A Note on the Non-Maximality of the Optimal Fines when the Apprehension Probability Depends on the Offense Rate

Jeong-Yoo Kim*
Department of Economics
Kyung Hee University

February 16, 2009

Abstract

This paper reconsiders the problem of optimal law enforcement when the apprehension probability depends on the offense rate as well as policing expenditures. A natural consequence of such an apprehension probability is the possible multiplicity of the equilibrium due to strategic complementarity, and the actual offense rate is realized by the self-fulfilling nature of the offense rate. If people believe that lowering the fine will lead to a lower offense rate, each individual will be less inclined to commit an illegal activity due to their expectation of a higher apprehension probability. Thus, the maximal fine may not be socially optimal.

Running Head: Non-Maximality of the Optimal Fines

Key Words: apprehension probability, law enforcement, self-fulfilling offense rate, strategic complementarity

JEL Classification Code: K42

*Corresponding author: Department of Economics, Kyung Hee University, 1 Hoegidong, Dongdaemunku, Seoul 130-701, Korea, (Tel) +822-961-0986, (Email) jyookim@khu.ac.kr

1 Introduction

The conventional wisdom on the optimal law enforcement following Becker (1968) is that the fine for committing an illegal act should be set as high as possible – equal to the individual's entire wealth. The reasoning is quite simple. If the fine is strictly less than the wealth of the individual, raising the fine and lowering the apprehension probability proportionally can reduce the enforcement costs without affecting the deterrence effect, implying that the non-maximal fine cannot be optimal.

In this note, I will show that if the apprehension probability depends on the offense rate as well as policing expenditures, the optimal fine can be less than the wealth of the individual offender. This assumption on the apprehension probability is quite realistic, although most literature on law enforcement adopts the simple assumption that the probability is entirely determined by the police's enforcement expenditures.[1] Given the enforcement expenditure, as more people engage in criminal activity, the per-individual monitoring expenditure is reduced. Accordingly, the probability that a given criminal is apprehended becomes lower; in an extreme, if everyone in a society commits a crime, the chance that an individual is caught will be very low, and in another extreme, if only one individual commits a crime, the chance that he will be arrested will be very high. Regulating illegal protests against the government is a typical example in which the apprehension probability is dependent on the offense rate.

The main reason why the Becker's argument of the maximal sanction fails in this situation is that the apprehension probability is no longer a control variable of the regulatory authority, since it depends on the decentralized individuals' decisions as well. To elaborate, suppose that the fine is below the wealth of the individual offender and that the government contemplates raising the fine and lowering the monitoring expenditures. If the individual regards an increase in the fine and a decrease in the monitoring activity as a sign of a higher (future) offense rate, he will be more inclined to commit a violation, because he expects a lower probability of being caught. This implies that the offense rate will be actually increased. Thus, the social desirability of increasing the fine will not be warranted. This suggests the possibility of the optimality of the non-maximal fine.

[1] To name a few, see Polinsky and Shavell (1979, 1991), and Bebchuk and Kaplow (1992).

If the apprehension probability relies not only on enforcement expenditures but also on the overall offense rate, the actual offense rate will depend on the expectation of the offense rate. If individuals believe that the offense rate will be higher, each individual has a stronger incentive to commit a violation. Hence, a higher offense rate will be actually realized. Conversely, the belief of a low offense rate discourages him from engaging in an illegal activity; hence, a lower offense rate. After all, the realized equilibrium will depend on the belief that people form and it has the self-fulfilling nature. This leads to the possibility of multiple equilibria. The multiplicity is a natural consequence of strategic complementarity; one offense breeds more offenses, that is, one offense is a complement to another in this situation.

The insight that when crime increases, it is harder to detect a criminal mainly due to the budget constraint has been shared by several authors,[2] and its consequence of possible multiple equilibria has been also demonstrated. However, none of them developed the insight into the problem of determining the optimal fine by assuming the exogenously fixed fine.

There have been many previous studies explaining why fines are not maximal in reality. Possible reasons include risk aversion (Polinsky and Shavell, 1979), avoidance activities (Malik, 1990), diverse wealth levels across individuals (Polinsky and Shavell, 1991), imperfect information about the apprehension probability (Bebchuk and Kaplow, 1992), marginal deterrence consideration (Stigler, 1970; Shavell, 1992) etc.[3] This paper provides a new explanation by regarding the endogeneity of the apprehension probability as a possible cause of non-maximal sanctions.

2 Model and Analysis

There are risk-neutral individuals who contemplate whether to commit an illegal act. An individual who engages in an illegal activity will be caught and fined with some probability. This probability depends on not only the monitoring expenditures of the society but also the offense rate.

