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TAXING GUNS VS. TAXING CRIME: AN APPLICATION OF THE “MARKET FOR OFFENSES MODEL”

Isaac Ehrlich
Tetsuya Saito

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ABSTRACT

The interaction between offenders and potential victims has so far received relatively little attention in the literature on the economics of crime. The main objective of this paper is twofold: to extend the “market for offenses model” to deal with both “product” and “factor” markets, and to apply it to the case where guns are used for crime commission by offenders and for self-protection by potential victims. Our analysis offers new insights about the association between crime and guns and the limits it imposes on the efficacy of law enforcement and regulatory policies aimed to control both crime and guns.

Isaac Ehrlich
415 Fronczak Hall
State University of New York at Buffalo
and Center for Human Capital
Box 601520
Buffalo, NY 14260-1520
and NBER
mgtehrl@buffalo.edu

Tetsuya Saito
State University of New York at Buffalo
Buffalo, NY 14260
tsaito5@buffalo.edu

I. The Role of Theory in Guiding Work on the Economics of Crime

Much of the work on the economics of crime in recent years centers on intriguing public policy issues ranging from the reexamination of the impact of criminal sanctions on felonies and white collar crimes to new insights about the relevance of other means of crime prevention and deterrence such as abortions and guns. There has also been much attention paid to searching for instrumental variables that could in principle improve the identification of the causal effects of critical policy variables. This has indeed been a principal theme of the literature on the economics of crime since the early 1970s (see the "three equation econometric model" in Ehrlich 1973, 1974, 1975, Ehrlich and Brower, 1987 and Ehrlich and Liu, 1999). The econometric literature offers alternative approaches to overcoming the identification of the effects ascribed to causal factors, which range from classical econometric techniques to semi-experimental design methodologies. While search for valid instruments is a critical ingredient in improving our understanding of how to reduce crime in our free society, it is also important to point out that a better understanding of the role of causal factors rests not just on the choice of econometric techniques, but also on a more comprehensive accounting for the basic economic and institutional factors underlying the incidence of specific crimes (see McAleer, Pagan and Volker, 1985, Ehrlich and Liu, 1999). In this paper we wish to illustrate the relevance of theory in guiding empirical work and deriving related policy implications by extending and applying what one of us has dubbed the "market for offenses" model.

The essence of the market model is the interaction between public law enforcement and private self-protection by individuals. Accounting for such interaction in the context of a market model helps to understand better the determinants of the supply of crime by offenders on the hand, and the demand for safety, or the derived (inverse) demand for crime, by potential victims, on the other. The point has been stressed in Ehrlich (1981), which illustrates the relevance of the interaction between supply and demand forces in determining equilibrium in the virtual market for offenses, and the implications this may have on the relative efficacy and efficiency of alternative means of crime control, such as rehabilitation, incapacitation and deterrence.

In this paper we attempt to illustrate the additional insights such approach may yield by applying it to the association between crime and guns. The seminal work on this issue has been Lott and Mustard (1997). Their work draws attention to a relatively neglected issue: the role of guns as self-protection by potential victims. The market model of crime may indeed be of particular importance in pursuing the relevance of regulation and law enforcement in reducing the volume of crime, or guns, or both. We are not aware, however, of attempts to purse this line of attack on the problem so far. We attempt to do so through fairly simple extensions of the model which link the markets for crime and guns.

Our point of reference is that guns serve as means of self-protection by potential victims, but also as factors of production for offenders, by increasing the expected gains from criminal activity. Gun regulations, which generally increase the full costs of acquiring guns to all users, can have mixed effects on the incidence of crime. Our analysis offers some new insights concerning the efficacy of both gun regulation and law enforcement in reducing crime and gun-holding, and also about how to trace the relevant effects empirically.

We start with a short outline of the market for offenses model, and then expand it to incorporate the dual markets for crime and guns under both competitive and non-competitive market structures. We conclude with some remarks about the policy implications of our analysis and the insights it offers about the design and implementation of further empirical studies into the interaction between offense and defense in the virtual markets for offenses.

II. A General Illustration of the Single Market Model

In the market for offenses model (Ehrlich 1981, 1996), the equilibrium flow of offenses results from the interaction between the aggregate supply of offenses, direct or derived demand for offenses by potential victims, and public law enforcement, which operates like a tax on criminal activity. Some behavior classified as crime, such as prostitution and consumption of illicit drugs, involves the interaction between suppliers and consumers in an *explicit* market setting. But even crimes against persons and property can be analyzed in the context of a *virtual* market that involves the interaction between offenders and potential victims. This happens through the latter's demand for self-protection, which creates a negative demand for crime. In "markets for offenses" involving material gains, equilibrium establishes a simultaneous solution for the volume of crime, the optimal levels of law enforcement and private protection by potential victims, and the net return per offense. [1]

A. The "market" concept and equilibrium

For the sake of a simple illustration, consider two specialized population groups of large numbers which are homogeneous within groups: *offenders* and *potential victims.* Offenders seek to appropriate wealth owned by potential victims, and the latter demand protection for their wealth. For simplicity we assume that offenses are of a uniform type (there is a *single* virtual market), all individuals are risk neutral, and the groups are distinguished by income levels: offenders have poorer legitimate earning opportunities and lower wealth initially, as well as in any equilibrium involving participation in crime. The purpose of self-protection by potential victims is to increase the costs of appropriation to the offenders, so as to reduce their incentive to commit crime. Formally, the model can be described as follows:

(1) $q^s = S(\pi)$,

This equation represents the aggregate supply of offenses, Q, normalized in terms of their frequency in the population, N, or the "crime rate" $q = Q/N$, such that $S'(\pi) \geq 0$. The inside term, π, in turn, is defined by the net gain to the offender per offense:

(2) $\pi = d - pf$,

where $d = (w_i - w_l) - c$ stands for the differential gain per offense – the loot, w_i, less opportunity cost of time per offense, w_l, less the direct cost the offender incurs from committing crime, the major one perhaps being to overcome the various form of resistance by the potential victim, c, which we call self-protection. The higher the self-protection the lower is the differential loot. This can be formalized through the function $d = d(I)$, with $d'(I) \leq 0$. Furthermore, optimal self-protection expenditure rises with the magnitude of the potential private loss from crime and the probability of becoming a victim, which under rational expectations can be equated with the actual crime rate, q, or $I = I(q)$. This can be shown to establish a "tolerance for crime" function, which is derived from the willingness of potential victims to self-protect against crime. The higher the risk of victimization, the higher is self-protection spending, and the lower becomes the differential reward to the offender. The tolerance, or "derived demand", for offenses can thus be generally specified by:

(3) $d = D(q^d)$ with $D'(q) \leq 0$, as $d'(I) \leq 0$ and $I'(q) \geq 0$.

Society resists crime collectively as well as individually by enforcing the law to increase the prospect of apprehending and punishing offenders. The expected punishment $\tau = pf$ thus acts like an added tax on criminal payoffs, bringing it down to the net payoff in equation (2). The optimal magnitude of τ is derived by the law enforcement authority – the government – so as to minimize the social cost of crime, as detailed separately in the succeeding subsection:

(4) $\tau = pf = \tau(q)$, such that $\tau'(q) \geq 0$.

Equilibrium is defined as:

(5) $q^s = q^d$.

Equations (1) and (2) give the supply of offenses in terms of π:

(5') $q^s = S(d - pf)$.

Therefore, by Eq. (3), given optimal enforcement, equilibrium is solved as a fixed-point problem:

(6) $q^* = S[D(q^*) - pf]$.

The condition assuring the existence of equilibrium, or $q^* \geq 0$, is $D(0) - pf \geq 0$. We can also prove that the equilibrium q^* is unique if the net reward from crime becomes negative as q rises above its equilibrium value, which is easily verified as $\mathrm{d}S(\pi)/\mathrm{d}q = D'(q)\, S'(\pi) < 0$.

