THE RELATIONSHIP BETWEEN THE GUN OWNERSHIP RATE AND THE CRIME RATE IN THE UNITED STATES

A Thesis
submitted to the Faculty of the
Graduate School of Arts and Sciences
of Georgetown University
in partial fulfillment of the requirements for the
degree of
Master of Public Policy
in Public Policy

By

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Washington, DC
April 12th, 2019
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ABSTRACT

Current research on the relationship between the US gun ownership rate and the crime rate reflects three different strands of opinions – a higher gun ownership rate will cause an increase in the crime rate, a higher gun ownership rate will cause a decrease in the crime rate, or there is no relationship between the gun ownership rate and the crime rate. To reduce this disagreement, my research develops a new fixed effects model to estimate the relationship between gun ownership rate and the crime rate using state level data. My results show that a higher gun ownership rate is related to a higher crime rate. Every 1 percentage point increase in gun ownership rate is associated with a 6.08 percentage point increase in the crime rate. This result suggests that state governments should implement gun policies to control criminal and illegal gun ownership.
ACKNOWLEDGEMENTS

I would like to thank my thesis advisor, Andrew Wise, for his comments and advice. I am deeply grateful of his help in the completion of my thesis. Without his encouragement and guidance, this thesis could not be in its present form.

I would also like to thank Jeff Mayer, for helping me with the framing and wording process of my thesis.

The research and writing of this thesis is dedicated to everyone who helped along the way.

Many thanks,

Shanlin Huang
INTRODUCTION

In recent years, according to ATF and FBI data, the gun ownership rate in the US has been increasing, while the crime rate keeps decreasing. However, most studies in this field show that a decrease in the gun ownership rate can lower the crime rate. My hypothesis is that a lower gun ownership rate should have a negative correlation with the crime rate. This effect can be successfully estimated using a new model that I developed and that takes the crime rate in each state as the dependent variable, and the gun ownership rate and other relevant factors as independent variables.

The paper proceeds as follows. Section 1 contains a literature review. Section 2 contains a theoretical framework outlining the general mathematical framework of my analysis. Section 3 discusses my data and descriptive statistics. Section 4 contains the empirical model detailing the model I use to examine my hypothesis. Section 5 describes my findings and analysis. Section 6 discusses limitations of this study. Finally, Section 7 contains the conclusion and Section 8 discusses my policy implications.
 CHAPTER I

BACKGROUND AND LITERATURE REVIEW

Background

As we know, a time-honored gun culture in the US means that many Americans value gun ownership very much. A Congressional Research Service (CRS) report shows that currently Americans own an estimated 310 million firearms—approximately 90 guns for every 100 people. However, with an increase in individuals’ demand for guns, many crimes that threaten public safety occurred. According to a 2010 study, compared to 22 other high-income nations, the U.S. gun-related murder rate is 25 times higher. Although it has half the population of the other 22 nations combined, the US has 82 percent of all gun deaths.

Since 1960s, a widespread “crime gun hypothesis” associated high crime rates with high gun ownership rates. In pursuit of lower crime rates, the gun ownership rate is subject to control at the federal level and the state level. A series of gun policies were implemented for the sake of controlling gun ownership rate and lowering the crime rate. The federal government has enacted 7 laws since 1791 and the most recent one is the Federal Assault Weapons Ban in 1994. The first federal legislation related to firearms was the Second Amendment to the United States Constitution, ratified in 1791. The fundamental gun policy of modern society is the 1986 Firearm Owners Protection Act, which is also

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known as the McClure-Volkmer Act. It changed some restrictions in the 1968 Act, allowing federally licensed gun dealers and individual unlicensed private sellers to sell at gun shows, while continuing to require licensed gun dealers to require background checks. The most recent Violent Crime Control and Law Enforcement Act of 1994 included the Federal Assault Weapons Ban, and was a response to public concern over mass shootings.

At state level, over 20,000 gun control policies have been passed to restrict gun ownership. Common subjects of state gun control laws are dealer regulations, buyer regulations, prohibitions for high risk gun possession, background checks, ammunition regulations, possession regulations, concealed carry permitting, assault weapon and large-capacity magazines restrictions, child access prevention, gun trafficking, “Stand your ground”, preemption, immunity and domestic violence.

However, the crime gun hypothesis was challenged by researchers using different data sources and models at different levels. Indeed, after years of discussion, the relationship between gun ownership and the crime rate is neither concrete nor explicit. Thus, in this paper I would like to study the relationship between gun ownership and crime rate using the most recent government dataset. While testing the predominant hypotheses mentioned above, I will also seek policy innovations to reduce the crime rate as well as to control gun ownership.

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Differences in study levels

The existing studies vary in the levels of geography studied due to different analysis standards and data availability. For international-level studies, Killias’s study chose to focus on an international perspective across 21 countries. Others may focus their studies on a specific country of interest. For example, Benjamin Taylor and Jing Li chose Australia as their country of interest and assessed the impact of that country’s 1996 National Firearms Agreement (NFA) on crimes in there. For researchers who chose the US as their research observation, their studies were at three levels: Bordua used the individual level using data for Illinois; Stolzenberg and D’alessio focused on the state level using data for each state; and Kleck focused on the national level using data for the US as a whole.¹ ² ³ ⁴

Differences in logic

Different thought processes in reflecting the cause and effect relationship between gun ownership and the crime rate can result in different framings of estimated models. A series of researchers focus on the effect of gun ownership on crime, while other researchers believe that crime has an effect on gun ownership in reverse.⁵ Though both of

these paths of logic are reasonable, I think the first path of logic is more suitable for a macro level analysis, while the second path of logic is more suitable for an individual level analysis. This causal problem was also addressed in the study of Hauser by using individual level data to show that the crime rate does not have a constant influence on gun ownership. In any case, Kleck concluded, “the hypothesis that crime rates affect gun ownership is more than a mere logical possibility – there is considerable empirical evidence to indicate that such an effect is a reality.”

