Exploring State Demographics as Determinants of Gun Ownership and Gun Sales

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1. Introduction

On average, each state adds about 100,000 new weapons to its arsenal each year. Much research has been conducted on crime and guns given the rise in homicides and suicides each year. While there is a lot of research on the topic of the effect of gun sales, little is said about the determinants of gun sales. Therefore, in this work, we performed exploratory research to determine whether there is a direct relationship between state demographics and gun sales.

The average age, racial makeup, income, and education levels are the main demographic factors we have selected for our study. We focus on the sales data of handguns and long guns collected by the FBI over the last two decades. We also include permits issued and background checks that are conducted annually. These factors provide some light on the State Department's vigilance in observing the sales of firearms.

Historically, Americans feel very strongly about gun ownership. On one hand, this has led to research that seems contradictory at times. On the other hand, it has armed enthusiasts with rhetoric that has gained more popularity than its statistical soundness. Therefore, our research might not reflect all that the gun debate usually encompasses. One such thing is the variable of illegal firearm sales, which is not present in our data due to the difficulty of quantifying this underground aspect of gun sales.

In our paper, the term 'Permit' refers to the legal permission to buy, hold, or carry any type of firearm as long as they are legal. The variable of background checks refers to any check conducted for any reason. This variable could potentially include repeat checks to the same individual or checks that did not result in the sale of a gun. Handguns and long guns are classified according to the Bureau of Alcohol, Firearms, Tobacco, and Explosives. We focus on a variable that measures these two categories' combined sales.

There is a lot of research on the effects of gun ownership on other variables while there is not much literature that explores the determinants of gun ownership. Our research focuses on trying to link state demographics to the sales of firearms, something most literature simply links to "gun culture" without much elaboration.

In our initial analysis, we found promising patterns. We discovered some correlation between the average age of the state and the sales of firearms, where some older states tend to buy more firearms. Some states are not affected by this trend, however. This implied that other variables had more influence in the sales of firearms. Of these variables we highlight the following two: average education and political leaning.

We demonstrate that the average education level of a given state correlates to the sales of firearms. This variable, combined with historical political leaning of the state are factors that drive the sales of firearms. States that historically vote republican tend to acquire more firearms as the education level (and the acquisitive power) of the state increases. States that historically vote democratic tend to decrease their consumption of firearms as education level increases. We also control for other factors such as geographic region and urbanization indexes to show these factors do not show any correlation with the sales of firearms.

2. Background

America is positioned uniquely in the world when it comes to firearm ownership. It is no secret that the U.S. owns the most amount of weapons and sales don't seem to slow down

(Black, 2022). New legislation and a stronger emphasis on background checks have halted some sales (Molotsky, 2000) but not enough to change the direction of the overall trend. In 1999, the denied sales due to background checks not clearing an individual only accounted for 2.4% of attempted sales. Today, most gun owners seem to suggest some degree of safety policies (Politico, 2022). However, no such policies are being discussed. In the 2022 midterms, only one state had a ballot measure on gun control (NBC, 2022) while other states seem focused on limiting the power of such potential measures (Niedelman, 2022).

While only one-third of the population of the U.S. owns a gun (Kalesan, 2015), this is not an evenly distributed statistic. Northeastern states account for lower rates of gun ownership while the South accounts for the highest rates of gun ownership. Kalesan, et. al., point towards gun culture as the driving factor for this data. They found that states with active social gun cultures were associated with 2.25-times greater gun ownership (PR=2.25, 95% CI 2.02 to 2.52) than those without it. But what exactly constitutes gun culture?

In a survey of 539 Cincinnati Residents, the research found a significant correlation between protective and general (or "sport") firearm ownership based on gender and childhood socialization (Cao, 1997). Protective gun ownership appeared to be linked to crime-related factors. Residents of neighborhoods with higher crime rates indicated their increased possession of firearms was for defensive purposes. At the same time, informal collective security (the belief that neighbors help prevent crime victimization) reduced possession of protective weapons. But the perception of crime is not the only factor that determines gun ownership

According to a number of sociologists and cultural psychologists, the United States is primarily an individualistic country. Katazyna (2007) finds a unidimensional list of independence and collectivism to analyze weapon proprietorship and weapon control. The researcher identifies individualism as both a driving factor of weapon proprietorship and weapon control.

From the available literature on the topic of firearm ownership, most of the research does not focus on the analyzing determinants of firearm ownership. Most sources available on the topic of firearms tend to focus on the effects this ownership bears on other variables like crime, homicides, or suicides. While this might be beyond the scope of this paper, they point to relevant variables that might still be of interest to us. A study determined a correlation between suicide rates, gun ownership, populace thickness, and county elevation (Kim, 2011). This research proves that the factors that constitute gun culture are not only social factors, and can extend to geographical and demographical factors.

Research even shows that gun culture might be propagated by specifically targeted marketing campaigns (Blair, 1995). In their research, they analyze the effects of the latest merchandising of weapons and gun-associated merchandise on girls, to primarily test the impact of gun-related promotions on women's and men's states of mind toward owning weapons or guns. After demonstrating a huge impact on the research matter, the researchers raise questions of legality and ethics regarding these practices.