This algebraic solution can be derived diagrammatically using a four-quadrant chart (Figure 1). The lower-right quadrant depicts the optimal self-protection function $I(q)$ as an increasing function of the probability of victimization, or the crime rate, q. The impact of self-protection on the differential reward per offence is depicted in the lower left quadrant by curve $d'd'$. The auxiliary 45-degree line in the upper left quadrant maps the lower left quadrant onto the upper right quadrant to produce the (negative) derived demand for crime, or the tolerance for crime, by potential victims dd. The supply of offenses function is given by $S(\pi)$. Finally, the optimal tax function $\tau = pf$ sets the equilibrium solutions for π^* and q^* at point E.

B. Optimal public enforcement and private protection

While equation (6) holds for any given level of enforcement "tax", the optimal law enforcement policy, like taxation, depends on the welfare function the law enforcement authority, i.e., the government, chooses to pursue. Economic models of optimal taxation typically produce solutions based in part on some normative considerations. In the seminal Becker (1968) approach, which much of the Law and Economics literature has adopted, the criterion for optimal enforcement has been based on maximization of social income. Becker has actually chosen a more direct concept – minimization of the social loss from offenses including three major components: the social costs of private losses to actual and potential victims of crime, the direct costs of law enforcement through apprehension, prosecution and conviction of suspected offenders, and the costs of punishing those convicted, which depend on the type of sanction imposed. These three elements are summarized by equation (7a) below. Note, however, that in our case the social value of the private losses per-capita include outlays on private self-protection in addition to all the private damages from offenses:

(7a) $L = \Delta(q) + C(q, pf) + b(t)pfq,$

where L denotes the total expected social losses per-capita (which can be taken to be known with certainty); q denotes the aggregate crime rate in the population; $\Delta(q)$ is the full social costs of private losses from crime per-capita; $C(q, pf)$ is the direct costs of enforcement by police and courts; t is the index of the form of punishment used, which in this analysis are taken to be set by the institutions governing the legal system; $b(t)$ is the multiplier transferring the offender's expected private cost term pfq into the public cost measure, and $b(t)qpf$ is the per-capita costs of punishing those convicted[2]. The components Δ and C are assumed to have the following properties: $\Delta(0) = 0$, $\Delta'(q) > 0$; and $C(q, 0) = C(0, \tau) = 0$, $\partial C/\partial q > 0$, $\partial C/\partial \tau > 0$.

As for the government's role, equation (5) would yield the market equilibrium solution corresponding to the optimal enforcement level pf as $q^* = q(pf)$, such that $q'(pf) < 0$. Substituting $q(pf)$ into equation (6), we obtain

(7b) $$L(pf) = \Delta[q(pf)] + C[q(pf), pf] + b(t)q(pf)pf,$$

which is minimized with respect to pf. Under the assumed set of assumptions, we can easily show that an interior solution for $\tau^* = (pf)^*$ exists and is unique, regardless of the interaction between public enforcement and private self-protection. This interior solution also solves for the other major endogenous variable in the market model – optimal self-protection, $I^*(pf)$, and the consequent net reward to offenders per offence, $\pi(pf)$.

Under a stable equilibrium, it can be shown that any exogenous reduction in the marginal cost of enforcement (say a reduction in $b(t)$ because of a lower social cost of the sanction imposed on convicted offenders) will lead to a higher optimal level of enforcement and a reduction in the crime rate, regardless of whether public and private protection (law enforcement and self-protection) are technical "substitutes" in the production of protective services. A similar result holds in case the marginal cost of self-protection falls as a result of an exogenous advance in the technology of private protection.

Proposition 1. *Under the specification of the single market for offenses, if equilibrium exists and is unique, an exogenous reduction in the marginal cost of enforcement (say a lower* $b(t)$ *would lead to an increase in the optimal level of law enforcement,* pf*, and lower the crime rate and private self-protection levels, regardless of whether public law enforcement and private self-protection are independent, complements, or substitutes in the provision protective services. A corollary result holds in the case where the marginal cost of self-protection falls as a result of an exogenous technological advance.*

Proof: In a unique and stable equilibrium, the initial level of law enforcement, $\tau_0 = pf_0$, is optimal. Let law enforcement increase ($d\tau > 0$) due, say, to a downward shift in the marginal cost of law enforcement. If public and private protection were independent in the provision of safety, this would not affect the optimal private self-protection schedule $d(I^*)$, and hence the tolerance for crime schedule *dd* in Figure 1. Equilibrium q^* would fall along with the optimal level of self-protection. The same result would occur if public and private protection were complements, since then a higher τ (more police on the street) would shift both the $d(I^*)$ and *dd* schedules downward, reinforcing the effect of the higher τ on q^* and I^*. If public and private protection were substitutes, in contrast, both $d(I^*)$ and *dd* would shift upward. By the maximum principle, however, q^* and thus the level of self-protection, must still fall. If the net effect of a higher optimal τ were to raise q^*, this would be a contradiction to the optimality and stability of the initial equilibrium, since a solution in which $q_1^* > q_0^*$ was available at the initial equilibrium at a lower social cost corresponding to $\tau < \tau_0$. Thus q^* must fall as a result of a rise in optimal τ regardless of the interdependency between public and private protection.

III. Extending the Model to Multiple Markets: Crime and Guns

An important aspect of illegal activities is that they are often linked through different markets. Some illegal enterprises are linked vertically, such as illicit drugs and prostitution, or counterfeiting and money laundering, while other illegal endeavors are linked horizontally, like burglaries and pawn shops. Little work has been done to date to tackle this issue, perhaps because such links may be minor in many cases. One example that stands out is the interaction between crime and guns, where the empirical literature has focused on the impact of the demand for handguns on what we model as the "derived demand" for related offenses.

Guns, and particularly handguns, offer an example of a self-protective device for potential victims of crime. At the same time, however, offenders often use guns as a means of increasing the prospect of a successful heist, or to protect the cash acquired through illegal transactions ranging from loan-sharking to human trafficking. In this section, we consider the interaction between the market for offenses and the market for guns in an attempt to throw some new light on controversies concerning the association between guns and crime. The analysis can also help compare the effectiveness of alternative policies of government intervention in these markets through gun regulations, such as the right to carry concealed weapons, or stiffer expected penalties, especially when these involve use of guns. A reduction in gun holding in the population can be seen as an independent objective of public policy because it increases the safety of innocent victims from accidental gun shooting, even if the policy has no effect on crime.

In the following analysis, however, we are not addressing the solutions for the *optimal* level of enforcement and regulations as this requires the specification of a broader social loss function involving the sundry social costs arising from crime and gun holding, as well as arbitrary assumptions regarding the relative costs of raising the levels of regulation and law enforcement as alternative means of crime and gun control. We can address without loss of generality, however, the *effectiveness* of marginal shifts in these policy variables on the two basic endogenous variables of the model – gun holding and the rate of crime – starting from an initial equilibrium solution presumed to involve optimal values of both.

A. Basic framework

To analyze these issues we start with a simple extension of the single market for offenses, incorporating the market for guns. The assumptions underlying the analysis in section II and equations (1)-(7) provide the basic structure for the market for offenses. The supply and demand sides of the market for guns, and the various possible channels through which the two markets interact, however, need to be identified and formalized before we proceed with the analysis.

Our analysis treats gun holding by both offenders and victims as crime related. Therefore by “guns” we generally mean hand guns, not rifles which are used primarily for hunting. We recognize that markets for guns, especially those acquired by offenders, may operate as part of the underground economy, so the analysis would allow for separate submarkets which involve different transaction costs (see below). Modeling gun ownership in this fashion enables us to assess changes in regulation as a “regulation tax”, or a “tax on guns”, since it increases the marginal cost of acquiring a gun. The motivation for holding guns, however, is very different for the groups of offenders and potential victims. Offenders demand guns as “factors of production”, to secure a successful acquisition of the return from crime, i.e., its expected gross value, w_i or the “loot” net of the opportunity cost of crime ($w_i - w_l$), which is the exogenous part of the differential gain from crime, d, in equation (2). In contrast, potential victims demand guns as self-protection, to protect their property, or business, i.e., to increase the direct costs to offenders of successfully committing a crime, which works to reduce the differential gain to offenders, d.

