Guns and Suicide:
Correlation or Causation?

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1. Introduction

In 1998, more than thirty thousand American citizens took their own lives, making suicide the ninth leading cause of death in that year. Furthermore, it represented the third leading cause of death for the 10-14, 15-19, and 20-24 age groups, and the fourth leading cause of death for those aged 25-44. While the suicide rate has been declining during the last decade, the high rates of suicide that still exist in the United States represent an important social problem.

Nearly 60% of suicides are committed with a gun. Previous research suggests that individuals who use a firearm when attempting to commit suicide are more likely to be "successful".[1] If this is the case, then it is possible that gun availability affects the overall suicide rate rather than simply the fraction of suicides in which a gun is used. Similar instrumentality effects have been persuasively documented for assaults and robberies,[2] though if suicidal tendencies are persistent or if suicide-prone individuals simply substitute to other equally effective methods[3] when a gun is not available, then they may have much less of an impact on the suicide rate.

An alternative channel through which gun availability may affect the suicide rate is by increasing the number of attempts. Certain individuals may find suicide with a gun more appealing than alternative methods – perhaps because of the speed, the high probability of success, or because it is a culturally accepted method[4] - and thus only attempt suicide when a gun is available.

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[1] Clarke and Lester (1989); Card (1974).

[2] Zimring (1968); Zimring (1972); Cook (1987).

[3] Newton and Zimring (1969) point out that other methods of attempting to commit suicide (i.e. jumping from heights or drowning) are just as likely to result in an individual's death.

[4] Boor (1981).

Determining whether gun availability affects the suicide rate through either of these channels presents a difficult identification problem. Within the U.S., rates of suicide at the state and local level are significantly positively related to the fraction of individuals who own a gun. But this could plausibly be driven by self-selection – individuals who own a gun or live in an area with relatively many gun owners may be more inclined than observably similar individuals in other places to attempt to take their own lives. To investigate the importance of each of these three forces – the instrumentality effect, the impact of firearms availability on the number of suicide attempts, and the relationship between suicidal tendencies and gun ownership - I take three primary approaches in my empirical analyses.

I begin by examining the relationship between state-level gun and non-gun suicide rates and the average rate of gun ownership. If suicide rates are higher in places with more gun ownership simply because firearms are more likely than alternative methods to result in an individual's death, then one would expect to observe a positive relationship between gun ownership and gun suicides and negative relationship of gun ownership with non-gun suicides. My findings demonstrate, however, that non-gun suicide rates are not significantly lower in places with more gun ownership while gun suicide rates are, suggesting that the fraction of the population that attempts to commit suicide is higher in places with relatively many gun owners.

An alternative explanation for this first set of findings is that gun availability influences the suicide rate by increasing the number of suicide attempts rather than simply the success probabilities. Perhaps use of a firearm differentially appeals to some individuals who would not otherwise try to take their own lives. If this were true, one would not necessarily detect a negative relationship between gun availability and the non-gun suicide rate even though access to firearms was causing an increase in the number of suicides. However, my findings suggest

that gun owners in high ownership states are more likely than gun owners in low ownership states to take their own lives. This suggests that suicidal tendencies are significantly higher in states with the highest rates of gun ownership, and thus that a significant part of the state-level relationship between gun ownership and suicide is driven by a correlation between firearms ownership and this other factor.

These results do not rule out the possibility that gun availability increases the number of suicides, but instead strongly suggests that a significant part of the relationship is driven by a correlation between gun ownership and suicidal tendencies. To further explore whether the availability of a firearm has a causal effect, I exploit differences between men and women in the probability of using a gun to commit suicide. While almost 62% of males who commit suicide use a firearm, only 38% of their female counterparts do. If gun availability causes an increase in the suicide rate, then one would, under plausible assumptions, expect to find that the male suicide rate is more responsive to the rate of gun ownership than is the female suicide rate. To test this hypothesis, I explore whether the ratio of the male suicide rate to the female suicide rate is associated with the average rate of gun ownership. My finding that this ratio is significantly positively related to gun ownership suggests that instrumentality effects may partially explain the relationship between gun ownership and suicide, though I cannot rule out the alternative hypothesis that suicidal tendencies among men are more strongly related to gun ownership than they are for women.

In the final empirical section, I exploit two decades of annual state data to examine whether changes in gun ownership are significantly related to the overall suicide rate. During this time period, the household prevalence of gun ownership has declined substantially, and the overall suicide rate has fallen to its lowest level in more than three decades. My findings there

suggest that the decline in gun ownership is not driving the recent reduction in the suicide rate, as states with the largest declines in gun ownership do not see significantly larger reductions in their suicide rates. The power of this empirical test is limited, however, as state-level rates of gun ownership have been quite stable and the actual ownership rate is measured with error.[5]

Taken together, the results presented in this paper suggest that much of the positive relationship between firearms ownership and suicide is driven by selection – individuals with above average suicidal tendencies are more likely to own a gun and to live in areas with relatively many gun owners. But because female suicide rates are less responsive to the rate of gun ownership than are male suicide rates, it does appear that instrumentality effects also play some role. And finally, while suicide rates have been declining in the U.S. in recent years, the reduction in the fraction of households who own a gun does not appear to be the force that is driving this decline.

The outline of the paper is as follows. Section two provides information about trends in the U.S. suicide rate during the last two decades. The third section presents a theoretical framework that emphasizes the identification challenges inherent in estimating the effect of gun ownership on suicide. Much of the previous literature that examines the relationship between gun availability in suicide is briefly summarized in section four. The empirical analyses are presented in the fifth section, and the final section concludes.

2. Background

In 1980, the U.S. suicide rate stood at 11.8 per 100,000, with approximately 57% of cases involving a firearm. As shown in Figure 1, during the next six years the suicide rate steadily increased, reaching a peak of more than 12.9 per 100,000 in 1986. During this time, the fraction of suicides in which a gun was used also increased slightly (Figure 2) and continued to do so

[5] Azrael, Cook, and Miller (2001).

during the next several years until it rose above 61% in 1990. By 1998, both the suicide rate and the fraction in which a gun was used were below their 1980 levels.[6]

The likelihood that an individual will commit suicide varies substantially by gender and age. In 1998, a man was more than four times as likely as a woman to take his own life, with gender-specific suicide rates equaling 18.6 and 4.4 per 100,000, respectively.[7] Table 1 demonstrates that suicide rates are significantly lower among teenagers than among non-elderly adults, but are especially high for those over the age of 75. Interestingly, this effect is entirely driven by elderly male suicides, as women aged 75 and up are actually less likely than non-elderly adult women to take their own lives.

From 1980 to 1998, suicide rates declined substantially for women but less so for men, as is shown in Table 2.[8] During this time period, the fraction of women who committed suicide in the year fell by more than 20%, while the corresponding fraction for males remained virtually unchanged. The decline was especially large for women between the ages of 20 and 34 and those aged 55-74, whose suicide rates fell by approximately one-third. Male suicide rates in these age categories also declined but by a much smaller percentage. Had it not been for changes in the age structure of the U.S. population, overall male suicide rates would have declined and the 20% drop for women would have been even larger.

The most disturbing trend that is apparent from this table is the increase in the suicide rate among teenagers. Specifically, the suicide rate among boys aged 10-14 almost doubled from

[6] Gender, age, and state-specific suicide data were not available at the time of this writing for 1999 but aggregate U.S. data are.

[7] Suicide rates also vary substantially by race. For example, in 1998 the suicide rate among African-Americans was 5.7 per 100,000 versus 12.4 for whites. The fraction of suicides in which a gun is used does not vary much across races, with the 1998 values standing at 56% and 58%, respectively, for these two groups.

[8] See Stevenson and Wolfers (2000) for an empirical examination of changes in divorce laws, which they argue led to a substantial decline in the suicide rate among women.

1980 to 1998 while the rate for girls in this age group more than tripled. Rates for "older teenagers" between the ages of 15 and 19 increased slightly over this time period. Thus despite the fact that teenagers are still much less likely than adults to commit suicide, the recent increases represent an important social problem.[9]

The way in which individuals kill themselves varies substantially by gender. Males who commit suicide are much more likely than their female counterparts to use a firearm, as is shown in Table 3. Much of this difference is accounted for by a greater likelihood of suicide by drugs among women. As Table 4 shows, the likelihood that male and female suicide victims do use a gun has remained fairly stable over the sample period, with the male fraction declining from 63.0% to 61.6% and the female share falling from 38.6% to 38.4%.

The relationship between age and method of suicide is somewhat similar for males and females. For both groups, middle-aged individuals who commit suicide are the least likely to use a gun, with teenagers being somewhat more likely than the average. Elderly males who commit suicide are much more likely to use a firearm than are the non-elderly, while no corresponding relationship is observed for elderly women relative to middle-aged women.

While the fraction of all suicides in which a gun is used has remained fairly stable from 1980 to 1998, there has been substantial variation within particular age groups during this same time period. This is especially true for males, as can be seen in Figure 3A. Males under the age of 55 are now much less likely to use a firearm when committing suicide than they were in 1980, while males 55 and older are significantly more likely to use a firearm when taking their own lives. Interestingly, the fraction of older women who use a gun to commit suicide has also increased during the time period of interest.

[9] See Cutler, Glaeser, and Norberg (2000) for an explanation of the increase in the teenage suicide rate in the post World War II period.