**Differences in methods**

These studies use different methods to estimate the potential relationship. First, the data source varies in each study. Taylor’s study used government reports instead of household surveys, which were more precise and reliable; while Kleck used the data from surveys, which provided a direct, feasible measurement of variables like gun ownership. However, there is a double calculation problem imposed here for gun ownership when using data from household surveys, which is how to calculate the number of guns rented, guns bought, and guns stolen.

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Second, different studies have different dependent variables and independent variables. As an independent variable, gun ownership has been represented by different variables such as CCR (concealed carry permits rate), GLR (Gun owners license rate), GRR (Gun registrations rate), HGS (handgun sales), HLR (Hunting license rate), or NPP (Number of handgun purchase permits).  

As a dependent variable, crime has been represented by different variables such as AAR (Aggravated assault rate), ATR (Auto theft rate), BUR (Burglary rate), GAR (Gun aggravated assault rate), GHR (Gun homicide rate), GRR (Gun robbery rate), HAR (Homicide, assault and robbery index), ICR (Index crime rate), LAR (Larceny rate), RMR (Robbery murder rate), THR (Total homicide rate), TPR (Total rape rate), TRR (Total robbery rate), or VCR (Violent crime rate).  

Third, different models are used for estimations, including binomial regression models, multivariate regression models, difference in difference models, and two-way fixed effects models. Each model has its own advantages and disadvantages. To increase precision, some researchers also used a combination of several methods.  

Differences in outputs and conclusions  
Prior studies of the relationship between gun ownership and crime rate find three different kinds of effects: a positive effect, a negative effect, and a not significant effect.

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Those who observe a positive effect believe that an increase in gun ownership will increase the crime rate, thus a stricter gun policy should be implemented. “In Siegel’s study, “gun ownership was a significant predictor of firearm homicide rates (Incidence Rate Ratio = 1.009; 95 Percent Confidence Interval= [1.004, 1.014])”. His model indicated that for each percentage point increase in gun ownership, the firearm homicide rate increased by 0.9 percentage points. Conversely, Geisel concluded that a one-unit increment in gun control will be associated with a -0.172 decrease (with a 0.113 probability of sign error) in homicide rates, indicating that gun control probably has a negative effect on homicide by firearm and total homicide rates. In all five sets of Geisel’s equations, “the estimated gun control coefficient is negative and in only one case is there more than a fifteen percent chance that the coefficient's sign is positive”. “

Those who observe a negative effect believe that increasing gun ownership can significantly reduce the possibility of crime and, therefore, that a more flexible gun policy should be implemented. In Wintemute’s work, he found that small caliber handguns are at relatively low risk to be used in homicides. “Among pistols, 0.32 caliber weapons account for only 9 percent of pistol-involved homicides.” Thus, he concluded, gun control on the small caliber handguns would not be effective in lowering crime rate.

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 Those who control for the confounding effect of variables, and find that there is no significant relationship between gun ownership and crime rates, believe that crime and gun ownership do not affect each other. In Kovandzic’s study, his result showed that “gun levels have either no impact, and possibly a negative impact, on total homicide rates”.

**Strengths and weaknesses**

The strengths of these studies rest in four aspects: developing multiple methods, controlling for biases, using convincing data, and allocating the causal problem. They used multiple kinds of methods including binomial regression, multivariate regressions, difference in difference, and two-way fixed effects method to estimate the relationships. The biases are carefully controlled by different means and the causal effects are successfully allocated as mentioned above.

However, there are weaknesses in these studies as well. First, the studies done at the individual level are constrained under strict conditions. The results are closely correlated with a state’s characteristics and are not applicable to other cases, even if implemented correctly.

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Second, some of the studies’ economic models are questionable since they do not use methods to control for potential bias. For example, in a country level study like Kleck’s, a univariate regression seems to be too simple to eliminate potential biases. Even in estimating a multivariate-regression model, most researchers still make little effort to control for confounding variables, and many make no effort at all.

Third, when choosing the predictors of variables, researchers’ capabilities vary. On the one hand, the choice of an independent variable for gun ownership is important, because when taking the black market into consideration, gun ownership is hard to estimate precisely. Thus, Kleck concluded, “in order to establish that there is an association between gun levels and crime rates, one must have a valid measure of gun levels, but most studies use proxies that are either known to be invalid or whose validity has not been established.” Some researchers may also choose gun policy to estimate the gun ownership, but their approaches cannot provide evidence of a policy’s effect on the gun ownership.

On the other hand, the choice of an outcome variable is also important. Many studies choose different crime types but do not specify the hidden logic of choosing the specific outcome variable. And an endogeneity issue will arise when using the crime caused by a

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firearm to estimate the gun ownership or when using illegal gun ownership to estimate the crime.

**Original contribution to existing literature**

Over all the studies in this topic, a variety of hypotheses regarding the relationship between gun ownership rate and crime have been tested at different levels through different methods. My study uses the newest data from 2013 to 2017 to estimate the most recent trend in this field of study to test the relationship in a country base of the US. By using the crime rate, but not specific types of crime, as the dependent variable and using gun ownership rate, but not gun policy, as the independent variable of interest, this study investigates a new overall relationship with multivariate regression and fixed effects models based on panel data. The study is conducted at national/state level to minimize the potential biases caused by local characteristics or international differences. This study builds upon existing literature by involving several independent variables to indicate the effect of gun policies on the relationship between gun ownership rate and the crime rate, which were not directly explored in earlier studies. By exploring the gun policy factor, this study controls both the linear effect of gun policy on gun ownership and the confounding effect of gun policy on the crime rate instead of taking gun ownership as a result of the gun policy directly.
CHAPTER II
THEORETICAL FRAMEWORK

To estimate the relationship between crime rates and gun ownership rate in the US, I estimate the following theoretical model:

\[ C = f(\text{GO}, \text{GP}, \text{D}, \text{Y}, \varepsilon) \]  

(1)

C is crime rate; D stands for demographic characteristics including region, economic status, and employment; GO is gun ownership, including the gun ownership rate, the number of guns that are stolen, the gun flows among states, the age distribution of gun owners and the proportion of guns used in crime; GP is gun policy, including the number of gun related policies in each state; Y is the year; and \( \varepsilon \) is the error term. The model is tested at national/state level.