3. Data

The data cleaning process involved two separate datasets: The firearm background checks dataset from the FBI and the state demographics dataset from the Census Bureau.

For the firearm dataset, we first separated the *Month* column into two separate columns; one with the year and another with the month. This is so we would be able to match the dataset later on with another dataset by year. Next, we eliminated the rows corresponding to years not included in the census dataset. We kept the years going from 2002 to 2019 for this reason.

Next, we removed the territories not included in the dataset from the Census Bureau. These had: Guam, the District of Columbia, Puerto Rico, the Mariana Islands, and the Virgin Islands.

Then, we summarized the information in the firearms and background checks dataset by year and state. Since this dataset contains twelve data points (one for each month of the year) per state per year, we added all permits, handguns, long guns, and background checks so that each row represented the total amount of these variables sold or performed per state in a given year.

The last thing we did was select the variables we were interested in for this dataset. These variables were: *year, state, permit, handguns, long guns, and totals*. *Permits* represent the number of permits emitted in one year, *handguns* and *long guns* represent the number of handguns sold per year according to the guidelines established by the US Bureau of Alcohol, Tobacco, Firearms & Explosives. *Totals* correspond to the number of background checks performed that year, for whatever reason. This was all the data cleaning performed on the firearm and background check dataset.

For the dataset containing demographic information from the United States Census Bureau we first started by removing outliers that could potentially skew our data later on. We removed all the rows in the "total income" variable that contained a max amount of *99999999* because this meant that someone earned over this amount in a given year, or the minimum of *0* which could mean someone was homeless and unemployed or a stay at home parent. We chose to eliminate these rows because they could skew the data negatively.

Next, we removed any entries on territories like Guam, because the fact that they have military presences would bias the data toward an increased presence of firearms that does not reflect a pattern in the rest of the continental United States. Afterward, we eliminated columns that were not of interest or were redundant like the *detailed education*, *detailed race*, and *detailed Hispanic*, which only further subdivided these variables to a degree we did not have a need for.

The next step was to turn the categorical variable of race, which ranged from 1 to 6, into four binary variables. A 1 on this variable represented White, 2 represented African ancestry, 3 represented Native Americans, and variables 4, 5, and 6 represented 3 different subcontinents of Asia which were grouped into one variable for reduced complexity. The Hispanic variable was also turned into a binary variable where all the different subdivisions of Hispanics were grouped into one category for the same reasons as the last variable.

The *sex* variable was also turned into a binary variable. The original variable had 1 corresponding to male and 2 corresponding to female. This was turned into a Bernoulli variable

(0 and 1) for better data storage. The last variable manipulated was the *static* variable, where the rows had code numbers that corresponded to a state. The codes were substituted for the state names to later join the two datasets by these names.

Once all this cleaning was done, the dataset was summarized by year and state, similar to what was done with the previous dataset. Grouped by state and year we summarized the age into a mean age variable, where each row displayed the average age of a given state in a given year. The *educ* variable was summarized into a mean educational attainment variable where each row corresponded to the average education level of each state in a given year. In the same vein, total income was averaged by the state each year. The demographics of sex, race, and Hispanic ethnicity were summarized to show the percentage of the population of a given state that was part of said demographic. These percentages were then rounded to the nearest decimal for simplicity.

Afterward, these two datasets were joined to form one dataset where all the above information was displayed by state and year. Once this was done, we added three more variables to the joined dataset.

The first variable was an index of urbanization to determine how rural or urban a state was. This continuous variable was extrapolated from research done by FiveThirtyEight. They define their index as the natural logarithm of the "average number of people living within a five-mile radius of every census tract" (Baseballot, 2020). The next variable added was a regional identifier that split the states into four categories: West, Midwest, Northeast, and South.

The last variable added was that of historical political leaning. This index was also taken from FiveThirtyEight. They created the index by calculating the "average margin difference between how a state or district votes and how the country votes overall." (Baseballot, 2021). From this data we divided the index into three categorical variables: Blue, Red, and Purple. Blue and Red states scored 4.0 or higher on the index, while purple states scored lower than that benchmark.

4. Descriptive Statistics

Table 1 is the summary of the firearms dataset obtained from the FBI. The data collected are for the last twenty years. The variables in this dataset are permits emitted, firearms sold by type and total, and total background checks conducted.

The arithmetic mean for permits issued is 106,000 per state in a given year. There were some states that issued no permits and states that had a maximum of 4.6 million permits issued in one year. Similarly, the sales of firearms vary from 0 in at least one state to a maximum of 1.16 million in one year. The average falls around 194,000 for firearm sales. For background checks, some states conducted a minimum of 6.5 thousand background checks and a maximum of almost 5 million background checks. The average falls around 336,000 background checks conducted by a state in one year.