In the guns market, we denote the rates of gun holding by the separately homogeneous groups of potential victims and specialized offenders in a representative period as x and y, respectively. We specify the number of homogeneous potential victims and offenders as $N_x > 0$ and $N_y > 0$ respectively, so $N_x + N_y = N$ represents the total population. The aggregate demands for guns by potential victims and offenders are then given by $X = N_x \times x$ and $Y = N_y \times y$, respectively. Since we model the groups as specialized, non-competing groups, x stands for the number of guns held by the representative potential victim, or the probability that a potential victim owns a gun, while y likewise stands for the probability that an offender holds a gun. In this formulation, $(N_x x+N_y y)/N$ measures the per-capita gun holding in the population, and x/y stands for the likelihood ratio of defensive over offensive gun holding.[3]

We consider the market for guns to be competitive with homogeneous firms producing guns via a constant-return-to-scale technology and constant raw material prices. If there are no separating unit taxes – such as registration fees, license fees, fines, and regulatory obligations – there would be just one effective price for guns, $P_0 = P_x = P_y$. The market for guns, however, may be split between two submarkets – for law abiding potential victims (primary) and for offenders (secondary) – because of different transaction, or search and location costs, which are affected by regulation, $T_x \geq 0$ and $T_y \geq 0$. The "full" prices for X and Y would then be given by $P_x = P_0\ (T_x)$ and $P_y(T_y)$, respectively, where T (a fixed or ad-valorem "tax") represents the impact of a "regulation-tax" on the "full" price of guns. An important issue for our analysis is the way gun regulation affects the two submarkets. In general, the prices in these submarkets are linked simply because prices in the secondary (used guns') market frequent by offenders should derive from prices charged in the primary (new guns) market frequent by law abiders. But the linkage depends also on the type of regulation invoked. While licensing may affect mainly, or exclusively, law abiders, restrictions on the right to carry guns affect the full price of gun holding for all users. Although in the following analysis we invoke for convenience the "neutral" assumption that P_x/P_y is independent of regulation, we also allow for regulations affecting just P_x but not P_y.[4]

a. Competitive dual-market model

The markets for offenses and guns can be analyzed through a number of possible channels of interaction. We start with a basic channel linking guns to crime as competing instruments of self-protection by potential victims and offenders and assume that the markets for offenses and guns are "competitive", i.e., neither offenders nor victims form organized groups. The only organized activity is law enforcement, as in section II, and the law enforcement authority sets the optimal tax on crime, $(pf)^* = \tau^*$, which offenders and potential victims take as given. The advantage of this "baseline" model is that it makes the least number of assumptions to guarantee the existence and uniqueness of the multi-market equilibrium. Yet some of the basic policy implications we derive from this model are quite general, as extensions of the model which recognize additional channels of interaction will demonstrate.

Our point of reference is that guns in the hands of offenders (y) and potential victims (x), or alternatively the probabilities that the offender and victim hold a gun in a crime-related encounter, have offsetting effects on the likelihood of a successfully executed crime, and thus on the *expected* loot (gross payoff) to the offender, w_i, which is also the expected loss to the potential victim from being victimized. To make this assumption operational, we need to explicitly specify the dependence of w_i on the relative magnitudes of x and y. We will make the neutral assumption that w_i, and hence the expected net return to the offender, depend on the likelihood ratio of defensive over offensive gun holding in a criminal encounter, r, and the level of per-capita wealth in the community, W, which we take to be exogenous to the model, or

(15a) $w_i = w_i(r; W)$, where

(15b) $r = x/y = (N_y/N_x) \times (X/Y)$.

The ratio r is determined, in turn, by the relative magnitudes of the *aggregate* demands for guns by offenders and victims. In this competitive setting, potential victims and offenders thus take r as given since they cannot control the market-determined r by individual action.

The next step in the analysis is to specify the demand functions for guns as self-protection devices for potential victims and factors of production for offenders. To simplify the analysis, we assume that guns represent the only means of self-protection by potential victims.

Their demand for guns will be affected by the price of guns for law abiders (P_x), the probability of becoming a victim ($v = q$), and the magnitude of their loss if victimized $w_i = w_i(r, W)$, as specified in equation (15a). This translates the $I(q)$ function as stated in section II to a direct demand function for guns $x^d = G_x(P_x, q, w_i)$. A higher marginal cost of self-protection (here the unit price of guns) reduces its optimal value while a higher probability of victimization increases the desired self-protection, as does the potential loss to the victim which forms the offender's gross loot. We can thus write the demand function in reduced form as follows:[5]

(16) $x^d = G_x(P_x, q, r)$,

with $\partial x^d / \partial P_x < 0$, $\partial x^d / \partial q > 0$, and $\partial x^d / \partial r = (\partial G_x / \partial w_i)(\partial w_i / \partial r) < 0$.

Offenders, in contrast, demand guns to enhance their expected loot, w_i. We thus assume implicitly that $w_i = f(y)$, with $f'(y) > 0$. The representative offender's derived-demand for guns as a factor of production can thus be specified by the standard economic theory of derived-demand for factors of production as an indirect function of factor and product prices. In our case the unit price of guns is P_y (the analog of c in equation 2), but the product price, which involves a crime, is the expected net return from crime $\pi = d - \tau$, where $d = w_i - w_l$ is the expected differential gain per offense and $\tau = pf$ is the expected criminal sanction.[6] Again, since the expected gross loot $w_i(r,W)$, and hence $d(r,W)$ are functions of the potential victims' wealth and the likelihood ratio of defensive over offensive gun holding in equation (15a), r, we can write the derived demand by offenders for guns in reduced form as

(17) $y^d = G_y(P_y, r, \tau)$,

with $\partial y^d / \partial P_y < 0$, $\partial y^d / \partial \tau < 0$, and $\partial y^d / \partial r = (\partial y^d / \partial d)(\partial d / \partial r) < 0$, as $\partial y^d / \partial d > 0$ and $\partial d / \partial r < 0$.

The derived demand for offenses in equation (3) can now be specified as

(18) $d(r) = D(q^d|r)$, with $d'(r) = \partial d/\partial r < 0$,

and as in section II, for any given likelihood ratio of defensive over offensive gun holding, the market equilibrium condition solves the fixed-point problem:

(19) $q^* = S[D(q^*|r) - \tau]$,

where $\partial q/\partial\tau < 0$ by our analysis in section II. The condition assuring the existence of market equilibrium for any value of r and $\tau = pf$ is here $D(0|r) - \tau > 0$. We'll tentatively denote the equilibrium point as

(20a) $q^*(r) = q(\tau, r)$.

We next consider the market equilibrium solutions for gun holdings by potential victims and offenders. Since the guns' supply curves are flat, the solutions are assured by the strong law of demand: the downward sloping demand curves for guns with respect to their shadow prices (given wealth). The equilibrium solutions in the markets for guns can be stated as:

(20b) $r^* = r(P_x, P_y, q) = G_x(P_x, r, \tau) / G_y(P_y, r, \tau)$.

The dual-market equilibrium solution for the markets for crime and guns are thus given by

(20c) $q^* = q(r^*; \tau, P_x, P_y)$.

b. Policy implications: taxing guns versus taxing crime

The impact of the policy variables entering equation (20a) and (20b) on the crime rate, the likelihood ratio of defensive over offensive gun holding (15a), and total gun holding in the population which we treat implicitly as an independent policy objective, can now be obtained through total differentiation of these equations. By differentiating equation (20a), we obtain:

(21a) $\mathrm{d}q^*/q^* = e_{q,\tau}\, \mathrm{d}\tau/\tau + e_{q,r}\, \mathrm{d}r^*/r^*$, and by likewise differentiating equation (20b), $\mathrm{d}r^*/r^* = \mathrm{d}x^*/x^* - \mathrm{d}y^*/y^*$, we obtain

