

Running Title: Radar Detectors, Fixed and Variable Costs of Crime

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ABSTRACT

Raising the sanction will always reduce the utility of the criminal. However, raising the sanction will not always lead to less crime, and may lead to more crime. If a criminal has the opportunity to commit multiple criminal acts and has fixed and variable costs of committing these acts, then an increase in the criminal sanction, over a certain range of sanctions, may actually lead the criminal to commit more crime. The reason is that as the sanction is increased, the criminal may increase his expenditures on fixed costs, which may decrease his variable costs of committing a criminal act. Once the criminal pays his fixed costs, they will be sunk costs, and thus they will no longer enter into the criminal's decision process of committing criminal acts. But the variable cost of crime will enter into the criminal's decision process. If raising the sanction leads to decreasing variable costs of crime then raising the sanction may actually lead to more crime. The example of the criminal's decision to purchase a radar detector and to speed is used to illustrate the point.

* Department of Engineering-Economic Systems, Stanford University. I thank Randy Barnett, A. Mitchell Polinsky and Stacy Stanley for comments and discussion of the ideas in this paper, and my brother, Jeff Stanley, for allowing me to observe his economically rational behavior, which led to the numerical example and main idea of the paper. I also thank the John M. Olin Program in Law and Economics at Stanford Law School for financial support.

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I. Introduction

The economic theory of rational criminal behavior tells us that an actor who is considering whether to commit a criminal act will compare his private benefits with his private costs associated with the act.¹ The criminal will commit the act if his private benefits outweigh his private costs. The private costs to a criminal of committing a crime include both the cost of actually performing the criminal act, as well as the expected sanctions imposed on him by society²

In most situations a criminal's expected costs of committing a crime will increase as the sanction increases. Thus one will normally expect that raising the sanction will increase the deterrence an actor faces when deciding whether to commit a crime. Certainly this is true for the single opportunity crime.³ But I will show that if a criminal has the opportunity to commit multiple criminal acts and has fixed and variable costs of committing these acts, then, perversely, an increase in the criminal sanction, over a certain range of sanctions, may actually lead the criminal to commit more crime.

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¹ Becker (1968).

² Becker (1968). Or certain equivalents if one is assuming non-risk neutral behavior. See Polinsky and Shavell (1979) for an analysis of risk averse behavior.

³ See section II below where I formally prove this. While the increase in the nominal sanction may lead to an increase or a decrease in the expected sanction, in all situations the actor's total private costs of committing a crime (the actual costs of committing the crime plus the expected sanction) will increase.

Fixed costs are costs that do not depend upon the number of times a criminal act is committed. Variable costs are costs that do depend upon the number of times a crime is committed. Both fixed and variable costs can consist of action costs and expected sanction costs.⁴

The reasoning behind the possible increase in crime when the sanction is increased is relatively simple. As the sanction is increased, the criminal may increase his expenditures on fixed costs. The increased fixed costs may lead to decreased variable costs of committing the crime. The key is that once the criminal pays his fixed costs, they will be sunk costs, and thus will no longer enter into the criminal's decision process of committing criminal acts. The variable cost of crime, however, will enter into the criminal's decision process. Decreasing the variable cost of crime can actually lead to more crime. If increased sanctions ultimately lead to decreased variable costs, then increased sanctions may lead to more crime.⁵

I will show that the criminal will always be worse off if the sanction is raised, even if the criminal is committing more crimes.⁶ As a result, there may be some potential criminals that choose to opt out of committing any crimes, and this factor needs to be considered when determining whether raising the sanction does in fact raise the aggregate number of crimes committed by all criminals.⁷

This paper does not provide an argument against increasing a sanction or fine to an extremely high amount.⁸ For a crime that is definitely detrimental to society an extreme increase in the sanction might be a good policy, as it will likely deter individuals from entering into the activity

⁴ Action costs are the actual costs of committing the act. Also, I am examining private costs faced by the criminal in making his decision. Sanctions that are mere transfers from the criminal to society are seen as costs in the criminal's decision process.

⁵ That increases of a sanction in certain situations may lead to more crime, is not just a hypothetical oddity. In fact it was an observation of this type of behavior that led to this paper.

⁶ There are two things to keep track of that are quite different. First the amount of crime and second the utility of the criminal. Raising the sanction will always reduce the utility of the criminal, however, raising the sanction may not lead to less crime, and in fact may lead to more crime.

⁷ See Shavell (1980) for an analysis of the level of activity versus the level of care in the tort realm.

⁸ There have been many rationales as to why increasing the fine as high as feasible might not be optimal. These explanations include marginal deterrence issues (Stigler 1970), the risk averseness of individuals (Polinsky & Shavell 1979), avoidance and concealment costs (Malik 1990, Stanley 1995) and variations of wealth among individuals (Polinsky & Shavell 1991).

all together and thus decrease crime. What is shown is that for a certain range of sanctions, increasing a sanction may cause criminal activity to rise. The multiple act model will show that if one wants to deter crime, and not just punish the individual criminal, it may be necessary to increase sanctions to high amounts outside of this middle range.

From a policy standpoint, if we do not want to set the sanction at an extremely high amount to deter all criminal acts, then sanctions should be structured in a way that account for the concealing behavior of a criminal. As sanctions are increased criminals may increase their expenditures on concealment, thus reducing the probability of detection and conviction.⁹ Where the criminal has multiple opportunities to commit criminal acts simply raising the sanction in itself might not decrease the amount of crime. To ensure that total crime will decrease, it is important that the variable cost of the crime increase. If possible, we will want to raise the sanction based on the amount of the criminal's concealment expenditures in such a way that the criminal will face a higher variable cost of crime and thus be less likely to commit more crimes when the sanction increases. It is important to remove criminals' incentives to engage in this concealment activity.¹⁰

This article proceeds as follows. Section II will examine the simple single criminal opportunity case. It will be shown that raising the sanction will always lead to increased deterrence for the one opportunity crime, although the expected sanction may decrease. Section III will examine the multiple opportunity case where criminal costs can be both fixed and variable. It will be shown that raising the sanction will make the criminal worse off, although it might not decrease, and may even increase, the amount of crime committed. Section IV presents extensions of the model. Section V examines some policy implications from the analysis. Section VI provides a conclusion.

⁹ Malik (1990).

¹⁰ I have written another paper that more extensively examines optimal sanctions for crimes committed with concealment behavior. Even for the one opportunity crime we will prefer to discourage concealment. Raising the probability of detection and conviction by giving a criminal an incentive not to conceal is socially more desirable than raising it by expending enforcement resources. See Stanley (1995).

II. Single Opportunity for Committing a Criminal Act

We will first examine the single crime opportunity case, where all criminal costs can be seen as variable costs. We will reexamine the basic criminal decision model and show that raising the sanction will lead to increased deterrence. This will be true even where an increase in the sanction may lead to the criminal increasing his concealment costs, lowering his probability of detection and conviction, and thus possibly lowering his expected sanction of committing the crime.

