An Economic Analysis of Guns, Crime and Gun Control

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and Great Cities Institute
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The Great Cities Institute

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Abstract

A model is posited in which guns are demanded for recreation, self-protection or criminal purposes, and in which crime is supplied. Crime rates influence guns demanded for self-protection, and guns demanded by criminals depend upon guns held by law-abiding citizens. Comparative-static analysis is used to investigate the effects of crime and gun control policies. The results show that increases in crime control policies may reduce crime by less than one would expect because of the indirect negative effect on guns owned by the law-abiding public. Gun control policies reduce the demand for guns, but the effect on premeditated crime is ambiguous because of the negative effect on guns owned for self-protection and recreation.

An Economic Analysis of
Guns, Crime and Gun Control

Introduction

The news that criminals are becoming increasingly well armed, coupled with the television images of storekeepers defending their property with firearms in hand, suggests that economists and other policy analysts should increase their efforts to understand the market for deadly weapons and the related criminal activity. The purpose of this paper is to formulate an economic model of guns, crime, and gun control measures. A great deal of research (much of it by economists) has been done on firearms, violence, and gun control [e.g., Kates (1984), Kleck (1991), and Wright, Rossi, and Daly (1983)]; Polsby and Brennen (1995) provide a review of recent empirical research. But this paper is the first attempt at formal modeling. The goals of this modeling effort are to set out a simple set of equations that captures the primary features of the policy debate, and then to use that set of equations to examine the likely effects of changes in crime and gun control policy on crime rates and gun ownership. The model is expressed in the conventional mathematics used in economics and taught in undergraduate courses in mathematical economics using texts such as Chiang (1985).

Kleck (1991) reported that there were 31,606 deaths in the U.S. in 1985 caused by firearms. Some 55 percent of those deaths were suicides, and 37 percent were homicides. Accidental deaths were 5 percent of the total, and the rest were either killings by police in the line of duty or were of undetermined cause. In addition, in 1985 there were an estimated 131,241 nonfatal gunshot woundings. Most of these (76 percent) were criminal assaults, and most of the rest were accidental shootings (18 percent). The remaining nonfatal woundings were suicide attempts, police shootings, or due to undetermined causes. Kleck (1991, p. 50) estimated that there were 190.5 million guns in civilian hands in the U.S. in 1985, or 798 per 1,000 population (including children). In other words, it is estimated that there is more than one gun per adult in private hands in the U.S. With so many guns in private hands, perhaps it is remarkable that there are not more shootings. As it is, in 1985 there were 16.6 deaths and 68.9 nonfatal woundings per 100,000 guns.

The plan of the paper is first to discuss the demand for guns for recreational use, self-protection, and criminal intent. The connections between guns and premeditated crime and unpremeditated crime, accidents, and suicides are specified next. The model consists of five equations: three gun demand equations and two "crime" equations. Comparative static analysis of the basic model is then used to examine the effects of crime and gun control policies on gun demand and crime.

Demand for Guns

The market under consideration is the market for "guns," implements of deadly force that do not require that the user stand in close proximity to the intended victim. In other words, guns are not knives or clubs. Guns are very effective at forcing victim compliance when a crime is being committed, but they are also used for recreational and self-protection purposes. See Balkin and McDonald (1984) for a more extended and elementary discussion of the demand for guns for these three uses.

People who demand guns for recreational purposes can be assumed to maximize a utility function that includes the pertinent form of recreation as one of the goods. Recreation is "produced" by combining guns and other purchased inputs with recreational time. Maximization of the utility function subject to income and time constraints produces a demand function

$$G_r = G_r(y, P, F_g, T), \quad (1)$$

where G_r is guns for recreational purposes, Y is income, P is the price of guns, F_g is the expected value of the punishment for possession of a gun (which could be zero), and T is the time budget for nonwork activities. Assume that P and F_g have negative effects on G_r.

