right] + (1 - \lambda) \left[(1 - G_H^*)p_H s_1 + p_2(r_2)s_2 \int_0^{\theta_H^*} \theta dG \right], \tag{4}$$

using G_i^* to denote $G(\theta_i^*)$. To explain, with probability λ, circumstances are such that the detection probability for act 1 is low. Even in this scenario, offenders consider undertaking

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[2]A similar specification is used by Spier (1994) for the accident probability in a tort setting.

[3]Our setup follows Example 1 in Wilde (1992) in this regard.

[4]It is reasonable to assume that the detection probability of the composite act is determined by a different level of resources than that of act 1 alone given its greater severity.

act 2. With probability $(1 - G_L^*)$, the offender will refrain from committing act 2 because the context is such that the composite act is associated with a relatively high expected sanction. In that case, the applicable expected sanction is $p_L s_1$. Otherwise, the offender commits act 2 in addition to act 1 and faces an expected fine of $\theta p_2 s_2$. Alternatively, with probability $(1 - \lambda)$, the offender finds himself in a situation in which the evidence implies a high detection probability. In this scenario, the offender will be more likely to commit act 2 in an attempt to lower his expected sanction.

Deterrence is influenced by the law enforcement parameters in the following way

$$\frac{\partial D}{\partial s_1} = \lambda(1 - G_L^*)p_L + (1 - \lambda)(1 - G_H^*)p_H > 0 \tag{5}$$

$$\frac{\partial D}{\partial s_2} = p_2 \left[\int_0^{\theta_L^*} \theta dG + (1 - \lambda) \int_{\theta_L^*}^{\theta_H^*} \theta dG \right] > 0 \tag{6}$$

$$\frac{\partial D}{\partial r_1} = \lambda' \left[(1 - G_L^*)p_L s_1 - (1 - G_H^*)p_H s_1 - p_2 s_2 \int_{\theta_L^*}^{\theta_H^*} \theta dG \right] > 0 \tag{7}$$

$$\frac{\partial D}{\partial r_2} = p_2' s_2 \left[\int_0^{\theta_L^*} \theta dG + (1 - \lambda) \int_{\theta_L^*}^{\theta_H^*} \theta dG \right] > 0. \tag{8}$$

We can relate our setting to the one in which individuals must commit to undertaking either act 1 or the composite act at the initial decision node (as in Shavell 1992 and Wilde 1992). Committing act 1 only will be privately optimal when $b \geq p_1(r_1)s_1 = \min\{p_1(r_1)s_1; \ E[\theta]p_2(r_2)s_2\}$, whereas the composite act is preferable when $b \geq E[\theta]p_2(r_2)s_2 = \min\{p_1(r_1)s_1; \ E[\theta]p_2(r_2)s_2\}$.

3   The analysis

The social planner maximizes welfare, defined as the sum of gross criminal benefits less harm and enforcement costs, by choosing the sanctions and enforcement levels, subject to the constraints that fines cannot exceed the level of wealth. The Lagrangian function is

$$\max_{s_1, s_2, r_1, r_2, \mu_1, \mu_2} L = \int_D^B (b - h_1 - h_2(\lambda G_L^* + (1 - \lambda)G_H^*))dF - r_1 - r_2 + \mu_1[w - s_1] + \mu_2[w - s_2] \tag{9}$$

The following conditions determine the optimum: $\mu_i \geq 0$, $L_{\mu_i} \geq 0$, and

$$L_{s_1} = Xf(D)\frac{\partial D}{\partial s_1} - (1 - F(D))h_2\left(\lambda g_L^* \frac{\partial \theta_L^*}{\partial s_1} + (1 - \lambda)g_H^* \frac{\partial \theta_H^*}{\partial s_1}\right) - \mu_1 = 0 \qquad (10)$$

$$L_{s_2} = Xf(D)\frac{\partial D}{\partial s_2} - (1 - F(D))h_2\left(\lambda g_L^* \frac{\partial \theta_L^*}{\partial s_2} + (1 - \lambda)g_H^* \frac{\partial \theta_H^*}{\partial s_2}\right) - \mu_2 = 0 \qquad (11)$$

$$L_{r_1} = Xf(D)\frac{\partial D}{\partial r_1} - (1 - F(D))h_2\lambda' \left(G(\theta_L^*) - G(\theta_H^*)\right) - 1 = 0 \qquad (12)$$

$$L_{r_2} = Xf(D)\frac{\partial D}{\partial r_2} - (1 - F(D))h_2\left(\lambda g_L^* \frac{\partial \theta_L^*}{\partial r_2} + (1 - \lambda)g_H^* \frac{\partial \theta_H^*}{\partial r_2}\right) - 1 = 0 \qquad (13)$$

$$L_{\mu_i}\mu_i = 0 \qquad (14)$$

where $X \equiv (h_1 + h_2[G_L^* + (1 - \lambda)(G_H^* - G_L^*)] - D)$ is positive by condition (12). Accordingly, the level of deterrence D falls short of the expected harm for act 1 (i.e., $h_1 + h_2[G_L^* + (1 - \lambda)(G_H^* - G_L^*)]$), which is a standard result when law enforcement is costly.

Our interest lies in the structure of the sanctions for act 1 and the composite act. The possible outcomes are (i) $s_1, s_2 < w$, (ii) $s_1 < w = s_2$, (iii) $s_1 = w > s_2$, or (iv) $s_1 = w = s_2$. In the following, we will provide arguments that rule out the possibilities (i) and (iii), which leaves the possibilities of an increasing sanction scheme and a flat one.