3. Theoretical Framework

Isolating the causal effect of gun ownership presents a difficult identification problem. Individuals who choose to purchase a gun are likely to differ in unobservable ways from those who do not. A finding that suicide rates are significantly related to gun ownership may reflect a causal effect of gun ownership on suicide or instead simply a different propensity to commit suicide among gun owners. Suppose that the probability individual i commits suicide depends on his/her observable characteristics, gun ownership, and his/her unobserved tendency to commit suicide as specified in the following equation.

$$(1)\ \Pr ob(Suicide_i) = \alpha + \beta * X_i + \gamma * Gun_i + \lambda * \Pr opensity_i + \varepsilon_i$$

Here X_i represents a set of observable control variables, Gun_i equals one if the individual owns a gun and zero otherwise, and $Propensity_i$ is the unobserved tendency to commit suicide. The parameter of interest is γ, which represents the induced change in the probability of committing suicide after the acquisition of a firearm. Suppose that the propensity to commit suicide is correlated with gun ownership as follows:

$$(2)\ \Pr opensity_i = \mu + \sigma * Gun_i + \zeta_i$$

If $Propensity_i$ is unobserved by the econometrician, then the coefficient estimate in equation (1) above will be biased if σ is non-zero. Combining equations (1) and (2) yields:

$$(3)\ \Pr ob(Suicide_i) = (\alpha + \lambda\mu) + \beta * X_i + (\gamma + \lambda\sigma) * Gun_i + (\varepsilon_i + \lambda\zeta_i)$$

While one would like to know the value of the parameter γ, instead the coefficient estimate on Gun_i in equation (3) confounds the correlation between suicidal tendencies and gun ownership with the effect of gun ownership on suicide.

Absent an instrumental variable that provides plausibly exogenous variation in gun ownership, one can try to gauge the relative importance of causality (γ) versus selection ($\lambda\sigma$) by

determining the empirical regularities that should be observed in the data in the limiting case with $\sigma=0$. Suppose that the probability that an attempted suicide results in death is equal to γ_g if a gun is used and γ_o if an alternative method is chosen. Overall suicide rates will differ if γ_g is not equal to γ_o and if those who unsuccessfully attempt to commit suicide in the current period do not necessarily try again in the subsequent period (e.g. suicidal impulses are, to some extent, temporary). In this limiting case, if $\gamma_g > \gamma_o$ and if owners are more likely to use a gun when trying to commit suicide, then one should observe higher rates of gun suicide and lower rates of non-gun suicide in areas with more gun ownership.

Consider the case in which each individual will, with identical probability η, attempt to commit suicide in the current period. Aggregating across individuals, rates of gun and non-gun suicide will be related to the fraction of individuals who own a gun as follows:

$$(4)\ GunSuicRate_j = \eta^* \gamma_g * Gun_j$$

$$(5)\ NonGunSuicRate_j = \eta^* \gamma_o * (1 - Gun_j)$$

If γ_g equals γ_o then suicide rates will be unrelated to gun ownership and only the method will vary across geographic areas. If instead $\gamma_g > \gamma_o$ then overall suicide rates will be higher in places with more gun ownership:

$$(6)\ SuicideRate_j = \eta^* ((\gamma_g - \gamma_o) * Gun_j + \gamma_o)$$

This setup assumes that individuals who are unsuccessful in a suicide attempt have the same probability η of attempting suicide in the next period as do those who did not attempt to commit suicide in the current period. Even if one relaxes this assumption the positive relationship between gun ownership and suicide rates would remain as long as η was less than 1 for those who failed in a suicide attempt in the previous period.

The implication of this simple model is that, if the propensity to commit suicide is unrelated to gun ownership, rates of non-gun suicide would be lower in places with more gun ownership but overall suicide rates would be higher. The magnitude of the effect would be positively related to the difference in the two probabilities γ_g and γ_o and declining as the persistence of suicidal tendencies increased. If one observed that gun suicide rates were significantly greater in areas with more gun ownership but that this was not partially offset by a lower rate of non-gun suicides, then this would suggest that unobservable factors play an important role, though an alternative explanation would be that gun availability increases the number of suicide attempts.

A final way to assess the role that firearms play in determining the suicide rate is to examine the relationship between changes in the suicide rate and changes in gun ownership. Suppose that the propensity to commit suicide η varies across individuals but that the distribution of η does not vary within geographic areas over time. In this case, the overall suicide rate would increase following a rise in gun ownership if firearms increase the probability of suicide for the marginal gun owner. The elasticity of the suicide rate with respect to gun ownership would depend on the difference $(\gamma_g - \gamma_o)$, the suicide propensity for the marginal gun owner, and the persistence of suicidal motives. However, if the change in gun ownership is correlated with changes in suicidal tendencies then one must probe more carefully to determine whether the relationship is driven by gun ownership or this other factor.

To summarize, the theoretical framework presented here underscores the difficulty associated with estimating the effect of gun ownership on the suicide rate, even if one did have perfect data. Cross-sectional approaches can differentiate between different methods of suicide to test for a relationship between gun ownership and average suicidal tendencies. But this

approach is not fully satisfactory because it does not pin down the relative importance of gun ownership and unobservable factors. Empirical analyses that exploit within-area variation in gun ownership must confront the possibility that the observed changes in gun ownership are driven by factors that are simultaneously affecting the suicide rate.

Thus while neither approach is ideal for identifying the effect of gun ownership on suicide, each one can shed some light on this issue. In the empirical work in section five, I use both approaches to investigate whether gun ownership partially explains the cross-area and within-area variation in the suicide rate. I then discuss the need for more work that identifies sources of plausibly exogenous variation in gun ownership in the conclusion.

4. Previous Literature

A substantial body of previous work has examined the relationship between gun availability and suicide, with some arguing that firearms increase the suicide rate through an "instrumentality effect" while others assert that individuals simply substitute to alternative methods when a gun is not available.[10] It seems plausible that, for many of the 18,000 individuals who commit suicide with a gun during a typical year in the U.S., the alternative methods with similarly high "success" rates (i.e. hanging or leaping) are less appealing. If this is true and if suicidal impulses are to some extent temporary, then gun availability could cause an increase in the suicide rate.

Studies of international data have shown, however, that gun availability is by no means the only determinant of the suicide rate. While the U.S. has much higher rates of gun ownership than most other industrialized countries, its suicide rate is much lower.[11] For example, during

[10] Brent, et al (1988); Rich, et al (1990).
[11] Kates (1990).

the 1980s, the U.S. suicide rate was approximately 12 per 100,000, while in Japan, West Germany, and France the corresponding rates stood at 20, 20, and 22, respectively.

One widely cited study finds that individuals who commit suicide in their own homes were more likely to own a gun than were observably similar individuals in the same neighborhood.[12] The authors conclude that gun ownership may increase the risk of suicide, but are careful to point out that the victims may differ in unobservable ways from their matching controls with respect to their suicide propensities. While suggestive, it is therefore difficult to assign a causal interpretation to this set of findings.

Another prominent article compared suicide rates in Seattle and Vancouver, arguing that these two metropolitan areas in the Pacific Northwest are similar on most dimensions but are, as a result of government legislation, quite different with respect to their rates of gun ownership.[13] The authors' findings demonstrate that suicide victims in Seattle are much more likely to use a firearm, but that overall suicide rates are not significantly different between the two areas, suggesting that individuals hoping to take their own lives will substitute to other methods if a gun is not available. The results do suggest that suicide rates for younger individuals (those aged 15-24) are significantly greater in Seattle, though this is offset by a significantly lower suicide rate among older residents of Seattle. Of course, no strong conclusions can be drawn from a cross-sectional study that compares just two local areas.

A related body of research examines the effect of changes in gun control legislation. One study compares the suicide rate in Washington, D.C. before and after the passage of a law that banned the purchase, sale, transfer, or possession of handguns by civilians.[14] The authors show

[12] Kellerman, et al (1992).

[13] Sloan, et al (1990).

[14] Loftin, et al (1991). See McDowall, Loftin, and Wiersma (1996) for a follow-up analysis that uses similarly sized cities (rather than suburbs) such as Baltimore as a control group

that gun suicides occurring in the D.C. metro area declined by 23% following the passage of the law, and that non-gun suicides declined by a statistically insignificant 9%. One result that is potentially problematic for this analysis is that gun suicides occurring in nearby Maryland and Virginia suburbs rose by a statistically significant 12%, suggesting that many of the suicides that were prevented in Washington, D.C. may have occurred in a neighboring area. Additionally, the finding that non-gun suicides also decline suggests that the share of the D.C. population with suicidal tendencies was declining.

In a recent paper, Ludwig and Cook investigate the effect of the Brady Handgun Violence Prevention Act on state-level suicide rates.[15] This legislation required that federal firearms dealers conduct a background check and observe a five-day waiting period for individuals aged 21 and older who purchased a gun. The authors find that this legislation did not reduce the overall suicide rate, though it did appear to cause a reduction in the gun suicide rate among those aged 55 and older.[16] This finding suggests that suicidal impulses are, to some extent, temporary, as individuals who did not own a gun but tried to purchase one were apparently less likely to take their own lives once the five-day period had elapsed. This policy experiment presumably does not allow one to estimate the effect on suicide rates for those who already owned a gun, but provides convincing evidence that restricting gun availability may reduce the suicide rate among older individuals. The fact that this suicide victims in this age group are much more likely to use a gun (partially because a larger proportion are males) suggests that this "heterogeneous treatment effect" is plausible.