Table 1

	permits	handguns	long_guns	total_gun	bg_checks
Min.	0	0	0	0	6,521
1st Qu.	35	20,362	38,242	62,771	91,197
Median	18,386	52,258	81,608	142,328	197,470
Mean	106,159	91,201	103,643	194,844	336,542
3rd. Qu	89,954	119,706	137,807	251,248	372,993
Max.	4,655,016	662,308	873,543	1,166,589	4,949,570

Table 2 displays summary statistics of the dataset obtained from the Census Bureau, which gives us a brief overview of the arithmetic mean demographics in the U.S. for the last twenty years, approximately.

We can see that the average age is 49 years old, with younger states averaging 42 years old and older states being almost 54 years old. The average percentage of females is an even split of 50%, with the states with the lowest percentage of female population being around 46% and the highest being 54%.

The average educational achievement nationwide is that of finishing the first year of college. States with lower levels of educational achievement have, on average, a population that has finished high school. States with higher levels of education average the completion of the second year of college. When it comes to average total income, the median income nationwide over the last twenty years is about $37,000. States with lower total income average around $23,600 and states with higher levels of total income average around $67,000.

When it comes to racial diversity we can see that, on average, 83% of the population identifies as White across all states. However, when all states are weighted equally, only 7% of the population identifies as Black or African American. This can be explained by the unequal distribution of this racial population across all 50 states. This is evidenced by some states containing around 34% of the black population. Similarly, Native Americans represent almost 2% of the total population but represent 32% of the population of some states. People that identify themselves as Asian represent 4% of the total population but over 50% of some states.

Table 2

	avg_age	avg_ed	avg_inc	per_fem	per_white	per_black	per_nat	per_asian	per_hisp
Min.	42.24	6.198	23,626	0.46	0.26	0.002	0.001	0.003	0.005
1st Qu.	48.16	6.933	33,182	0.50	0.76	0.016	0.003	0.010	0.022
Median	49.33	7.140	37,597	0.51	0.86	0.052	0.005	0.017	0.042
Mean	49.14	7.148	38,465	0.50	0.83	0.076	0.018	0.036	0.068
3rd. Qu	50.33	7.345	42,575	0.51	0.92	0.110	0.012	0.034	0.074
Max.	53.88	8.032	67,002	0.54	0.98	0.340	0.323	0.568	0.382

5. Data Visualizations

Figure 1 shows the relationships of three important variables in the topic for firearms across time: Permits, background checks, and gun sales. We can see that while they fluctuate over time, these three variables maintain their relationship to each other.

There are always more background checks conducted than guns sold or permits emitted, and there are always more guns sold than permits emitted. The key difference is that a person can only hold one permit but can buy and own more than one firearm. This seems to indicate that people with firearm permits usually tend to own more than one firearm, at least at a national level.

An observable trend in this graph, other than both the increase of background checks over time, is that of a drop in sales after the year 2014. This "slump" in sales continues until the year 2019, never quite matching the total of the year 2013. Anecdotal evidence collected by NPR suggests that the firearms market might have been oversaturated at this point in time. After an consistent increase in sales and a big shift in the production of firearms moving to the U.S. (Stephens, 2018). The market actually found that buyers had bought most of the firearms they wanted, as evidenced by the slump in sales due to decreased demand.
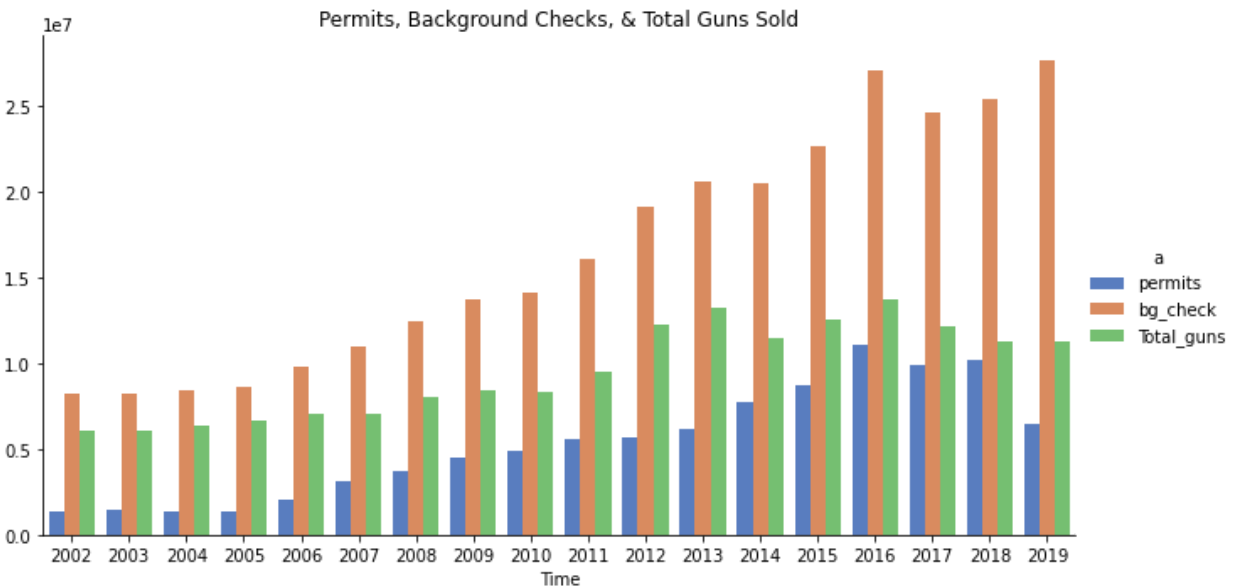
Figure 1

Figure 2 shows two distinct pictures of the different states. On one hand, some states have almost no change in the sales of firearms over time like Wyoming, Montana, and South Carolina. While on the other hand, some states have consistently bought more and more guns like California and Texas. The growth rate of population might explain this behavior, given that more rural states are experiencing a drainage and states like Texas are experiencing an influx of migrants from various states. However, this change in growth rate over time does not explain all the relationships presented in this graph. This suggests that there is something about the different populations that determines the likelihood of the sales of firearms changing.