[2]See, for example, Ehrlich (1973), Lui (1986) and, Schrag and Scotchmer (1997).

[3]For excellent surveys on the optimal law enforcement, see Garoupa (1997) and, Polinsky and Shavell (2000).

The following notation will be used throughout the paper.

h = social harm caused by an illegal act ($h > 0$)
b = benefit from committing an illegal act
$g(b)$ = probability density of b ($g > 0$ for all $b \geq 0$)
$G(b)$ = probability distribution of b ($0 \leq G \leq 1$ for all $b \geq 0$)
r = offense rate ($0 \leq r \leq 1$)
r^e = expectation on the offense rate
w = wealth of an individual
f = fine ($0 \leq f \leq w$)
m = monitoring expenditures of the society ($m \geq 0$)
$p(m, r)$ = probability of apprehension ($p > 0$ for all m, r).

Since the offense rate is determined *ex post* by individuals' decisions whether to engage in the activity, each individual does not know it before he actually makes a choice. However, because his choice is to be made by taking the apprehension probability into account, he must base his decision on his expectation on the crime rate r^e instead of r. I assume that all individuals have the same expectation. Thus, an individual will commit an illegal act if and only if

$$b \geq p(m, r^e)f. \tag{1}$$

Social costs can be defined by the sum of the social harm caused by the offense and monitoring costs.[4] Hence, the total social cost is

$$C = \int_{p(m,r^e)f}^{\infty} hg(b)db + m. \tag{2}$$

The offense rate is given by

$$r = \int_{p(m,r^e)f}^{\infty} g(b)db = 1 - G(p(m, r^e)f) \equiv H(p(m, r^e)f). \tag{3}$$

[4] I am implicitly assuming that the benefits obtained by individuals who commit the illegal act is negligibly small relative to the social harm h or is just wealth-transferring as in the case of theft, embezzlement etc. However, including the individual benefit into the social welfare function would affect the main insight. For the discussion, see Section 3.

Noting the strategic interaction among individuals, one must resort to the Nash equilibrium as a reasonable solution concept.[5] Let r^* be the equilibrium offense rate. Then, it is determined in the following equation (4), assuming that the expectation is actually fulfilled in equilibrium, i.e., $r^* = r^e$.

$$r^* = H(p(m, r^*)f). \tag{4}$$

If people expect that r^* will be high, implying a low apprehension probability, their incentive to commit a crime will be increased, and in turn a high criminal rate is actually realized. If they expect a low criminal rate, it will be also actually borne out. Therefore, multiple equilibria are possible, as usual in the case of strategic complementarity. The possibility is illustrated in Figure 1.[6] The actual offense rate is realized, depending on which outcome the individuals expect, i.e., on which outcome they coordinate on.

The optimality of non-maximal fines can be illustrated by a simple numerical example. Assume that b is uniformly distributed over $[0, 1]$. Consider the maximal fine $f = w = 1$ with the monitoring level $m = 1$ for simplicity. Also, assume that the apprehension probability is given by

$$p(1, r) = \begin{cases} \frac{3}{4} - r^2 & \text{if } r < \frac{1}{2} \\ \frac{1}{4} + (r-1)^2 & \text{if } r \geq \frac{1}{2}. \end{cases}$$

Then, it follows that

$$H(r) = \begin{cases} \frac{1}{4} + r^2 & \text{if } r < \frac{1}{2} \\ \frac{3}{4} - (r-1)^2 & \text{if } r \geq \frac{1}{2}. \end{cases}$$

The offense rate $r = r^e = 1/2$ satisfies equation (4), implying that $r = 1/2$ is an equilibrium offense rate given that $f = m = 1$. Suppose that $r = 1/2$ is actually realized when $f = m = 1$. Now, suppose that the legal authority lowers the fine to $f' = 1/\sqrt{2}$ possibly together with increasing policing activities slightly. If individuals believe that such a change in the enforcement policy will entail a fall in the offense rate, the actual offense rate will end up with $r = (\sqrt{2}-1)/2 < 1/2$. Thus, the social welfare is clearly increased. Hence, the maximal fine is not optimal in this example.

[5] The concept of the Nash equilibrium implicitly requires that every individual makes a choice based on the correct prediction of what others choose, i.e., the offense rate.

[6] If the apprehension probability does not depend on r^e, the schedule for $H(\cdot)$ becomes horizontal; hence, no possibility of multiplicity.

Generally speaking, if people believe that lowering the fine at a current level (possibly, maximal level) will drop the offense rate, more precisely, end in the equilibrium with the lower offense rate, the current level of fine cannot be optimal, because lowering the fine would be more desirable.