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when estimating the effect of the law change. The potential for a "spillover effect" in this case is much lower, as most of these cities are located further away from Washington, D.C. than the suburbs used in the 1991 paper.

[15] Ludwig and Cook (2000).

[16] The authors find a partially offsetting positive effect on non-gun suicides, so the estimated effect for the total suicide rate is negative but not statistically significant.

One final study that examines the relationship between gun ownership and suicide compares mortality among the 238,292 individuals who purchased a handgun in the state of California in 1991 with the rate for other observably similar individuals in the state.[17] The authors find that, in the week following the purchase, individuals were 57 times more likely than other observably similar California residents to take their own lives, and that this group was several times more likely to commit suicide in the year following purchase. Interestingly, the study points out that most handgun purchasers in California were young, with just 3.5% of them over the age of 65. Given the result for the previous study, which suggested that older individuals were more affected by laws that influenced the ease of purchase, this age distribution is surprising. Additionally, one cannot know from this set of results whether the suicide rates among handgun purchasers would have been any different if guns were less available.

Taken together, the literature has demonstrated that gun owners in the U.S. are more likely to take their own lives, but has reached different conclusions about whether the availability of a gun is partially responsible for this. Particular policies that have restricted access to firearms appear to lead to fewer suicides for particular groups but have relatively little effect on the overall suicide rate. The empirical analysis presented in the next section takes a different approach from the studies described here to gauge the relative importance of gun availability and suicide propensity in explaining the significantly greater suicide rate among gun owners.

5. The Relationship Between Gun Ownership and Suicide: Correlation or Causation?

Measuring Gun Ownership

Section three above outlined the difficulties associated with investigating the causal effect of gun ownership on the suicide rate conditional on having complete data. Making this problem even more difficult, the available data are far from perfect. The suicide data is actually

[17] Wintemute, et al, 1999.

quite good, as one can, for example, know from available data sets that 1036 Illinois residents committed suicide in 1998, and that in 486 of these cases the decedent used a firearm. Unfortunately, one cannot obtain similarly reliable data on rates of gun ownership, so instead researchers have typically used proxy variables to estimate average rates of gun ownership by geographic area.[18]

Two proxies have recently been proposed to estimate this elusive variable. One study uses sales rates for *Guns & Ammo*, one of the nation's largest gun magazines and the largest one that focuses primarily on handguns, to estimate annual rates of gun ownership at the state and the county-level. Results from another recent paper suggest that the fraction of suicides in which a gun is used more reliably estimates differences across areas and the variation within geographic areas over time in the rate of gun ownership.[19]

The results presented in the first column of Table 5 demonstrate that there is a significantly positive relationship between these two variables. The variable Log(*G&A*) in this first specification is equal to the log of each state's average magazine sales rate from 1980-1998, while the variable Log(FS/S) is equal to the log of the fraction of suicides during that time period in which a gun is used. The coefficient estimate of 0.632 is precisely estimated and reveals that the variables are quite closely related. The second column demonstrates that this significantly positive relationship also holds up when one uses 19 years of state-level data (1980-1998) and

[18] Survey data do exist, though the sample sizes for most states are usually quite small and the surveys are typically not designed to be representative at the state, county, or MSA level. For example, the General Social Survey polls approximately 1500 individuals in a year about gun ownership, and thus the sample size for the average state is just 30. Furthermore, the survey is not designed to be representative at the state level and concerns have been raised that some individuals do not truth-tell. The limitations of the survey data have prompted researchers to utilize proxy measures.

[19] Duggan (2001); Azrael, Cook, and Miller (2001).

state and year fixed effects. It therefore appears that these variables are capturing similar variation.

The next four columns compare the "fit" of each of these variables to survey data from the General Social Survey. These regressions utilize both average state and annual state level data, and show that one cannot reject the hypothesis that there exists a one-for-one relationship between the estimated rate of gun ownership from the GSS and the gun magazine sales rate.[20] The observed relationship is slightly more than one-for-one using the fraction of suicides with a gun as a proxy.

Using annual state data in the last two specifications, both proxy variables are significantly related to the rate of gun ownership after controlling for state and year fixed effects. While the coefficient estimate for the Log(FS/S) variable is closer to one, the precision of the corresponding estimate for Log(*G&A*) is greater. Thus it appears that both variables are good proxies for the average rate of gun ownership.

In most of the empirical work that follows, however, I will utilize the magazine sales rate as my estimate of the rate of gun ownership in a state. The reason for this is that, even if the gun suicide fraction is an excellent proxy for gun ownership, random fluctuations in it will lead to a mechanical relationship between the outcome variables of interest and the estimated rate of gun ownership.[21] Of course the Log(*G&A*) variable is by no means immune to measurement error problems. The sales rate of the gun magazine will depend not only on the rate of gun ownership,

[20] It is worth pointing out that the state-level data are not intended to be representative of each state's population. The fact that Cook, et al (2001) obtain similar results when using regional data suggests that the bias introduced is not too great, but it should be kept in mind when interpreting the results.

[21] I discuss this issue in detail in the appendix at the end of the paper.

but also on the propensity of both gun owners and those who do not own a gun to purchase this magazine as specified in the following equation:

$$(7)\ \frac{Magazines_j}{Population_j} = \mu_{gun,\,j} * \theta_j + \mu_{non,\,j} * (1 - \theta_j)$$

in which μ_{gun} and μ_{non} represent the probability that individuals in each group will purchase the magazine and θ_j equals the share of people who own a gun. Even if only gun owners buy the magazine ($\mu_{non} = 0$), variation in this proxy variable could be driven either by variation in gun ownership or in the propensity of gun owners to buy it. But the same is also true for the gun suicide fraction, which will depend both on the rate of gun ownership and on the likelihood that the average gun owner commits suicide.[22]

Unlike with the gun suicide fraction, however, random variation in the magazine sales rate should not be mechanically related to the outcome variable of interest, and is much more likely to be orthogonal to the measurement error in the suicide rate. In most of the empirical analyses below, I therefore use the magazine sales rate as the proxy for gun ownership.

The Cross-Sectional Relationship Between Gun Ownership and Suicide

The number of suicides depends both on the number of suicide attempts and on the average probability that each one of those attempts will result in the individual's death. Thus there are two channels through which gun availability could affect the suicide rate. First, if some individuals who try to take their lives choose a gun when it is available but an alternative method when no gun is present, then access to firearms could increase the suicide rate if the "success probability" for guns is relatively high. This mechanism has been referred to as the

[22] This measure will also depend on the probability that those who do not own a gun commit suicide and the probability that individuals in each group use a firearm when committing suicide.

instrumentality effect in the literature that examines the relationship between gun ownership and crime.[23] The potential importance of instrumentality effects for suicide will be a decreasing function of the persistence of suicidal tendencies – if a person who survives a suicide attempt today will simply try again tomorrow then the steady state rate of suicides would be relatively unaffected by access to firearms.

The second channel through which gun prevalence could affect the suicide rate is by causing some individuals who would not otherwise have tried to take their own lives to do so. Boor points out that the accepted method of suicide varies greatly across cultures, and argues that the availability of this method influences the probability that an individual will attempt to take his/her own life.[24] Thus either by influencing the success rate or by the number of suicide attempts, gun ownership could plausibly be related to the overall suicide rate.

I begin the empirical analysis by exploring the relationship between overall suicide rates and rates of gun ownership at the state level.[25] The results summarized in Table 6 utilize both of the proxy measures as explanatory variables in specifications of the following type:

$$(8)\ Log(SuicideRate_{ij}) = \alpha + \beta * Log(GunOwnRate_j) + \varepsilon_{ij}$$

with j indexing states and i indexing age groups within each state.[26] The coefficients presented in the first row suggest that suicide rates are substantially higher in places with more gun ownership. The estimate of 0.747 on the Log(*G&A*) coefficient is virtually identical to the corresponding estimate of 0.690 for the Log(FS/S). The estimates presented in the next several

[23] Cook, Moore, and Braga (2001).

[24] Boor (1981).

[25] It would be preferable to estimate this set of regressions at the individual level. One could then differentiate between gun owners who kept their guns locked versus those that did not, and between non-owners who had friends or neighbors with access to a gun and those that did not. Absent this type of detailed data, I am unable to do this.

rows utilize age-specific suicide rates as the dependent variables.[27] In virtually every case, the coefficient estimates are quite similar in magnitude. The estimates for the Log(*G&A*) coefficients are generally higher than the corresponding ones for Log(FS/S) for younger age groups, while the reverse is true for the older age groups. Perhaps surprisingly, both measures suggest that the relationship between rates of gun ownership and the frequency of suicide is strongest for teenagers.

The next set of regressions presented in Table 7 divides suicides into those committed with a gun and ones in which an alternative method was used. If gun ownership was not related to suicidal tendencies and affected suicides only through the instrumentality channel described above, then one would expect to observe a positive relationship between gun ownership and gun suicides and a negative one between gun ownership and the non-gun suicide rate. The first row of results suggest that instrumentality alone cannot explain the positive relationship between the suicide rate and gun ownership, as non-gun suicide rates are not significantly lower in places with more firearms. In fact, for younger individuals the non-gun suicide rate is found to be somewhat higher in states with greater gun ownership. One possible, but by no means the only, explanation for this relationship is that some teenagers may choose to imitate their peers. Thus gun availability could directly affect the suicide propensity of individuals with access to a gun and indirectly affect the probability for other individuals with no such access through a "contagion effect". The results for the three oldest age groups are consistent with the hypothesis

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[26] These regressions utilize data from 1996, the most recent year in which individual-level death data are available from the National Center for Health Statistics.