The deterrence that a criminal faces will be composed of three items. The costs that the criminal spends on committing the crime, including the costs of avoiding detection, the probability of detection and conviction, and the sanction. The costs that the criminal spends avoiding detection will always be faced, while the sanction will only be encountered if the criminal is detected and convicted. If the total costs to the criminal are greater than the benefit, then the criminal will be deterred from committing the crime. I will be assuming a risk neutral actor in the analysis.

I will use the following notation:

b	the utility to criminal of the activity.
s	the sanction.
c	the criminal's cost of the criminal act, including concealment costs.
$p(c)$	the probability of detection and conviction. ¹¹

The criminal will only engage in the activity if $b - [c + (p(c)s)] \geq 0$. This is the rationality constraint, namely that a criminal will only engage in activities that bring him a net surplus.

The criminal's choice variable is the amount he spends on concealment costs, c . The criminal will choose c such that he is maximizing his expected benefit of $\max\{b - [c + (p(c)s)], 0\}$.

¹¹ The probability of detection will also depend upon law enforcement expenditures. In the model though I am holding these resources constant and thus I have removed the variable from the function for increased readability.

Let \hat{s} and \tilde{s} be sanctions such that $\hat{s} > \tilde{s}$. I will first examine the case where the sanction is low. Suppose the sanction is \tilde{s} . If the criminal decides to undertake the criminal act then the criminal will choose to spend costs \tilde{c}^* such that $\tilde{c}^* + p(\tilde{c}^*)\tilde{s} \leq c + p(c)\tilde{s}$ for all c . This is simply stating that the criminal will choose to spend costs \tilde{c}^* such that he is minimizing his total expected costs of the crime, namely the concealment costs plus the expected sanction.

Now examine the case where the sanction is high. Suppose the sanction is \hat{s} . In this case if the criminal decides to undertake the criminal act then the criminal will choose to spend costs \hat{c}^* such that $\hat{c}^* + p(\hat{c}^*)\hat{s} \leq c + p(c)\hat{s}$ for all c . Once again the criminal is minimizing his total expected costs.

Proposition 1: The actor's expected benefit of the criminal act under a lower sanction is greater than or equal to the actor's expected benefit under a higher sanction.

When the sanction is low, \tilde{s} , we have:

$$\tilde{c}^* + p(\tilde{c}^*)\tilde{s} \leq c + p(c)\tilde{s} \text{ for all } c. \quad (1)$$

As this is true for all c , it will be true for $c = \hat{c}^*$, and thus we get:

$$\tilde{c}^* + p(\tilde{c}^*)\tilde{s} \leq \hat{c}^* + p(\hat{c}^*)\tilde{s} \quad (2)$$

We also have $\hat{s} > \tilde{s}$, which will give us:

$$\hat{c}^* + p(\hat{c}^*)\tilde{s} \leq \hat{c}^* + p(\hat{c}^*)\hat{s} \quad (3)$$

With equations (2) and (3) we obtain:

$$\tilde{c}^* + p(\tilde{c}^*)\tilde{s}^* \leq \hat{c}^* + p(\hat{c}^*)\hat{s}^* \quad (4)$$

and thus

$$b - [\tilde{c}^* + p(\tilde{c}^*)\tilde{s}^*] \geq b - [\hat{c}^* + p(\hat{c}^*)\hat{s}^*] \quad (5)$$

Adding in the rationality constraint we have thus shown:

$$\therefore \max\{b - [\tilde{c}^* + p(\tilde{c}^*)\tilde{s}^*], 0\} \geq \max\{b - [\hat{c}^* + p(\hat{c}^*)\hat{s}^*], 0\} \quad (6)$$

Proposition 2: The deterrence of committing a criminal act faced by an actor under a lower sanction is less than or equal to the deterrence faced by an actor under a higher sanction.

This follows from equation (4) above where it shows that if the sanction is raised the criminal will face higher total costs and thus more deterrence.

Notice I have placed no restriction on how the expected sanction $p(\hat{c}^*)\hat{s}$ relates to $p(\tilde{c}^*)\tilde{s}$. It could be the case that the expected sanction is lower when the sanction is high, that is $p(\hat{c}^*)\hat{s} < p(\tilde{c}^*)\tilde{s}$ even though $\hat{s} > \tilde{s}$. Of course it could also be the case that $p(\hat{c}^*)\hat{s} \geq p(\tilde{c}^*)\tilde{s}$. The point is that the effect of the change in sanction on the expected sanction is ambiguous. But what is not ambiguous is that the total costs – the costs of committing and concealing the crime plus the expected sanction – a criminal faces will be higher when the sanction is higher. Raising the sanction always increases deterrence in this one act model.

Some of the model's assumptions need to be lifted to show that raising the sanction may lead to more crime. This can be done by dividing up criminal costs into fixed costs and variable costs. I thus proceed to the multiple act case.

III. Multiple Opportunities for Committing Criminal Acts

When a criminal has multiple opportunities to commit a crime, his costs of committing a criminal act can be divided into fixed costs and variable costs.

Fixed costs are costs that do not depend upon the number of times a crime is committed. An example of such a fixed cost device is a radar detector which, once bought, can be used many times.

Variable costs are costs that do depend upon the number of times a crime is committed. Each time a crime is committed a criminal faces these costs. These variable costs consist of two parts, variable action costs and variable expected sanction costs. For the speeding example the variable action costs may include the costs of turning on the radar detector as well as the effort of checking one's mirrors while speeding. In addition a criminal faces expected sanctions each time he speeds, which are an additional variable cost.

Interestingly we may find situations where increasing the sanction leads to more crime. The reason is quite simple: the sanction increases, causing the criminal to increase the amount he spends on fixed costs; the higher fixed costs lead to smaller variable costs and thus when the criminal faces an additional opportunity to commit a crime, he is more likely to do so.

A few caveats. First it should be noted that the criminal will always be worse off when the sanction is increased. I prove this below. Some criminals might opt out of committing any crimes, and thus the aggregate amount of crime may fall for this reason. Second in many, if not most, situations raising the sanction will still lead to less crime for individual actors. What is being shown is that one cannot be certain that less crime will be committed by any given actor. Third, if the sanction is raised to a high enough level all crimes will be deterred or the criminal will have reached a state where he is undetectable, not prosecutable or judgment proof (and thus can commit as many crimes as he wishes without regard to the sanction). I will show results by examining a

model where the criminal has two opportunities for committing criminal acts.¹² I will be assuming a risk neutral actor throughout the analysis.

A. The General Two Opportunity Model

I will use the following notation

b_i	the utility to criminal of the activity for opportunity i .
s	the sanction.
c_i	the criminal's variable cost of the criminal act for opportunity i .
k	the fixed costs of committing criminal acts.
$p_i(k, c_i)$	the probability of detection and conviction for opportunity i .

