# Firearms and Homicide

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I. Introduction

According to the brief filed by the District of Columbia in defense of the handgun ban in that city, handguns are used in 54% of all murders, 60% of all robberies, and 87% of all murders of police officers. In the District in 1974 handguns were used to commit 155 of the 285 murders in that year. The District also noted that, "Although only a third of the Nation's firearms are handguns, they are responsible for far more killings, woundings, and crimes than all other types of firearms combined." And, "People who live in houses with firearms, particularly handguns, are almost three times more likely to die in a homicide…." (p.52)

There is also some academic evidence that guns cause crime, especially homicide. A survey of the literature by Hepburn and Hemenway (2004) concludes, "A broad array of evidence indicates that gun availability is a risk factor for homicide, both in the United States and across high-income countries. Case-control studies, ecological time-series and cross-sectional studies indicate that in homes, cities, states and regions in the US, where there are more guns, both men and women are at higher risk for homicide, particularly firearm homicide." According to the Coalition for Gun Control, "The link between accessibility to firearms and death rates has been suggested in a number of studies…[a] review of 13 countries showed that there was a strong correlation between gun ownership and homicide rates and suicide rates."[1]

It would appear that guns cause crime, especially homicide. Therefore, the following propositions should follow. (1) A world without guns could be expected to be safe and peaceful. (2) Over time, more guns, especially handguns, should lead to more crime, especially murder. (3) Across geographical regions, areas where guns are

[1] http://www.guncontrol.ca/Content/international.html

prevalent should experience more crime, especially homicide, than those areas where guns are relatively scarce.

However, even if a positive correlation is found, the hypothesis is not necessarily true. Firearms, especially handguns, are also particularly well suited for self-defense. Therefore, a positive association between firearms and crime could be the result of citizens arming themselves in response to crime, rather than guns causing crime. Therefore, a study that finds a positive association between handguns and murder cannot conclude that handguns increase murder, unless it allows for the possibility that murder caused handguns to increase.

In this paper, I will attempt to summarize the best available evidence concerning the relationship between guns and crime. To conserve space, I will limit the analysis to the relationship between handguns and homicide. As the District noted, handguns are the weapon of choice for most criminals. However, handguns are also the weapon of choice for most individuals seeking to defend themselves. Limiting the analysis to murder saves having to repeat the analysis for the other crimes. Also, if victim costs are taken from Miller, Cohen and Wiersema (1996, Table2), the industry standard, a harm-weighted crime index would weigh murder at 97 percent.

A recent study by Kovandzic, Schaffer and Kleck (KSK, 2005) reviewed 33 studies on the relationship between guns and crime. Of these studies, 21 found a positive relationship between guns and crime. However, only six of those 21 studies attempted to deal with the possibility that crime causes guns, of those six only three properly dealt with the simultaneity issue, according to KSK, and none of those found a positive relationship between guns and crime. The remaining 15 studies finding a positive relationship between guns and crime made no attempt to deal with reverse causation.

The outline of the paper is as follows. In the next section I examine evidence from societies where there are no firearms. I also review the time series evidence on the relationship between handguns and murder, including an updated Granger causality analysis. The fourth section briefly reviews the cross-section evidence, including the international evidence. In that section I discuss a potentially serious flaw in all of the cross-section analyses. The next section looks at the pooled cross-section and time-series (panel) data evidence. Panel data analyses are the most compelling for several reasons, including the fact that it is the only design that can address the critical flaw in the cross-section analyses. I add some final thoughts in the last section.

## II. The Long View

### A. English History

There is a substantial amount of data in the English historical records concerning crime, especially homicide. According to Joyce Lee Malcolm, "…homicide rates in thirteenth century England were 10 to 20 times higher than in the twentieth century while homicide rates in the sixteenth and seventeenth century were 5 to 10 times higher. (Malcolm 2002 p. 19-20) The homicide rate in the thirteenth century was 20 per 100,000 which dropped to 15 per 100,000 in the sixteenth century, coinciding with the introduction of firearms, and to 6 per 100k in the 17'th Century (Beatty 1974, p. 61) coinciding with the introduction of the flintlock, and continued dropping after that. By comparison, the homicide rate in England in the 19'th Century was 1.5 per 100,000, about the same as in 1999. (Malcolm 2002, p. 115) The most common weapons used to commit homicide in the thirteenth century were knives, staffs (long sticks), hands, feet and improvised weapons. (Malcolm 2002, p. 31)

By 1650 muskets and pistols were commonplace, as evidenced by the laws regarding their use. Firearms were not particularly expensive. A common soldier could purchase his own musket with as little as a week's wages. Court records reveal that laborers, bricklayers, carpenters, farmers and servants owned their own firearms. Ordinary citizens were actually required to keep firearms as part of their peace keeping and militia duties.

If guns cause crime, then the world before guns might be expected to be peaceful and safe. However, according to Malcolm, "Medieval England was boisterous and violent…. This high level of homicide and violent crime existed when few firearms were in circulation." (Malcolm 2002, p. 33.) Instead, as firearms became common, there was a persistent decline in homicide that continued into the twentieth century. The decline was sharpest in the seventeenth century. For example, the homicide rate in Essex County in the late 1500's was 6.75 per 100,000. However, the rate for 1600-1650 was 4.3 and the rate for 1650-1700 was 2.8. (Stone 1983) This dramatic fall in lethal violence is more understandable if we consider that the flintlock, introduced in the early 1600's, was particularly useful for personal self-defense as it could be kept and carried primed and loaded. It was much more efficient than the older matchlock weapons.[2]

[2] Weapons that could be carried primed and loaded were available in the 16'th century, but were relatively scarce and expensive. The fact that a flintlock pistol could be carried primed and loaded for personal defense is demonstrated in a Spanish play circa 1619 in which a pistol is accidentally discharged. (Lavin 1965, pp. 159-60)

Of course, it could just be the advancement of civilization that caused the decline in the level of violence from the 13'th to the 20'th century. However, if that is the case, we would not expect a precipitous decline that just happens to coincide with the introduction of an extremely efficient method of self-defense. Also the 1600's in England saw the regicide of Charles I, the English Civil War, Cromwell's dictatorship, and constant wars with Scotland and Holland. Not a very civilized century.