(21b) $\mathrm{d}r^*/r^* = (e_{x,q}\, e_{q,\tau}\, \mathrm{d}\tau/\tau - e_{y,\tau}\, \mathrm{d}\tau/\tau - \varepsilon_x\, \mathrm{d}P_x/P_x + \varepsilon_y\, \mathrm{d}P_y/P_y)/(1 - e_{x,r} + e_{y,r} - e_{x,q}e_{q,r})$,

where $\varepsilon_x = -(\partial x/\partial P_x)(P_x/x) > 0$ and $\varepsilon_y = -(\partial y/\partial P_y)(P_y/y) > 0$ denote the absolute price elasticities of demand for guns from equations (16) and (17), and the e terms entering equations (21a) and (21b) represent partial elasticities of the variable in their first subscript with respect to the second; e.g., $e_{q,\tau} = (\partial q/\partial \tau)(\tau/q)$. The partial elasticities of the crime rate with respect to r and τ, $e_{q,r} < 0$ and $e_{q,\tau} < 0$, are seen to be negative from equation (19). The signs of the partial elasticities of the demand for guns by potential victims and offenders with respect to the risk of victimization and the expected enforcement sanction, $e_{x,q} > 0$ and $e_{y,\tau} < 0$, follow from equations (16) and (17), respectively. Also note that $(e_{x,q}\, e_{q,r})$ has a negative sign, while the partial effects of r on the demand for guns by the representative offender and victim respectively, $e_{x,r} < 0$ and $e_{y,r} < 0$ is also expected to be negative by equations (16) and (17), but the sum $(- e_{x,r} + e_{y,r})$ can be shown to be necessarily less than unity.[7]

By combining equations (21a) and (21b) we can now derive the general condition governing shifts in the equilibrium crime rate by totally differentiating the crime rate with respect to the basic policy variables of the model: the tax on guns, and thus P_x and P_y, and the tax on crime, $\tau = pf$. Expressed in terms of the condition for the crime rate to fall, or remain unchanged, from (21a) and (21b), we obtain

(22a) $-\mathrm{d}q^*/q^* \geq 0$ iff $(1 - e_{y,\tau})\mathrm{d}\tau/\tau - \varepsilon_x\, \mathrm{d}P_x/P_x + \varepsilon_y\, \mathrm{d}P_y/P_y \geq 0$.

Consider first the impact of the "taxing crime" policy $\{\mathrm{d}\tau > 0, \mathrm{d}P_x = 0, \mathrm{d}P_y = 0\}$. In this case, since $e_{y,\tau}$ is negative, equation (22a) holds, implying that

(22b) $\mathrm{d}q^*/\mathrm{d}\tau|_{\mathrm{d}P=0} = \partial q^*/\partial \tau < 0$.

The inference then is that more stringent law enforcement unambiguously reduces the crime rate.

In contrast, the effect of a more stringent law enforcement policy, i.e., a higher τ, on the equilibrium total gun holding in the population, $(x^* + y^*)$ is ambiguous. This can be seen through the ambiguous effect a higher τ has on the equilibrium likelihood ratio of defensive over offensive guns (r^*) because a rise in r^* can be shown to imply a fall in $(x^* + y^*)$.[8] The rationale is that a higher τ lowers the net return from crime to offenders, π, which in turn lowers the equilibrium crime rate q^* by equation (22b). By equation (17), a higher τ also lowers the offenders' derived demand for guns, y^*. By itself, this would raise r. By equation (16), however, the lower crime rate leads to a decline in optimal self-protection by potential victims, x^*, which, if sufficiently large, could lower r and raise the potential victims' demand for guns. The effect on equilibrium r^* and therefore on total gun holding in the population, $x^* + y^*$, is thus ambiguous.[9]

Proposition 2. *Under competitive markets for crime and guns, a more stringent law enforcement policy will always reduce the crime rate, but its effect on the likelihood ratio of defensive over offensive gun holding, and thus on the total volume of gun holding, is ambiguous.*

Consider now the impact of more stringent gun-control regulations on equilibrium gun holding by offenders and potential victims. By totally differentiating equation (20c) under the policy package $\{d\tau = 0, dP_x > 0, dP_y > 0\}$, we can easily show that a rise in either P_x, or P_y alone would unambiguously lower the equilibrium values of x^* and y^*, respectively. However, while the cross effects of an increase in P_y on x^* is to decrease the latter's value, that of P_x on y^* is ambiguous. This is essentially because when the price faced by offenders alone, P_y, rises, its direct effect is to decrease the optimal gun holding by offenders, y^*, which *raises* the market level of the likelihood ratio $r^* = x^*/y^*$ faced by potential victims. Since the higher r lowers the expected loss to potential victims, w_i, the latter's optimal self-protection, thus the demand for guns, x^*, falls as well ($e_{x,r} < 0$ in equation 16). The net effect of the rise in P_y is thus to decrease the equilibrium value of total gun holding, or $\mathrm{d}(x^* + y^*)/\mathrm{d}P_y < 0$ when $\{\mathrm{d}P_x = \mathrm{d}\tau = 0\}$. In contrast, when the price of guns faced by potential victims alone, P_x, rises, its direct effect is to lower gun holding by law abiders, x, which *lowers* the equilibrium level of the likelihood ratio of gun holding $r=x/y$. faced by offenders. This, in turn, *raises* the offenders differential gain from crime and thus their derived demand for guns, y^*. The sign of $\mathrm{d}(x^* + y^*)/\mathrm{d}P_x$ when $\{\mathrm{d}P_y = \mathrm{d}\tau = 0\}$ is thus ambiguous. A more stringent gun regulation that raises proportionally the full price of guns for all users, i.e., $\mathrm{d}P_x/P_x = \mathrm{d}P_y/P_y = \mathrm{d}P/P$, therefore also has an ambiguous effect on total gun holding in the population.[10]

Similarly, whether regulations can reduce the crime rate in this competitive setting cannot be answered unambiguously. This depends again on the impact of regulation on the ratio of gun holding, $r^* = x^*/y^*$. If regulation has an equal proportional impact on the price of guns, then the effect on r^* will depend strictly on the price elasticity of demand for guns by each group. This is seen from equations (21a) and (21b): $\mathrm{d}q^*/\mathrm{d}P|_{\mathrm{d}\tau=0} = \partial q^*/\partial P < 0$, e.g., requires that $\mathrm{d}r^*/\mathrm{d}P|_{\mathrm{d}\tau=0} = \partial r^*/\partial P > 0$, i.e., that $\mathrm{d}x^*/x^* > \mathrm{d}y^*/y^*$, which can be stated as follows: $\partial q^*/\partial P < 0$ iff $\varepsilon_y > \varepsilon_x$.

Proposition 3. *Under competitive markets for crime and guns, a more stringent gun regulation that raises the full price of guns to either offenders or potential victims will unambiguously lower the equilibrium gun holding by each group, respectively. If a more stringent regulation raises proportionately the full price of guns to all users, however, the impact on total gun holding will be ambiguous. Such increase in regulation also has ambiguous effects on the crime rate, depending on the price elasticities of demand for guns by potential victims and offenders. If offenders have a less elastic demand, stricter regulation will lower the crime rate. The outcome will be reversed if potential victims have a less elastic demand.*

Of course, if stiffer gun regulations, such as licensing requirements, affect just the primary market's full-price for guns where potential victims shop, but does not impact at all the (illegal) secondary market's price of guns where offenders shop, this is tantamount to $\varepsilon_x > \varepsilon_y = 0$ in equation (24). In this case, stiffer gun regulations will unambiguously increase the crime rate.

IV. Extended Model with Strategic Interactions

Our modeling of the markets for crime and guns in section III has not allowed for any strategic interactions between offenders and potential victims on the grounds that the market was purely competitive. Specifically, we have assumed that neither has the power to control the likelihood ratio of gun holding, r. However, the two groups may interact with each other if individuals in each group develop rational expectations about the decisions of the other group to hold guns, or if the two groups were actually organized. Examples of informal organizations include neighborhood crime watch and volunteer crime patrol groups, or neighborhood alliances on the part of potential victims, and gangs or criminal organizations on the part of offenders. The potential of strategic reactions by offender's or victim's groups is important for our analysis since it implies an ability to control the likelihood ratio of guns holding, the expected net reward from crime, $\pi = d - pf,$ and hence the prevalence of both crime and guns in the population. It can also set additional limits on the efficacy of public policy to control crime and guns.

To formally accommodate the existence of such interactions, we restate the demand functions for guns in equations (16) and (17) as follows:

(23a) $x^d = G_x(P_x, y, q)$,

(23b) $y^d = G_y(P_y, x, \tau)$, where $\tau = pf$.