Different variables are further explored to attempt to single out meaningful variables when it comes to firearm sales per state.

Figure 2

States and Total_arms

Figure 3 shows a pattern that indicates there is some correlation between age and total firearms sold. As the average age increases there is a significant increase in total firearms sold as well. At the same time, some states continue to represent lower sales in relation to their counterparts. This can be seen by data points still present towards the lower end of the graph across all ages.

Although there are some outliers, the overall trend is bell-shaped yet slightly skewed towards the right. The age range of 48 and 50 represents the maximum height of firearm sales. The fact that sales seem to mostly drop after this age range seems to indicate there are one or more variables that are also influencing the variable of interest.

The data also shows that some individuals, despite their aging, do not follow the trend of buying more firearms later in life. This seems to suggest that age is not the only driving factor for this trend.
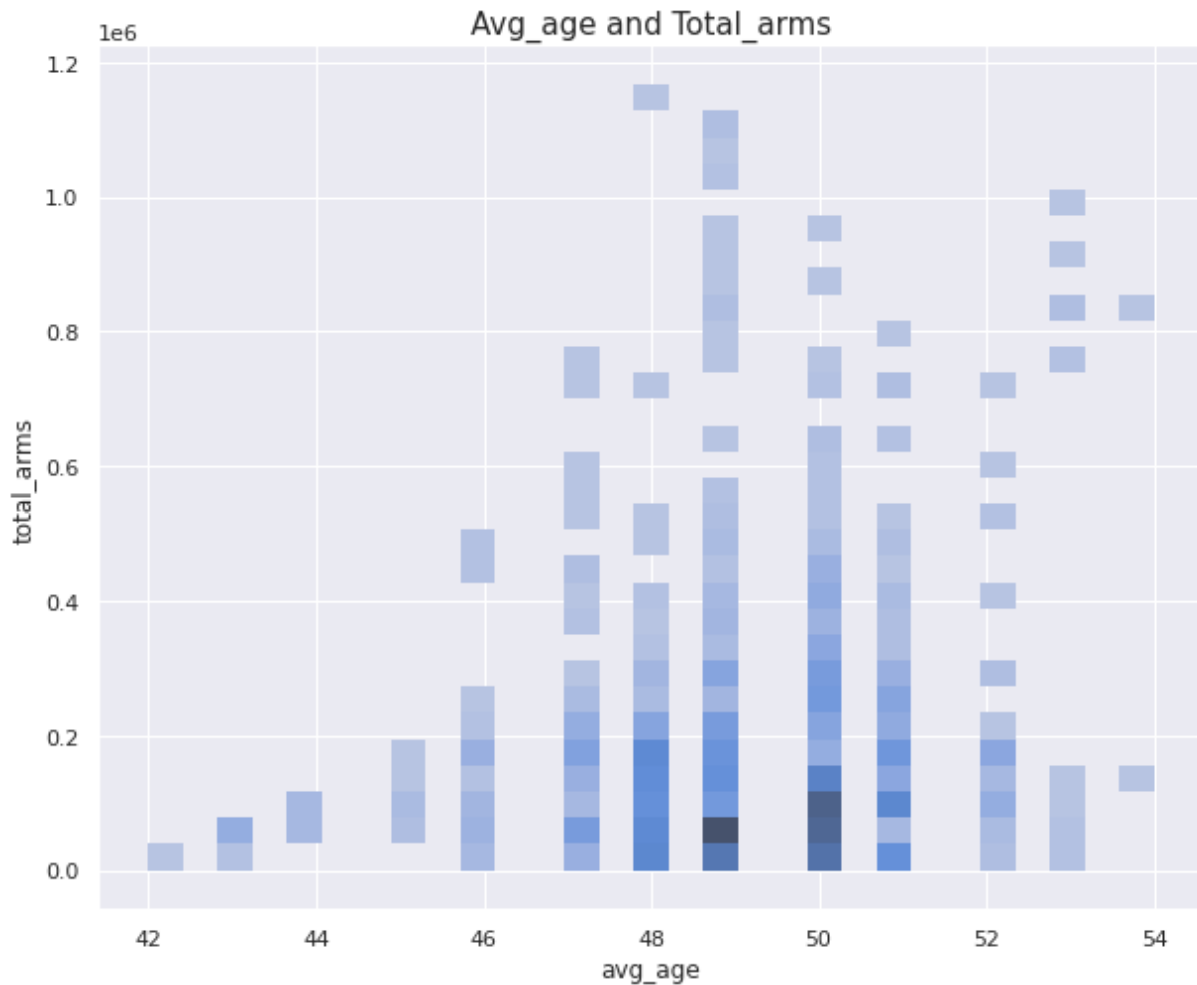
Figure 3