[27] I am unable to get age-specific magazine sales rates and must therefore use the overall state sales rate. If, as seems likely, the sales rate does vary systematically by age group, then the coefficient estimates will provide a biased estimate of the relationship between gun availability for a particular age group and the suicide rate. The estimates obtained from using both state-level aggregate and age-specific Log(FS/S) measures are quite similar, suggesting that the absence of state-level, age-specific sales rates is not too problematic.

that gun availability may lead to fewer non-gun suicides, but overall suicide rates are not more strongly related to gun ownership for this group than for the younger age categories.

This first set of results suggests that the fraction of individuals with suicidal tendencies is larger in states with more gun ownership, as the relationship between the overall suicide rate and gun availability cannot simply be explained by substitution from non-gun to gun suicide attempts. The fact that all of the coefficient estimates in the Log(GunSuicideRate) specifications are greater than one provides further support for this hypothesis. The intuition for this is straightforward and can be seen from the following equation that describes the average number of gun suicides within state j:

$$(9)\ \frac{Gun\,Suicides_j}{Population_j} = \left(\frac{Gun\ Owners_j}{Population_j}\right) * \omega_j * P_{j,gun}$$

with ω_j equaling the fraction of the state's gun owners who try to commit suicide with a gun and $P_{j,gun}$ set equal to the probability that the attempt results in the individual's death. If ω_j and $P_{j,gun}$ were common across states, then one would expect to find a coefficient closer to 1.00 in the gun suicide regressions in Table 7.[28] The fact that it is substantially greater suggests that ω_j is higher in places with more gun ownership. Thus, both those who own and those who do not own a gun in states with high rates of firearms ownership appear to be more likely than their counterparts in low ownership states to take their own lives.

While this set of results suggests that part of the relationship between gun ownership and the suicide rate is induced by cross-state differences in the propensity to commit suicide, it does

[28] The coefficient estimate of 1.439 in the middle column of Table 7 indicates that a 10% increase in the rate of gun ownership is associated with approximately a 14.4% increase in the gun suicide rate. It therefore appears that gun owners in a state with a 22% rate of ownership would be 4% (equals (1.144 / .22) / (1.000 / .20)) more likely than their counterparts in a state with a 20% rate to commit suicide.

not demonstrate whether instrumentality also partially explains it. One way to probe the likely importance of this effect is to exploit differences between men and women in the probability of using a gun in a suicide attempt. Women are significantly less likely than men to commit suicide and to use a gun when committing suicide. This latter difference is partially driven by the higher rates of gun ownership among men, though many women who do not themselves own a gun may still have access to one if other individuals in their households do.

The number of suicides that occur is the product of the number of attempts and the average success probability. This average probability can be expressed as depending on the fraction of households with one or more guns (Gun_j), the likelihood that a person with access to a gun uses it when trying to commit suicide (δ), the success probability for guns (P_g), and the success probability for the alternative method (P_d) as follows:

$$(10)\ P = Gun_j * \left(\delta P_g + (1-\delta) P_d\right) + (1 - Gun_j) * P_d$$

If $P_g > P_d$ and if $\delta_f < \delta_m$ (women with access to a gun are less likely to use it if they attempt suicide), then this average success probability should increase more rapidly for men than for women in areas with relatively many guns.[29]

Using this framework, one can now test empirically for instrumentality effects by examining whether the ratio of the male to the female suicide rate is systematically related to the rate of gun ownership. If suicidal impulses are persistent (i.e. a person who attempts today but does not succeed will continue trying) and if the number of females with suicidal tendencies is

[29] In other words, if attempts with a gun are more likely to result in the individual's death, then $d(P_M / P_F) / dGun > 0$. This assumes that the number of attempts is not affected by the availability of a gun, that women are less likely to use a gun when committing suicide (either because they are less inclined to use a gun when one is available or because they have less access to firearms), and that the ratio of male to female suicide attempts in a state is not systematically related to the state-level rate of gun ownership.

proportional to the number of males with suicidal tendencies, then one should detect no systematic relationship between the rate of gun ownership and the male/female suicide ratio.

The set of regressions summarized in Table 8 suggest that there is a positive relationship between the rate of gun ownership and the male/female suicide ratio. The coefficient estimates in the first two columns of the first row reveal that suicide rates among males are more strongly related to the rate of gun ownership than are suicide rates among females. Specifically, a ten percent increase in gun ownership is associated with a 7.9% increase in the male suicide rate but only a 5.2% increase in the female suicide rate.[30] This difference is statistically significant, as the coefficient estimate of 0.272 in the third specification shows. In every age category, the male suicide rate is more strongly related to the rate of gun ownership than is the female suicide rate, with an especially large difference for the youngest and oldest age groups. Thus while one can tell alternative stories to explain this pattern,[31] this set of results is consistent with the hypothesis that instrumentality effects partially explain the high rates of suicide in states with relatively many gun owners.

Taken together, the results presented in this section suggest that much of the observed relationship between rates of suicide and gun ownership at the state level is driven by differences in suicidal tendencies that are themselves correlated with gun ownership. The difference in the relationship for men and women suggests that instrumentality may also play a role, though one cannot rule out other plausible stories that could also explain this relationship. The empirical analysis in the next section investigates whether within state changes in gun ownership during

[30] See Lester and Murrell (1980) for a study that examines whether the effect of gun control laws on suicide rates differs by gender.

[31] For example, if the ratio of men to women with suicidal tendencies is higher in places with more gun ownership then one would, all else equal, observe a positive relationship even in the absence of an instrumentality effect.

the last two decades partially explain changes in the suicide rate that have occurred during this time period.

Do Changes in Gun Ownership Partially Explain Changes in the Suicide Rate?

During the last decade, the U.S. suicide rate has fallen substantially, from a peak of 12.9 per 100,000 in 1986 to just 11.3 per 100,000 in 1998. This decline has coincided with a downward trend in the rate of gun ownership. In this section, I investigate whether these two series appear to be related by estimating specifications of the following type:

$$(11)\ \Delta SuicideRate_{jt} = \alpha_1 + \beta_1 * \Delta GunOwnershipRate_{jt} + \mu_{1t} + \rho_{1j} + \varepsilon_{1jt}$$

$$(12)\ \Delta GunSuicideRate_{jt} = \alpha_2 + \beta_2 * \Delta GunOwnershipRate_{jt} + \mu_{2t} + \rho_{2j} + \varepsilon_{2jt}$$

$$(13)\ \Delta NonGunSuicideRate_{jt} = \alpha_3 + \beta_3 * \Delta GunOwnershipRate_{jt} + \mu_{3t} + \rho_{3j} + \varepsilon_{3jt}$$

There are two important limitations to this approach. First, even if one finds a significant estimate for the parameter β_1, it is possible that the very factors leading some individuals to purchase firearms are also causing them to commit more suicides, and thus β_1, β_2, and β_3 would not represent causal effects of gun ownership on suicide. Second, even if firearms do lead to more suicides than would otherwise occur, if state-level rates of gun ownership are quite stable then one may fail to detect a relationship because the variation in measured gun ownership would be driven primarily by measurement error. While the former effect would be lead to an upward bias in the estimate for β_1, the latter one would be likely to induce a downward one.[32]

Despite these limitations, this approach can provide some insight into the role (if any) that gun availability plays in determining the suicide rate by answering the question – did suicide

[32] This specification only examines the relationship between current changes in gun ownership and current changes in the suicide rate. I estimated a similar set of specifications that included once and/or twice lagged changes in gun ownership. The findings from those

tend to decline more in the places with the largest declines in gun ownership? The set of results presented in Table 9 summarize specifications similar to (11), (12), and (13) above, and reveal that changes in the suicide rate are not significantly related to changes in estimated gun ownership. The estimate of .033 for β_1 in the first column suggests that a 10% increase in gun ownership is, on average, associated with just a 0.3% rise in the suicide rate. This variable is not precisely estimated, though, so one cannot reject the hypothesis that there is no relationship between changes in gun ownership and the suicide rate.[33] The estimates for β_2 in the third and fourth specifications are somewhat larger than the corresponding ones for β_3 in the last two columns of this table, though the difference is not statistically significant. This is consistent with the findings presented above, which suggested that increases in gun ownership are associated with increases in the fraction of suicides in which a gun is used.[34]

It is worth comparing these estimates to the corresponding ones obtained using the alternative proxy variable Log(FS/S). As was mentioned above, random fluctuations in the number of gun and non-gun suicides will lead to a mechanical relationship between estimated gun ownership and each of the three suicide rates. This problem is likely to be especially severe if rates of gun ownership are quite stable within states over time, with the magnitude of the bias depending on the extent of random variation in both gun and non-gun suicides. If, conditional on a particular rate of gun ownership, non-gun suicides are much more variable than gun suicides,

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regressions are similar to the ones reported here – past changes in gun ownership are not significantly related to current changes in the gun, non-gun, or overall suicide rate.