Guns are also an input into the production of self-protection. The empirical research reviewed by Kleck (1991, Ch. 4) indicates strongly that many individuals purchase guns for self-protection, and that criminals report that they have been thwarted on occasion by guns owned by potential victims. Self-protection can be produced by guns and other purchased inputs such as locks and other weapons, and by the use of time to avoid risky situations or to invest in self-defense courses. The formal analysis is essentially the same as in the case of recreational demand, except that the demand for self-protection is a function of crime. The demand for guns for self-protection can be expressed as

$$G_s = G_s(Y, P, F_g\ C, T), \quad (2)$$

where G_s is guns for self-protection and C is a crime rate (or vector of crime rates). Assume that P and F_g have negative effects and C has a positive effect on G_s.

A critical issue in the modeling of guns and crime is whether the demand for guns for self-protection is also a function of guns possessed by criminals. Empirical evidence supports the hypothesis that crime rates influence the demand for guns (especially handguns) for self-protection [Kleck (1991, Ch. 4) and Wright, Rossi, and Daly (1983, Ch. 5)]. However, no known study has determined whether, at given crime rates, greater use of guns by criminals is an independent factor in the demand for guns for self-protection. One can make casual arguments on both sides of the issue. It may be that potential victims have no desire to engage in gunplay with criminals, and so the use of guns by criminals (at given crime rates) would have little or no effect on guns demanded for self protection. On the other hand, potential victims may feel that, if more criminals are using guns, crime deterrence depends more heavily on owning a gun. The implications of such a domestic "arms race" are examined below. This is a standard notion of an arms race because nations engaged in an arms race are stimulated by the weapons possessed by the other side, even if those weapons are never used.
The criminal segment of demand consists of those persons who would use guns in the commission of crimes such as robbery, burglary, and premeditated murder. Such persons make some or all of their livelihoods through crime. Assume that the criminal produces income by combining time spent in the planning and perpetration of crimes with purchased inputs such as guns and other tools of the trade. For simplicity, assume that criminals are neutral to risk; the offender has a utility function

$$U = U[E(Y), L], \quad (3)$$

where E(Y) is the expected value of income and L is leisure time. The offender maximizes utility subject to a time constraint. The equation for the expected value of income per time period is

$$E(Y) = (1-J-S)Y_c + J(Y_c-F), \qquad (4)$$

where J is the probability of apprehension and punishment, S is the probability of encountering an intended victim with a gun, F is the value of punishment suffered for commission of a crime, and Y_c is criminal "net" income (gross income from crime minus expenses, which include money spent on guns and F_g, the expected value of punishment for gun possession). The term (1-J-S) is the probability that the criminal will be successful in the commission of the crime and will escape apprehension. Equation (4) includes the assumption that the criminal gains no income when he meets a potential victim who is armed with a gun. This simple theory of criminal behavior leads to a demand function for guns

$$G_c = G_c(P, F_g, S, J, F, T), \qquad (5)$$

where Gc is guns for criminal purposes. S, the probability of encountering an armed intended victim, is a function of guns held by the citizenry, or

$$S = S(G_r, G_s). \qquad (6)$$

Assume that P, F_g, J, and F all have negative effects and that S has a positive effect on G_c.

A reading of Kleck (1991) and Wright, Rossi, and Daly (1983) reveals that evidently there are no studies of the demand for guns by criminals that would shed light on the question of whether S influences G_c. The use of a gun is very effective in forcing compliance by an unarmed victim, but an encounter with an armed potential victim is another matter. The proposition embodied in the model in Equation (4) is that the criminal cannot force the compliance of an armed victim. The proposition that S has a positive effect on G_c is based on the notion that an unarmed criminal does not wish to encounter an armed potential victim. An armed criminal confronting an armed potential victim creates a standoff in which the crime is not completed. Kleck (1991) reported that each year potential victims kill between 2,000 and 3,000 criminals and wound 9,000 to 17,000.