These equations indicate the fundamental difference between this extended model and the purely competitive model of Section III. While in Section III, all agents take the likelihood ratio of defensive gun holding as exogenously given, in this section the likelihood ratio is an endogenous variable. Indeed, the underlying purpose of strategic reactions is to control r.

Equations (23a) and (23b) introduce strategic interactions specified as complementary reactions that are consistent with cost minimizing behavior for a given differential gain from crime, $\partial G_y/\partial x > 0$ and $\partial G_x/\partial y > 0$. The potential victims group will thus react to any partial increase in the number of guns held by the other group by increasing their own holdings. If a stable equilibrium exists, however, the reactions by offenders and victims must converge. As Figure 2 shows, the conditions for such convergence require that

(24a) $\partial G_y/\partial x < 1/(\partial G_x/\partial y)$ or equivalently $e_x\, e_y < 1$,

where e's are elasticities of strategic responses defined by

(24b) $e_x = (\partial G_x/\partial y)\,(y/x) \geq 0$ and $e_y = (\partial G_y/\partial x)\,(x/y) \geq 0$.

In Figure 2 we also prove that if the stability condition (24) holds, it implies not just that the product of the elasticities $e_x e_y$ must be less than unity, but also the magnitude of each elasticity must be less than unity, because by the stability conditions $\partial G_y/\partial x < y/x < 1/(\partial G_x/\partial y)$, which in turn imply that $e_x \leq 1$ and $e_y \leq 1$. These results can be formally stated as follows:

Lemma 1. *A stable strategic interaction between the groups of offenders and victims requires that* e_x, $e_y \leq 1$ *with* $e_x\, e_y < 1$.

The system explored in this extension is technically that of section III, the main difference being that we add strategic parameters to the demand for guns functions. Specifically, the equilibrium solution for the crime rate is still characterized by equations (19) and (20a). But the equilibrium solution for the likelihood ratio of defensive gun holding in equation (21a) is here modified as follows:

(25) $r^* = r(P_x, P_y, x^*, y^*, q^*) = G_x(P_x, y^*, q^*)/G_y(P_y, x^*, \tau)$.

A. Policy insights

Having described the equilibrium solutions for q^* and r^*, we can evaluate the impact of policy changes on the magnitudes of these variables, and indirectly the total amount of guns held by the population, through the standard analysis of comparative statics. For computational convenience, we will measure the effects of policies on offenses, the likelihood ratio of gun holding, and the per-capita level (or probability) of gun holding by potential victims and offenders in terms of the rates of change in their magnitudes $\mathrm{d}q^*/q^*$, $\mathrm{d}r^*/r^*$, $\mathrm{d}x^*/x^*$, and $\mathrm{d}y^*/y^*$.

We assume that potential victims and offenders are "organized", and thus have positive strategic-reaction elasticities $e_x \geq 0$ and $e_y \geq 0$. By totally differentiating q^* and r^* and solving the system of linear equations, we obtain the condition for the crime rate to decline as follows:

(26) $$\mathrm{d}q^*/q^* = e_{q,r} \, \{[(1 - e_x e_y)(e_{q,\tau}/e_{q,r}) - e_{y,\tau}] \, \mathrm{d}\tau/\tau - (1 - e_y)\varepsilon_x \, \mathrm{d}P_x/P_x + (1 - e_x)\varepsilon_y \, \mathrm{d}P_y/P_y\}$$
$$\times \{(1 - e_x e_y) - (1 - e_y)e_{x,q} \, e_{q,r}]\}^{-1} < 0.$$

We first consider the policy $\{\mathrm{d}\tau > 0, \mathrm{d}P_x = \mathrm{d}P_y = 0\}$, i.e., increasing law enforcement against crime with no change in regulations. The impact of this policy can be assessed from equations (26). Since $\mathrm{d}\tau/\tau > 0$, the sign of $\partial q^*/\partial\tau$ can be determined by evaluating the sign of $\mathrm{d}q/q$ in equation (26). Since $\mathrm{d}P_x/P_x = \mathrm{d}P_y/P_y = 0$, and given the strategic stability condition $e_x, e_y < 1$ in Lemma 1, it can be immediately seen that condition (26) is satisfied. Therefore, $\partial q^*/\partial\tau < 0$.

By totally differentiating (23a) and (23b), we can also show that any increment in our basic policy variables – law enforcement, (raising τ), or gun regulations (raising all gun prices proportionately) – lowers the equilibrium gun holdings for both law abiders and offenders, or

$\partial x^*/\partial\tau < 0$ and $\partial y^*/\partial\tau < 0$. Furthermore, by totally differentiating equation (26) with respect to τ we can show that stricter law enforcement raises the likelihood ratio of gun holding, $\partial r^*/\partial\tau$. These results are summarized in the next proposition.

Proposition 4. *An increase in expected punishment severity, with no change in regulations, reduces the crime rate in this expanded model as well, where we allow for strategic interactions concerning gun holding by both offenders and potential victims. The likelihood ratio of defensive gun holding, r, also declines, along with total gun holding in the population.*

Proposition 4 partly restates the message expressed in Proposition 3. To wit, the existence of strategic interaction between offenders and potential victims does not alter the direction of change established by Proposition 3, whereby a more severe expected punishment on crime reduces the equilibrium crime rate. The difference in Proposition 4 relative to Proposition 3 is that under strategic interactions, a larger expected punishment *unambiguously* lowers the incentive to hold guns by both offenders and potential victims, and more so by the latter. This result stems from the fact that in the "competitive" model, the diminished incentive for potential victims to hold guns, i.e., to engage in self-protection, following a stiffer law enforcement policy, would come strictly from the fall in the crime rate (the probability of being victimized). Under strategic interactions, in contrast, potential victims react not just to the fall in the crime rate, but also to the reduction in the demand for guns by offenders as a result of their lower incentive to commit crime. Since potential victims react to the decline of guns in the hands of offenders, they further reduce their gun holding absolutely and relative to offenders. This explains why the likelihood ratio of defensive gun holding falls as well. The bottom line in this case is that we expect the imposition of stricter law enforcement to generate both less crime as well as lower gun possession in the population. But the causal effect comes not from the impact of gun control, but from the impact of the government imposing a stiffer "tax on crime".

Turning to the alternative policy of enhanced regulations ("taxing guns") which raises either P_x, P_y or both by equal proportions, we can now show that their impact on gun holding will be *unambiguous* – "more regulations, less guns" as shown by condition (26). This result stands *in contrast* to the impact of enhanced gun regulations in the competitive setting of section III, where "taxing guns" produced ambiguous effects on total gun holding (see Proposition 3 and footnote 9). The reason is that both offenders and potential victims now react directly, and in a complementary manner, to gun holding by the rival group, as both e_x and $e_y > 0$. Specifically, when the price of guns faced by the victims group alone, P_x, rises, both its *direct* effect on the demand for guns by potential victims, x^*, and its cross effect on the demand for guns by *offenders,* y^* can be shown to u*nambiguously lower* its desired level, because offenders react directly to the fall in x (the market level of $r = x/y$, is here an endogenous variable). By similar reasoning, when P_x, alone rises, the equilibrium levels of both x and y, hence total gun holding, would fall, $\mathrm{d}(x^* + y^*)/\mathrm{d}P < 0$ when $\mathrm{d}\tau = 0$.

The effect of more stringent gun regulation on the crime rate, however, is more complex. To see this, let the effectiveness of regulations raise proportionately the full price of guns on both potential victims and offenders. The impact of regulations on the population crime rate is then found from equation (26) as follows:

(27) $\quad \partial q^*/\partial P < 0$ iff $\varepsilon_y/(1 - e_y) > \varepsilon_x/(1 - e_x)$.

Equation (27) implies that the magnitudes of offenders' price elasticity of demand for guns as well as their elasticity of strategic reactions must exceed those of potential victims. This condition is also consistent with the elasticity conditions derived under the purely competitive model in section III, requiring that $\varepsilon_y > \varepsilon_x$.