Let \hat{s} and \tilde{s} be sanctions such that $\hat{s} > \tilde{s}$. For whatever sanction the actor faces, he will choose to spend fixed costs and variable costs such that he is maximizing his utility. That is the actor will choose an optimal triplet comprised of the fixed cost k , the first criminal opportunity variable action cost c_1 and the second criminal opportunity variable action cost c_2 . Should the criminal choose to opt out of any criminal acts, the variable action cost will be 0. Should the criminal choose to opt out of all criminal acts, the variable action costs and the fixed cost will all be 0, as will be the actor's total utility.¹³ We can now define the optimal triplets for the given sanctions.

¹² Examining a model in which there are more than two acts does not substantively add to the analysis or conclusions.

¹³ A few general comments equations (7) - (13). The inner "max" terms allow the actor to opt out of committing any particular crime, in which case he will receive 0 utility for that opportunity. The actor will opt out of committing a particular crime if his benefit is less than his expected variable costs for that crime.

The outer "max" term allows the actor to opt out of committing all crimes, and thus opting out of spending any resources on fixed costs. If the actor opts out of committing any crimes he has a total utility 0.

Suppose the sanction is low. If the sanction is \tilde{s} , the criminal will choose the optimal triplet $\{\tilde{k}^*, \tilde{c}_1^*, \tilde{c}_2^*\}$, such that for all triplets $\{k, c_1, c_2\}$ we have the following:

$$\begin{aligned} & \max\left\{\left[\max\left\{\left[b_1 - \left[\tilde{c}_1^* + p(\tilde{k}^*, \tilde{c}_1^*)\tilde{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\tilde{c}_2^* + p(\tilde{k}^*, \tilde{c}_2^*)\tilde{s}\right], 0\right] - \tilde{k}^*\right\}, 0\right]\right\} \geq \\ & \max\left\{\left[\max\left\{\left[b_1 - \left[c_1 + p(k, c_1)\tilde{s}\right], 0\right] + \max\left\{\left[b_2 - \left[c_2 + p(k, c_2)\tilde{s}\right], 0\right] - k\right\}, 0\right]\right\} \end{aligned} \quad (7)$$

The actor's choosing of the optimal triplet is simply stating that the criminal will choose to spend costs $\{\tilde{k}^*, \tilde{c}_1^*, \tilde{c}_2^*\}$ such that he is maximizing his total benefit costs of the criminal activity when the sanction is \tilde{s} .

Suppose the sanction is high. If the sanction is \hat{s} , the actor will choose the optimal triplet $\{\hat{k}^*, \hat{c}_1^*, \hat{c}_2^*\}$, such that for all triplets $\{k, c_1, c_2\}$ we have the following:

$$\begin{aligned} & \max\left\{\left[\max\left\{\left[b_1 - \left[\hat{c}_1^* + p(\hat{k}^*, \hat{c}_1^*)\hat{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\hat{c}_2^* + p(\hat{k}^*, \hat{c}_2^*)\hat{s}\right], 0\right] - \hat{k}^*\right\}, 0\right]\right\} \geq \\ & \max\left\{\left[\max\left\{\left[b_1 - \left[c_1 + p(k, c_1)\hat{s}\right], 0\right] + \max\left\{\left[b_2 - \left[c_2 + p(k, c_2)\hat{s}\right], 0\right] - k\right\}, 0\right]\right\} \end{aligned} \quad (8)$$

The actor's choosing of the optimal triplet is simply stating that the criminal will choose to spend costs $\{\hat{k}^*, \hat{c}_1^*, \hat{c}_2^*\}$ such that he is maximizing his total benefit costs of the criminal activity when the sanction is \hat{s} .

Proposition 3: For the two opportunity criminal act model, the total expected benefit of the act for a criminal where the sanction is low is greater than or equal to the total benefit where the sanction is high.

When the sanction is low, \tilde{s} , we have:

$$\begin{aligned} & \max\left\{\left[\max\left\{\left[b_1 - \left[\tilde{c}_1^* + p(\tilde{k}^*, \tilde{c}_1^*)\tilde{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\tilde{c}_2^* + p(\tilde{k}^*, \tilde{c}_2^*)\tilde{s}\right], 0\right] - \tilde{k}^*\right\}, 0\right]\right\} \geq \\ & \max\left\{\left[\max\left\{\left[b_1 - \left[c_1 + p(k, c_1)\tilde{s}\right], 0\right] + \max\left\{\left[b_2 - \left[c_2 + p(k, c_2)\tilde{s}\right], 0\right] - k\right\}, 0\right]\right\} \end{aligned} \quad (9)$$

As this is true for all triplets $\{k, c_1, c_2\}$, it will be true for the triplet $\{\hat{k}^*, \hat{c}_1^*, \hat{c}_2^*\}$, and thus we get:

$$\begin{aligned} & \max\left\{\left[\max\left\{\left[b_1 - \left[\tilde{c}_1^* + p(\tilde{k}^*, \tilde{c}_1^*)\tilde{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\tilde{c}_2^* + p(\tilde{k}^*, \tilde{c}_2^*)\tilde{s}\right], 0\right] - \tilde{k}^*\right\}, 0\right]\right\} \geq \\ & \max\left\{\left[\max\left\{\left[b_1 - \left[\hat{c}_1^* + p(\hat{k}^*, \hat{c}_1^*)\tilde{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\hat{c}_2^* + p(\hat{k}^*, \hat{c}_2^*)\tilde{s}\right], 0\right] - \hat{k}^*\right\}, 0\right]\right\} \end{aligned} \quad (10)$$

We also have $\hat{s} > \tilde{s}$, which will give us:

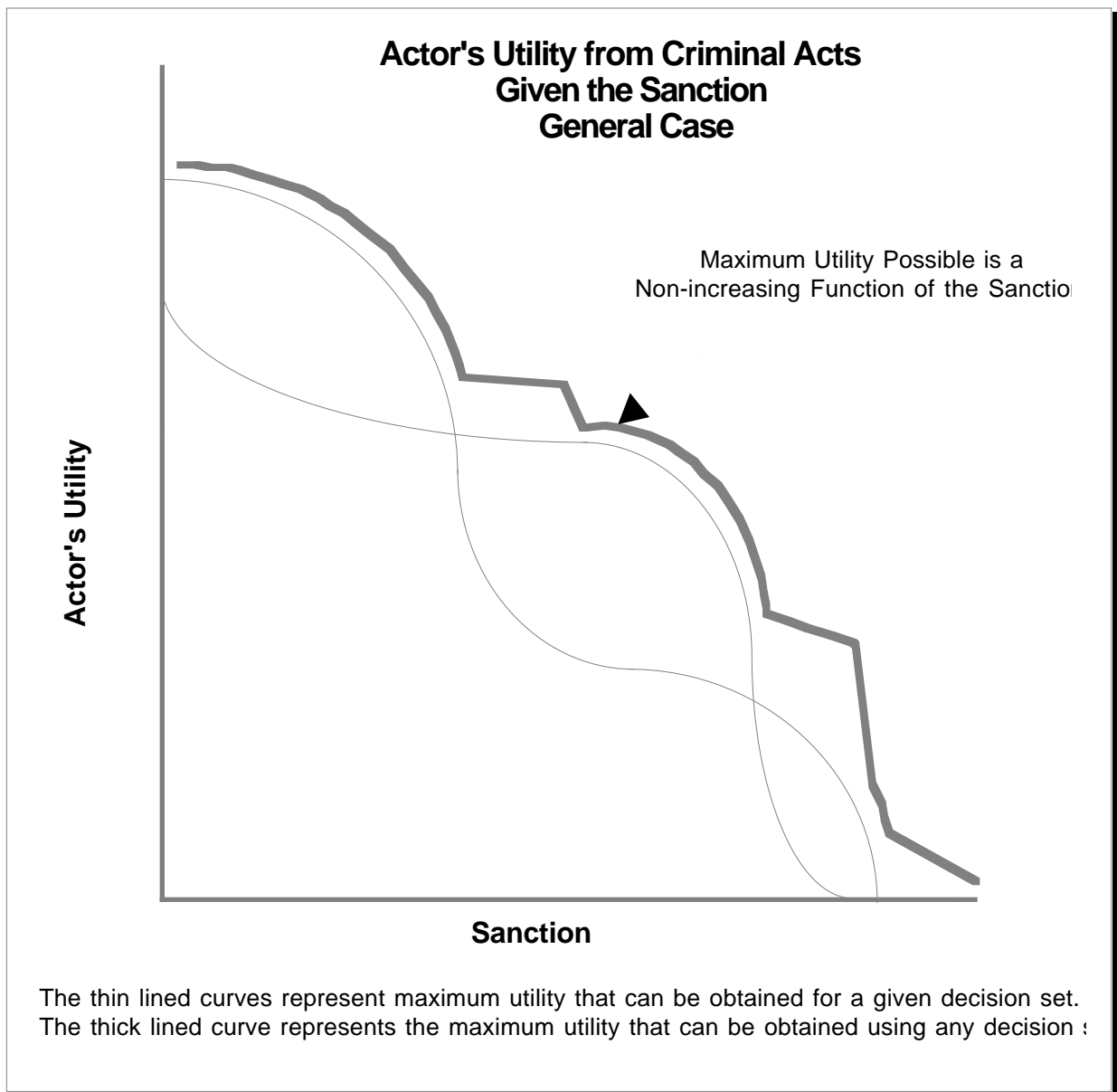
$$\begin{aligned} & \max\left\{\left[\max\left\{\left[b_1 - \left[\hat{c}_1^* + p(\hat{k}^*, \hat{c}_1^*)\tilde{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\hat{c}_2^* + p(\hat{k}^*, \hat{c}_2^*)\tilde{s}\right], 0\right] - \hat{k}^*\right\}, 0\right]\right\} \geq \\ & \max\left\{\left[\max\left\{\left[b_1 - \left[\hat{c}_1^* + p(\hat{k}^*, \hat{c}_1^*)\hat{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\hat{c}_2^* + p(\hat{k}^*, \hat{c}_2^*)\hat{s}\right], 0\right] - \hat{k}^*\right\}, 0\right]\right\} \end{aligned} \quad (11)$$

With equations (10) and (11) we obtain:

$$\begin{aligned} \therefore & \max\left\{\left[\max\left\{\left[b_1 - \left[\tilde{c}_1^* + p(\tilde{k}^*, \tilde{c}_1^*)\tilde{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\tilde{c}_2^* + p(\tilde{k}^*, \tilde{c}_2^*)\tilde{s}\right], 0\right] - \tilde{k}^*\right\}, 0\right]\right\} \geq \\ & \max\left\{\left[\max\left\{\left[b_1 - \left[\hat{c}_1^* + p(\hat{k}^*, \hat{c}_1^*)\hat{s}\right], 0\right] + \max\left\{\left[b_2 - \left[\hat{c}_2^* + p(\hat{k}^*, \hat{c}_2^*)\hat{s}\right], 0\right] - \hat{k}^*\right\}, 0\right]\right\} \end{aligned} \quad (12)$$

The graph below demonstrates the implications of these equations. Equation (11) shows that the utility from each decision action is non-increasing in the sanction. This can be seen by the non-increasing utility curves of the possible decision actions in the graph. Equation (12) shows

that the utility from the optimal decision action at each sanction will also be non-increasing in the sanction. The optimal decision action utility is shown by the heavy line in the graph.¹⁴



Graph 1: Actor's Net Utility from Criminal Acts Given the Sanction

¹⁴ I have slightly offset this maximum utility line so that one can more clearly see the individual decision utility curves.

Although we can show the criminal will be worse off as the sanction increases, we do not know how the variable cost for any particular criminal opportunity changes as the sanction increases. In the above graph, the variable costs are represented by the slope of the lines. One can easily see that the variable costs (slopes) may rise or fall as the sanction is increased, depending upon the criminal's decision at any particular sanction.¹⁵

In the two opportunity model, for any given opportunity we do not know if it is more likely that a particular criminal act will be committed when the sanction is low or when the sanction is high. That is we do not know the relationship among the benefit less the variable costs under the two different sanctions for each act:

$$\begin{aligned} \max\left\{\left[b_1 - \left[\tilde{c}_1^* + p(\tilde{k}^*, \tilde{c}_1^*)\tilde{s}\right], 0\right\} & ? \max\left\{\left[b_1 - \left[\hat{c}_1^* + p(\hat{k}^*, \hat{c}_1^*)\hat{s}\right], 0\right\} \\ \max\left\{\left[b_2 - \left[\tilde{c}_2^* + p(\tilde{k}^*, \tilde{c}_2^*)\tilde{s}\right], 0\right\} & ? \max\left\{\left[b_2 - \left[\hat{c}_2^* + p(\hat{k}^*, \hat{c}_2^*)\hat{s}\right], 0\right\} \end{aligned} \quad (13)$$

Once fixed costs are sunk, it is the variable cost that enters into the criminal's decision process as to whether to enter into a criminal act. The fact that we do not know how variable costs will change as the sanction increases indicates that we cannot be sure how the crime rate will be affected by an increase in the sanction. If the variable costs fall then it is possible that the crime rate will increase.¹⁶

Proposition 4: For the two opportunity criminal act model, when the sanction is increased, no general conclusions can be made as to the direction that the variable costs of each criminal opportunity will change.

¹⁵ That is the slope of the optimal decision curve for a given sanction might be steeper or flatter than the slopes of the other decision curves at the given sanction. If the slope is flatter, then the variable costs are lower.