Guns and Crime

It is assumed that there are two crimes of interest: intentional premeditated crimes committed by offenders, C_1, and unpremeditated crimes of violence, accidents, and suicides, all of which can be committed by anyone with a gun, C_2. Crimes of type C_1 are supplied according to a conventional Becker (1968) supply-of-crime function

$$C_1 = C_1 [P, F_g, F, J, S(G_r\ G_s)]. \qquad (7)$$

C_1 is a function of F and J as in Becker's model, and C_1 is also a function of P (price of guns) and F_g (expected penalty for illegal possession of a gun) because they influence G_c, an input into the production of crime. Note also that C_1 is influenced (negatively) by G_r and G_s through their effects on S, the probability of encountering an armed intended victim. The empirical studies of gun availability and crime reviewed by Kleck (1991) and Wright, Rossi, and Daly (1983) generally show that variations in gun availability are not related to variations in crime rates. These studies make no distinction between guns available to criminals and guns owned by potential victims. Equation (7) suggests that guns available to criminals and guns owned by potential victims may indeed have offsetting effects on crime rates. The comprehensive empirical study by Kleck and Patterson (1993) found that gun control laws of various kinds are almost never associated with lower rates of crime. The only clearly negative effects in the Kleck-Patterson study are:

- a ban on gun possession by the mentally ill reduced murder,
- a requirement for gun dealer licenses by state or local government, and
- a ban on handgun sales reduced robbery.

The review of other recent studies by Polsby and Brennen (1995) showed that some researchers attribute lower crime rates to gun control laws, while others do not.

Crimes, suicides and accidents of type C_2 are determined simply as

$$C_2 = C_2(G_r, G_s, G_c). \qquad (8)$$

All guns potentially could be used in unpremeditated crimes, cause accidents, or be used in a suicide, although the magnitudes of the effects represented in Equation (8) are much in dispute. For example, Kleck (1991) argued that suicide victims are serious about their intentions and would use other means in the absence of an available gun. Others doubt this assertion. The empirical study by Kleck and Patterson (1993) found that greater gun ownership had a positive effect on suicide rates under one estimation procedure, but not in another. A study by Sloan, et al. (1990) found that suicide rates were lower in Vancouver compared to Seattle, and attributed the difference to gun control in Canada that was enacted in 1977. However, Polsby and Brennen (1995) pointed out that Sloan, et al. (1990) did not measure actual gun ownership in the two cities.
Kleck (1991, Ch. 7) reports that there were 1,959 fatal gun accidents in the U.S. in 1980, including 316 children under the age of 15. Kleck (1991) has also estimated the total stock of guns in civilian hands in 1980 at 167.7 million (51.7 handguns), so the accidental death rate for 1980 is estimated at 1.17 per 100,0000 guns per year. The figures for 1985 (from above) are 1,649 accidental deaths and 190.5 million guns, or a rate of .87 deaths per 100,000 guns. Polsby and Brennen (1995) point out that the number of deaths from gun accidents has declined steadily from 2,406 in 1970 to 1,441 in 1991. Kleck and Patterson (1993) found that gun ownership rates were not associated with higher rates of fatal gun accidents.

Comparative Static Analysis of the Basic Model

The basic model presented above consists of five equations: the three demand functions [Equations (1), (2), and (5)] and the two supply-of-crime functions [Equations (7) and (8)]. In the basic version of the model, the demand for guns for self-protection is assumed to be a function of crime rates, but not a function of guns held by criminals. The endogenous variables are G_r, G_s, G_c, C_1, and C_2. Exogenous variables of interest are P, F_g, F, and J. P, the price of guns, is taken to be exogenous; guns are elastically supplied at P. Given values of the exogenous variables, equilibrium values for gun ownership and the crime rates are assumed to exist.

The effects of various crime and gun control policies can be investigated by performing comparative- static analysis of the model. Each of the five equations is totally differentiated. For example, the total differential of Equation (1) is

$dG_r = G_{rp}dP + G_{rf}dF_g$,

where G_{rp} is the partial derivative of G_r with respect to P (the price of guns), and G_{rf} is the partial derivative of G_r with respect to F_g (the expected punishment for the possession of a gun).