Proposition 5. *More stringent gun regulations lower the willingness to hold guns by both offenders and potential victims. The effect of regulations on the crime rate, however, is ambiguous, depending on the relative price elasticities of demand for guns and the relative elasticities of strategic reactions by offenders and potential victims.*

Condition (27) is illustrated in Figure 3. Starting from a benchmark case where $e_y = e_x$ and $\varepsilon_y = \varepsilon_x$, i.e., we are on the 45-degree line from the origin, and assuming that regulations increase the effective price of guns by equal proportions for both offenders and victims, the analysis suggests that a rise in the effective price has no effect on crime. If we deviate from this case, however, we can easily see that if $\varepsilon_y / \varepsilon_x$ is less than 1 and $e_y/e_x < 1$, more stringent regulations would increase the crime rate, or $\partial q^* / \partial P > 0$. Conversely, when $\varepsilon_y / \varepsilon_x$ exceeds 1 and $e_y/e_x > 1$, more regulations will lower the crime rate, or $\partial q^* / \partial P < 0$.

B. Strategic reactions as proxies for organizational power of offenders and potential victims

Proposition 5 can be illustrated via two special cases: In the first case, potential victims are unorganized or "passive" as a group, while offenders are "active" in seeking to control the likelihood ratio of defensive gun holding. In the second, potential victims form neighborhood patrols groups or volunteer safety organizations, e.g., while offenders are passive. In terms of our formal model these two extreme cases can be viewed as involving the following two sets of strategic reaction elasticities: a. $\{e_x = 0, e_y > 0\}$ when offenders have effective control over the neighborhood, in which case imposing stiffer gun regulations would unambiguously lead to more crime; and b. $\{e_x > 0, e_y = 0\}$ when potential victims have a defensive lock on the neighborhood, in which case regulation becomes an effective tool for crime control. More generally, for any given value of e_y, the higher the value of e_x, the more likely is a higher expected penalty on offenders or a larger regulatory tax to lower the crime rate (see Figure 3).

Furthermore, our model suggests that the elasticities of strategic reactions by offenders and victims also generate second-order effects on the efficacy of policies designed to reduce crime, by augmenting the *magnitude* of the change in the crime rate or in gun holding produced by stricter law enforcement or gun control. By taking the cross partial derivatives of the crime rate or gun holding with respects to e_x or e_y we obtain the following inferences:

Proposition 6. *The elasticities of strategic response by offenders and potential victims, which can be interpreted as the organizational power of each group, affect not just the direction of change in, but also the efficacy of, law enforcement and crime control policies. Specifically, e_x and e_y reinforce the absolute impacts of regulation and enforcement policies in a way that benefits their respective groups' interests*. (See Figure 3 and equation 29).

The message of Proposition 6 is that a higher intensity of offenders' reactions to guns in the hands of victims (e_y), reflecting offenders' greater organizational power, will diminish the effectiveness of government policies aiming to reduce crime and guns, while a higher intensity of potential victims' reaction to gun holding by offenders (e_x), reflecting victims' organizational prowess, will reinforce the effectiveness of government policies that can reduce guns and crime.

V. Taxing both Guns and Crimes Committed with Guns

Our formal model has treated crime as a single offense category, say "all crimes against property", or "breaking and entering", and has recognized just a single sanction to be imposed on crime. In reality, the law distinguishes offense categories in which an offender uses a gun (or other life-threatening weapons) to help carry out the offense (e.g., "robbery"), as opposed to other categories in which guns are not used (e.g., "burglary", "larceny", or "auto theft"). The social costs associated with the former category are higher by virtue of the risk to life it involves, and thus higher penalties can be imposed on offenders committing such crimes. This introduces the possibility of employing a third crime control policy which taxes both guns (via "gun regulation") and crimes committed with guns, in addition to taxing all offenses". A general treatment of the problem calls for recognizing at least two offense categories, say "crimes committed with guns (or weapons)" and "crimes committed without guns", and applying different penalties on each. To preserve the simple analytical framework pursued in previous sections, however, we will continue to recognize a single crime category and homogeneous groups of offenders and potential victims, but recognize an expected punishment scheme by which an offense committed with the use of guns carries a higher penalty, in proportion to the number of guns employed, as in equation (28) below:

(28) $\tau = pf(1 + \alpha y)$,

where pf is an expected base penalty applying to all offenses, and α denotes a surcharge imposed if a gun is used (for a similar penalty specification see Rubin and Dezhbakhsh, 2003). The implicit assumption is that all offenses within the single crime category require the use of guns, but that the intensity, or frequency, of gun use is a choice variable.

A. Behavioral implications

Under the competitive setting of section III, we note that while the surcharge α will reduce the demand for guns by offenders, y, as is shown below, the elasticity of y with respect to α must be less than 1, because a higher α cannot reduce τ_0 – if it did, q will be higher than q_0, which would indicate an unstable initial equilibrium, as optimal α would then be zero. A higher α must therefore increase the effective punishment for crime, τ, and thus reduce the offenders' demand for guns, y, the net profit from crime, π, and the crime rate, q (see equation 17). The fall in y, in turn, will raise the likelihood ratio of defensive over offensive gun holding, r. The inference is that the demand for guns by potential victims will fall as well, since the demand by potential victims is a decreasing function of both the risk of victimization, q, and r (see equation 16).

By this analysis, a higher surcharge α lowers both the crime rate and total gun holding in the population. The effect of more regulation is *unambiguous* on gun holdings by victims and offenders, and therefore on per-capital gun holding as well, $(x + y)$, but it remains *ambiguous* on the crime rate, q, by Proposition 3. These results mirror those derived in Sections III and IV.

Under strategic interactions, the preceding inferences about the impact of a surcharge on the expected penalty for crimes committed with guns is qualitatively the same as under the competitive case. By similar reasoning, a higher α lowers the crime rate and the demand for guns by offenders, which in turn lowers the optimal demand for guns by potential victims. A higher α thus causes both the crime rate and total gun holding to fall, but the impact of more stringent gun regulation on the crime rate remains ambiguous.

B. Further Extensions

The more general version of our model can be further extended to recognize two separate categories of crime within the market for offenses: crimes committed with guns ("robbery") and crimes committed without guns ("theft"). The corresponding crime rates would now be measured by q_1 and q_0, respectively. The penalty surcharge specified in equation (28) will now apply strictly to robbery, since guns held by offenders (y) are employed exclusively in the commission of "robbery". The penalty for "theft", in turn, will remain just the base penalty, *pf*.

The difference between this extended case and the simpler case developed in the previous section concerns the substitutability in production of q_1 and q_0. In an interior competitive equilibrium solution, “robbery” and “theft” **cannot** be perfectly substitutable in production; i.e., the production possibilities frontier (PPF) governing offenders’ allocation of the fixed labor time between the two crime categories cannot be a straight line. To avoid corner solutions, the PPF must be concave toward the origin. In an interior equilibrium, the marginal rate of transformation between the two $-\mathrm{d}q_1/\mathrm{d}q_0 = m(q_1, q_0) > 0$ is thus rising as q_1/q_0 falls.

A higher surcharge on guns held in the commission of robbery, α, will thus always lower the equilibrium ratio of q_1/q_0, lowering the robbery rate while raising the theft rate in the population. If theft and robbery were perfect substitutes in production around the equilibrium position, so that m = constant = 1, there would be no change in the total incidents of crimes per-capita, measured simply as $q = q_1 + q_0$, since q_0 would increase by the same number of units as the fall in q_1. More generally, the impact on the total crime rate depends on the aggregation rule for counting the different crime categories and computing the marginal rate of transformation. If the two crime categories were less than perfect substitutes in production, so $m(q_1, q_0) \neq 1$, an increase in the penalty surcharge α will also decrease, or increase, the total crime rate measured by the incidence of crime if m were less than, or greater than 1, respectively. In contrast, if the two crime categories were perfect complements in production, then an increase in α will have no impact on “theft”, but “robbery” and the total crime rate would necessarily fall when the penalty surcharge increases.