In summary, firearms in the form of muskets and pistols came into common use in the seventeenth century, coinciding with the greatest decline in homicide in English history. Thus, in the long view, more guns were associated with less crime, at least in England, despite political upheavals, wars, famines, and other social stresses. One possible explanation is that the widespread adoption of effective weapons of self-defense, weapons that were readily available and did not require the user to be physically powerful, increased the risk of serious injury or death to potential murderers and thereby reduced the murder rate.

B. Homicide and violence in primitive, gun-free societies[3]

Perhaps if we look at modern-day simple gun-free cultures we can find a world that is peaceful and safe. However, the evidence is that primitive cultures are anything but peaceful. The Bushmen of the Kalahari, named the Harmless People by Elizabeth M. Thomas and featured in the movie *The Gods Must Be Crazy,* had a homicide rate of 41.9 per 100k for the years 1920-1955. (Knauft 1990, p. 1014)  In contrast, the homicide rate in the US in 2005 was 5.6 per 100,000.[4] The Gebusi are a small, primitive, gun-free

[3] I would like to thank Carlisle A. Moody for help in writing this section.

[4] http://www.ojp.usdoj.gov/bjs/homicide/tables/totalstab.htm

society of 450 people who live in a lowland rainforest in New Guinea. Sixty percent of all males admit to committing one or more homicides and almost one-third of all deaths are due to violence. Knauft estimates the homicide rate at the equivalent of 568 per 100,000. He also estimates that the precontact homicide rate (1940-1962) was even higher, 683 per 100,000. (Knauft 1987, p. 462-3) Other primitive gun-free societies also have high homicide rates. The Yanomamo of the Brazilian rainforest have a homicide rate of 165.9 per 100k. The Hewa of New Guinea have an even higher rate, 778 per 100k. (Knauft 1987, p 464)

According to Robert Edgerton, "The Kaingang of Brazil's tropical rainforest were described by anthropologist Jules Henry in 1941 as nomadic hunters who lived in bands of related kin. …any conflict with Kaingang from other bands led inexorably to violence, followed by more deadly retaliatory raids. The resulting cycle of raids and counter-raids was so unbreakable that the Kaingang population was drastically reduced…." (Edgerton 1992, p. 179) In fact, their population was reduced by as much as 75 percent as a result of constant raids and retaliation. Ambushes, raids and counter-raids, resulting in very high homicide rates characterize many primitive societies including the Aboriginal Australians, Alaskan Eskimos, Northwest Coast Indians, and Great Plains Indians. (Gat 1999, p. 575)

Another way to compare homicide rates is to calculate the proportion of all deaths due to homicide. In the U.S. in 2005 homicide accounted for 0.7 percent of all deaths (1.1 percent of males, 0.3 percent of females). [5] In contrast, in New Guinea 28.5 percent of the males and 7 percent of females died violent deaths. In tribal Montenegro in 1901-1905, 25 percent of all deaths were by violence. Gat (1999, p. 575) concludes, "All this

[5] http://wonder.cdc.gov/mortSQL.html

suggests that average human violent mortality rates among adults in simple societies may have been in the order of 15 percent (25 percent for the men)." This implies a homicide rate 22 times higher for males and 49 times higher for females than in the US today.

The situation is similar for pre-historic humans. In the Madisonville, Ohio late pre-historical site, 22 percent of the adult male skulls had wounds and 8 percent were fractured. In the Norris Farm site in Illinois, 16 percent of the individuals found there died violent deaths. (Gat 1999 p. 575)  Of 36 Australopithecine bodies from the Pleistocene era found in Africa, 20 (56%) of them apparently died due to purposeful violence by other hominids. (Roper 1969, p. 430)  Similarly, the remains of 25 individuals have been found in European prehistoric sites, of whom 16 (64%) show evidence of death by violence at the hands of other hominids. (Roper 1969, p. 437) Life in gun-free societies is not necessarily peaceful and safe in fact it appears to be nasty, brutish, and short.

Of course, the progress of civilization is almost certainly responsible for much of the remarkable decline in homicide in modern times compared to pre-historic times, modern day primitive societies, or medieval societies. However, the development of firearms is inextricably linked with the development of civilization after 1500. It is therefore difficult to identify the effect of civilization on the homicide rate independent of the effect of firearms. Nevertheless, it is suggestive that the greatest drop in homicide in English history coincides almost exactly with the introduction of an effective weapon that could be used for self-defense and did not require the user to be physically powerful. This is especially interesting in that England from 1600-1700 was suffering considerable social upheaval most of the time.