Total differentiation of the five-equation model produces the following system of equations written in matrix form:

$$\left|\begin{array}{ccccc} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -G_{s1} & 0 \\ -G_{cr} & -G_{cs} & 1 & 0 & 0 \\ -C_{1r} & -C_{1s} & 0 & 1 & 0 \\ -C_{2r} & -C_{2s} & -C_{2c} & 0 & 1 \end{array}\right| \left|\begin{array}{c} dG_r \\ dG_s \\ dG_c \\ dC_1 \\ dC_2 \end{array}\right| = \left|\begin{array}{c} G_{rp}dP+G_{rf}dF_g \\ G_{sp}dP+G_{sf}dF_g \\ G_{cp}dP+G_{cf}dF_g+G_{cJ}dJ+G_{cF}dF \\ C_{1p}dP+C_{1f}dF_g+C_{1J}dJ+C_{1F}dF \\ 0 \end{array}\right|$$

The second subscript denotes partial derivatives with respect to variables as follows: r for G_r, s for G_s, c for G_c, 1 for C_1, p for P, f for F_g, J for J, and F for F.

Cramer's rule can be used to solve for the effects of the exogenous variables on the five endogenous variables. In each case the denominator of the comparative - static results is equal to the determinant D of the matrix on the left-hand side of the system of equations, or

$$D = 1- C_{1s}G_{s1}. \qquad (9)$$

The sign of G_{s1} is positive because the partial derivative is the effect of an increase in crime on guns for self-protection. C_{1s} is negative because this partial derivative is the effect of an increase in guns owned for self-protection on the crime rate, so D>O. It is highly unlikely that an increase in crime C_1 ultimately results in a decrease in C_1 through the effect on guns held for self-protection, so $C_{1s}G_{s1}$ is less than I in absolute magnitude and D is greater than I and less than 2. Empirical tests obviously are needed here.

Because D is greater than 1, the direct effects of policies are reduced. For example,

$$dG_c/dJ = (1/D)[G_{cJ}(1 - G_{s1}C_{1s}) + G_{cs}G_{s1}C_{1J}] = G_{cJ} + (GcsGs1C1j/D) < 0. \qquad (10)$$

Increasing J, the probability of apprehension and punishment, reduces the demand for guns by criminals directly (G_{cJ}) and indirectly through the effect of J on guns owned for self-protection. However, because D>I, this indirect effect is somewhat muted.

Table 1 is a summary of the comparative - static results. Crime control policies are represented by J, the probability of apprehension and punishment, and F, the value of punishment. Increases in J and F have no effect on G_r, unambiguously reduce G_c and G_s, and hence reduce C_2. Furthermore, their effects on C_1 are also negative. For example,

$$dC_1/dJ = (1/D)C_{1J} < 0. \qquad (11)$$

Table 1
Comparative Static Results: Model of Guns and Crime

Independent Variables	G_r	G_s	G_c	C_1	C_2
	Dependent Variables				
F	0	-	-	-	-
J	0	-	-	-	-
P	-	-*	-*	?	-*
F_g	-	-*	-*	?	-*

*Sign of effect is most likely negative.

However, note once again that the direct effect of increasing the probability of apprehension and punishment on crime, C_{1J} is muted by the (1/D) term because a reduction in crime leads to a reduction in guns owned for self-protection. Crime control policies still work to reduce crime, but this effect is scaled down in a world in which private gun owners own guns for protection against crime.