Consider first condition (11). A marginal increase of the sanction for the composite act has two marginal benefits and zero marginal costs, implying that s_2 will always be maximal. The marginal benefits can be explained as follows. First, an increase in the fine for the composite act increases the level of deterrence, which is valuable since there is underdeterrence. Second, increasing s_2 makes it less likely that the offender will commit act 2, thereby creating marginal deterrence. The latter effect is due to θ_i^* being a decreasing function of s_2. In other words, the offender is more likely to refrain from act 2 when $p_i s_1$ looks more favorable in comparison to $p_2 s_2$. In summary, it must be that $\mu_2 > 0$ and $s_2^* = w$. Similar marginal benefits result from a marginal increase in the resources devoted to the composite act, r_2, in condition (13). However, an increase in p_2 has marginal costs of one.

Having established that the sanction for the composite act is maximal, we now analyze whether or not s_1 is maximal as well. From (10), it is clear that s_1 has both marginal benefits and marginal costs. The marginal costs stem from the fact that a higher fine for act 1

undermines marginal deterrence. In order for $\mu_1 = 0$ and $s_1 < w$, it is required that

$$Xf(D)\frac{\partial D}{\partial s_1} = (1 - F(D))h_2\left(\lambda g_L^* \frac{p_L}{p_2 w} + (1 - \lambda)g_H^* \frac{p_H}{p_2 w}\right), \tag{15}$$

that is, that marginal costs are equal to the marginal benefits for some $s_1 \in (0, w)$. For (15) to hold, the marginal benefits must exceed (fall short of) marginal costs for small (high) levels of s_1. The marginal costs of the sanction for act 1 are decreasing when g' is small. This implies that an interior solution is only possible when the marginal benefits are decreasing at a faster rate than marginal costs. To shed more light on the possibility of the scheme where $s_1 < s_2 = w$, we note that (12) implies

$$Xf(D)\frac{\partial D}{\partial r_1} > (1 - F(D))h_2\lambda'\left(G_L^* - G_H^*\right). \tag{16}$$

That is, the beneficial impact of more resources r_1 on the level of deterrence dominates the adverse impact on the level of marginal deterrence. The level of marginal deterrence is adversely affected by an increase in r_1 because the offender is more likely to find act 2 desirable in the state in which p_H applies. Using (15) and (16), we can state a necessary condition for $s_1 < w$:

$$\frac{\partial D/\partial s_1}{\partial D/\partial r_1} < \frac{\lambda g_L^* \frac{p_L}{p_2 w} + (1 - \lambda)g_H^* \frac{p_H}{p_2 w}}{\lambda'\left(G_L^* - G_H^*\right)}. \tag{17}$$

The absolute reduction in r_1 required to hold deterrence constant after a marginal increase in s_1 (the LHS) falls short of the reduction required to keep the expected harm from act 2 constant (the RHS). In other words, when the social planner attempts an exchange of r_1 for s_1 to save on enforcement costs while keeping deterrence constant, this increases the expected social costs from offenders engaging in act 2.[5] Using all of the information contained in (12) in condition (10), we deduce that the following is required for $s_1 < w$ to be part of a maximum:

$$\frac{\partial D/\partial s_1}{\partial D/\partial r_1} = \frac{(1 - F(D))h_2\left(\lambda g_L^* \frac{p_L}{p_2 w} + (1 - \lambda)g_H^* \frac{p_H}{p_2 w}\right)}{1 + (1 - F(D))h_2\lambda'\left(G_L^* - G_H^*\right)}, \tag{18}$$

which goes beyond condition (17) by including the marginal resource costs of r_1.

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[5]The centrality of (17) for the result of an increasing sanction scheme can also be made apparent by supposing that it holds the other way around. Then, it is possible to increase s_1 and lower r_1 to keep D constant, thereby decreasing the expected harm from act 2.

Proposition 1 *In a sequential two-act model, the sanction for the less harmful act may be less than maximal despite the availability of specific enforcement. The sanction for the more harmful (composite) act will always be set at the maximal level.*

Proof. The proposition follows from the preceding argument using condition (18) and is corroborated by a numerical illustration in Section 4. ∎

4   Numerical illustration

We illustrate the possibility of an increasing sanction scheme with a simple example. Assume that b and θ are uniformly distributed in $[0,1]$, and that $p_L = .02$, $p_H = .2$, $h_1 = .5$, $h_2 = .8$, $w = 10$, $\lambda(r_1) = e^{-r_1}$, and $p_2(r_2) = 1 - e^{-.25r_2}$. In this case, we obtain the optimal policy vector $(s_1^{FB}, s_2^{FB}, r_1^{FB}, r_2^{FB}) = (6.049, 10, .471, 6.167)$, which yields welfare of $W = .084$. It follows that $\lambda = .624$, $p_2 = .786$, $\theta_L^* = .004$, $\theta_H^* = .023$, and $D = .085$. Note that the equilibrium levels of θ_i^* imply that the probability that offenders will actually undertake act 2 after act 1 is very small. Nevertheless, the presence of act 2 produces an optimal sanction scheme in which the level of s_1 is smaller than the level of the maximal fine by a considerable margin. Quite intuitively, the optimal level of s_1 approaches w when h_2 decreases. Reducing h_2 to .2, for example, while maintaining the other assumptions from above, gives $(s_1^{FB}, s_2^{FB}, r_1^{FB}, r_2^{FB}) = (9.024, 10, .270, 3.515)$, whereas $h_2 = .1$ yields a flat sanction scheme; that is, $s_1^{FB} = s_2^{FB} = w$.

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