¹⁶ The fixed costs are also important, since if the optimal fixed costs for a certain sanction are high enough then the criminal may choose to opt out of crime altogether, and thus the crime rate might fall for this other reason. See Shavell (1980).

I will show this by way of the numerical example below. I will demonstrate that for some increases in the sanction the variable costs of a criminal act will increase, while for other increases in sanctions the variable costs will decrease. The numerical example shows a situation where increasing the sanction over a certain range can lead to more crime, although increasing the sanctions even further leads to less crime.

That raising the sanction can lead to more crime is based on observations of my brother Jeff's behavior. Jeff when faced with a higher penalty for speeding bought a radar detector and actually ended up speeding more than he did before he faced the higher penalty. In this case the purchase price of the radar detector is the fixed cost of his criminal activity, while his effort in turning it on and the expected sanctions are his variable costs of his criminal activity. I now give a numerical example based on my brother's behavior.

B. Numerical Example:

Suppose an actor has two opportunities to commit the criminal act of speeding. Assume that if he speeds, one time the actor will receive a benefit of 40, and the other time he will receive a benefit of 10. Also assume that the actor receives this benefit regardless of whether he is or is not caught.¹⁷ Suppose the individual can buy a radar detector for 15. Assume that the criminal will have variable criminal action costs of 1 regardless of whether he has bought a radar detector or not.¹⁸ Finally assume that if the actor does not have a radar detector he will be detected and

¹⁷ For example a husband may receive a benefit of 40 for speeding when trying to get his pregnant wife to the hospital. The husband gets caught for speeding, but then the police officer drives them to the hospital. While in the waiting room the police officer writes the husband a ticket. After all it is the law.

Think of the situation where there is a dip in the road and it is fun driving fast over that dip as one where the actor's utility of speeding is 10. In this case one speeds over the dip, gets his utility of 10, and then gets stopped for speeding by the police officer. Again the utility is gained even though detection occurs.

If one wants to remove the criminal's benefit when the act is detected this will be equivalent to shifting the fine up by the benefit received. Having a sanction that varies with the benefit received, as opposed to the harm caused, will not be optimal for deterrence reasons. See Polinsky and Shavell (1994). Instead such a sanction will be for pure punishment reasons.

¹⁸ In this numerical example, I am assuming the same variable action costs whether an individual has a radar detector or not and thus letting the expected sanction be the only variable cost

convicted with probability 1 while if he does have a radar detector he will be detected and convicted with probability 0.3.

We will now examine the actor's behavior under five different sanctions. These five different sanctions will lead to five different sets of behavior by the actor. The criminal has three binary choices to make: (1) whether to buy the radar detector; (2) whether to speed when his utility is 40; and (3) whether to speed when his utility is 10. This leads to eight potential decision outcomes by the actor. Of these eight, three are strictly dominated by other decisions.¹⁹ The numbers in this example have been "fixed" so that all five types of non-strictly dominated behavior will be optimal for some sanction. It could be the case, however, that less than five types of behavior are optimal, or even that only one type of behavior is optimal, for the entire range of sanctions.

For some sanctions it may be that the criminal is not going to buy a radar detector because the fine for speeding is so low that the criminal cannot cost justify purchasing a radar detector. If the sanction is somewhat raised, however, the criminal may decide to buy a radar detector and thus speed even more. But if the sanction is raised a great amount then the criminal chooses to opt out of committing any crimes altogether. Moving the sanction from the low range to the high range, the chart below shows the five types of behavior that will be present in the example.

that changes in the analysis. But this assumption of the same variable action costs is not necessary. We can have situations where the action cost does depend upon the fixed costs. For the driver who buys a radar detector there may be a higher action cost to turn on the radar detector, or there may be a lower action cost because he does not have to check his mirrors for police as often.

What is important to the analysis is the total variable cost, that is the variable action costs plus the expected sanction. In this example I am letting expected sanctions vary to solely reflect the change in total variable costs.

¹⁹ The three choices that will never be optimal for the criminal are: (1) buying a radar detector and speeding only when his utility is 10 (always dominated by the situation of buying a radar detector and only speeding when his utility is 40); (2) not buying a radar detector and speeding only when his utility is 10 (always dominated by the situation of not buying a radar detector and only speeding when his utility is 40); and (3) buying a radar detector and never speeding (always dominated by not buying a radar detector and never speeding).

Sanction	5	10	20	40	100
Speed when utility from speeding is 10?	yes	no	yes	no	no
Speed when utility from speeding is 40?	yes	yes	yes	yes	no
Buy Radar Detector	no	no	yes	yes	no
Net Utility	38	29	21	12	0
Best Course of Action	Do not buy radar detector Speed twice	Do not buy radar detector Speed once	Buy radar detector Speed twice	Buy radar detector Speed once	Do not buy radar detector Never Speed

Table 1: Five types of behavior in the two act opportunity numerical example.

I will work out the details when the sanction is 10 and 20, as increasing the sanction in this range leads to the peculiar case that more crime is committed. I will give the results in a table for when the sanction is 5, 40 and 100 to show the other possible behaviors of the actor.²⁰ I also graph the optimal behavior and the variable costs of the different behaviors over the range of sanctions.

If the sanction is 10 and the driver does not buy the radar detector, he will speed one time when his utility is 40. He will be caught that one time and pay a fine of 10, have a variable action cost of 1 and thus have a benefit of 29. The driver will not speed in the situation where his utility is only 10 because he will be caught and have to pay a fine of 10 and have a variable action cost of 1, for total costs of 11, and a benefit of -1. Since the driver can receive a net benefit of 0 by not speeding in this situation, he will choose not to speed. The total benefit to the driver will thus be 29.

²⁰ It should be easy to follow in the table the calculations as to how the actor's decision is made.

If the sanction is 10 and the driver does buy the radar detector, he will speed twice. He will speed when his utility is 40, be caught 30% of the time and have an expected fine of 3, have a variable action cost of 1 and thus have a benefit of 36. The driver will also speed in the situation where his utility is only 10 because he will again have an expected fine of 3 and have a variable action cost of 1, for total costs of 4 and a benefit of 6. Thus the actor will receive 42 in utility from speeding twice. But he will have paid 15 for the radar detector, and thus have a total benefit of only 27.

Since $29 > 27$, the driver will choose not to buy the radar detector and will speed only once.

If the sanction is 20 and the driver does not buy the radar detector, he will again speed one time when his utility is 40. He will be caught that one time and pay a fine of 20, have a variable action cost of 1 and thus have a benefit of 19. The driver will not speed in the situation where his utility is only 10 because he will be caught and have to pay a fine of 20 and have a variable action cost of 1, for total costs of 21, and a benefit of -11. Since the driver can receive a benefit of 0 by not speeding in this situation, he will choose not to speed. The total benefit to the driver will thus be 19.