Gun control policies are represented by P and F_g, the price of guns and the expected penalty for possession of a gun. An increase in P can be brought about by a tax on guns or by making the production or sale of guns illegal. In the latter case guns would still be available, but the market price must increase to compensate the producers and sellers for the risk of being caught violating the law. Increases in P and F_g unambiguously reduce G_r, most likely reduce G_c and G_s, and hence most likely reduce C_2. An element of ambiguity arises, for example, as follows:

$$dG_c/dP = (1/D)\{G_{cp}(1 - G_{s1}C_{1s}) + G_{cs}(G_{S1}C_{1p} + G_{sp}) + G_{rp}[G_{cr}(1 - G_{s1}C_{1s}) + G_{cs}G_{s1}C_{1r}]\}. \qquad (12)$$

Here the direct negative effects of P on G_c, G_s, and G_r all tend to reduce G_c. Also, an increase in P reduces C_1, and thus reduces G_s and G_c. However, an increase in P reduces G_r, which increases C_1 and hence increases G_s and G_c. It appears unlikely that this last indirect effect outweighs all of the more direct effects of P on G_c. A similar ambiguity arises in the result for dG_s/dP.

Finally, increases in P and F_g have ambiguous effects on C_1; C_1 is reduced directly by gun control measures by making crimes more costly and inconvenient to commit because guns are more expensive, but reductions in G_r and G_s tend to increase C_1. The equation for this result is:

$$dC_1/dP = (1/D)[C_{1p} + C_{1r}G_{rp} + C_{1s}G_{sp}]. \qquad (13)$$

Note that C_{1p} is negative, but that the other two terms in brackets are positive. (Each is a negative times a negative.) This equation appears to be at the crux of an issue that is hotly debated. It is said that, "If guns are outlawed, only outlaws will have guns." Of course, this is true only in the most trivial sense. If guns are against the law, then anyone who possesses a gun is breaking the law. But it certainly will be true that some people who are otherwise not law-breakers will continue to possess guns. Some guns will still be possessed for self-protection, and probably for recreation as well. The empirical question is the elasticity of demand for the three demand functions. If citizens who demand guns for self-protection and recreation refuse to give up their guns in the face of laws against gun ownership, then the crime rate C_1 will not rise.

This discussion suggests that gun control penalties applied only to gun use in the commission of a crime would be more effective at reducing premeditated crime, C_1. However, such a policy might be less effective at reducing C_2 (unpremeditated crimes, accidents, and suicides), to the extent that guns owned for self-protection and recreation are involved in these incidents.

Comparative Static Analysis of the “Arms Race” Model

It was suggested above that the demand for guns for self- protection might also be a function of guns held by criminals. In this case, the demand for guns for self-protection becomes

$$G_s = G_s(Y, P, F_g, C, G_c, T). \qquad (2')$$

This version of the model produces an "arms race" effect that does not exist in the basic version of the model in above. As shown above, the effects of crime and gun control policies can be investigated by performing comparative static analysis of the model, which now consists of Equations (1), (2'), (5), (7), and (8). Total differentiation of the five-equation model produces the following set of equations in matrix form:

$$\begin{vmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & -G_{sc} & -G_{s1} & 0 \\ -G_{cr} & -G_{cs} & 1 & 0 & 0 \\ -C_{1r} & -C_{1s} & 0 & 1 & 0 \\ -C_{2r} & -C_{2r} & -C_{2c} & 0 & 1 \end{vmatrix} \begin{vmatrix} dG_r \\ dG_s \\ dG_c \\ dC_1 \\ dC_2 \end{vmatrix} = \begin{vmatrix} G_{rp}dP+G_{rf}dF_g \\ G_{sp}dP+G_{sf}dF_g \\ G_{cp}dP+G_{cf}dF_g+G_{cJ}dJ+G_{cF}dF \\ C_{1p}dP+C_{1f}dF_g+C_{1J}dJ+C_{1F}dF \\ 0 \end{vmatrix}$$

The notation is the same as before. The only difference between this system of equations and the corresponding system for the basic model in Section 4 is the presence of the $-G_{sc}$ term in the matrix on the left-hand side.