For demographic factors like age, region, economic status and employment, I create variables for each factor in each state and eliminate relevant data from the state governments’ database. The economic status factor is defined as a GDP variable - “GDP in each state”. For the employment factor, I create a ratio variable – the employment rate. For the region factor, I create a categorical variable to examine different regions.

For my gun ownership factor, I combine firearm ownership data and firearm stolen data to estimate potential true gun ownership in each state. For my gun ownership rate variable, I use the number of guns traced in the state divided by the state population. For
the guns flow among states, I use the number of guns sold in a state minus the number of
guns traced in that state. For the age distribution of gun owners, I use the average age of
gun owners. For the proportion of guns to crimes, I use data that come directly from the
ATF.

For my gun policy variable, since it is hard to quantify the effect of gun policy, I estimate
the number of gun policies in states. I gather these data from Boston University’s state
firearm laws research.
CHAPTER III

DATA AND DESCRIPTIVE STATISTICS

To estimate my models, I use four fundamental categories of data: crime data from the Federal Bureau of Investigation (FBI) Crime Statistics; gun ownership data from the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Firearms Statistics; gun policy data from Boston University’s State Firearm Laws National Data; and demographic data from the United States Census Bureau. I assemble data from 2013 to 2017 for the 50 states. My database consists of 250 observations and 20 independent variables in total. “Table 1: Descriptive Statistics” provides descriptive statistics for my variables.

Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
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<td>Year</td>
<td>250</td>
<td>2015</td>
<td>1.42</td>
<td>2013</td>
<td>2017</td>
</tr>
<tr>
<td>Population</td>
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<td>6407595</td>
<td>7154407</td>
<td>579315</td>
<td>39536653</td>
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<tr>
<td>Totalcrime</td>
<td>250</td>
<td>372043.8</td>
<td>431897.8</td>
<td>19090</td>
<td>2383594</td>
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<tr>
<td>Crimerate(%)</td>
<td>250</td>
<td>5.75</td>
<td>1.36</td>
<td>3.05</td>
<td>9.45</td>
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<td>3899.44</td>
<td>4339.22</td>
<td>62</td>
<td>22804</td>
</tr>
<tr>
<td>Gunsellnumber</td>
<td>250</td>
<td>3880.79</td>
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<tr>
<td>LnGDP</td>
<td>250</td>
<td>13.63</td>
<td>1.03</td>
<td>11.65</td>
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</tr>
<tr>
<td>GDP($)</td>
<td>250</td>
<td>1425004</td>
<td>1782663</td>
<td>114760</td>
<td>10987494</td>
</tr>
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<td>Gunpolicynumber</td>
<td>250</td>
<td>26.64</td>
<td>26.31</td>
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<td>Averagegunownershipage</td>
<td>250</td>
<td>36.01</td>
<td>3.04</td>
<td>31.15</td>
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<tr>
<td>Ownershiptocrime</td>
<td>250</td>
<td>10.28</td>
<td>1.94</td>
<td>6.61</td>
<td>22.90</td>
</tr>
<tr>
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<tr>
<td>Gunownershiprate(%)</td>
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<td>0.03</td>
<td>0.00</td>
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<td>Gunspill</td>
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<td>7659</td>
</tr>
<tr>
<td>Employmentrate(%)</td>
<td>250</td>
<td>60.29</td>
<td>5.56</td>
<td>48.45</td>
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</tr>
<tr>
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<td>250</td>
<td>0.24</td>
<td>0.43</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>NE</td>
<td>250</td>
<td>0.18</td>
<td>0.38</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>S</td>
<td>250</td>
<td>0.32</td>
<td>0.47</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>W</td>
<td>250</td>
<td>0.26</td>
<td>0.44</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>State</td>
<td>250</td>
<td>25.50</td>
<td>14.46</td>
<td>1</td>
<td>50</td>
</tr>
</tbody>
</table>
My dependent variable is the crime rate that I calculate based on crime data from FBI Crime Statistics. For the purposes of this study, this variable is recoded as *CrimeRate*. It is a continuous variable that provides the crime rate in percentage term for each state in a certain year. I also include the number of total crimes and the population in my dataset since I do some calculations based on them. These variables are coded as *Population* and *TotalCrime*.

For my independent variables, the primary factor of interest is gun ownership. To encode my gun ownership factor, I use independent variables coded as *GunOwnershipRate*, *OwnershipToCrime*, *AverageGunOwnershipAge*, *Gunspill* and *GunstolenNumber*. I also include some demographic independent variables – e.g., *Year*, *Region*, *Employment rate* and *GDP*.

To calculate the gun ownership variables, I use the data from ATF Firearms Statistics, encoded as *GunInStateNumber*, for the number of guns found in source states; *GunRsellNumber*, for the number of guns found in recovery states; and *GunstolenNumber*, for the number of guns recorded as stolen. I combine these three variables with the *Population* variable, which is derived from FBI Crime Statistics, to create my new variables.

My *GunOwnershipRate* variable, which encodes the gun ownership rate, is the total number of guns traced in each state divided by the state population term. It is a
continuous variable that provides the gun ownership rate in percentage term for each state in a certain year.

*Gunspill* is a continuous variable that indicates whether the state is a gun import or gun export state. The *Gunspill* variable is calculated as *Gunsellnumber* minus *Guninstate number* in a state in a certain year. If *Gunspill* is a positive integer, the state is a net “gun export” state, which sells guns to other states; if *Gunspill* is a negative integer, the state is a net “gun import” state, which buys guns from other states.