More formally, assume that $p(m, r)$ is differentiable with respect to m and r. Differentiating (4) with respect to m and f yields

$$\frac{\partial r^*}{\partial f} = -\frac{gp}{1 + gfp_2}, \tag{5}$$

$$\frac{\partial r^*}{\partial m} = -\frac{gp_1 f}{1 + gfp_2}, \tag{6}$$

where $p_1 = \partial p/\partial m$ and $p_2 = \partial p/\partial r$, as long as $1 + gfp_2 \neq 0$. The signs of $\partial r^*/\partial f$ and $\partial r^*/\partial m$ rely on the sign of $(1 + gfp_2)$. The optimal enforcement policy (f^*, m^*) is to minimize

$$C(f, m) = \int_{p(m, r^*(f,m)f)}^{\infty} hg(b)db + m, \tag{7}$$

subject to the fine constraint, $f \leq w$. The partial derivative of (7) with respect to f yields

$$\frac{\partial C}{\partial f} = -hg(pf)(p + p_2 \frac{\partial r^*}{\partial f} f) = -\frac{hgp}{1 + gfp_2} \tag{8}$$

by using (5). Then, $\partial C/\partial f > 0$ if $1 + gfp_2 < 0$, implying that lowering the fine can be better in terms of the social cost. This possibility can occur if $|p_2|$ is very large as at the point B.

Under the prescribed belief, the socially optimal fine must be attained at the level that makes the curve $r = H(\cdot)$ tangent on the 45 degree line. To understand the logic, consider Figure 2. Suppose that the current equilibrium occurs at point B. A decrease in f shifts the curve $r = H(\cdot)$ upwards[7] and thus the new equilibrium ends up with point B' given the belief. Then, this cannot be optimal because an even lower offense rate, say point B'', could be reached by lowering the fine even further. Suppose the fine is f'' and the corresponding equilibrium point is B''. If the fine is lowered further, there will be no self-fulfilling equilibrium with a lower offense rate. So, people will believe that lowering the fine will cause a big upward jump in the offense rate. Therefore, the fine f'' which leads to point B'' must be optimal.[8]

[7] Assuming the differentiability of H, differentiating (3) with respect to f yields $\partial r/\partial f = -gp < 0$.

[8] The prescribed belief implicitly implies that raising the fine will increase the offense rate.

The non-optimality of the maximal fine hinges critically on the prescribed belief. Is the belief reasonable? Since people can form virtually any belief, it will not be possible to argue that it is the only reasonable belief, but the belief can be at least justifiable in a situation where lowering the fine could alleviate the atmosphere of distrust against the legal authority.[9]

3 Discussion and Conclusion

This paper provides a new explanation for non-maximal fines observed in reality. If the probability that the offender is apprehended depends on the overall offense rate, there is strategic complementarity involved in the illegal activity in the sense that an offense is a complement to another offense, and the resulting upward or downward spirals can lead to multiple equilibrium offense rates. In this situation, the society's expectation about the offense rate is crucial to the realization of the actual offense rate and consequently the determination of the optimal fine. Depending on the expectation, the maximal fine may not be optimal.

I believe that the main insight of this paper does not rely on the specific features of the model. For instance, the result is still valid even if the government takes the private benefit of the offender into account in computing the social welfare. To see this, recall the argument of Polinsky and Shavell (1984). In optimum, some underdeterrence occurs in the sense that $pf < h$ due to the costly monitoring activities, because the optimum must be to balance the marginal social benefit of deterring more offenses of low-benefit individuals ($b < h$) with the marginal social cost of monitoring expenditures. Now, suppose the government lowers the fine. If people believe that it would cause a fall in the offense rate, the apprehension probability will increase, and consequently the offenses of more low-benefit individuals will be deterred without increasing the social cost of monitoring expenditures. This suggests that the maximal fine may not be optimal.

[9]See Kim (2008) for the role of beliefs in the context of the broken window theory.

References

[1] Bebchuk, L., and Kaplow, L., 1992, Optimal Sanctions when Individuals are Imperfectly Informed about the Probability of Apprehension, Journal of Legal Studies 21, 365-370

[2] Becker, G., 1968, Crime and Punishment: An Economic Approach, Journal of Political Economy 76, 169-217

[3] Ehrlich, I., 1973, Participation in Illegitimate Activities: A Theoretical and Empirical Investigation, Journal of Political Economy 81, 521-565

[4] Garoupa, N., 1997, The Theory of Optimal Enforcement of Law, Journal of Economic Surveys 11, 267-95

[5] Kim, J.-Y., 2008, Strategic Complementarity in Criminal Behavior and the Broken Window Theory, Mimeo