III. Time Series Data

I am aware of eight studies that use time series data to examine the relationship between guns and murder. All of these studies suffer from small sample size, which leads to potential omitted variable bias, as many potentially relevant variables cannot be included in the regressions because of the lack of degrees of freedom. Phillips et.al. (1976) has a sample size of eighteen. Kleck (1979) uses 27 observations while Kleck (1984) uses 32 observations. Magaddino and Medoff (1984) make do with 31 observations while McDowall (1991) uses 36 and Sorenson and Berk (2001) are limited to 22 observations. Aside from limited sample sizes and potential omitted variable bias, none of these studies test for unit roots. Since unit roots are common in time series, we can safely assume that many of the time series utilized were random walks. If so, the resulting regressions could very well be spurious. (Granger and Newbold 1974)

The most serious problem with evaluating the relationship between gun prevalence and homicide is the absence of good gun prevalence data. The only real data on the number of guns in the United States come from the Bureau of Alcohol, Tobacco and Firearms (ATF). The ATF collects data from gun manufacturers on the annual production guns for civilian use, subtracts exports and adds imports to get the net change in the gun stock. The net change is added to the previous stock level to generate the current stock. Because guns last indefinitely if stored in a dry place, most analysts assume that the depreciation rate is zero. This may result in an overestimate of the gun stock in that it does not count guns that are lost or damaged beyond repair. It also does not count guns that are illegally imported and exported. Nevertheless, most analysts are comfortable with a zero depreciation rate. Thus, the only good data on gun prevalence based on a count of firearms is an annual time series at the national level, with a debatable depreciation rate assumption.

The best use of these data is by Southwick (1997). He estimates a Granger causality model in which lagged values of guns are regressed on various crime measures using the lagged values of the crime measure as controls. The advantage of this approach is that it can be done with few or no other control variables. If there is some important variable that is correlated with both crime and guns, but omitted from the analysis, then the results suffer from omitted variable bias. However, if the omitted variable is also correlated with lagged values of crime or guns, which is likely to be the case, then these lags act as controls and allow unbiased estimates of the coefficients. Nevertheless, most researchers who employ the Granger model use exogenous controls when possible.

Southwick's sample was 1946-1993. Since then eleven more observations have become available (N=59), so I have taken the opportunity to update his study concentrating on the relationship between handguns and homicide. To keep the analysis simple, I measure homicide as the FBI series (murder plus non-negligent manslaughter) and I use the ATF series of handgun production as the only gun measure, both divided by population. Preliminary unit root tests indicated that both series had unit roots.

I do the Granger causality analysis in both levels and first differences; given that unit root tests are notoriously weak. I also do the analysis using both the raw data and in logs and I allow for one to three lags. Finally, I include three control variables. The first is a simple linear trend to control for slowly moving variables such as the aging of the population, economic growth, etc. The second is a measure of the crack epidemic developed by Fryer et.al. (2005). The one variable that is almost always significant in any crime equation is the prison population, which is an overall measure of the effectiveness of the criminal justice system. Because murderers make up a very small proportion of incarcerated felons, there is little possibility of simultaneity between murder and the prison population. Therefore I include the per capita prison population as an exogenous control variable.

The null hypotheses of interest are as follows. (1) The sum of the coefficients on lagged handguns in the murder equation is zero. (2) The sum of the coefficients on lagged crime in the handgun equation is zero. Note that these are not the F-tests applied in many Granger causality tests, which test whether the coefficients are jointly significant. It is quite possible that the coefficients on lagged handguns in the murder equation could be jointly significant according to the F-test, but if the estimated coefficients have opposite signs, the net effect could be zero. In this paper, I test the net effect for significance. The results are presented in Table 1 below.

Table 1
Granger causality tests: do handguns cause homicide?
US National Data 1946-2004

| Lags | Raw data | Logs | Raw data with controls | Logs with controls |
|---|---|---|---|---|
| Stock | | | | |
| 1 | N | N | N | N |
| 2 | N | N | N | N |
| 3 | N | N | N | N |
| First differences | | | | |
| Lags | Raw data | Logs | Raw data with controls | Logs with controls |
| 1 | N | N | N | N |
| 2 | N | N | N | N |
| 3 | N | N | N | Y |

Notes: "Y" indicates that the F-test on the sum of coefficients on the lags of the test variables was significant at the .10 level. "N" indicates not significant at the .10 level. The sums were always positive. Unit root tests indicated that murder and handguns are both nonstationary.

The overwhelming result from Table 1 is that handguns do not cause homicide. There is only one significant result out of twenty-four possible outcomes, which is less than would be expected using the ten percent significance level.

Table 2
Granger causality tests: does homicide cause handguns?
US National Data 1946-2004

| Lags | Raw data | Logs | Raw data with controls | Logs with controls |
|---|---|---|---|---|
| Stocks | | | | |
| 1 | Y | Y | Y | Y |
| 2 | N | Y | Y | Y |
| 3 | N | Y | Y | Y |
| First differences | | | | |
| Lags | Raw data | Logs | Raw data with controls | Logs with controls |
| 1 | N | Y | Y | Y |
| 2 | Y | Y | Y | Y |
| 3 | Y | N | Y | Y |

Notes: "Y" indicates that the F-test on the sum of coefficients on the lags of the test variables was significant at the .10 level. "N" indicates not significant at the .10 level. The sums were always positive. Unit root tests indicated that murder and handguns are both nonstationary.

Table 2 overwhelmingly indicates that homicide causes handguns. Of the twenty-four possible outcomes, the coefficients on lagged murder are jointly significant in twenty cases. This is far more than the two or three cases that would be expected randomly assuming a ten percent significance level. Thus, the time series data strongly indicate that handguns do not cause murder, but that murder causes handguns. This means that studies finding a positive relationship between guns and crime are under some obligation to distinguish between the two possible lines of causation.