Figure 4 incorporates two different demographic variables and explores their relationship with the sales of firearms per state. The first variable of interest is the urbanization index, which can be found along the x axis. This variable mostly has a positive correlation to the sales of firearms. As states become more urban, they tend to have higher sales of firearms. By adding the second variable of region, we can see which regions represent this pattern. Western and Southern states are the two regions driving this relationship. States in both regions tend to buy more firearms with increased urbanity. This pattern can easily be explained with an increased population.

Conversely, states in the Midwest fittingly represent a cluster in the middle of the graph, not really lending itself to any sort of easily observable pattern. States in the Northeastern region actually decrease their consumption of firearms with increased urbanity.
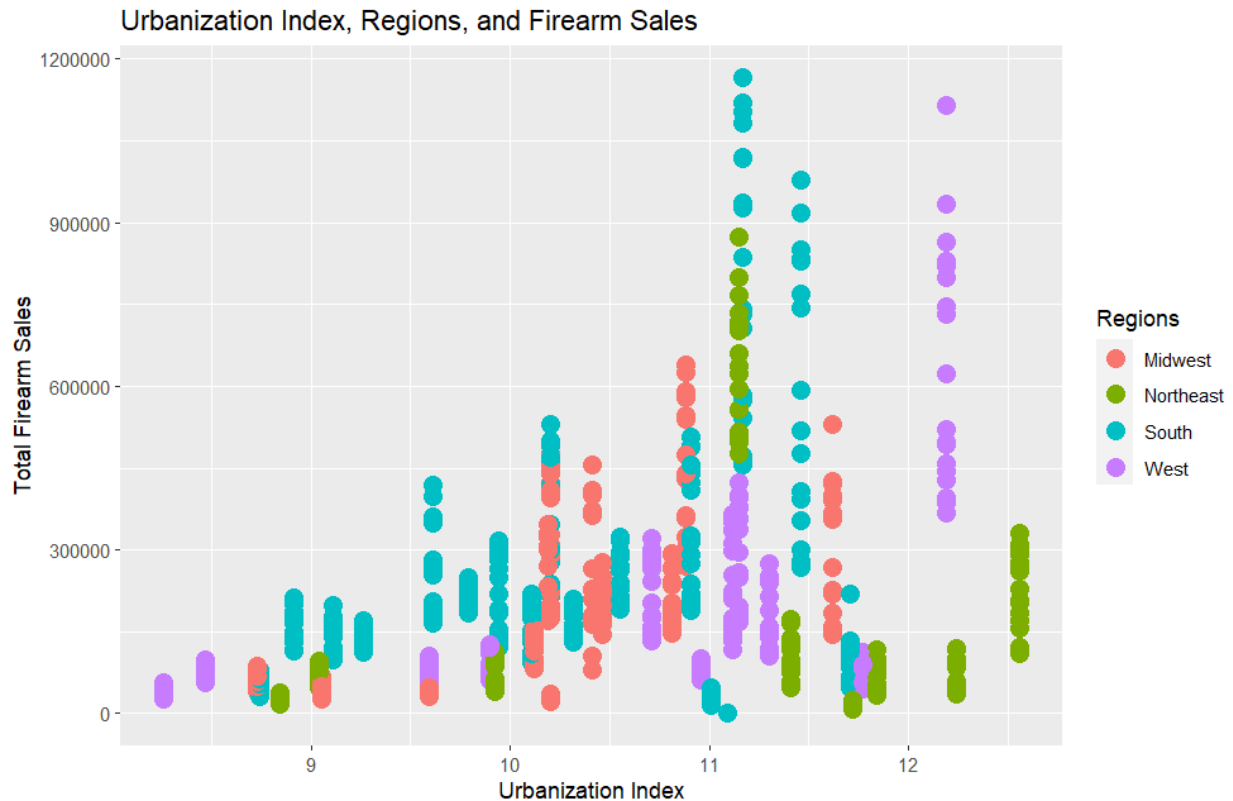
Figure 4

Figure 5 shows a gradual rise in the sales of firearms until the year 2012, where we have our first decrease. The trend continues to rise after this year before another decrease in the year 2016. These trends are correlated with election cycles. This relationship has been observed and researched for many years now (Schneider, 2016) and is nothing new. However, the notable overall increase of the trend over time is likely due to something else.