Conclusion

The interaction between offenders and potential victims of crime has so far received relatively little attention in the theoretical literature on the economics of crime. The virtual “market for offenses” model seems to be the relevant analytical framework for addressing such interaction and fleshing out its implications for optimal crime control policies. The main objective of this paper has been twofold: to extend the market model to deal with both “product” and “factor” markets; and to apply it to the case where guns are used for crime commission by offenders and for providing private self-protection by potential victims. Our analysis offers new insights about the association between crime and guns, or related weapons, and the limits it imposes on the efficacy of law enforcement and regulatory policies aimed to control both crime and guns.

The main insights are that under a competitive market setting, in which both offenders and victims behave independently, gun regulations may have ambiguous effects on both gun holding and the incidence of crime in the population, to the extent that it raises the full price of guns for both offenders and victims. In contrast, law enforcement policies involving criminal sanctions necessarily reduce the frequency of crimes involving the use of guns. A critical assumption leading to these inferences is that guns serve as both means of self-protection by potential victims, which lower the probability of becoming victims of crime, and as factors of production for offenders, which enhance their expected gain from committing offenses. The equilibrium ratio of gun holding by victims relative to offenders, or the likelihood ratio of defensive over offensive guns, affects both the incidence of crime and the distribution of private gains and losses from crime.

In the competitive setting, both offenders and victims behave independently and take the equilibrium ratio of defensive over offensive gun holding as given while making decisions about acquiring guns. The market may also be “organized”, however, in the sense that offenders (through gangs) or potential victims (through neighborhood watches, patrols, and other community actions) can directly affect the equilibrium ratio of defensive over offensive guns in the population. By allowing for strategic interactions between victims and offenders, we show that in this case, crime control policies through stiffer law enforcement can unambiguously lower the incidence of *both* crime and gun holding in the population. Likewise, the effects of regulation on gun holding by *both* offenders and potential victims are unambiguous in this case. However, the effects of gun regulation on the crime rate remain ambiguous in this case as well. Furthermore, relative organizational power by offenders or victims affects the efficacy of law enforcement or gun regulations in a direction that is more beneficial to their constituent groups.

While our analysis focuses on deriving policy implications concerning crime and gun controls, it also offers some lessons concerning the design and interpretation of empirical investigations concerning the association between crime and guns. The recent empirical literature on the impact of stiffening or relaxing gun control regulations alluded to in the introduction has spawned an intense debate about whether less regulation (more guns) lead to more crime, or vice versa (see, e.g., Lott, 2001, and Duggan, 2001). Our analysis offers a possible reconciliation of conflicting empirical findings, since by our analysis the answer depends on the relative magnitudes of price elasticities of demand for guns as well as the relative magnitudes of strategic reactions by offenders and victims under non-competitive market conditions whereby offenders or potential victims can form group responses. While data on gang activity and neighborhood patrol groups are not readily available, they are nevertheless relevant for isolating the impact of gun and crime control policies in connection with specific crime categories or geographical locations that are known to be subject to organized activity.

Related insights concern the design of empirical tests. Empirical findings may be consistent with the hypothesis of "less guns – less crime" not because of the effect of regulation, but because of more severe law enforcement policies which raise the expected punishment for crime. Empirical investigations into the relation between gun regulations and crime need to be conditional on a full accounting of criminal sanctions for which data are typically incomplete. While studies typically control for the probability of arrest and imprisonment, data are generally not available about the severity of the penalties imposed upon conviction. It is thus important to fully control for all the components of public law enforcement when estimating the hypothesized effect of gun control policies on crime.

Furthermore, by our analysis in section V, where we recognize two interrelated crime categories: offenses committed with guns ("Robbery") and offenses committed without guns, ("Theft"), stiffer expected penalty surcharges, even though they lead to a reduction in the incidence of robbery, may result in a higher incidence of "theft" and thus of all property crimes as well. An increase in the base penalty applying to all crime categories will reduce the total incidence crime. The impact of stiffer gun regulation, however, remains ambiguous, even on the incidence of "robbery". In studying the impact of both gun control and crime control policies, interrelated crimes should ideally be investigated jointly, rather than separately.

These inferences bring us back to the underlying theme of this paper: the importance of reliance on the economic theory of crime in designing empirical investigations of the role of policy variables and in interpreting apparently conflicting findings about their efficacy. The virtual market setting we develop in this paper may also be useful in addressing other policy issues where the interaction between offenders and potential victims is a key component of the analysis.

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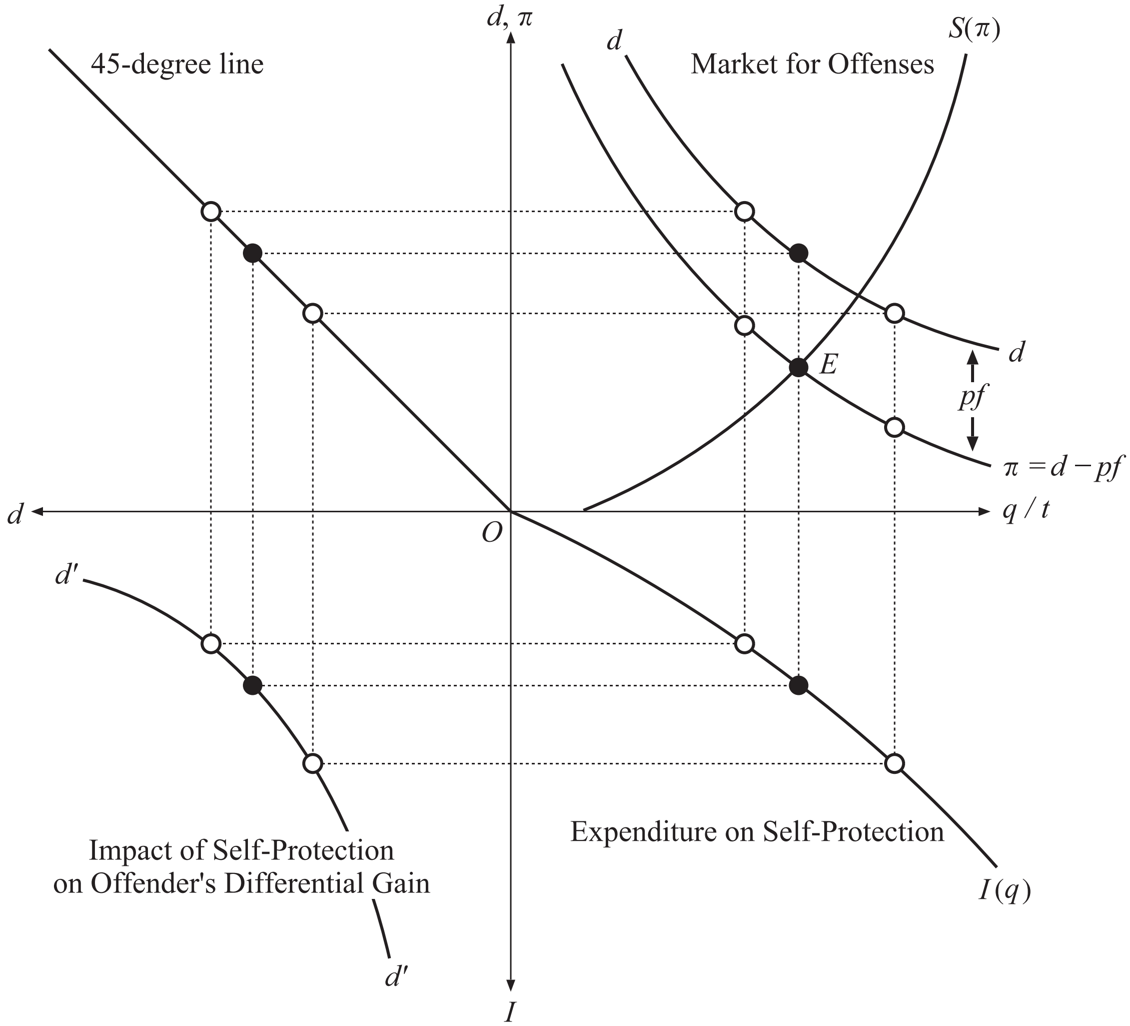