While I used the zero depreciation rate for the main results discussed above, I also estimated the model with other depreciation rates. Since we know that handguns are very durable, I concentrated on the low depreciation rates (1-3 percent) but I also included 5 percent and 10 percent depreciation rates. The results are very similar. There are twelve possible outcomes in levels and twelve in first differences yielding 24 possible outcomes for each of five possible depreciation rates (1, 2, 3, 5, and 10 percent). The null hypothesis that handguns do not cause murder is rejected in 12 out of the 120 cases. Since this is exactly what we would expect by chance alone, at the ten percent level, there is no support for the hypothesis that handguns cause murder. On the other hand, the null hypothesis that murder does not cause handguns is rejected 104 times out of 120 (87 percent), over eight times the level predicted by chance. Therefore, even if I assume a range of possible depreciation rates for handguns, the results indicate no support for the hypothesis that guns cause murder, but overwhelming support for the hypothesis that murder causes people to acquire handguns. Any study purporting to shed light on the relationship between guns and crime, especially handguns and murder, must allow for the possibility of reverse causation from crime to guns.

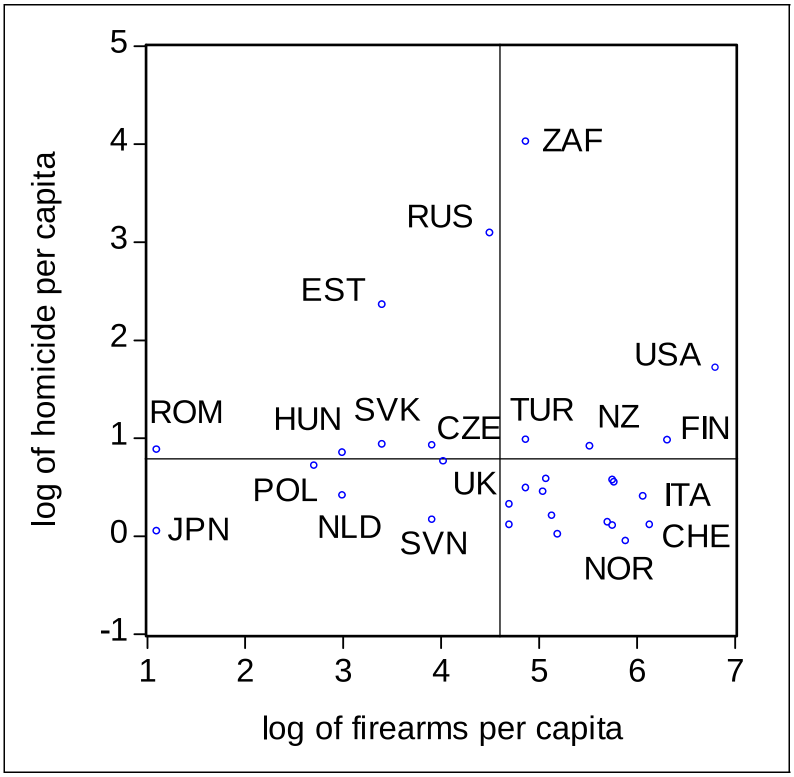
## IV. Cross-Section Data

### A. International Studies

I am aware of six studies (Hoskins 2001, Killias 1993, Killias, et.al. 2001, Lester 1996, Miron 2001, and Kates and Mauser 2007) which examine the relationship between firearms and homicide using international data. Of these studies, three find a positive relationship and three find no relationship. Of the three finding a positive relationship, only one (Hoskins) attempts to correct for possible reverse causation. The Hoskins study suffers from small sample size (n=36) and omitted variables (e,g,, he included no sanction variables such as prison population or legal variables such as gun prohibition or drug laws). It also suffers from questionable identification of the equation of interest. To identify the homicide equation, Hoskins assumed that neither population density nor the age group 15-24 had any effect on homicide.

The international situation can be summarized in the following graph and table. Homicide rates are from Barclay and Tavares (2003). Firearms per capita are from Kopel, et. al (2008) which relies on the Small Arms Survey (www.smallarmssurvey.org). I use logs to reduce the variance and make the graph more readable, otherwise most of the data is concentrated on the horizontal axis. The horizontal and vertical lines are the two (log) means.

Figure 1




The data is shown in Table 3 below. The means divide the data into four sections: high homicide and low guns (upper left), high homicide and high guns (upper right), low homicide and low guns (lower left), and low homicide and high guns (lower right).

Table 3
International Cross Section Data

| Country | Homicide Rate | Guns per capita (%) |
|---|---|---|
| High Homicide, High Guns | | |
| South Africa | 55.86 | 13 |
| United States | 5.56 | 90 |
| Turkey | 2.67 | 13 |
| Finland | 2.66 | 55 |
| New Zealand | 2.50 | 25 |
| | | |
| High Homicide, Low Guns | | |
| Russia | 22.05 | 9 |
| Estonia | 10.61 | 3 |
| Slovakia | 2.55 | 3 |
| Czech Republic | 2.52 | 5 |
| Romania | 2.41 | 0.3 |
| Hungary | 2.34 | 2 |
| | | |
| Low Homicide, High Guns | | |
| Belgium | 1.79 | 16 |
| Canada | 1.77 | 32 |
| France | 1.73 | 32 |
| Malta | 1.63 | 13 |
| Australia | 1.57 | 16 |
| Italy | 1.50 | 43 |
| Greece | 1.38 | 11 |
| Austria | 1.23 | 17 |
| Germany | 1.15 | 30 |
| Spain | 1.12 | 11 |
| Switzerland | 1.12 | 46 |
| Sweden | 1.11 | 32 |
| Denmark | 1.02 | 18 |
| Norway | 0.95 | 36 |
| | | |
| Low Homicide, Low Guns | | |
| United Kingdom | 2.14 | 6 |
| Poland | 2.05 | 2 |
| Netherlands | 1.51 | 2 |
| Slovenia | 1.18 | 5 |
| Japan | 1.05 | 0.3 |

The homicide rate is the number of homicides per 100,000 people. Guns per capita is the number of guns divided by the population, expressed as a percentage.