[33] It is worth noting that the magnitude of the estimate for β_1 is just one-seventh as large as the estimate for the analogous parameter in the homicide rate specification found in Duggan (2001). Given that the Table 5 estimates suggest that a 10% increase in magazine sales is associated with just a 3.5% rise in gun ownership, a more accurate point estimate of the relationship between gun ownership and the suicide rate is closer to 0.1 (= .033 / .35).

then one would observe a negative relationship between overall suicide rates and estimated gun ownership, as high realizations of non-gun suicides would tend to be associated both with high rates of suicide and relatively low rates of gun ownership. The opposite would be true if instead gun suicides were more variable.

The set of results summarized in Table 10 suggest that this proxy may not be the appropriate one for estimating the relationship between changes in gun ownership and changes in the suicide rate. Of particular concern is the precision of the estimates for β_2 and β_3, which have t-statistics of 26.5 and -22.4, respectively, in specifications three and five. This precision suggests that the mechanical relationship implied in a first-differences version of equations (10) and (11) is dominating the estimation. The estimate of -.128 for β_1 suggests that changes in gun ownership are associated with significant *reductions* in the suicide rate.

One explanation for this is that non-gun suicides may be more variable than gun suicides because the success probability with a gun is closer to one. Thus the total number of gun suicides would have a lower variance than the number of non-gun suicides because both are a function of P * (1-P), which will be closer to zero as P rises above 50% and toward 100%. An alternative one is that gun ownership causes individuals to become less suicide prone. The fact that the measurement error effect appears to be so important in this set of regressions suggests that the previous proxy is preferable for this application, as the measurement error in that variable does not cause a mechanical relationship.

Taken together, the set of results presented in this section suggest that changes in gun ownership have not been a central factor in explaining the observed changes in the suicide rate

[34] The analogous state fixed effect (rather than first difference) regressions – either with or without state-specific time trends – also indicate that the state-level gun suicide rate is more strongly related to the rate of gun ownership than is the non-gun suicide rate.

during the last two decades. But one must stop short of the statement that firearms do not exert a causal effect, as the estimation is limited by the actual changes that have occurred. If gun purchase decisions by suicide-prone individuals are not changing substantially within states over time, then this estimation strategy will not reliably estimate the change in the probability of suicide induced by the acquisition of a firearm.

6. Conclusion

Individuals who own a gun are more likely to commit suicide than are other individuals. The results presented in this paper demonstrate that much of the relationship between state-level gun ownership and suicide rates appears to be driven by a positive correlation between suicidal tendencies and gun ownership. The finding that the male-female suicide ratio is significantly greater in places with more gun ownership suggests that instrumentality effects may also partially explain this relationship, though one cannot rule out the hypothesis that gender-specific suicidal tendencies vary with the availability of guns. Finally, it appears that reductions in gun ownership have not been the driving force behind the fall in the suicide rate.

The ideal approach to estimating the causal effect of gun ownership on the suicide rate would be an experiment that randomly allocated gun ownership to households, giving firearms to those in a treatment group and then preventing those in the control group from obtaining access to guns. But because fewer than 12 in 100,000 individuals take their own lives in a year, the number of guns that would need to be randomly allocated to obtain a precise estimate of the causal effect would number in the millions.

A second-best approach to the problem would exploit a regulatory change that induced a substantial change in gun ownership and then identified the groups whose purchase decisions were affected by the policy. While some previous studies have utilized this “natural experiment”

strategy, few have identified the group whose gun ownership decisions were impacted. The existence of individual-level gun purchase and registration data in particular states would permit a detailed analysis of the effects of recent policies. Combining this information with comparably detailed information about suicide victims, one could estimate the "treatment effect" of gun ownership for the marginal owner whose behavior is most likely to change in response to government policies. This represents an important direction for future research.

Appendix:

Suppose that the mean number of suicides in jurisdiction j for its current level of gun ownership is equal to S_j but that the realized value fluctuates around this value according to $s_j = S_j + \varepsilon_{sj}$.[35] The corresponding realizations for gun and non-gun suicides are g_j and n_j, respectively, and the fraction of individuals who own a gun is assumed to be equal to $G_j/(G_j+N_j)$. As the following pair of equations demonstrates, even if the rate of gun ownership does not vary across areas and thus all jurisdictions have the identical values for G_j and N_j, one will observe a significant relationship between gun ownership and each of the two types of suicide:

$$(A1)\ Log\left(\frac{G_j+\varepsilon_{gj}}{Pop_j}\right)=\alpha_1+\beta_1*Log\left(\frac{G_j+\varepsilon_{gj}}{G_j+\varepsilon_{gj}+N_j+\varepsilon_{nj}}\right)$$

$$(A2)\ Log\left(\frac{N_j+\varepsilon_{nj}}{Pop_j}\right)=\alpha_2+\beta_2*Log\left(\frac{G_j+\varepsilon_{gj}}{G_j+\varepsilon_{gj}+N_j+\varepsilon_{nj}}\right)$$

Above average realizations of ε_{gj} will lead to an increase in both the left and right-hand side variables in (A1), while similar variation in ε_{nj} will cause a negative relationship between the two variables of interest in (A2). Even without any variation in gun ownership or in the true suicide rates G_j and N_j across geographic areas, one would find a positive relationship between gun ownership and gun suicide rates, and a negative relationship of gun ownership with non-gun suicides. The magnitude of the coefficient estimates for β_1 and β_2 would then depend on the

[35] This variation could simply be driven by random fluctuations in the number of individuals who try to commit suicide and in the uncertain "success" of each suicide attempt. Suppose that there are N individuals in a jurisdiction, a fraction θ of whom own a gun. If the probability that a gun owner will try to commit suicide is λ_{gun} and the corresponding probability for a non-gun owner is λ_{non}, then the total number of suicides will equal $\theta N\lambda_{gun}P_{gun} + (1-\theta)N\lambda_{non}P_{non}$, with P_{gun} and P_{non} equaling the probability that a suicide attempt of each type results in the individual's death. Even for a constant θ, the number of suicides that occur in each period will vary depending on how many individuals in each group try to commit suicide and the frequency with which these attempts result in the individual's death.

variance of ε_{gj} and ε_{nj}, as well as the covariance between these two error terms. This would also affect the estimate for β_3 in the following specification that explains the overall suicide rate:

$$(A3)\ Log\left(\frac{G_j+\varepsilon_{gj}+N_j+\varepsilon_{nj}}{Pop_j}\right)=\alpha_3+\beta_3*Log\left(\frac{G_j+\varepsilon_{gj}}{G_j+\varepsilon_{gj}+N_j+\varepsilon_{nj}}\right)$$

If, for example, the variance of ε_{gj} were much greater than the corresponding one for ε_{nj}, one would find a positive relationship between the overall suicide rate and the estimated rate of gun ownership even in the absence of any variation in the true rate of gun ownership across areas.

Of course, actual rates of gun ownership do vary substantially across geographic areas. If the measurement error caused by random fluctuations in ε_{gj} and ε_{nj} is much smaller in magnitude than the variation in G_j and N_j, then the results from cross-sectional regressions similar to equations (9), (10), and (11) will provide more accurate estimates of the relationship between gun ownership (estimated by the fraction of suicides in which a gun was used) and the suicide rate. Thus one can investigate whether suicide rates are systematically different in places with more gun ownership using the gun suicide fraction as a proxy, recognizing that the mechanical relationship described above may lead to biased estimates of the parameters of interest.

It seems plausible, however, that within-area variation in gun ownership will be much smaller than this variation across geographic areas. As Azrael, Cook, and Miller (2001) point out, "the geographic structure of gun ownership has been highly stable." Thus even if the fraction of suicides in which a gun is used is an excellent proxy for the rate of gun ownership, the measurement error effect described above is likely to be important in a regression that investigates the relationship between changes in suicide rates and changes in gun ownership, as estimated by the fraction of suicides in which a gun is used.

References

Azrael, Deborah, Philip Cook, and Matthew Miller, "State and Local Prevelance of Firearms Ownership Measurement, Structure, and Trends," NBER Working Paper 8570.

Boor, M., "Methods of Suicide and Implications for Suicide Prevention," *Journal of Clinical Psychology* 37: 70-75.

Brent, David A., Joshua A. Perper, Charles E. Goldstein, David J. Kolko, Marjorie J. Allan, Christopher J. Allman, and Janice P. Zelenak, "Risk Factors for Adolescent Suicide," *Archives of General Psychiatry* 45:581-588.

Card, J.J., "Lethality of Suicide Methods and Suicide Risk: Two Distinct Concepts," *Omega* 5: 37-45.

Clarke, Ronald, and David Lester, *Suicide: Closing the Exits*, Springer-Verlag, New York, 1989.

Cook, Philip, Mark Moore, and Anthony Braga, "Gun Control," in *Crime*, edited by James Q. Wilson and Joan Peterselia.

Cook, Philip, "The Technology of Personal Violence," *Crime and Justice*, 1991, edited by Michael Tonry.

Cook, Philip, "Robbery Violence," *Journal of Criminal Law and Criminology*, 1987, 78: 357-376.

Cutler David, Edward Glaeser, and Karen Norberg, "Explaining the Rise in Youth Suicide," NBER Working Paper 7713, 2000.

Duggan, Mark, "More Guns, More Crime," *Journal of Political Economy*, 2000, 109: 1086-1114.

Farmer, R. and J. Rohde, "Effect of Availability and Acceptability of Lethal Instruments on Suicide Mortality: An Analysis of Some International Data," 1980, 62: 436-446.