Schneider suggests anecdotally that buyers have accumulated a certain anxiety or fear that their favorite products might no longer be as readily available. Fears that Hillary Clinton would win the presidential election are one of the main reasons buyers claimed to have increased their consumption of firearms (Schneider, 2016). It might be worthwhile to consider the widespread coverage of firearms in the news and the several bills proposed to limit the ease with which a buyer can obtain a firearm (Givens, et al., 2022) as a reason for the continued increase in sales of firearms, given the anxieties explored by Schneider.
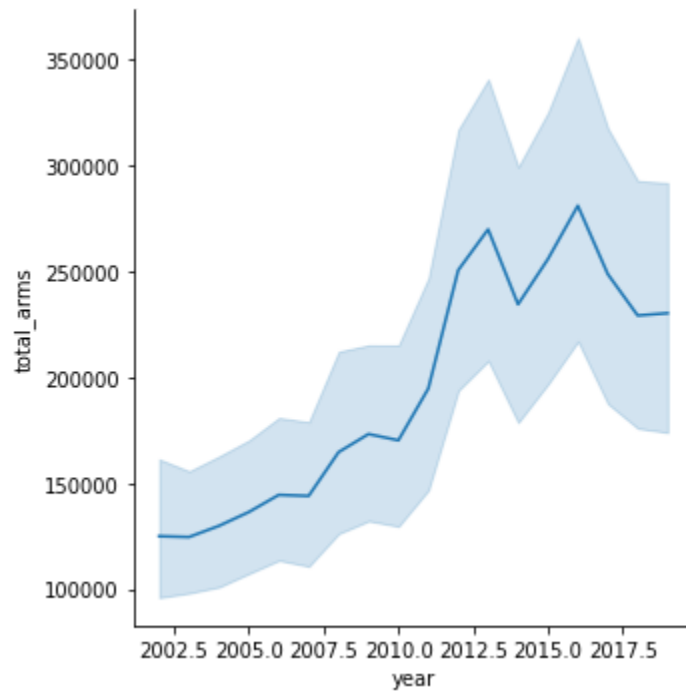
Figure 5

Figure 6 seems to imply that there is a relationship between average income and the number of gun sales. The distribution resembles a bell curve, one whereas income increases in a state, the sales of firearms also increase. However, at some point, this positive correlation reaches a peak, and then it becomes a negative correlation. After pouring through our data, we were able to find a variable that could explain this pattern
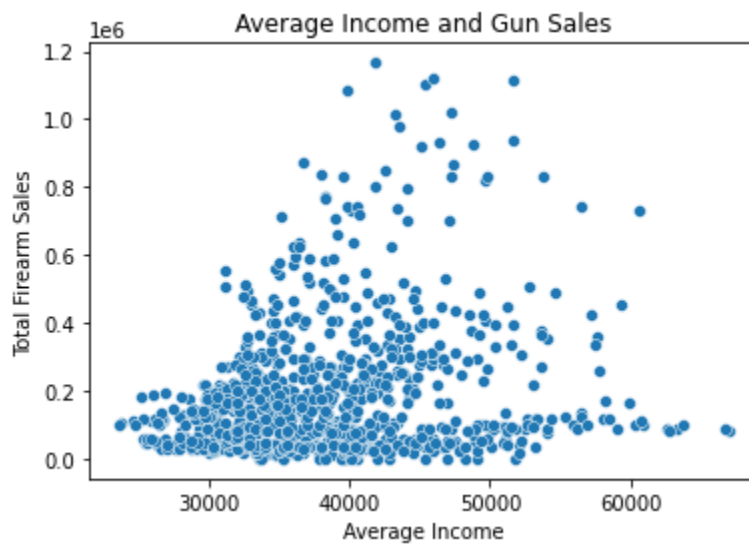
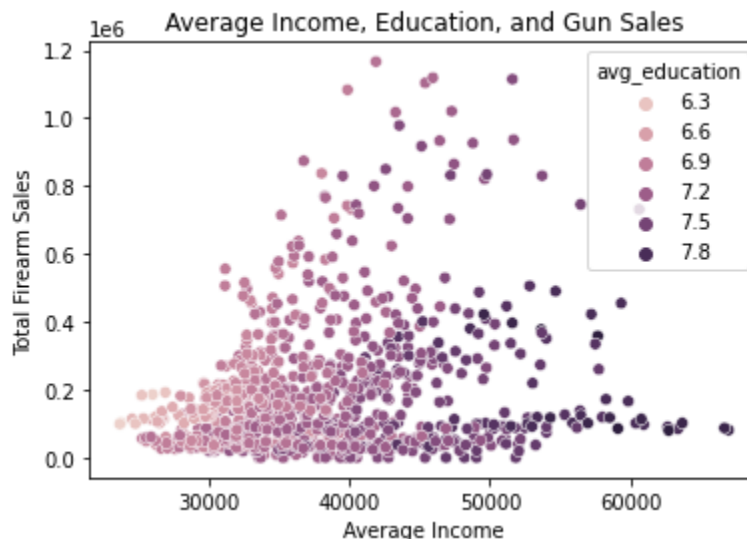Figure 6

Average Income and Gun Sales

Figure 7 introduces the variable of average education. We can now see that states with lower levels of education are on the left side of the graph, which corresponds to lower levels of income. This relationship has been studied and researched deeply by other researchers. The consensus on this relationship is a simple one: with increased education, an individual is more likely to experience an increased income level (Gregorio, 2002). However, this research is beyond the scope of our own, since it doesn't deal with the sales of firearms, permit emissions or background checks conducted.