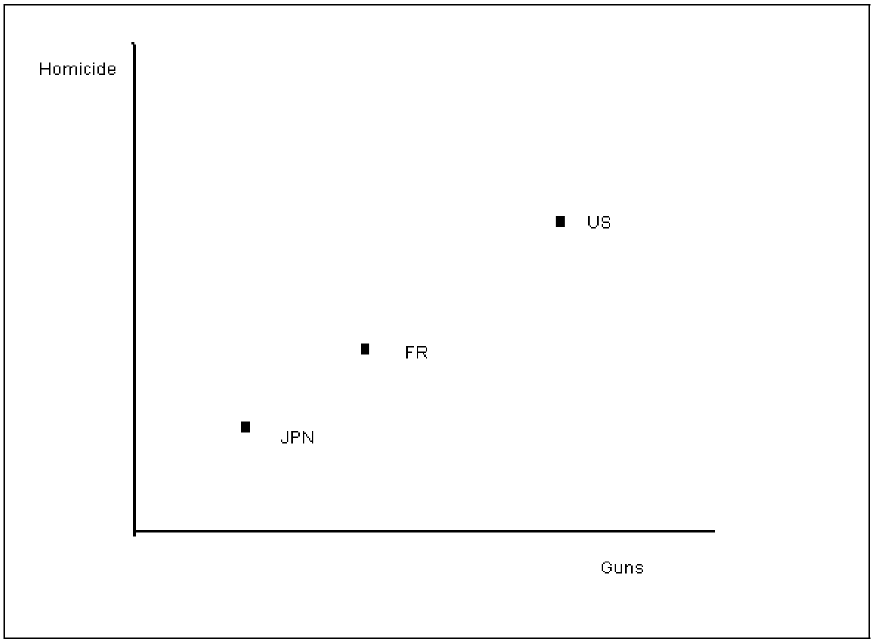
If guns caused homicide, we would expect to find most of the data concentrated in the lower left and upper right quadrants. However, the data is actually scattered throughout the four quadrants, with the majority in the “low homicide, high guns” sector. The simple correlation coefficient is -.04. If we use the raw data, before logging, the correlation is -.08. There is apparently no relationship between firearms and homicide internationally.

Kates and Mauser (2007) argue convincingly that homicide arises from basic social, economic and cultural factors, not the availability of weapons. Miron (2001) finds no relationship between gun prevalence and homicide, but he does find that countries with particularly strong drug laws have higher violent crime rates because contracts in illegal markets can only be enforced through violence. Studies that compare crime rates across countries therefore suffer from a serious omitted variable problem if they don’t take drugs or drug laws into account.

B. A problem with cross-section data

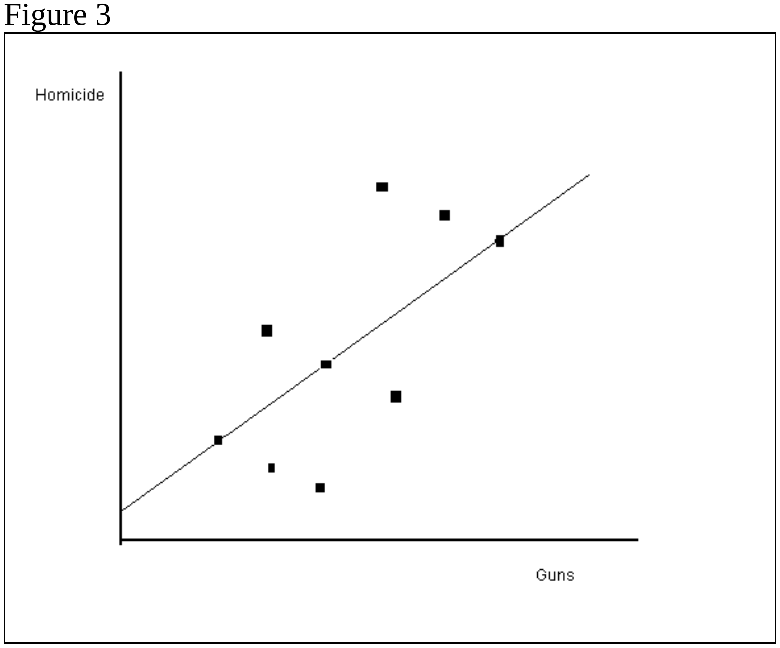
A potentially serious problem with cross-section analyses is unobserved heterogeneity. Suppose we have three countries, Japan, France, and the US. Suppose also that we have data for a single year for these three countries. Finally, suppose that Japan has low homicide and low guns, the US has high rates of both homicide and guns, and that France is in the middle. A cross-section regression would indicate a positive relationship between guns and homicide that might lead one to conclude that guns cause homicide. See Figure 2 below.

Figure 2




However, one possible explanation for these observations is that the US is simply a more violent country than the other two. Suppose that two more years of data become available for these countries.