If the sanction is 20 and the driver does buy the radar detector, he will speed twice. He will speed when his utility is 40, be caught 30% of the time and have an expected fine of 6, have a variable action cost of 1 and thus have a benefit of 33. The driver will also speed in the situation where his utility is only 10 because he will again have an expected fine of 6 and have a variable action cost of 1, for total costs of 7 and a benefit of 3. Thus the actor will receive 36 in utility from speeding twice. But he will have paid 15 for the radar detector, and thus have a total benefit of only 21.

Since $21 > 19$, the driver will choose to buy the radar detector and will speed twice.

Thus I have shown a situation where raising the fine has led to increased criminal activity. When the fine is 10 the driver only broke the law once. When the fine is 20 the driver bought a

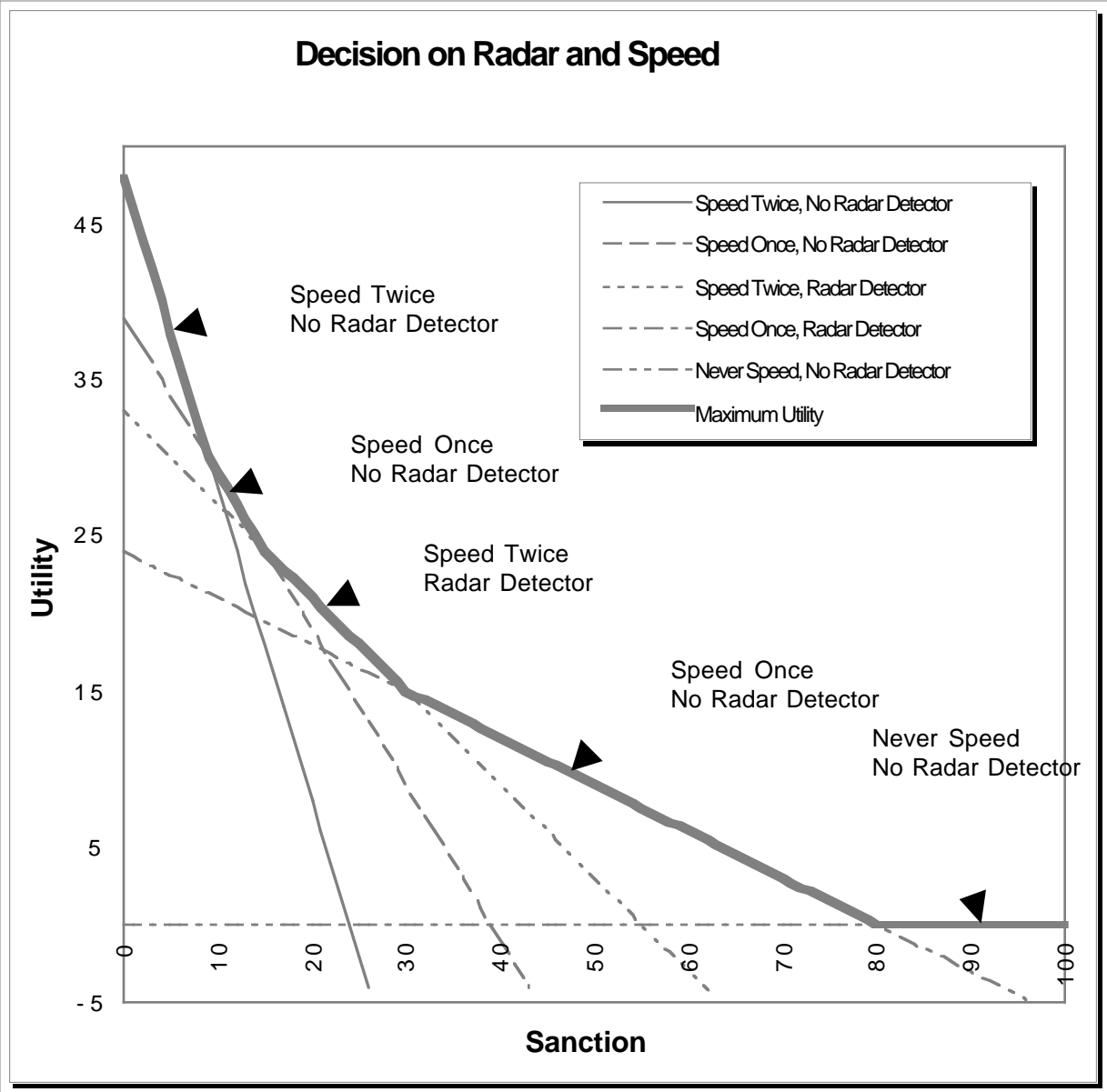
radar detector, decreased his variable costs of crime, and broke the law twice. The following table shows the analysis for the sanctions leading to the other types of optimal decision behavior.

=====
INSERT TABLE 2
Click Here For .pdf Link
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The following is a graph over the range of sanctions. I plot the five different decision choices that a driver can make: (1) not buying a radar detector and speeding twice; (2) not buying a radar detector and speeding when his utility is 40; (3) buying a radar detector and speeding twice; (4) buying a radar detector and speeding when his utility is 40; and (5) not buying a radar detector and never speeding. Each of these decision sets may be the optimal decision choice for the driver at certain sanctions.²¹

²¹ If the probability of detection and conviction fell to 0 at a certain sanction for a decision then we would see a horizontal line from that sanction extending outward to higher sanctions, as increasing the sanction would not effect the actor's utility.

We would have a similar horizontal line if the actor is judgment proof. On the graph, a judgment proof problem could be seen by setting the maximum sanction at the actor's wealth. For example if the actor's wealth is 20, the actor would treat all sanctions above 20 as though they are 20 and thus speed twice with a radar detector. Each decision choice would become a horizontal line once at the point the sanction reached the judgment proof amount of 20, with the utility and of each decision being the same as the criminal would make when the sanction is 20. The optimal decision