Kates, Donald B., *Guns, Murder, and the Constitution: A Realistic Assessment of Gun Control*, Pacific Research Institute, San Francisco, 1990.

Kellermann, Arthur, Frederick Rivara, Grant Somes, Donald Reay, Jerry Francisco, Joyce Gillentine Banton, Janice Prodzinski, Corinne Fligner, Bela Hackman, "Suicide in the Home in Relation to Gun Ownership," *New England Journal of Medicine*, 1992, 327: 467-472.

Lester, David and Mary Murrell, "The Influence of Gun Control Laws on Suicidal Behavior," *American Journal of Psychiatry*, 137, 1980, 121-122.

Loftin, Colin, David McDowall, Brian Wiersema, and Talbert Cottey, "Effects of Restrictive Licensing of Handguns on Homicide and Suicide in the District of Columbia," *New England Journal of Medicine*, 1991, 325: 1615-1620.

Ludwig, Jens and Philip Cook "Homicide and Suicide Rates Associated With Implementation of the Brady Handgun Violence Prevention Act," *Journal of the American Medical Association*, 284, 2000: 585-591.

Newton, Greg and Franklin Zimring, *Firearms and Violence in American Life*, U.S. Government Printing Office, Washington, D.C. 1969.

Rich, Charles, James Young, Richard Fowler, John Wagner, and Nancy Black, "Guns and Suicide: Possible Effects of Some Specific Legislation," *American Journal of Psychiatry*, 1990, 147: 342-346.

Sloan, John, Frederick Rivara, Donald Reay, James Ferris, M. Path, and Arthur Kellerman, "Firearm Regulations and Rates of Suicide: A Comparison of Two Metropolitan Areas," *New England Journal of Medicine*, 1990, 322: 369-373.

Stevenson, Betsey, and Justin Wolfers, "'Til Death Do Us Part: Effects of Unilateral Divorce on Suicide, Domestic Violence, and Intimate Homicide," Stanford University mimeo, 2001.

Wintemute, Garen, Carrie Parham, James Beaumont, Mona Wright, and Christiana Drake, "Mortality Among Recent Purchasers of Handguns," *New England Journal of Medicine* 1999, 341: 1583-1589.

Zimring, Franklin E., "Is Gun Control Likely to Reduce Violent Killings?" *University of Chicago Law Review* 35: 721-737.

Zimring, Franklin E., "The Medium is the Message: Firearm Calibre as a Determinant of Death from Assault," *Journal of Legal Studies* 1: 97-124.

Figure 1: U.S. Suicide Rate from 1980-1999

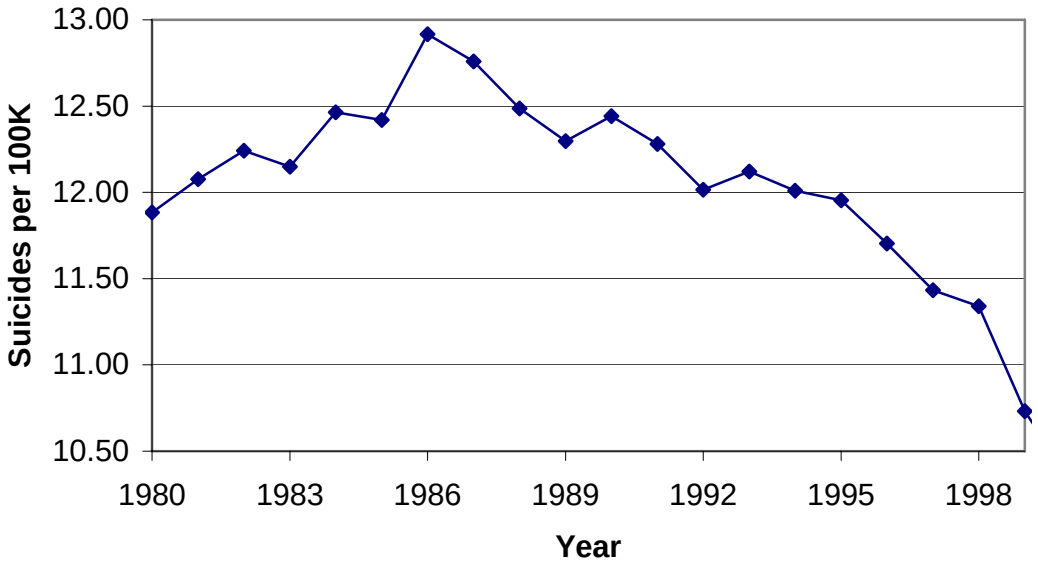
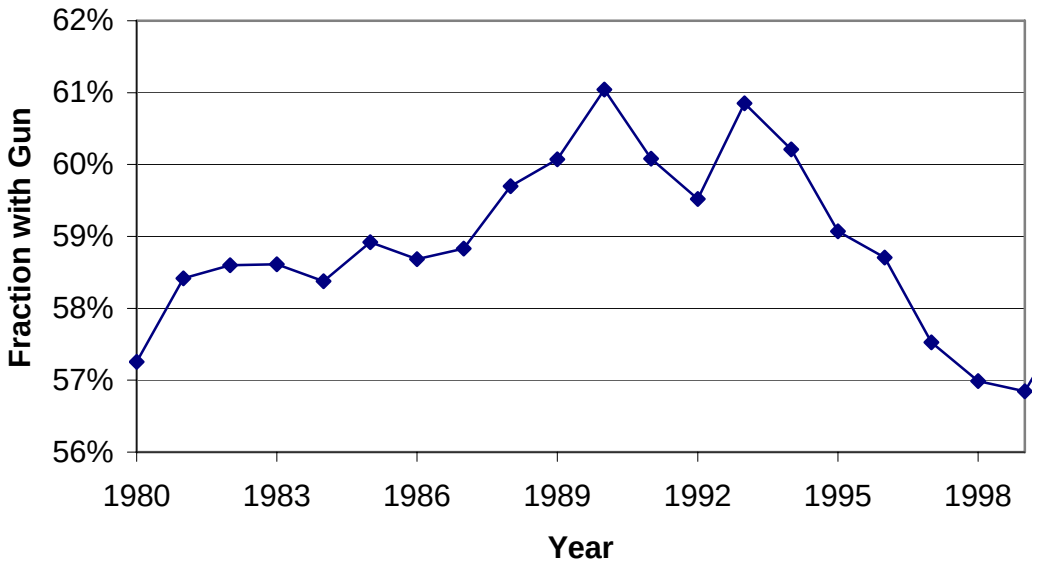


Figure 2: % of Suicides in Which Gun Was Used



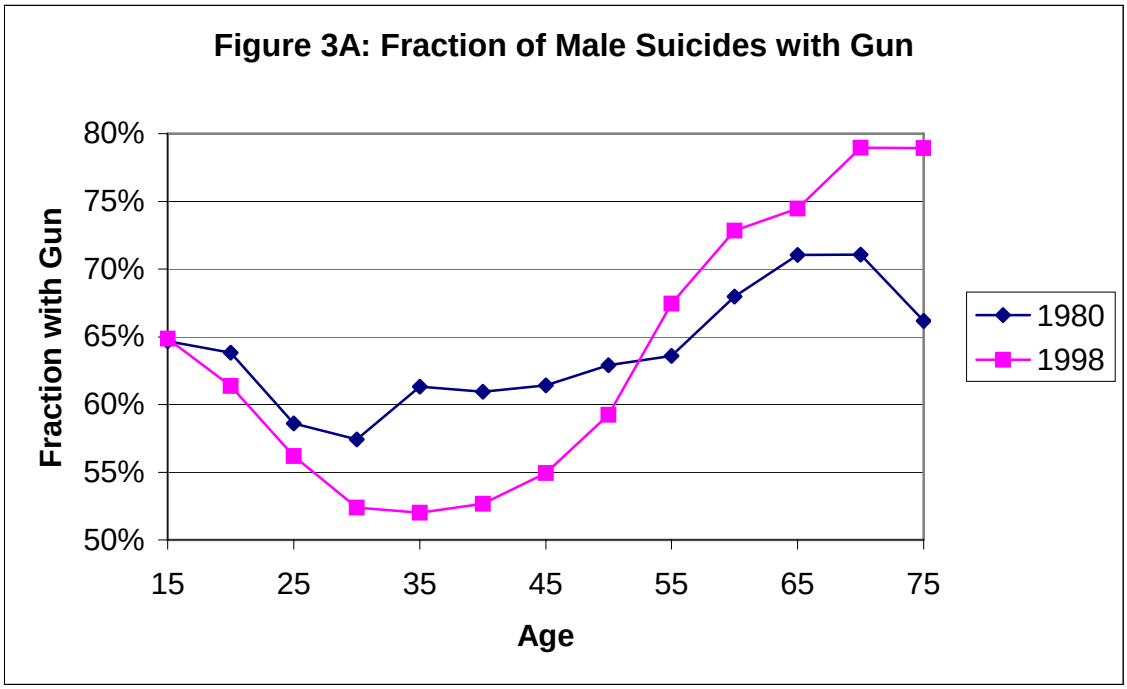


Figure 3A: Fraction of Male Suicides with Gun
80%
75%
70%
65%
60%
55%
50%
Fraction with Gun
15
25
35
45
55
65
75
Age
1980
1998