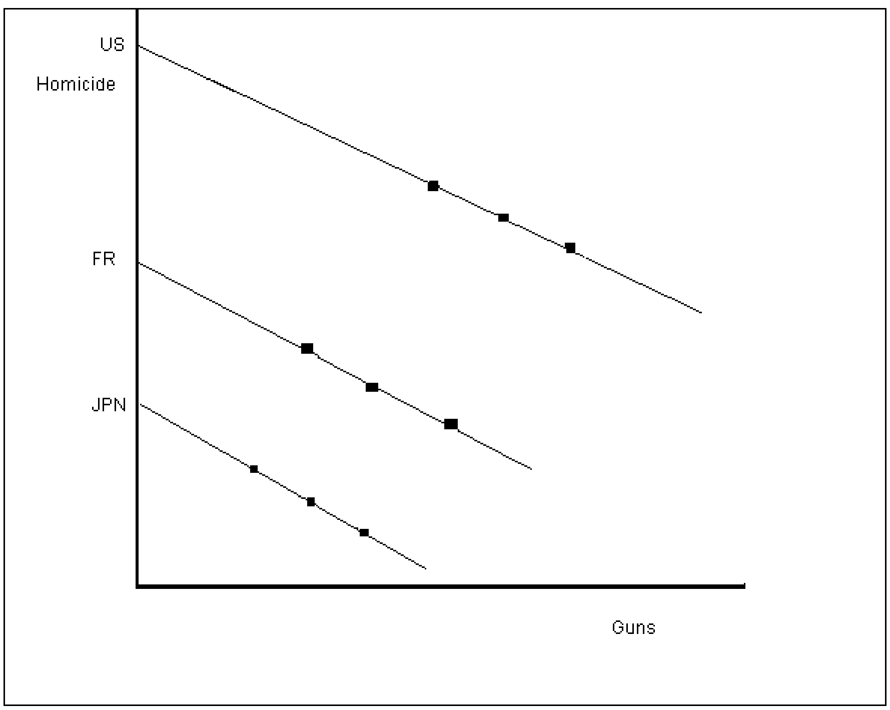
Figure 3



Even though there is now both time series and cross section data, a simple regression will still indicate a positive relationship between guns and homicide. The reason is that there is no control for the unobserved heterogeneity caused by the fact that some countries are simply more violent than others.

Finally, suppose we take the pooled time series and cross section data, also known as panel data in Figure 3 and regress homicide on guns, but allow a separate intercept for each country. The result is depicted in Figure 4, where the relationship between guns and crime is clearly negative. That is, within each country, an increase in the number of guns will cause homicide to go down.

Figure 4




This model is called the fixed-effects model because the unobserved heterogeneity is assumed to be fixed over time. Note that the US has a higher homicide rate, for all years, than the other two countries, perhaps because it has a more violent culture. The presence of unobserved heterogeneity is testable because the individual intercepts are computed as the coefficients on a set of dummy variables, one for each country. The test is a simple F-test that all these coefficients are equal to zero. In my experience, the fixed effect dummies are always significant.

C. US data

There are no actual data on the number of firearms per capita across states. The best measure of gun availability comes from the General Social Survey (GSS) conducted by the National Opinion Research Center. If the respondent admits that there are firearms in the house, the interviewer asks a follow up question to determine if the firearms are handguns, rifles, or shotguns. The major problems with the GSS are that it is a relatively small survey and it has many missing values because the survey is not conducted in every state every year. Thus there is a need for a proxy measure. The preferred proxy is the proportion of suicides committed by guns (percent gun suicide or PGS). (Azrael, et.al. 2004) The next problem is that if one uses a proxy such as PGS in place of the actual gun measure, then the only possible use of the resulting coefficient is to determine sign and significance. Some researchers (e.g., Duggan 2001, Cook and Ludwig 2006) attempt to calculate elasticities of crime with respect to guns from such regressions, as if the proxy was the actual measure. This technique ignores the relationship between the true measure of firearms and the proxy, which is unknown. See Moody and Marvell (2003) for a discussion.

Moody and Marvell (2005) offer a solution to this problem. They regress the GSS values on the percent gun suicide and use the predicted values to replace the missing GSS values. This allows the use of the actual GSS values whenever possible and a predicted value when not. The resulting estimated coefficients can be used to compute elasticities as well as to determine sign and significance.

There are several studies that use US cross section data (cities, states, or regions) to explore the relationship between guns and homicide. Kovandzic, et. al. (2005) list thirteen such studies, of which six find a positive and significant relationship. The other seven studies find no relationship. Of the six that find a positive relationship, none consider the possibility of reverse causation from homicide to guns.

The best published cross-section analysis is Kleck and Patterson (1993) where the authors estimate a two-equation model of crime and gun prevalence using data from 170 large cities. They employ a principal components factor of several proxies for guns, including percent gun suicide. Using two stage least squares, they find that gun prevalence is not significant in the homicide equation, but that homicide is highly significant in the gun equation, confirming the results from the Granger causality test above. Kovandzic, et. al. (2005) using county data for 1990 find that, if they make no attempt to correct for reverse causation from crime to guns, there is a positive relationship between PGS and crime. However, when the reverse causation is corrected, the association between guns and crime becomes negative. They conclude, "…we must treat gun levels as endogenous, and when this is done we find that they are, if anything, associated with lower, not higher, rates of gun homicide across counties." (p. 36).

All of these cross-section studies suffer from unobserved heterogeneity for the same reason as the cross section international studies. Texas and Florida are simply different from Vermont and Wisconsin. New York is more violent than Ohio. Such permanent effects must be controlled for in any regression model.