Keeping the relationship in mind, nonetheless, we can see that total sales appear to be correlated to income levels. Given the cost and level of necessity of firearms, it is no surprise that their sales are correlated to the levels of income in this manner. It is notable that towards the right hand side of the graph sales seem to fall. This would suggest that there are other variables affecting the sales of firearms other than simple acquisitive power. One such variable is that of education.

As education levels grow, the sales of firearms decline. The clustering observed in Figure 7 would suggest that with increased education, buyers obtain more acquisitive power to obtain firearms. However, more educated states decide to spend their income elsewhere, representing the decrease in the right hand side.

Figure 7

Given the impact that average education has on the sales of firearms, we performed further testing and exploration of this variable. Figure 8 traces the sales of firearms over average education and displays a familiar sight. We see a distribution that is similar to a normal distribution. This similarity to the bell curve can be explained by increased income and the associated acquisitive power. But what is it about education that causes the decrease in the right hand side of the graph in Figure 8?

We found that the variable of historical political leaning of the state disentangled this relationship. We see that states that historically vote republican tend to increase their consumption of firearms when they receive more education and attain higher incomes. In contrast, states that tend to vote democratic display the opposite relationship. With increased

education and income, these states tend to buy less firearms. Swing states, often called "purple" states, can be found in the middle of the graph.

Figure 8

Total Firearm Sales, Average Education, and Political Leaning
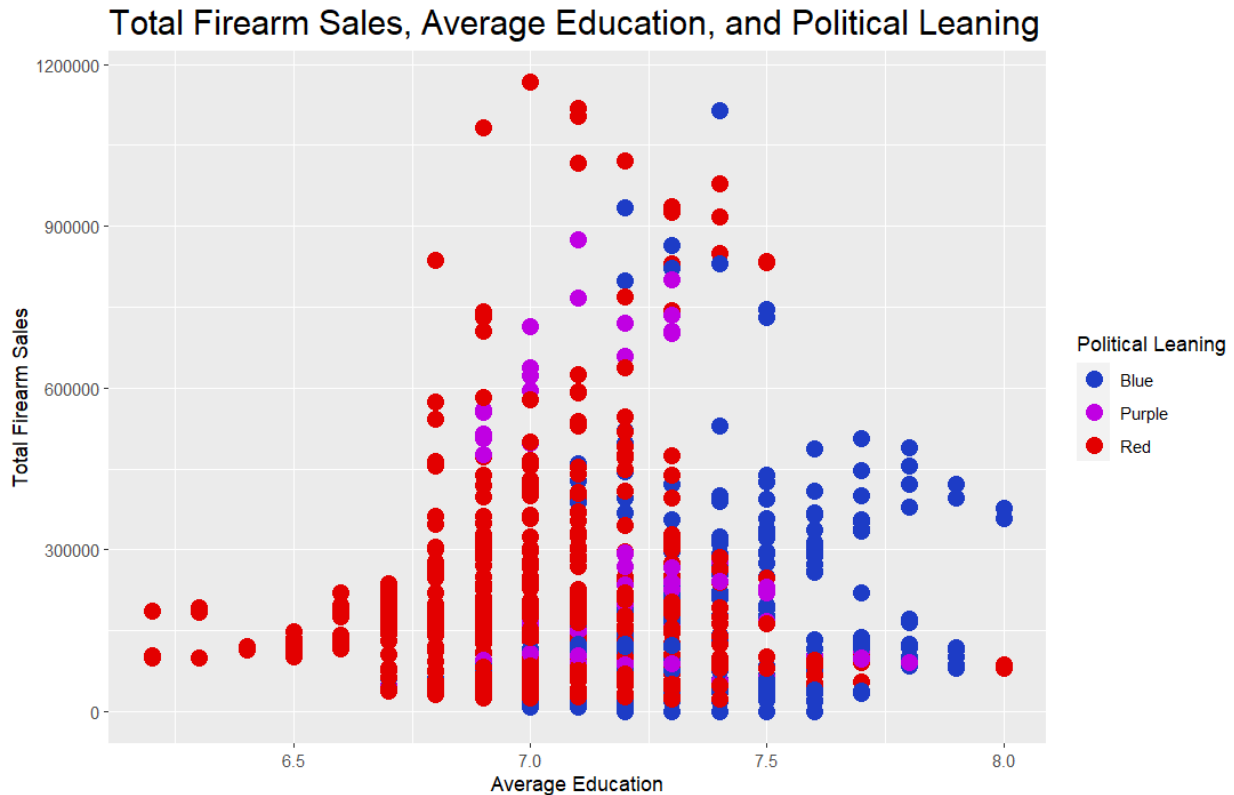
6. Inferences

From our initial data exploration we noticed a number of trends regarding the sales of firearms across different states. Age appeared as the first factor driving the sales of firearms. States with an older average age tended to buy more firearms. However this effect was not seen nationwide as some states were not affected by this trend. So while age drove the sales of firearms in some states, it failed to do so in other states. This suggests there is another variable to explore within this relationship. This variable would most likely be correlated to age, which would explain why it appears that age drives sales in some states but not all.