Figure 1: Illustration of equilibrium in the market for offenses

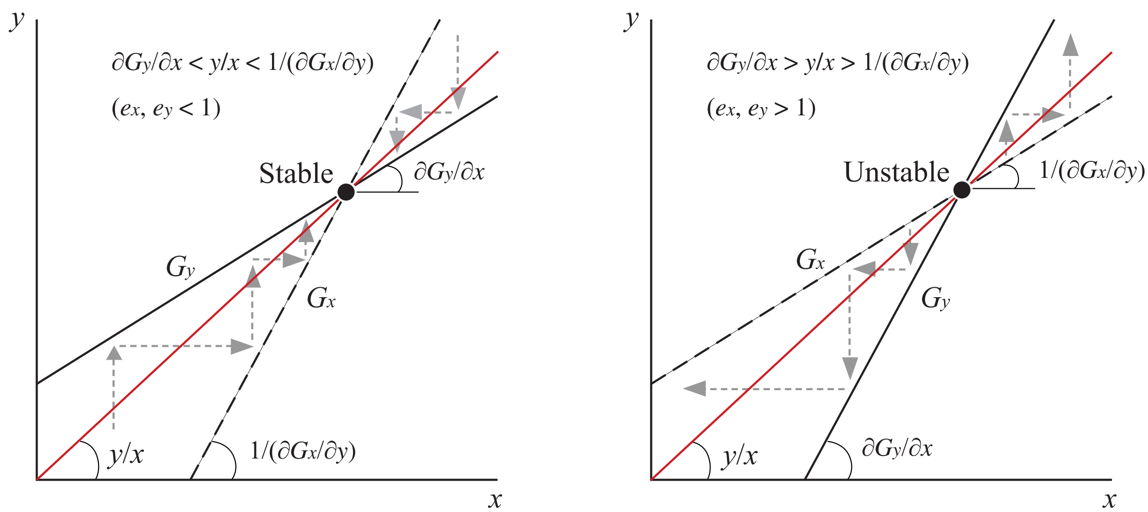

Figure 2: Existence and stability of the strategic equilibrium

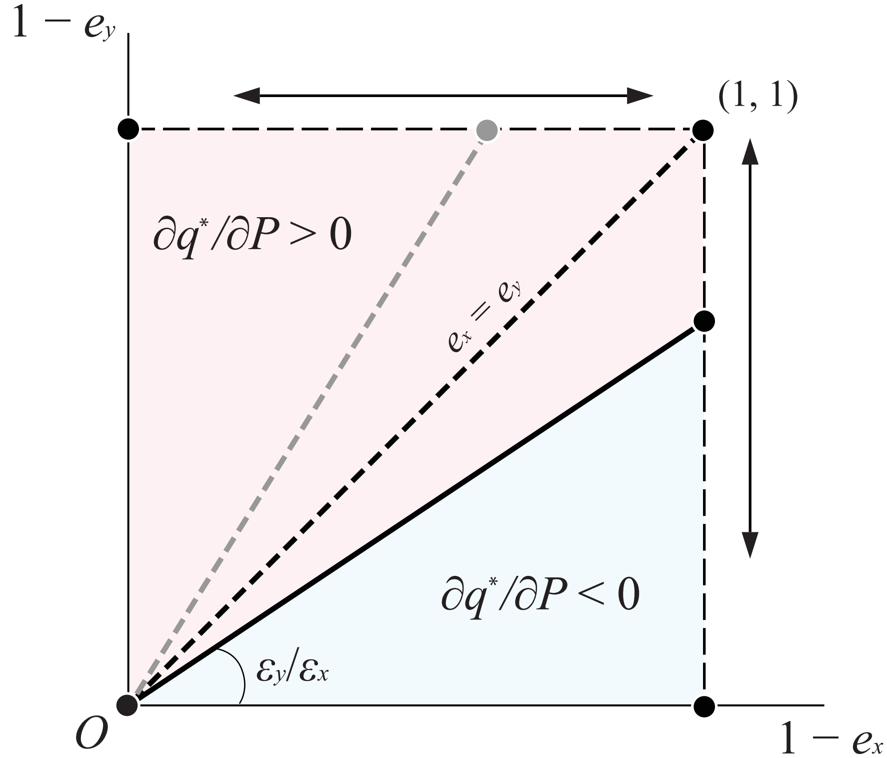

Figure 3: Effectiveness of regulation under alternative price and strategic reaction elasticities

Notes

[1] We are not modeling here "self-protection" by offenders, which typically involves legal defense to avoid conviction and punishment. In the next section, however, we model explicitly the direct cost c in equation (2), which offenders undertake to increase the expect loot.

[2] Note that C stands for the direct costs of apprehending, charging, and prosecuting offenders, which determines the probability of punishment, p. In Becker, (1968) and Ehrlich (1981) this component is therefore specified as $C(q, p)$. Since in the simplified market model the expected sanction τ is the sole instrument of enforcement, we have defined all components of the social loss function as functions of this variable.

[3] It is possible that a secondary motive for offenders to hold guns is to self-protect themselves from the probability of being victimized by other offenders. We abstract from this offender-on-offender crime risk in this competitive market setting, on the assumption that to offenders, the dominant motive for holding guns is offensive.

[4] Cook et al., (2007) provide some evidence on gun prices, which also imply that the used guns market may be thin. Our treatment of both markets as competitive is done for convenience.

[5] Note that since the price of guns is supply-determined in our model, public law enforcement (police) and private self-protection are taken to be independent in production because changes in law enforcement cannot affect the unit cost of guns.

[6] The differential gain in section II was defined as $d = (w_i - w_l) - c$, which we now separate more generally to $w_i - w_l$ and P_y, but for convenience we will continue to refer to the differential loot in this section as $d = w_i - w_l$. Note that q is not an argument in equation (16) because we maintain complete separation between offenders and potential victims. Put differently, we implicitly assume that offenders demand guns strictly for the purpose of committing successful crimes, not as self-protection against the risk of victimization, which they produce.

[7] The reason is that $(-e_{x,r} + e_{y,r})$ can be non-zero iff the ratio $r = x/y$ is changing. But in order for r to change (upward or downward), the numerator must change by a larger percentage than the denominator. Thus $-e_{x,r}$ must exceed $e_{y,r}$. This condition is also sufficient to assure the stability of an interior solution for r^*, which is $(1 - e_{x,r} + e_{y,r} - e_{x,q}e_{q,r}) > 0$, since $-e_{x,q}e_{q,r} > 0$.

[8] By equations (16) and (17) we have $(dx/d\tau)_{dP=0} = (\partial x/\partial r)(dr^*/d\tau)_{dP=0} + (\partial x/\partial q)(dq^*/d\tau)_{dP=0}$ and $(dy/d\tau)_{dP=0} = (\partial y/\partial r)(dr^*/d\tau)_{dP=0} + (\partial y/\partial \tau)$, respectively. We know that $(dq^*/d\tau)_{dP=0}$ and $\partial x/\partial r < 0$; $\partial x/\partial q > 0$; and $\partial y/\partial r$ and $\partial y/\partial \tau < 0$. Thus, to assure that $d(x^* + y^*)/d\tau < 0$, it is sufficient that $(dr^*/d\tau)_{dP=0} > 0$.

[9] By combining equations (22a) and (22b), we can show that $dr^*/r^* = (e_{x,q}\, e_{q,\tau} - e_{y,\tau})\, d\tau/\tau > 0$ iff $-e_{y,\tau} > -e_{x,q}\, e_{q,\tau}$,. We can also show that $(dy^*/y^*)/(d\tau/\tau) = e_{y,\tau}(1 - e_{x,\tau})/(1 - e_{x,r} + e_{y,r} - e_{x,q}e_{q,r}) < 0$, but that $dx^*/x^* = (e_{y,r} + e_{x,q}\, e_{q,\tau})\, dr^*/r^*$ is ambiguous in sign because $dr^*/d\tau$ is ambiguous in sign. This ambiguity cannot be eliminated under competition, because all agents take r as given.

[10] The condition for $d(x^* + y^*)/dP$ to be negative in sign is $-e_{y,r} / (1 - e_{x,r} - e_{x,q}\, e_{q,r}) < \varepsilon_y / \varepsilon_x$.