*Gunstolennumber* is a continuous variable that encodes the total number of guns that are reported stolen in a state in a certain year. The variable comes directly from the ATF Firearms Statistics.

*Averagegunownershipage* is a continuous variable indicates the average age of gun owners in a state in a certain year. The variable comes directly from the ATF Firearms Statistics.

*Ownershiptocrime* is a continuous variable that is derived from ATF Firearms Statistics. It shows the number of guns that are recorded as claiming for crimes in a state in a certain year.

For my gun policy factor, I use *Gunpolicynumber* to encode the number of gun policies. *Gunpolicynumber* is a continuous variable that provides the number of gun related policies in each state for a specific year, derived from the Boston University’s State’s Firearm Laws National Data.
My *Year* variable, which stands for the different years for the data, is a categorical variable that consists of 5 categories: 2013, 2014, 2015, 2016 and 2017.

My Region variables are derived from the U.S Census Bureau data and include four dummy variables: *W* for the west region, *S* for the south region, *NE* for the northeast region, *MW* for the mid-west region. If the state is located in the northeast region, NE=1; otherwise NE=0. If the state is located in the south region, S=1; otherwise S=0. If the state is located in the west region, W=1; otherwise W=0. Due to collinearity, I drop the MW variable automatically from all my models.

My population variable comes from the FBI Crime Statistics. It is coded as *Population* in the original crime data and I retain this coding in my own data. *Population* is a continuous variable that stands for the population in each state for a certain year. I do not use this variable directly in my models since there is a high collinearity between *Population* and *LnGDP*. But I use it to calculate the crime rate, gun ownership rate and employment rate.

*My LnGDP* variable comes from the U.S Census Bureau. It is coded as *GDP* (Gross Domestic Product) in the original demographic data, and is a continuous variable that indicates the economy status in each state for a certain year range using a specific number. My models use the log of this variable coded as *LnGDP*.
The *Employment rate* variable is a continuous variable that provides the employment rate in percentage terms for each state in a certain year. It is derived from the United States Census Bureau.
CHAPTER IV
EMPIRICAL MODEL SPECIFICATION

My analysis compares results of OLS models and fixed effects models.

\[ Crime \ rate = \beta_0 + \beta_1 \text{Gun ownership rate} + \mu \]  \hspace{1cm} (1)

My OLS Model (1) is a univariate regression model. It reflects a simply linear relationship between the gun ownership rate and the crime rate. Obviously, it is not sufficient to explain the complicated relationship, thus, I include more independent variables in OLS Model (2).

\[ Crime \ rate = \beta_0 + \beta_1 \text{Gun ownership rate} + \beta_2 \text{Gun to crime number} + \beta_3 \text{Gun ownership average age} + \beta_4 \text{Gun stolen number} + \beta_5 \text{LnGDP} + \beta_6 \text{Gun spill} + \beta_7 \text{Employment rate} + \mu \]  \hspace{1cm} (2)

I include gun ownership variables and economic variables in OLS Model (2). The result of OLS Model (2) should be more accurate than OLS Model (1) since Model (2) includes more variables.

\[ Crime \ rate = \beta_0 + \beta_1 \text{Gun ownership rate} + \beta_2 \text{Gun policy number} + \beta_3 \text{Gun to crime number} + \beta_4 \text{Gun ownership average age} + \beta_5 \text{Gun stolen number} + \beta_6 \text{LnGDP} + \beta_7 \text{Gun spill} + \beta_8 \text{Employment rate} + \mu \]  \hspace{1cm} (3)

In OLS Model (3), I add the gun policy variable to the base of OLS Model (2). I expect that the gun policy variable should be an important independent variable in my regression with statistical significance.
Crime rate = $\beta_0 + \beta_1\text{Gun ownership rate} + \beta_2\text{Gun policy number} + \beta_3\text{Gun to crime number} + \beta_4\text{Gun ownership average age} + \beta_5\text{Gun stolen number} + \beta_6\text{LnGDP} + \beta_7\text{Gun spill} + \beta_8\text{Employment rate} + \beta_9\text{year2013} + \beta_{10}\text{year2014} + \beta_{11}\text{year2015} + \beta_{12}\text{year2016} + \beta_{13}\text{year2017} + \beta_{14}\text{South region} + \beta_{15}\text{Northeast region} + \beta_{16}\text{West region} + \mu$ \hfill (4)

In OLS Model (4), I add the region variables and year variables to the base of OLS Model (3). Since there are unobserved characteristics of states, the region variables and year variables should be significant in this model. To fix these effects, I develop the fixed effects Model (5).

$$\text{Crime rate} = \beta_0 + \beta_1\text{Gun ownership rate} + \beta_2\text{Gun policy number} + \beta_3\text{Gun to crime number} + \beta_4\text{Gun ownership average age} + \beta_5\text{Gun stolen number} + \beta_6\text{LnGDP} + \beta_7\text{Gun spill} + \beta_8\text{Employment rate} + \beta_9\text{year2013} + \beta_{10}\text{year2014} + \beta_{11}\text{year2015} + \beta_{12}\text{year2016} + \beta_{13}\text{year2017} + \beta_{14}\text{South region} + \beta_{15}\text{Northeast region} + \beta_{16}\text{West region} + \beta_{17}\text{States ID} + \mu$$ \hfill (5)

In fixed effects Model (5), I control for the intrastate and interstate characteristics, the result should have more explanatory power than the OLS models.