One assumption we tested was that the explanatory variable of the relationship between age and firearm sales was urbanicity; the assumption being that more rural states tend to have an older population. Nonetheless, placing states in a rural-to-urban spectrum using an urbanization index doesn't provide any further insight to this relationship, as is seen in Figure 4. In fact, we see the opposite relationship, states with higher urbanization scores are responsible for a higher degree of firearm sales. While this might seem counterintuitive, we can explain this relationship by addressing the fact that more urban states tend to have much higher populations than rural states, therefore they would be more likely to have higher sales numbers than less populous states.

Another avenue we tested was that of grouping states by regions, seen in the color variable of Figure 4. By separating the U.S. into four regions, we tested to see if any behaviors were related to geography. It would be reasonable to assume that bordering states would share similar cultures and values, which could explain their attitudes towards gun ownership. However, when controlling for both urbanity and regional breakups, none of these two variables explains the number of gun sales across different states in a clear manner. There are, nevertheless, some observable patterns.

Western states are represented in the entire spectrum of urbanization, and the more urbanized they are the more firearms they tend to buy. Another surprising relationship, this behavior can be explained by the observed tendency that firearm owners have to own multiple firearms (Kalesan, 2015). In a state like California (the more urbanized of the western states) that has very strict firearm laws (Hubler, 2022), perhaps gun owners feel the need to own more firearms than they would without such strict laws. An individual that is influenced by gun culture (Kalesan, 2015) paired with a high individualistic values (Katazyna 2007) could have an overreaction to strict gun laws and acquire even more firearms.

Both the Southern and Midwestern states display low levels of firearm sales in the lower half of the urbanization index. This can be explained by the relationship between average income and firearm sales (lower income levels correspond to lower firearm sales) and the relationship between average income and urbanization (income increased on average with urbanization). The Northeastern states are the only region that show a decrease of sales numbers with increased urbanization, but only after an increase around the middle range of the urbanization index.

So while urbanization, geographical location, and age all only partially explain the number of firearm sales across states we looked for further variables that could disentangle these relationships. Placing firearm sales across average income in Figure 6 yields us something closer to a bell distribution. Intuition would tell us that with higher average income the acquisitive power of an individual grows. With this growth, an individual is more likely to acquire firearms. However, after a certain point, and even with an increased acquisitive power, individuals are then less likely to spend their income on firearms. This relationship points to the fact that there is yet another variable driving this relationship.

After some testing, we determined that the explanatory variable is average education. While we know education and income are correlated variables, Figure 7 demonstrates the effect education has on firearm sales. While some might be tempted to claim that increased education decreases the sales of firearms in a given state, further statistical testing is needed to ascertain the effect of education on the sales of firearms. What we do know is that education is one of the strongest variables correlated to firearm sales.

To further explain this relationship, we placed firearm sales across the spectrum of average education in Figure 8. Here we observe a similar distribution to that of Figure 7, where the data points fall closer to a normal distribution. The last variable we wanted to test was that of political leaning of the state. We can see that Republican states are represented in the first two thirds of the graph and the more educated Republican states show an increased consumption of firearms. This can be explained by the acquisitive power observed in Figure 7.

Democratic states, represented in the top third of the education spectrum, clearly explain the decreased consumption of firearms. It is important to remember that these states are those that have the highest acquisitive power in our dataset, yet they do not engage in the firearm

consumption seen in other states. This is enough evidence to dismiss income as a driving factor for the sale of firearms.

The last political group in Figure 8 are purple states, or swing states. These states, who traditionally do not hold to one political party or often see split tickets in midterm elections, fall predictably in the middle range of this distribution, giving further strength to the claim that education and political ideology might be the biggest determinants of firearm sales.

We can have added certainty of this relationship thanks to Figure 4. Since geographic region and urbanity do not have any incidence in the sales of firearms, we can be sure that political ideology is a big driver of firearm sales.

Culture by its own definition, is the mix and agglomeration of behaviors, demographics, beliefs, geographical factors, and much more. With this definition in mind, it is no surprise that many of our variables show correlation with one another. Nonetheless, we have made an effort to disentangle these relationships to find the two most influential variables. Therefore, according to the research we have conducted we can confidently claim that the two most influential variables for the sale of firearms we observed are that of education and political leaning. While these two variables might in themselves be correlated, it is further evidence of the hardships of attempting to quantify culture.

From our research, we can conclude that education plays a huge role in determining the strength of gun culture in a given state. With more education, an individual gains more acquisitive power, which corresponds to a higher purchasing power and increased likelihood of purchasing firearms in traditionally Republican states. However, in traditionally Democratic states, this increased education corresponds to a decrease in the sales of firearms, even with the increased purchasing power associated with higher levels of average education.

This is why the other important variable in our research is political leaning. Based on anecdotal evidence, we know that the Republican party usually advocates for the protection of firearm rights and often opposes any legislation that would add more steps or barriers to the sales of such items. In opposition, the Democratic party often advocates for more regulation and restrictions to the sale of firearms. Therefore, states that traditionally align with one of these two ideologies display sales figures that are congruent with said principles.

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