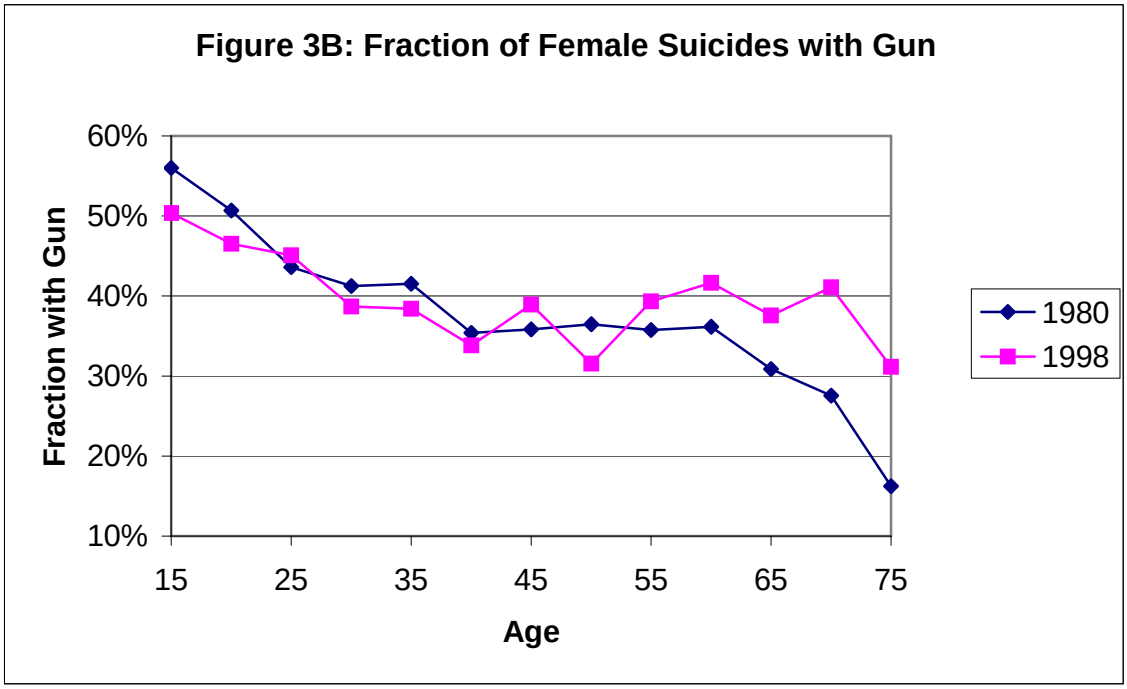


Figure 3B: Fraction of Female Suicides with Gun
60%
50%
40%
30%
20%
10%
Fraction with Gun
15
25
35
45
55
65
75
Age
1980
1998

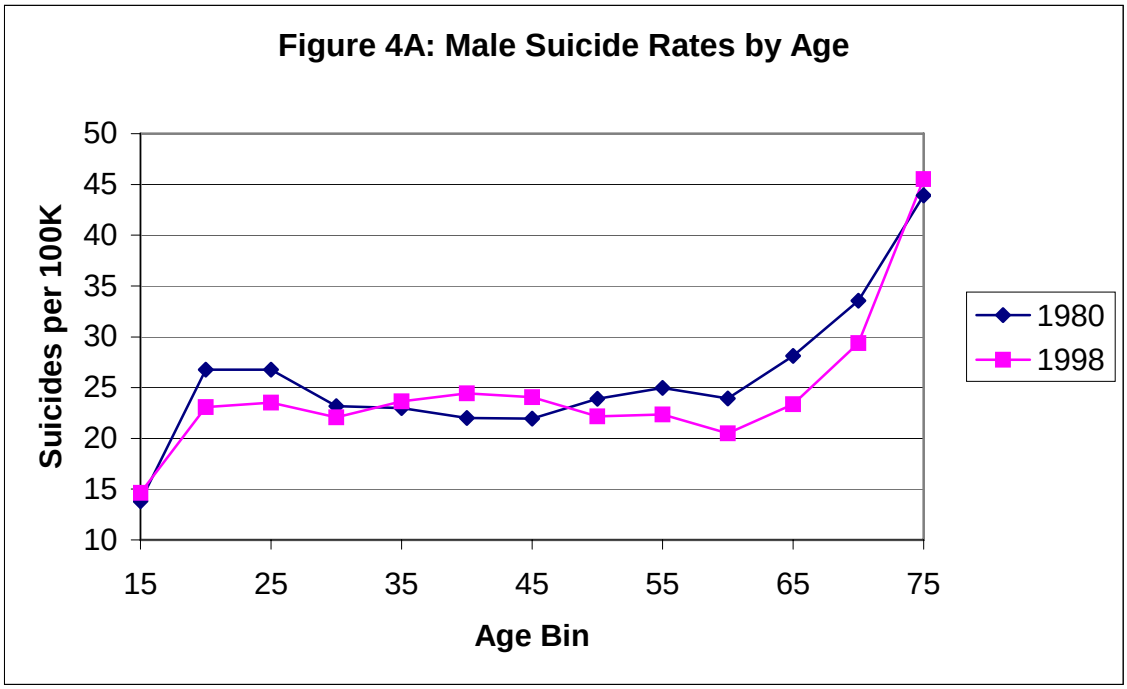


Figure 4A: Male Suicide Rates by Age
Suicides per 100K
50
45
40
35
30
25
20
15
10
15
25
35
45
55
65
75
Age Bin
1980
1998

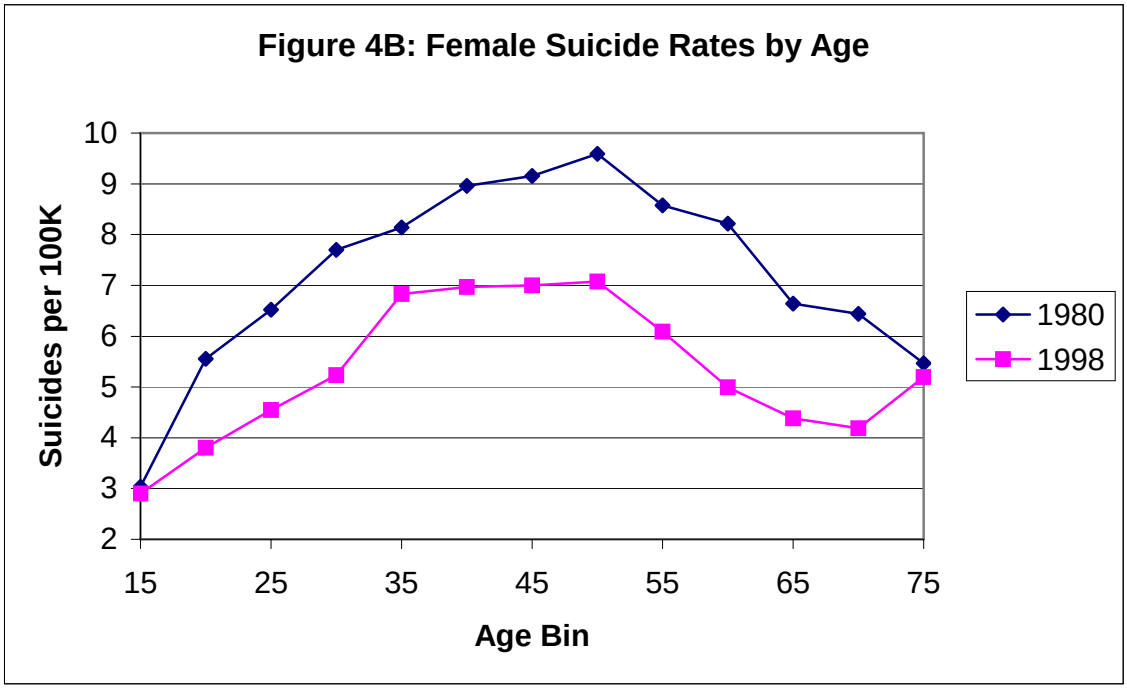


Figure 4B: Female Suicide Rates by Age
Suicides per 100K
10
9
8
7
6
5
4
3
2
15
25
35
45
55
65
75
Age Bin
1980
1998

Table 1: Suicide Rates by Gender and Age in 1998

Age Group	All	Males	Females	Male/Fem ratio
All Ages	11.3	18.6	4.4	4.3
10-14	1.7	2.4	0.9	2.7
15-19	8.9	14.6	2.9	5.1
20-24	13.6	23.1	3.8	6.1
25-29	14.0	23.5	4.6	5.2
30-34	13.6	22.1	5.2	4.2
35-39	15.2	23.7	6.8	3.5
40-44	15.6	24.4	7.0	3.5
45-49	15.4	24.1	7.0	3.4
50-54	14.4	22.2	7.1	3.1
55-59	13.9	22.4	6.1	3.7
60-64	12.3	20.5	5.0	4.1
65-69	13.1	23.4	4.4	5.3
70-74	15.2	29.4	4.2	7.0
75 +	20.2	45.5	5.2	8.8

Suicide data are obtained from the National Center for Health Statistics and population data from the Census Bureau. Numbers in the table represent suicide rates per 100,000 in 1998.