Models (1) to (4) are multivariate regression models with different combinations of independent variables and Model (5) is a fixed effects model. I expect my model will prove my hypothesis that a higher gun ownership rate is related to a higher crime rate. I expect to observe a statistically significant relationship between my main independent variable – Gunownershiprate – and dependent variable - Crimerate, at least in my fixed
effects model. I expect the coefficients on my other independent variables related to gun ownership – *Gunownershiptrate*, *Ownershiptocrime*, *Averagegunownershipage*, *Gunspill* and *Gunstolennumber* - to be significant in my multivariate regression models, but not significant in my fixed effects model, since the later model controls for interstate and intrastate effects. I expect the coefficient on my gun policy variable to be significant because it is closely related to gun ownership as well as crime rate. I assume that my economic variables - *LnGDP* and *Employmentrate* - will be significant since the economic situation is likely to have a major effect on the crime rate. Coefficients on other variables – e.g., regions and years - may be significant in the multivariate regression models due to unobservable characteristics of states, but they should be insignificant in the fixed effects model.
CHAPTER V

FINDINGS AND ANALYSIS

Results

Observing the data for average crime rate and average gun ownership rate (Figure 1 and Figure 2), I see that from 2013 to 2017, the gun ownership rate increases by 0.03 percent, while the crime rate in the US decreases by 0.6 percent. Thus, it seems that an increasing gun ownership rate can help to control the crime rate.

However, there may be a reverse relationship between the gun ownership rate and the crime rate since I notice that states are more dispersed in both the crime rate and the gun ownership rate, and this indicates that a simple mean may not reflect the true relationship.

Figure 1: 2013-2017 Crime Rate Changes in States
To explore the potential relationship between gun ownership and crime rate, I use OLS models and a fixed effects model to test my hypothesis. In all the regressions, I use panel data which include 250 observations on a panel of 50 states over the 5-year period from 2013 to 2017. My OLS Model (1) is a univariate model with the gun ownership rate as the independent variable and crime rate as the dependent variable. Model (2) includes several control variables, while Model (3) includes *Gunpolicynumber* as an important variable in addition. Model (4) includes all the variables in Model (3) and add the variables for regions and years. Model (5) is a fixed effects model which controls the fixed effects on the base of Model (4).

All the regressions show a statistically significant, positive relationship between gun ownership rate and crime rate at a 99-percent level of confidence. This is strong evidence
for my hypothesis that the increase in gun ownership rate causes an increase in the crime rate.

However, my OLS models show much higher estimated coefficients for the gun ownership rate than the results from my fixed effects model. Testing for collinearity in the OLS models indicates that there is no collinearity in the OLS models. A small variance and the link test indicate that the dependent variable is transformed accurately to the independent variable (see the test results in Appendix), but I am more convinced by the fixed effects result, since there may be omitted variables bias in my OLS models. This can be proved by omitted variable test results.

This diagnosis indicates that there may be an interstate (across state) variation in the different gun ownership rate as well as intrastate (within state) variation which is the variation in these states over time. Time-invariant characteristics of states could be correlated with other unobserved characteristics, which could bias my OLS results.

My fixed effects model reduces the omitted variables bias by controlling the effects of some unchanged or sustainable variables like regions and states, as well as by reducing the bias caused by some unknown characteristics that are not related to the outcome, but are to the time series. The Wald test and Hausman test show that a fixed effects model has more explanatory power than the OLS models (see the test results in Appendix).
Table 2: Regression Results

<table>
<thead>
<tr>
<th>REGRESSOR:</th>
<th>Model (1)</th>
<th>Model (2)</th>
<th>Model (3)</th>
<th>Model (4)</th>
<th>Model (5)</th>
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<td>Crime Rate</td>
<td>OLS</td>
<td>OLS</td>
<td>OLS</td>
<td>OLS</td>
<td>FIXED ECTS</td>
</tr>
<tr>
<td><strong>VARIABLES</strong></td>
<td></td>
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<tr>
<td>Gunownershiptate</td>
<td>18.96***</td>
<td>13.30***</td>
<td>12.85***</td>
<td>10.17***</td>
<td>6.082***</td>
</tr>
<tr>
<td></td>
<td>(2.246)</td>
<td>(3.281)</td>
<td>(3.199)</td>
<td>(3.193)</td>
<td>(2.054)</td>
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<td>(0.00497)</td>
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<td></td>
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<td>(0.00152)</td>
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<td>6.37e-05</td>
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<td>(5.17e-05)</td>
<td>(5.72e-05)</td>
<td>(5.01e-05)</td>
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<td>-0.0579</td>
<td>0.0341</td>
<td>0.0794</td>
<td>-2.920*</td>
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<tr>
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<td>(0.126)</td>
<td>(0.100)</td>
<td>(1.460)</td>
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</tr>
<tr>
<td>Employynentrate</td>
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<td>-0.0750***</td>
<td>-0.0331*</td>
<td>-0.0496</td>
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</tr>
<tr>
<td></td>
<td>(0.0175)</td>
<td>(0.0194)</td>
<td>(0.0194)</td>
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<td>(0.0255)</td>
<td>(0.0304)</td>
<td>(0.00977)</td>
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<tr>
<td>Ownershiptocrime</td>
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<td>-0.0132</td>
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<td>(0.0772)</td>
<td>(0.0680)</td>
<td>(0.0358)</td>
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<tr>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.678***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.204)</td>
</tr>
<tr>
<td>NE</td>
<td></td>
<td></td>
<td></td>
<td>-0.836***</td>
<td></td>
</tr>
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<td></td>
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<td>(0.177)</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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<tr>
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<td>-0.174**</td>
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<tr>
<td></td>
<td>(0.197)</td>
<td>(0.0679)</td>
<td></td>
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<tr>
<td>2015.Year</td>
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<td>-0.246**</td>
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</tr>
<tr>
<td></td>
<td>(0.204)</td>
<td>(0.104)</td>
<td></td>
<td></td>
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<tr>
<td>2016.Year</td>
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<tr>
<td></td>
<td>(0.212)</td>
<td>(0.149)</td>
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<tr>
<td>2017.Year</td>
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<td>-0.217</td>
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<tr>
<td></td>
<td>(0.247)</td>
<td>(0.211)</td>
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<td></td>
</tr>
<tr>
<td>Constant</td>
<td>4.553***</td>
<td>11.52***</td>
<td>9.236***</td>
<td>9.676***</td>
<td>48.28**</td>
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<tr>
<td></td>
<td>(0.160)</td>
<td>(2.531)</td>
<td>(2.919)</td>
<td>(2.536)</td>
<td>(18.76)</td>
</tr>
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<td>Observations</td>
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<td>231</td>
<td>231</td>
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<tr>
<td>R-squared</td>
<td>0.226</td>
<td>0.337</td>
<td>0.346</td>
<td>0.542</td>
<td>0.534</td>
</tr>
<tr>
<td>F statistics</td>
<td>71.27***</td>
<td>17.99***</td>
<td>20.55***</td>
<td>40.74***</td>
<td>17.39***</td>
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<tr>
<td>Number of State</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Table 2 shows that the estimated coefficients on my gun ownership rate variable are positive and statistically significant for all OLS and fixed effects models at a 99-percent level of confidence. Therefore, I conclude that, as expected, gun ownership rate has an increasing effect on the crime rate. In the OLS models, when I add more control variables, the coefficients shrink by nearly a half. Nevertheless, Model (4) indicates that a one percentage point increase in the ownership rate is correlated with a 10.17 percent point higher crime rate, holding all other variables constant. In the fixed effects Model (5), after soaking up the coefficients for time-invariant characteristics, holding all other variables constant, every 1 percentage point increase on the gun ownership rate is associated with a 6.08 percentage point increase in the crime rate – a smaller result than the results of my OLS models. This may reflect some unobservable state characteristics like the crime culture.