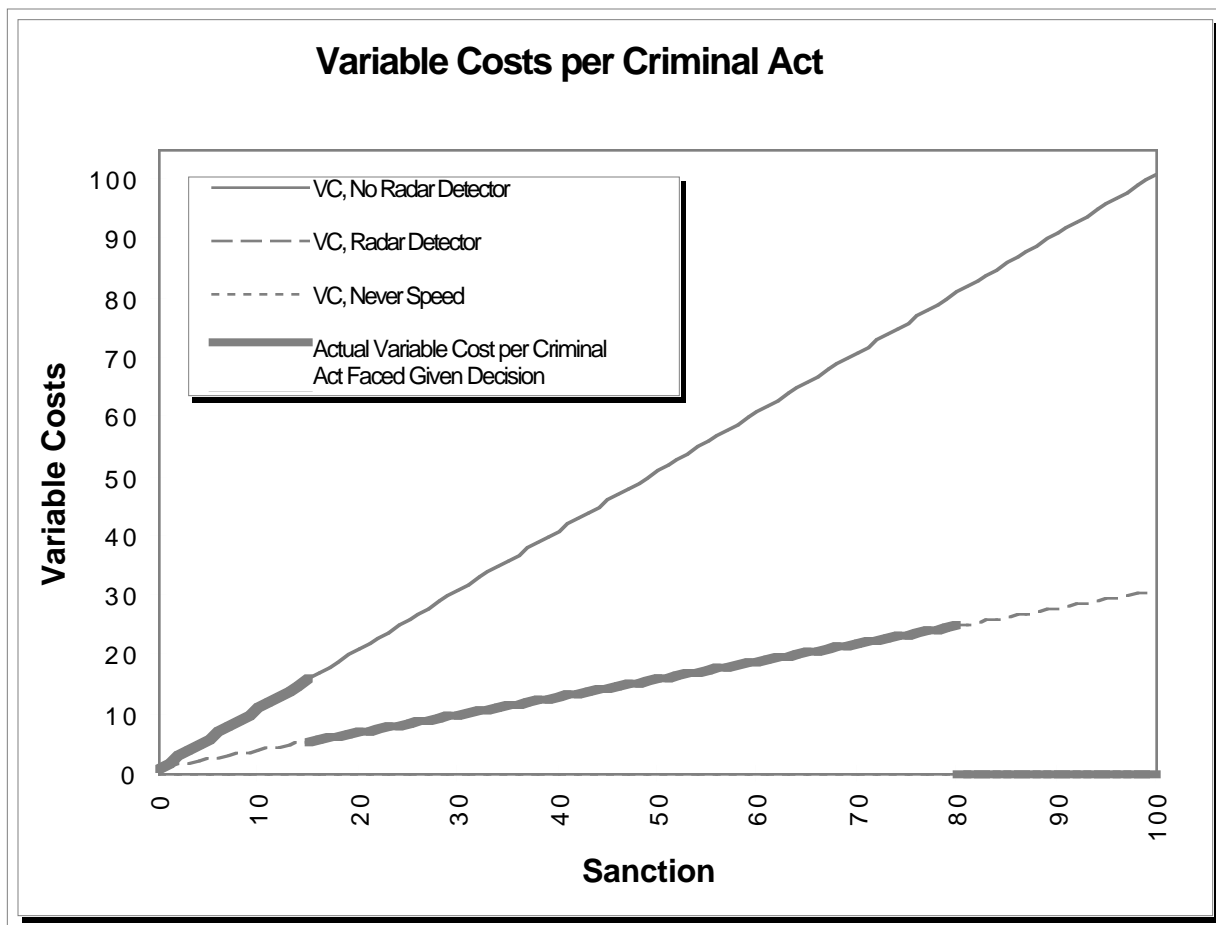


Graph 2: Decision on Radar and Speed

The next graph charts the variable costs per criminal act for the case of buying a radar detector and not buying a radar detector. When the actor never speeds, the variable costs is set at 0.

choice would also take the form of a horizontal line for sanctions above 20, with the utility and decision choice being the same as the criminal would make when the sanction is 20.

The thick line shows the actual variable cost the actor is facing at each sanction given his decision of buying a radar detector at that sanction.



Graph 3: Variables Costs given Decision

IV. Extensions:

A. Increased Law Enforcement Expenditures Leading to More Crime:

It could also be shown that there may be situations where increasing the amount spent on detection resources will lead to more crime. The reasoning is analogous to the analysis above: increasing the resources on detection causes the criminal to buy a fixed cost anti-detection device, this lowers his variable cost of committing criminal acts and the end result is actually more crime.

For example suppose all police departments spent their money on buying radar guns in order to catch speeders. It could be that this will lead speeders to buy radar detectors and a net result of more crime.

Law enforcement can of course invest in detection resources that cannot easily be evaded. Regardless, if law enforcement is going to invest money on detection devices, such as radar guns, then the law should not allow the legal sale of concealers, such as radar detectors or radar jammers. To allow these anti-detection devices can defeat the purpose of increasing the law enforcement resources in the first place, and may in fact make more criminal activity occur.²²

B. Trial and Appeals Effort

Criminals have some control over the sanction by forcing their case go to trial and making appeals. Higher nominal sanctions might actually lead to lower sanctions actually imposed on the criminal. To the extent that punishment can be postponed, criminals can exert effort, possibly through purchasing the services of high powered attorneys, in order to postpone any punishment. They may be more willing to expend this effort if the punishment is high. Again the criminal will be worse off if the sanction is increased, but the actual sanction they receive might be lower.²³

V. Policy Implications

The analysis above has shown that simply raising the sanction for a given criminal act may not have the intended effect of fewer crimes. It was shown that simply raising the sanction can lead to more criminal acts.

²² One would wonder how Jeff would respond if law enforcement did not use radar guns. In such a case he would be not buy a radar detector and thus would likely speed less.

Similar to the sanction case, this will be for a range of increased law detection resources. If there are radar detectors every five feet of road, then it is unlikely that criminals will spend resources on radar detectors, as they will not be of much value.

²³ Assume that the fine for murder is only \$50, many criminals would just pay the fine. But if the sanction were life imprisonment, then these same criminals might spend their money on expensive attorneys and by way of the legal process avoid any criminal sanction whatsoever. Of course the criminal will have spent money on legal fees and thus be worse off financially.

At least this is the case if we do not narrowly define the act to include the amount of concealment by the criminal that takes place.²⁴ My policy recommendation is that those criminals that conceal their crime should face higher costs than those who do not. In addition to solving the potential problem of increasing sanctions leading to increasing crime, the concealment costs themselves are a social waste,²⁵ as are the other costs the concealment may impose on society, such as additional harm or increased law enforcement expenditures. I have written on this more extensively elsewhere, but will discuss the main points here as they are relevant to this paper as well.²⁶

By setting the sanction such that the total costs a criminal faces when concealing his behavior are increased, we can give the criminal an incentive not to conceal his behavior.²⁷ There are two ways we can increase the cost of the crime where the criminal takes concealing actions. We can raise the cost of concealment or raise the sanction for concealment (or both). For example, we could raise the cost of buying a radar detector, possibly by making it illegal to buy (raising the cost to infinity, or at least to the black market price) or we could increase the sanction of using the radar detector by increasing the fine for speeding while using it. Whether we want to do one or both of these depends upon the concealment device being used. For concealment devices that are easy to detect when the criminal is caught, we will want to raise the sanction for their use. For concealment devices that have no legitimate purpose we will want to raise the direct cost, by way of taxes on the device or by making the purchase or ownership of it illegal. For a more detailed analysis of optimal penalties for concealment of crime see Stanley (1995).

²⁴ For definitely undesirable criminal acts we may also want to raise the sanction of the act to such a high level that it is deterred.

²⁵ That the costs of crime are a social waste, see Tullock (1967).