Table 2: Changes in Male and Female Age-Specific Suicide Rates from 1980 to 1998

	Male Suicide Rate			Female Suicide Rate		
	1980	1998	% Change	1980	1998	% Change
All Ages	18.7	18.6	-0%	5.5	4.4	-20%
10-14	1.2	2.4	+96%	0.3	0.9	+204%
15-19	13.8	14.6	+6%	3.0	2.9	-4%
20-24	26.8	23.1	-14%	5.6	3.8	-32%
25-29	26.8	23.5	-12%	6.5	4.6	-30%
30-34	23.2	22.1	-5%	7.7	5.2	-32%
35-39	23.0	23.7	+3%	8.1	6.8	-16%
40-44	22.0	24.4	+11%	9.0	7.0	-22%
45-49	21.9	24.1	+10%	9.2	7.0	-24%
50-54	23.9	22.2	-7%	9.6	7.1	-26%
55-59	25.0	22.4	-10%	8.6	6.1	-29%
60-64	24.0	20.5	-14%	8.2	5.0	-39%
65-69	28.1	23.4	-17%	6.6	4.4	-34%
70-74	33.5	29.4	-12%	6.4	4.2	-35%
75 +	43.9	45.5	+4%	5.5	5.2	-5%

Suicide data are obtained from the National Center for Health Statistics and population data from the Census Bureau. Numbers in the table represent suicide rates per 100,000 in 1980 and 1998.

Table 3: Cause of Death Among 1998 Suicide Victims

Method of Suicide	Male %	Female %
Firearm	61.6%	38.4%
Drug, Medicaments, and Biologicals	6.4%	26.1%
Hanging, Strangulation, and Suffocation	19.2%	16.8%
Gases and Vapors	5.4%	6.7%
All other	7.5%	12.0%
Total # of Suicides in 1998	24,538	6,037

Cause of death data is obtained from the NCHS website at http://www.cdc.gov/nchs/

Table 4: Fraction of Suicides by Firearm by Gender and Age in 1980 and 1998

	Males		Females	
	1980	1998	1980	1998
All Ages	63.0%	61.6%	38.6%	38.4%
10-14	53.1%	50.0%	69.2%	43.4%
15-19	64.7%	64.9%	56.0%	50.4%
20-24	63.8%	61.4%	50.7%	46.5%
25-29	58.6%	56.2%	43.6%	45.1%
30-34	57.4%	52.4%	41.2%	38.7%
35-39	61.3%	52.0%	41.5%	38.4%
40-44	60.9%	52.7%	35.4%	33.9%
45-49	61.4%	54.9%	35.8%	38.9%
50-54	62.9%	59.2%	36.5%	31.6%
55-59	63.6%	67.5%	35.7%	39.3%
60-64	68.0%	72.8%	36.2%	41.6%
65-69	71.0%	74.5%	30.9%	37.6%
70-74	71.1%	79.0%	27.6%	41.1%
75 +	66.2%	78.9%	16.2%	31.2%

Figures represent the fraction of suicides in which a firearm is used (ICD9 codes 9550-9554).

Table 5: Gun Magazine Sales and % Suicides w/Gun as Proxies for Gun Ownership

	Log (FS/S)		Log (GSS Ownership)			
	(1)	(2)	(3)	(4)	(5)	(6)
Log (*G&A*)	.632***	.101***	.975***		.354***	
	(.127)	(.018)	(.188)		(.114)	
Log (FS/S)				1.299***		.472***
				(.155)		(.239)
R-squared	.337	.959	.384	.748	.712	.708
# Observations	51	969	45	45	488	488

The dependent variable in the first two specifications is equal to the log of the fraction of suicides that are committed with a gun, while the variable in specifications (3) through (6) is equal to the log of the fraction of GSS respondents who own a gun. Survey data from 1980-1998 are used, with average state data over this period used in (3) and (4) and annual state data in specifications (5) and (6). Log(G&A) is equal to the log of the magazine sales rate. Regressions are weighted by state population in (1) and (2) and by number of survey respondents in (5) and (6). Robust standard errors are in parentheses.

Table 6: The Relationship Between Gun Ownership and Suicide

	Gun Ownership Measure	
	Log (*G&A*)	Log (FS/S)
All Ages	.747	.690
	(.101)	(.104)
Ages 10-19	1.143	1.036
	(.132)	(.174)
Ages 20-29	.842	.688
	(.096)	(.124)
Ages 30-39	.755	.622
	(.084)	(.107)
Ages 40-49	.731	.732
	(.141)	(.125)
Ages 50-59	.591	.619
	(.151)	(.131)
Ages 60-69	.651	.730
	(.136)	(.110)
Ages 70-79	.715	.818
	(.185)	(.131)

Dependent variable in the first row is equal to the log of the state suicide rate in 1996, the most recent year for which individual-level NCHS mortality data are available. Dependent variables in each subsequent row are equal to the age-specific suicide rate in the state. The first column of coefficient estimates utilize Log(G&A) as the explanatory variable, while those in the second column use Log(FS/S). Cell entries correspond to the estimates for each of these variables in specifications analogous to (13). Regressions are weighted by state population in the first row and by the number of state residents in the age group in the subsequent rows. Robust standard errors are included in parentheses.

Table 7: The Relationship Between Gun Ownership and Gun versus Non-Gun Suicides

	Log(SuicRate)	Log(GunSuicRate)	Log(NonSuicRate)
All Ages	.747 (.101)	1.439 (.207)	.044 (.105)
Ages 10-19	1.143 (.132)	1.598 (.234)	.673 (.174)
Ages 20-29	.842 (.096)	1.471 (.169)	.182 (.119)
Ages 30-39	.755 (.084)	1.595 (.174)	.122 (.133)
Ages 40-49	.731 (.141)	1.410 (.242)	.151 (.144)
Ages 50-59	.591 (.151)	1.294 (.244)	-.197 (.128)
Ages 60-69	.651 (.136)	1.231 (.253)	-.326 (.191)
Ages 70-79	.715 (.185)	1.516 (.365)	-.593 (.205)

Dependent variables in each column are the state-level suicide rate, gun suicide rate, and non-gun suicide rate in 1996. The first row is the overall state rate while the subsequent rows use age-specific suicide rates. The entries in each cell represent the coefficient estimate for the Log(G&A) variable in specifications analogous to (13). Regressions are weighted by state population in the first row and by the number of state residents in the age group in the subsequent rows. Robust standard errors are included in parentheses.

Table 8: The Relationship of Gun Ownership with Gender-Specific Suicide Rates

	Log(MaleSuicRate)	Log(FemaleSuicRate)	Log(M/F Ratio)
All Ages	.785 (.098)	.515 (.131)	.272 (.077)
Ages 10-19	1.206 (.160)	.910 (.152)	.300 (.240)
Ages 20-29	.905 (.106)	.459 (.173)	.439 (.182)
Ages 30-39	.759 (.085)	.660 (.111)	.100 (.081)
Ages 40-49	.737 (.131)	.562 (.210)	.188 (.142)
Ages 50-59	.583 (.133)	.508 (.248)	.082 (.161)
Ages 60-69	.647 (.168)	.480 (.188)	.170 (.237)
Ages 70-79	.822 (.178)	-.143 (.214)	.980 (.138)

Dependent variables in each column are the male suicide rate, the female suicide rate, and the ratio of the male to the female suicide rate in 1996. The first row contains data for all state residents while the subsequent ones use age-specific suicide rates. The entries in each cell represent the coefficient estimate for the Log(G&A) variable in specifications analogous to (13). Regressions in the first row are weighted by the state's gender-specific population in the first two columns and by the total population in the third column. The corresponding age-specific weights are used in the subsequent rows. Robust standard errors are included in parentheses.

Table 9: The Relationship Between Changes in Gun Ownership and Suicide: Proxy #1

	Δ Log(Suicide)		Δ Log(GunSuicide)		Δ Log(NonGunSuic)	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log(*G&A*)	.033 (.048)	.004 (.051)	.072 (.060)	.046 (.064)	.007 (.077)	-.029 (.081)
Year Effects?	Yes	Yes	Yes	Yes	Yes	Yes
County Effects?	No	Yes	No	Yes	No	Yes
# Observations	918	918	918	918	918	918
R-squared	.063	.078	.076	.085	.038	.054

The dependent variable in each specification is equal to the change in the log of the state-level suicide rate (total in (1) and (2), gun in (3) and (4), all other in (5) and (6)). The explanatory variable is equal to the change in the log of the gun magazine sales rate. The number of observations is 918 in all regressions. Each specification includes year fixed effects, and (2), (4), and (6) have state-specific effects. Specifications are weighted by the state's population share in each year and robust standard errors are in parentheses.

Table 10: The Relationship Between Changes in Gun Ownership and Suicide: Proxy #2

	Δ Log(Suicide)		Δ Log(GunSuicide)		Δ Log(NonGunSuic)	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log(FS/S)	-.128 (.038)	-.125 (.039)	.872 (.038)	.875 (.039)	-1.218 (.046)	-1.215 (.047)
Year Effects?	Yes	Yes	Yes	Yes	Yes	Yes
County Effects?	No	Yes	No	Yes	No	Yes
# Observations	918	918	918	918	918	918
R-squared	.075	.089	.415	.423	.463	.472

The dependent variable in each specification is equal to the change in the log of the state-level suicide rate (total in (1) and (2), gun in (3) and (4), all other in (5) and (6)). The explanatory variable is equal to the change in the log of the gun suicide fraction. The number of observations is 918 in all regressions. Each specification includes year fixed effects, and (2), (4), and (6) have state-specific effects. Specifications are weighted by the state's population share in each year and robust standard errors are in parentheses.