The *Gunpolicynumber* variable is included in Models (3), (4), and (5). In Model (3), it suggests that a higher number of gun policies implemented in a state can reduce the crime rate significantly at the 99-percent level of confidence. However, this effect is neither observed nor significant in Model (4), when I include region and year variables. In Model (5), the fixed effects analysis shows that the number of gun policies that have been implemented in state will affect the crime rate. If state has one more gun policy, then the crime rate will increase by 0.015 percentage point, when no other conditions change. This result, though statistically significant at the 90 percent level, is not very large. Thus, I am still doubtful about whether the number of gun policies in a state really affects the crime rate.
The estimated coefficients on the number of stolen guns are not significant in any of the models. This result may reflect a fact that the stolen guns are not related to the crime rate. This result gives me only a partial sense of the relationship between illegal gun ownership and crime rates, since the number of stolen guns only captures a method of potential illegal gun ownership. But at least I know that this kind of illegal source of gun ownership would not bias my overall conclusion very much.

The coefficients on *Gunspill* variable are positive and significant in Models (2) and (3) at a 95 percent level. It is not significant in Model (4), but very significant in my fixed effects Model (5) after controlling for regions and years. Every gun that is sold but not recorded in the state is correlated with a 0.0005 percent increase in the state’s crime rate. Since this variable encodes the guns that are sold in a state but not recorded in that state, it reflects two possible flows of guns: gun exports to other states, or illegal gun ownership. First, *Gunspill* may represent the fraction of guns that are exported to other states, probably as a result of different gun control policies in different states, especially for the policies like background checks and permit licenses. People may take advantage of different states’ gun control policies to buy guns outside their own states to avoid restrictions. In that case, states with higher *Gunspill* value are identified in my data as states with less gun control, which accounts for a higher crime rate. Second, *Gunspill* can also reflect illegal gun ownership, since the guns that are sold in a state but not recorded in that state may be related to the guns that are lost or used illegally. This possible source of illegal gun ownership shows that increasing illegal gun ownership may also be related to an increasing crime rate.
The estimated coefficients on $\text{LnGDP}$ are not significant in any of my OLS models, but the $\text{LnGDP}$ coefficient in my fixed effects model is significant at a 90 percent level of confidence. Every unit increase in $\text{LnGDP}$ will result in a 2.92 percentage decrease on the crime rate, if all other conditions are constant.

The estimated coefficients for the employment rate variable are negative and significant in OLS models, but not significant in the fixed effects model. This result indicates that the employment rate is an essential intrastate variable, but not very important in fixed effects analysis.

The estimated coefficient on average gun ownership age is only statistically significant in OLS Model (4). The model indicates that a one-year increase in age for those who own guns will be correlated with a 0.085 percentage point decrease on the crime rate. In Model (5), the relationship is also negative but not significant, after I control for fixed effects characteristics. My explanation for this result is that states have different minimum age requirements for gun ownership, in addition to federal laws. For example, the minimum age to possess a handgun in Alabama is 18 years old, but 21 years old in California, 16 years old in Vermont, but 19 years old in New Mexico. Thus, different intrastate characteristics affect the results in my OLS model, but not in my fixed effects model.

The coefficient on $\text{Ownershipcrime}$ is only significant in Model (2). This variable has negative coefficients in the OLS models, but a positive coefficient in the fixed effects
model. In Model (2), the number of guns that account for crime has a limited effect on the crime rate: every gun that is used in a crime is correlated with a reduction in the crime rate of 0.106 percent, holding all other conditions constant. This effect disappears when I add more variables in my model, thus I suppose that it is not a factor which will cause changes in the crime rate.

Model (4) includes three regional dummy variables: S for the south region, NE for the northeast region, and W for the west region. These regional dummy variables are unchanged in all my observations. The model indicates that being in the south region and the west region will increase the crime rate by 0.678 percent and 1.2 percent respectively, and the coefficients are positive and significant at the 99 percent level of confidence; while being in the northeast region will reduce the crime rate by 0.836 percent, and the coefficient is negative and significant at the 99 percent level. This result indicates that there may be unobserved influences in each region that are correlated with the crime rate. Thus, I use my fixed effects model (5) to soak up these coefficients.

Finally, the Year variables are included in OLS Model (4) and my fixed effects Model (5). In the OLS Model (4), the coefficients on all Year variables are all significant, and negative, indicating a declining crime rate over time. In Model (5), the coefficients on Year 2014 and 2015 are negative and significant.
Sensitivity tests

To test the accuracy and explanatory power of my models, I perform the omitted variable test and link test on my OLS Model (4). In my fixed effects model, I perform the Wald test and Hausman test, which prove that my fixed effects model has a higher explanatory power than my OLS models (see the test results in Appendix).