²⁶ See Stanley (1995)

²⁷ It is important to note that the expected sanction need not rise as the criminal expends more effort to conceal his crime. It is only necessary that the expected sanction plus the cost of concealment increase as the criminal exerts this concealment effort.

VI. Conclusion

We have seen that raising the sanction will increase the deterrence an actor faces when deciding whether to commit a one opportunity crime. But if a criminal has the opportunity to commit multiple criminal acts and has fixed and variable costs of committing these acts, then an increase in the criminal sanction, over a certain range of sanctions, may actually lead the criminal to commit more crime.

The reasoning behind the possible increase in crime when the sanction is increased is that as the sanction is increased, the criminal increases his expenditures on fixed costs, and this decreases his variable costs of committing a criminal act. Once the criminal pays his fixed costs, they will be sunk costs, and thus they will no longer enter into the criminal's decision process of committing criminal acts. But the variable cost of crime will enter into the criminal's decision process. If increasing the sanction leads to decreasing the variable cost of crime the increasing the sanction may actually lead to more crime.

Raising the sanction will always reduce the utility of the criminal, however, raising the sanction may not lead to less crime, and in fact may lead to more crime. It is important to note that this is not an argument against increasing a sanction or fine to an extremely high amount. For a crime that is definitely detrimental to society, an extreme increase in the sanction might be a good policy, as it will likely deter individuals from entering into the activity all together and thus decrease crime. If one wants to deter crime, and not just punish the individual criminal, it may be necessary to increase sanctions to high amounts.

What is really going on is substitution from one type of crime to another type, with the type of crime being defined by the resources the criminal expends concealing the crime. The reason for this substitution is that we are punishing the criminal act for the two types of crime with the same penalty. That is we are punishing the speeder who uses a radar detector the same as the speeder who does not use a radar detector and calling the crime a single name "speeding".

It is important that policy makers consider this substitution effect. One way to stop this substitution is to define the crime based on the amount of concealment associated with it. Thus we

define as different crimes speeding with a radar detector and speeding without a radar detector.²⁸

We should make the sanctions for the crimes depend upon the amount of concealment that occurs.

As this paper showed, the simple policy of raising the sanction to stop crime may not lead to the desired results. We need to pay more attention to the concealment of crime.

²⁸ Another way to do this with the same result will be to define additional crimes that are associated with the primary crime. For example we might define the accident as one act and then have an a separate crime of leaving the scene of an accident. Or we define speeding as one act and have a separate crime of using a radar detector to avoid detection. In this case the second crime is an ancillary crime to the first crime.

	Sanction = 5		Sanction = 10		Sanction = 20		Sanction = 40		Sanction = 100	
	Do Not Buy a Radar Detector	Buy a Radar Detector	Do Not Buy a Radar Detector	Buy a Radar Detector	Do Not Buy a Radar Detector	Buy a Radar Detector	Do Not Buy a Radar Detector	Buy a Radar Detector	Do Not Buy a Radar Detector	Buy a Radar Detector
Utility if speeding when utility is 10	10	10	10	10	10	10	10	10	10	10
Expected Fines from speeding	5	1.5	10	3	20	6	40	12	100	30
Variable Action Costs	1	1	1	1	1	1	1	1	1	1
Total Variable Costs	6	2.5	11	4	21	7	41	13	101	31
Utility - Expected Fines from speeding when utility is 10	4	7.5	-1	6	-11	3	-31	-3	-91	-21
max (0, benefit when speed)	4	7.5	0	6	0	3	0	0	0	0
Speed when utility from speeding is 10?	yes	yes	no	yes	no	yes	no	no	no	no
Utility if speeding when utility is 40	40	40	40	40	40	40	40	40	40	40
Expected Fines from speeding	5	1.5	10	3	20	6	40	12	100	30
Variable Action Costs	1	1	1	1	1	1	1	1	1	1
Total Variable Costs	6	2.5	11	4	21	7	41	13	101	31
Utility - Expected Fines from speeding when utility is 20	34	37.5	29	36	19	33	-1	27	-61	9
max (0, benefit when speed)	34	37.5	29	36	19	33	0	27	0	9
Speed when utility from speeding is 40?	yes	yes	yes	yes	yes	yes	no	yes	no	yes
Utility - Variable Costs	38	45	29	42	19	36	0	27	0	9
Fixed Cost of Radar Detector if Bought		15		15		15		15		15
Net Utility	38	30	29	27	19	21	0	12	0	-6
Buy Radar Detector	no		no			yes		yes	no	
Best Course of Action	Do Not Buy Radar Detector Speed twice Net Utility is 3 8		Do Not Buy Radar Detector Speed only once Net Utility is 2 9			Buy Radar Detector Speed twice Net Utility is 2 1		Buy Radar Detector Speed only once Net Utility is 1 2	Do Not Buy Radar Detector Never Speed Net Utility is 0	

Bibliography

- Becker, Gary S. 1968. "Crime and Punishment: An Economic Approach" *Journal of Political Economy* 76:169-217.
- Cooter, Robert and Thomas Ulen. 1988. *Law and Economics*, Harper Collins.
- Kaplow, Louis and Steven Shavell. 1994. "Optimal Law Enforcement with Self-Reporting Behavior" *Journal of Political Economy* 102:583-606.
- Malik, Arun S. 1990. "Avoidance, Screening and Optimum Enforcement" *RAND Journal of Economics* 21:341-353.
- Malik, Arun S. 1993. "Self-Reporting and the Design of Policies for Regulating Stochastic Pollution" *Journal of Environmental Economics and Management* 24:241-257.
- Mookherjee, Dilip and I.P.L. Png. 1994. "Marginal Deterrence and the Enforcement of Law" *Journal of Political Economy* 102:1039-1066.
- Polinsky, A. Mitchell and Steven Shavell. 1979. "The Optimal Tradeoff between the Probability and Magnitude of Fines," *American Economic Review* 69:880-891.
- Polinsky, A. Mitchell and Steven Shavell. 1991. "A Note on Optimal Fines When Wealth Varies Among Individuals," *American Economic Review* 81:618-621.
- Polinsky, A. Mitchell and Steven Shavell. 1994. "Should Liability Be Based on Harm to the Victim or Gain to the Injurer" *Journal of Law, Economics and Organization* 10:427-437.
- Polinsky, A. Mitchell and Steven Shavell. *The Economic Theory of Public Enforcement of Law*, forthcoming.
- Posner, Richard A. 1992. *Economic Analysis of Law*, 4th Ed., Boston: Little Brown.
- Steven Shavell. 1980. "Strict Liability versus Negligence" *Journal of Legal Studies* 9:1-25
- Stanley, Timothy J. 1995. "Optimal Penalties for Concealment of Crime" working paper
- Stigler, George J. 1968. "The Optimal Enforcement of Laws," *Journal of Political Economy* 78:526-536.
- Tullock, Gordon. 1967. "The Welfare Costs of Tariffs, Monopolies and Theft" *Western Economics Journal* 5:224.