V. Panel Data

The only way to avoid unobserved heterogeneity is to use the fixed effects regression model on panel data. I am aware of four studies that examine the relationship between homicide and guns using US panel data. Duggan (2001) found a positive relationship. However, his study suffers from the use of a particularly poor proxy for guns, namely the circulation rate of the magazine *Guns & Ammo*. It turns out that this magazine, to maintain its circulation (and advertising rates) routinely gives free issues to doctors, dentists and other professionals for their waiting rooms. The magazine targets areas of the country where interest in such a magazine would be high, including high crime areas. Thus the use of such a measure results in a spurious correlation between crime and *Guns & Ammo* circulation rates.

Miller, et.al. (2002) studied states and regions for the years 1988-1993. They found a positive relationship between guns and homicide across states, but not across regions. Despite the fact that they used panel data, they did not use the fixed effects model. As a result, they estimate a cross section model which suffers from unobserved heterogeneity. Their study also suffers from omitted variables in that no sanction variables such as prison population are included in the controls. Also, limiting the sample to the years 1988-1993 is peculiar, given that the data go back at least to 1977. Finally, they made no attempt to correct for possible reverse causation.

Moody and Marvell (2005) use the fixed effects model to estimate the relationship between guns and crime. They find no significant relationship between handguns and crime, including murder. However, they find some evidence that crime causes handguns, confirming the Granger causality test above and Kleck and Patterson (1993). The

Marvell-Moody (2005) study uses the best possible measure for gun prevalence across states, corrects for unobserved heterogeneity, uses a large number of controls, including the prison population, and allows for possible reverse causation.

Cook and Ludwig (2006) attempted to estimate the effect of guns on crime using two panel data sets, the first consisting of large counties and the second consisting of states, for the years 1980 to 1999. They used the fixed effects model, so their study does not suffer from unobserved heterogeneity. They attempted to control for possible reverse causation by using percent gun suicide lagged one year instead of the contemporaneous value. This technique is acceptable if there is no serial correlation in the residuals. Unfortunately, Cook and Ludwig did not report a test for serial correlation, so we don't know if this approach is legitimate. Also, Cook and Ludwig treated the proxy variable, percent gun suicide, as if it were the actual level of gun prevalence. This invalidates all of their subsequent calculations as to the social costs of gun ownership.

In addition, their choice of control variables is questionable. They did not use the prison population as a control in this study, even though they used it as a control variable in several of their own previous crime studies (e.g., Cook and Ludwig 2002, 2003) where it was highly significant. They also omitted unemployment, income, and alcohol consumption which they had included in their earlier analyses. Finally, they reported that when they conditioned on county-specific trends, their estimates are not significant. Unfortunately, they did not report whether the county-specific trends were significant. If the county trends are significant, and in my experience they are almost always significant, there is no relationship between guns and crime in the county data. The results were similar when they used state data. While the addition of individual state trends did not render their coefficients insignificant, the point estimates were reduced by half. Again, they did not report whether the individual state trends were significant, but I suspect that they were, meaning that, if there is a relationship between guns and crime, they are overestimating the cost of gun ownership by at least 100 percent.

I was able to replicate their state level results using my own data on homicide by state from 1979-2005. The results are presented in Table 4.

Table 4
Cook and Ludwig Model

| Variable | Coefficient | T-Ratio |
|---|---|---|
| Pct gun suicide (PGS) lagged one year | **0.013** | **3.49** |
| Robbery rate | **0.145** | **6.76** |
| Burglary rate | **0.024** | **3.97** |
| Percent black | 0.339 | 1.72 |
| Percent urban | -0.009 | -0.69 |
| Mobility | -0.011 | -0.94 |
| Pct. female headed households | -0.029 | -1.15 |
| N | 1000 | |
| R-square | .95 | |

Notes: All variables are logged. The dependent variable is the homicide rate by state and year from the CDC. The model includes state and year dummy variables. T-ratios are robust and clustered on states. The regression is weighted by population. Bold indicates significant at the .05 level, two-tailed. The LM test for serial correlation (Godfrey 1978) is significant (prob=.0000).

The apparent positive relationship between percent gun suicide and homicide replicates the Cook and Ludwig (2006) results. However, I find that there is significant serial correlation in the residuals, invalidating the use of the lagged PGS as an exogenous variable.

I also estimated a model using a different set of control variables. The results are presented in Table 5.

Table 5
Moody's Alternative Model

| Variable | Coefficient | T-Ratio |
|---|---|---|
| Pct gun suicide lagged one year | 0.002 | 1.25 |
| Homicide rate lagged one year | **0.236** | **4.37** |
| Prison population per capita | **-0.041** | **-2.67** |
| Robbery rate | **0.151** | **7.04** |
| Construction employment per capita | **0.008** | **5.69** |
| N | 1000 | |
| R-square | .97 | |

Notes: All variables are logged. The dependent variable is the homicide rate by state and year from the CDC. The model includes state and year dummy variables and individual state trends which are highly significant. T-ratios are robust and clustered on states. The regression is weighted by population. Bold indicates significant at the .05 level, two-tailed. The LM test indicates no significant serial correlation in the residuals.

The coefficient on percent gun suicide is now insignificant. On the other hand, all of the control variables are highly significant as are the year dummies and state trends. Unlike Cook and Ludwig's model, this model has no serial correlation in the residuals, so I can treat the lagged percent gun suicide as an exogenous variable.