The omitted variable test result shows that there is an omitted variable problem in my OLS Model (4). I reject the null hypothesis that the model has no omitted variables at a 95 percent significance level (Pro>F = 0.03). This result indicates that there are some unobservable characteristics in states that I do not include in my OLS models. Thus, a fixed effects model can work better in explaining the relationship between gun ownership and crime rate than OLS models.

The link test result shows that conditioned on the specification of OLS Model (4), the independent variable is specified correctly. The t-test result for independent variable is 0.82 and the t-test result for squared independent variable is 0.16. The t-test results for hat and hat squared are both insignificant so the equation is properly specified, and no additional independent variables should be significant except by chance.

After the fixed effects Model (5), I perform the Wald test for time fixed effects. My result shows that I can reject the null hypothesis that assumes the coefficients for all years are jointly equal to zero at a 99 percent level of confidence (Pro>F = 0.00). As a result, I conclude that my fixed effects model should include time fixed effects.
In the Hausman test, the test result shows that I can reject the null hypothesis that the difference in coefficients is not systematic at a 95 percent level of confidence (Pro>F = 0.03). According to this test result, a fixed effects model corresponds to my data more accurately than a random effects model.
CHAPTER VI

LIMITATIONS

Even though I have tried to prove my hypothesis with sufficient evidence and tests, there are still some potential problems that I haven’t solved in this paper.

My analysis is affected by a number of unsolved limitations. First, since there is illegal gun ownership and black markets in the real world of gun ownership that are hard to estimate, my data from ATF’s records on gun ownership are never the complete picture of gun ownership in the real world. To get a more accurate and convincing result, I would have to acquire more data to estimate the real gun ownership beyond the records from the ATF.

Second, my estimation method for gun ownership, as I mentioned in the literature review section, is one path of logic. It is also meaningful to do individual level research in accomplishment of this research. The gun ownership rate I use in this paper is measured by average gun ownership across the population. But the number of guns that an individual owns can denote gun ownership in a more specific way and may also resolve the relationship between gun ownership and crime rate.

Third, I use the number of gun policies as an independent variable in my research and the result shows that the number of gun policies is not very significant in my estimation. But as the result in my research shows, the variable Gunspill is statistically significant and it is more related to the gun policy. Thus, the number of gun policies may not be a good
indicator for gun policies. Indeed, since the number of gun policies is more closely related to the crime or gun history of a certain state, it may be more reasonable if the gun policies factor is classified into several variables, such as the increased number of gun policies for each year, different categories of gun policies and so on. I need to do further research on gun policies to control their effects on the relationship between gun ownership and the crime rate.

Finally, I find the Year variables particularly for 2014 and 2015, are significant in my fixed effects model. However, I need to acquire more data to further investigate whether there is something that happened in 2014 and 2015 that affected this relationship, or if the year variables soak up the coefficients of my main independent variables.
CHAPTER VII

CONCLUSION

My regressions show that there is a significant and positive relationship between the crime rate and gun ownership. Using a fixed effects model, I estimate that a lower gun ownership is associated with a decrease in the crime rate, holding all other factors constant. There is a 6.08 percent decrease in the crime rate associated with every one percent decrease in the gun ownership rate. The number of guns sold in a state but not recorded in that state is also an important indicator for crime rate. Every gun that is sold in a state but not recorded in that state is correlated with a 0.0005 percent increase in the state’s crime rate, holding all other factors constant. Thus, we should pay more attention to gun ownership and gun spill over when making gun control policies.
CHAPTER VIII
POLICY RECOMMENDATIONS

My results show that a higher gun ownership rate is correlated with a higher crime rate, which may cause many problems that threaten public safety. Thus, gun policies should be implemented to control gun ownership.

However, because of gun rights, gun ownership cannot be simply banned. There is a dilemma between personal gun rights and gun control policies. First, it is an issue of basic rights for individuals since the legal basis for firearm possession in the US is enshrined in the Second Amendment of the Constitution, which guarantees that “The right of the people to keep and bear Arms, shall not be infringed.” Gun control policies may offend people’s right to possess a gun on an equal basis. Second, gun control policies increase unfairness in access to guns, since gun resources are not distributed to everyone equally under these policies. Specifically, those who have more legal or illegal access to guns will have higher gun capabilities than those who do not. Last, there is a more or less intrusive role of government in the gun control process, which is in opposition to the initial role of government. Moreover, the traditional gun culture in the US is affected by gun control policies as well.

To deal with the problem of guaranteeing an individual’s gun rights and public safety, there are four possible policy alternatives: (1) “regulations on dealers and buyers”, which

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*In the twenty-first century, the amendment has been subjected to renewed academic inquiry and judicial interest. In District of Columbia v. Heller (2008), the Supreme Court handed down a landmark decision that held the amendment protects an individual’s right to keep a gun for self-defense.*
imposes regulations on the gun market and controls gun ownership from its source; (2) “restrictions on current gun ownership”, which restricts the current possession of guns through laws for carrying guns; (3) “restrictions on criminal and illegal gun ownership”, which puts restrictions only on individuals’ guns that are related to crimes or illegal possession; and (4) “public education programs on guns”, which raises people’s awareness of gun related problems and encourages them to be cautious about gun ownership.

To evaluate all the alternatives, I use five criteria: economic costs and benefits; effectiveness; moral risks; political feasibility; and technical feasibility. To evaluate economic costs, I mainly focus on the government spending on the alternatives and the effects on individuals in gun markets. For economic benefits, I focus on the revenue raised from imposing taxes and permits. For effectiveness, I estimate how well the alternative can address the problems both in the short run and in the long run. For moral risk, I consider if the alternative violates the basic gun rights of individuals and the gun culture in the US. For political feasibility, I evaluate whether enacting the policy is possible, and the possible reactivity problems associated with it. For technical feasibility, I estimate the possibility of data tracing and evaluation in a technical process.