[6] Lui, F., 1986, A Dynamic Model of Corruption Deterrence, Journal of Public Economics 32, 215-236

[7] Malik, A., 1990, Avoidance, Screening and Optimum Enforcement, 21 Rand Journal of Economics, 341-353

[8] Polinsky, M. and S. Shavell, 1979, The Optimal Tradeoff between the Probability and Magnitude of Fines, 69 American Economic Review, 880-891

[9] Polinsky, M. and S. Shavell, 1984, The Optimal Use of Fines and Imprisonment, Journal of Public Economics 24, 89-99

[10] Polinsky, M. and S. Shavell, 1991, A Note on Optimal Fines When Wealth Varies Among Individuals, 81 American Economic Review, 618-621

[11] Polinsky, M. and S. Shavell, 2000, The Economic Theory of Public Enforcement of Law, Journal of Economic Literature, 45-76

[12] Schrag, J. and Scotchmern, S., 1997, The Self-Reinforcing Nature of Crime, International Review of Law and Economics 17, 325-335

[13] Shavell, S., 1992, A Note on Marginal Deterrence, International Review of Law and Economics 12, 345-355

[14] Stigler, G. J., 1970, The Optimum Enforcement of Laws, 78 Journal of Political Economy, 526-536

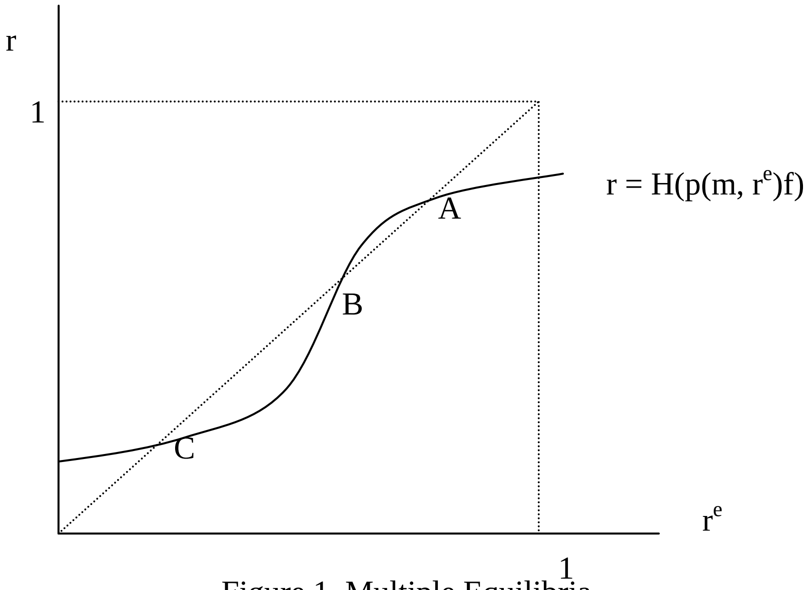

Figure 1. Multiple Equilibria

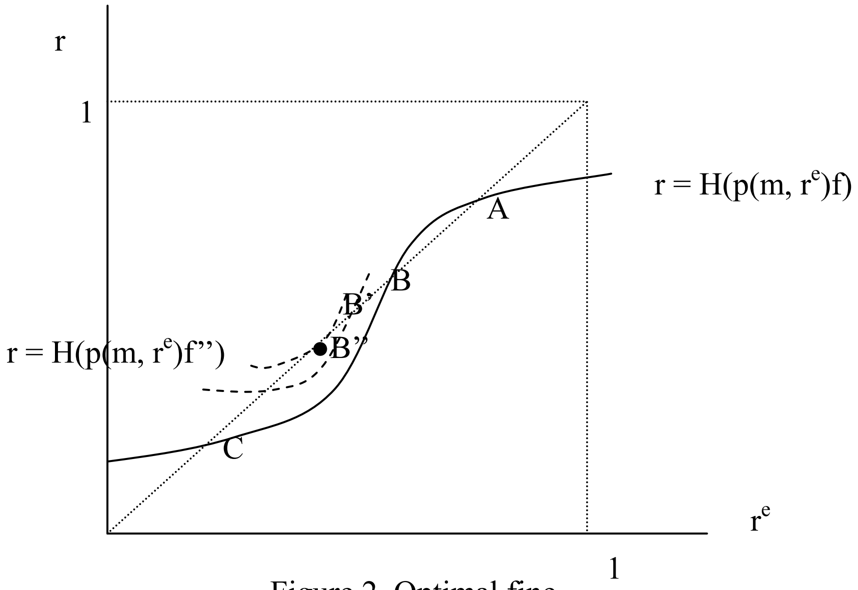

Figure 2. Optimal fine