Both models appear to be legitimate, so how does one choose between them? Fortunately there is a simple test, the J-test developed by Davidson and MacKinnon (1981), which is designed to answer these types of questions. To perform the test I combine the two models into a single overall model. I subject the unique variables in Cook and Ludwig's model (excluding burglary, which is common to both models) to an F-test for their joint significance. I then repeat the test for the variables that are unique to my model. If Cook and Ludwig are right, then their variables should be significant in the presence of my variables. If I am right, then my variables should be significant in the presence of theirs. The results of the J-test are as follows: the unique Cook and Ludwig variables have an F-ratio of 1.57 (prob=.19) which is not significant at the .10 level. My variables (excluding the state trends which are highly significant) have an F-ratio of

22.45 (prob=.0000) which is highly significant. Thus, my alternative model encompasses and dominates the Cook and Ludwig model.[6]

The Cook and Ludwig study is clearly fragile given that a reasonable, in fact a superior, set of alternative controls yields a radically different conclusion. Moreover, their model appears to suffer from serial correlation, which means that their gun measure is not exogenous. Finally, their use of a proxy means that their computation of social cost is invalid. In order to compute the elasticity of homicide with respect to handguns, I re-estimate my version of their model using the Moody and Marvell (2005) measure of handgun prevalence. This yields a measure of gun prevalence that can be used to analyze the costs of handguns. The results are presented in Table 6.

Table 6
The Social Costs of Handguns

| Variable | Coefficient | T-Ratio |
|---|---|---|
| Handguns lagged one year | 0.002 | 0.33 |
| Lagged homicide rate | **0.238** | **4.31** |
| Prison population per capita | **-0.042** | **-2.73** |
| Robbery rate | **0.151** | **7.06** |
| Construction employment per capita | **0.008** | **5.79** |
| N | 1000 | |
| R-square | .97 | |

Notes: All variables are logged. The dependent variable is the homicide rate by state and year from the CDC. Handguns are measured as the GSS survey estimates with missing values replaced by predicted values from a fixed effects regression of GSS on percent gun suicide. The model includes state and year dummy variables and individual state trends, which are highly significant. T-ratios are robust and clustered on states. The regression is weighted by population. Bold indicates significant at the .05 level, two-tailed. The LM test indicates no significant serial correlation in the residuals.

The coefficient on handguns, measuring the elasticity of homicide with respect to handguns is two-tenths of one percent. The t-ratio is close to zero. This result confirms

[6] I do not include the individual state trends in the J-test because they are highly significant. Their inclusion results in F= 2.68e+08.

the findings of Moody and Marvell (2005) using a somewhat different model. The social cost of handguns appears to be zero.

In summary, the best evidence from the best data (panel data) using the best model (fixed effects) with the best proxy is that handguns have no significant effect on homicide. The use of handguns by criminals is apparently offset by the use of handguns by citizens defending themselves and deterring homicide.

## VI. Some Further Thoughts

### A. Virgin Killers

The government of the District of Columbia, in its brief to the Supreme Court states that, "… 'many murders are committed by previously law abiding citizens, in situations where spontaneous violence is generated by anger, passion, or intoxication'..." (District of Columbia 2008, p. 5) Don Kates and Daniel Poseby (2005) trace this claim, which has been repeated many times in the gun control literature, back to a 1973 pamphlet issued by the City of New York. According to this pamphlet, "…most murders (73% in 1972) are committed by previously law abiding citizens committing impulsive gun-murders while engaged in arguments with family members or acquaintances." The pamphlet cites the FBI as the source of the 73% estimate. The cite cannot be correct because (1) the FBI figures for 1972 were not available at the time the pamphlet was written, (2) the FBI does not collect data on the impulsiveness of homicides, and (3) the FBI does not count the number of homicides involving family or acquaintances. However, the 1972 FBI report did estimate that the overall proportion of murders of all kinds committed with firearms was actually 65 percent.

The available evidence, in fact, shows clearly that murderers are previously law abiding citizens. For example, the 1972 FBI report also calculated that 75 percent of the individuals arrested for murder had a prior arrest record of violent crime or burglary. In Baltimore in 2006, 92% of those arrested for murder had criminal records. Similar results were found for New York City (90%) and St Louis (88%). The situation is similar with respect to the murder victims. Seventy-eight percent of the Baltimore murder victims had felony arrest records, very similar to the experience of Charlotte, NC where 71% of all gunshot victims had criminal records. (Kates and Poseby  2005) Apparently, neither the typical murderer nor the typical victim is a previously law abiding citizen.

B. Guns and Freedom

Kopel, Moody and Nemerov (2008), using the same Small Arms Survey data used in section IV-A above, find that gun prevalence is positively associated with both of the Freedom House measures of political and civil freedom and with the Heritage Foundation's measure of economic freedom, and negatively associated with Transparency International's measure of corruption. They conclude,

> There are many causal mechanisms by which guns and freedom can advance or inhibit each other. The mechanisms which are most influential at a given point in time can vary widely from nation to nation. Historically and today, we can find ways in which freedom has increased guns, guns have increased freedom, freedom has reduced guns, and guns have reduced freedom. International firearms scholars, except those based in North America, have tended to focus their research only on the latter two relationships, while ignoring the first two. Some of the more enthusiastic proponents of gun prohibition have asserted that the relationship between freedom and guns is always negative.
>
> The data in this Article reveal a more complex picture. As a general (but not invariable rule), countries with more guns have more economic freedom, less corruption, and more economic success. (Kopel, et.al. 2008, p. 21)

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