Cramer's rule again can be used to solve for the effects of the exogenous variables on the five endogenous variables. In each case the denominator of the comparative static result is equal to the determinant D of the matrix on the left-hand side of the system of equations, or

$$D = 1 - (G_{sc}G_{cs} + C_{1s}G_{s1}). \qquad (14)$$

Both G_{sc} and G_{cs} are presumed to be positive, but most likely the product of the two is less than 1. More guns in the hands of the public leads to more guns held by criminals (and vice versa), but this "arms race" is probably not explosive. As discussed above, the $C_{1s}G_{s1}$ term is negative and likely to be less than 1 in absolute value.

For the model to exhibit conventional results, it is necessary that D be positive. This shall be assumed; the arms race is not explosive. Furthermore, if D is positive and less than 1, there obtains what might be called a crime and gun control "multiplier effect." For example,

$$dG_c/dJ = (1/D)[G_{cJ}(1 - G_{s1}C_{1s}) + G_{cs}G_{s1}C_{1J}] < 0. \quad (15)$$

Increasing J, the probability of apprehension and punishment, reduces the demand for guns by criminals directly (G_{cJ}) and indirectly through the effect of J on guns owned for self-protection. Further, if $0 < D < 1$, these effects generate a multiplier effect. The arms race operates in reverse because both criminals and citizens who own guns for self-protection are reducing their ownership of guns, and these effects feed back on each other.

Crime control policies are represented by J, the probability of apprehension and punishment, and by F, the value of punishment. Increases in J and F have no effect on G_r, unambiguously reduce G_c and G_s, and hence reduce C_2. However, their effects on C_1 are ambiguous. For example,

$$dC_1/dJ = (1/D)[C_{1J}(1 - G_{cs}G_{sc}) + C_{1s}G_{sc}G_{cJ}]. \quad (16)$$

An increase in J has a direct negative effect on C_1 (the first term inside the brackets), but it also reduces G_c, which leads to a reduction in G_s and an increase in C_1. This last result is in contrast to the results in the basic model in Section 4, where the effects of crime control policies on crime are unambiguously negative.

The effects of gun control policies in this arms race model are qualitatively identical to those of the basic model in Section 4. Increases in P and F_g unambiguously reduce G_r, most likely reduce G_c and G_s, and hence most likely reduce C_2. The element of ambiguity in the effects on G_c and G_s once again arises because of the reduction in G_r, which can increase C_1 and therefore increase G_s and G_c. Increases in P and F_g have ambiguous effects on C_1 for the same reasons as in the basic model. Gun control measures make crimes more costly to commit, but the reductions in guns held by the law-abiding citizens tend to increase crime.

In summary, the arms race model has the same qualitative results as the basic model except in two cases; the effects of crime control policies on crime (C_1) are ambiguous. However, the arms race model also includes the possibility that there is a gun control multiplier effect.

Conclusion

Two economic models of guns and crime have been formulated that include interactions between criminals and law-abiding citizens. In the first model, law-abiding citizens demand guns partly in response to crime, and criminals demand guns partly in response to guns owned by potential victims. The second model adds the assumption that law-abiding citizens demand guns partly in response to guns owned by criminals.

The models have some unusual implications. In the first model, increases in the usual crime control measures may reduce crime by less than one would expect because of the indirect negative effect on guns owned by the law-abiding public. Gun control policies most likely reduce the demand for guns, but the effect on premeditated crime is ambiguous because of the negative effect on guns owned for self-protection and recreation. In the second model, the effect on crime of increases in the usual crime control measures might be muted even more, or reversed, by the reduction in guns owned by the law-abiding public. However, the second model also includes the possibility that gun control measures will multiply; reductions in guns held by the criminals lead to further reductions in guns held by law-abiding citizens (and vice versa).

Additional research of the sort presented in this paper should be undertaken. The model can be expanded by considering various types of guns and additional types of weapons, and by disaggregating crime into its various components (robbery, murder, burglary, etc.). Most important, empirical research is needed to test for the existence and to estimate the magnitudes of the various parameters of the model. Indeed, much of the debate about statistical tests in the existing empirical literature centers around the endogeneity or exogeneity of various variables. The model presented in this paper clarifies these issues.

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