**Regulations on dealers and buyers**

Regulations on dealers and buyers impact the gun market. Individuals who want to buy guns will face higher gun taxes or need to reduce their consumption of guns. There may be a substitution effect through which customers will try to buy other weapons instead of
guns and a complementary effect that the consumption of gun-related goods will decline. Overall, both dealers and buyers will be subjected to higher economic costs. But with taxes and new permits, governments can raise more revenue. The effectiveness of this alternative might be hard to estimate in the short run, since the alternative only controls gun ownership going forward but does not control current gun ownership. Thus, the alternative may not change the current situation but could improve public safety in the future. However, it violates the gun rights of individuals by restricting people’s freedom to access guns, and it also violates the gun culture in the US. Though it may be easy to trace the related data technically, it is hard for the federal government to implement regulations with significant political opposition. Moreover, the reactivity of regulations may be that the black market for guns will increase, which will in turn threaten the public safety.

**Restrictions on current gun ownership**

Enforcing restrictions on current gun ownership may be the most effective way to solve the problem of crimes. This alternative places the gun owners under stricter limits. It is also profitable because the government can raise revenue from imposing taxes and fees. However, this alternative is not politically feasible due to the large number of people who advocate for gun rights. This alternative violates the basic gun rights of individuals by putting them under the investigation of government agencies and it is also in opposition to American gun culture. The restrictions may also increase the costs for individuals who own guns.
Restrictions on criminal and illegal gun ownership

More restrictions on criminal and illegal gun ownership may be an optimal choice. The effectiveness aim is met by this option since it can control the most concerning public safety problem: crimes. In addition, the alternative does not offend the majority’s gun rights, since it focuses on criminal and illegal gun owners, who intrude across the boundaries of others’ rights, which should not be protected by the law. This alternative also respects the gun culture in the US. Since both advocates and opponents of gun control are likely to agree on this policy, which does not offend gun rights, while solving the public safety problem, the political feasibility of this alternative is high. But this choice may increase the government spending on police departments to control the illegal gun market without direct economic benefits, and it may also increase the work of technical departments to trace criminal and illegal behaviors.

Public education programs on guns

“Public education programs on guns” is a low-cost alternative. It does not have economic benefits, but it can improve public safety, since it can raise public awareness of the possible problems associated with gun ownership and encourage people to be more cautious about their guns. This alternative is also easy to implement since it is well acknowledged that there are pros and cons of gun ownerships. However, the effect of this alternative may be limited since it does not have an enforcing power like laws to restrict people’s behaviors. It is also hard to evaluate the results of education programs from a technical perspective.
Based on my research and policy analysis, I recommend that the US government should act to control criminal and illegal gun ownership. This policy remedy is an optimal choice to solve the conflict between individual gun ownership demands and safety requirements. It controls crimes effectively and respects basic gun rights for majority groups, and it does not offend American’s gun culture. It is also politically feasible since both advocates and opponents of gun control will admit that criminal and illegal gun ownership should be banned.

For the restrictions on criminal gun ownership, I suggest that more prohibitions should be enacted for those criminal individuals. For example, at the state level, we have prohibitions for high-risk gun possession by all people who have been convicted of a felony, by people who have committed violent misdemeanors punishable by more than one year of imprisonment, and by people who have been deemed by a court to be a danger to themselves or others. Also, we can have federal restrictions on people who are convicted of crimes or who are at high risk of committing crimes.

To control illegal gun ownership, I suggest that we have laws that enhance punishments for participants in the black market for guns, for those who commit illegal reselling behaviors, as well as those who possess guns illegally. According to the research result from the Giffords Center, about 48 percent of state prison inmates surveyed said they got the gun they used for a crime from a family member, friend, gun store, pawn shop, flea market, or gun show. Laws like those banning gun trafficking, which prohibit people

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from buying guns for resale or on behalf of others, should be enforced at federal level. Police departments should also make efforts to control the black market for guns.

Also, the significance of gun spill over rate suggests that federal and local laws should be consistent, otherwise people may take advantage of inconsistencies in federal-to-state and state-to-state laws to manipulate gun ownership.
APPENDIX

1. Vif test

<table>
<thead>
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<th>Variable</th>
<th>VIF</th>
<th>1/VIF</th>
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</tr>
<tr>
<td>Gunpolicynumber</td>
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<td>NE</td>
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<td>2014</td>
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</tr>
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<td>Mean VIF</td>
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<td></td>
</tr>
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2. Omitted variables test

Ramsey RESET test using powers of the fitted values of Crimerate

Ho: model has no omitted variables

\[ F(3, 212) = 3.03 \]

Prob > F = 0.0303

3. Link test

<table>
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<tr>
<th>Crimerate</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T test</th>
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<th>[95% Confident Interval]</th>
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<td>_hat</td>
<td>1.263856</td>
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<td>0.220</td>
<td>-0.7606205 - 3.288332</td>
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<td>-0.26</td>
<td>0.797</td>
<td>-0.19895 - 0.1529368</td>
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<tr>
<td>_cons</td>
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<td>0.800</td>
<td>-6.506991 - 5.023754</td>
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</table>
4. Year effect test

(1) 2014.Year = 0
(2) 2015.Year = 0
(3) 2016.Year = 0
(4) 2017.Year = 0

\[ F(4, 49) = 8.31 \]

\[ \text{Prob } > F = 0.0000 \]

5. Hausman test

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>(b) (B) fixed random</th>
<th>(b-B) Difference</th>
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</thead>
<tbody>
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Test: Ho: difference in coefficients not systematic

\[
\text{chi2}(10) = (b-B)'[(V_b-V_B)^{(-1)}](b-B)
\]

\[ = 19.69 \]

\[ \text{Prob } > \text{chi2} = 0.0323 \]

(V_b-V_B is not positive definite)
BIBLIOGRAPHY


