Do Firearms Directly Impact Homicide Rates in Brazil?

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***Abstract* — This purpose of this study is to find if there was an impact on the homicide rates in Brazil when the 2003 Disarmament Law was implemented by the government. It consists into an analysis of two datasets containing information about total homicide rates and firearms-only homicide rates in Brazil, from 1979 to 2017, by state. There is information about how the data was handled, prepared and cleaned as well as insights and analysis. Correlation and dependence test, sum of total and firearms-only homicides, graphics of rates and correlations, calculation of mean growth or decay per region and total. Following that, the interpretation of the information pulled from the dataset as well as the conclusion.**

***Index Terms* — Brazilian Homicide Rates, Firearms, Analysis, Disarmament Law**

I. Introduction

Brazil, the biggest Latin American country, known for great crystal-clear beaches, the Amazon forest, great football players and cheerful people is also home to incredibly high crime rate such as robbery, drug-traffic, rape and specially - and unfortunately, homicide. The finality of this analysis is to find out if there was an effect on the homicide rates of Brazil caused by the Brazilian Disarmament Law (Lei 10.826/2003) imposed on 2003 by the president Luiz Inácio Lula da Silva [1], in efforts to minimize the growing murder and violence scenarios in Brazil. This law prohibits civilians of carrying fire weapons, exempting proven needs. While the activity of carrying a weapon is forbidden, the acquisition and registration are not, but certain requisites must be met in order to do so [2]. Brazil is usually known for being one of the most violent countries worldwide. The previous governments, as well as the current one, are always trying new measures to fight against this growing violence but not always they are proven to be effective [3], [4]. The current president Jair Messias Bolsonaro, elected in 2019, has initiated a proposal for changing the current Disarmament Law in favor to facilitate the carrying of firearms by civilians but the results are yet to be seen. This analysis will try to understand relations with homicide rates and firearms in Brazil by analyzing two datasets containing information regarding total homicide rate and firearms only homicide rate, from 1979 to 2017, separated by state. Some of the analysis that will be performed during this report are a comparison per date, specially taking into consideration the Disarmament Law period, which states (and regions) were the most affected positively and negatively, which ones are growing and which ones are decreasing and, most importantly, finding correlation specifically with firearms and non-firearms homicides if either growing or decaying. Following below you will find information about the datasets as well as preparing, cleaning, merging and coding. With that, the insights analysis will be reviewed and a conclusion drawn.

II. Dataset Preparation

In order for this analysis to take place, two datasets were chosen from a Brazilian Government-ruled website named ‘Instituto de Pesquisa Econômica Aplicada (IPEA)’ which provides data for any type of analysis, free of charge. The datasets selected were ‘Homicidios’ [5], which contains homicide rates in Brazil, divided by state, from 1979 to 2017, and ‘Homicidios por Armas de Fogo’ [6], containing same categories of report but only fire-arms related homicides. Both datasets contained 1053 rows and 4 columns each, following the same pattern of report. The presented analysis was performed in R programming language. The data was handled 100% using R Studio and its libraries, which will be mentioned following the report.

With the two datasets in hand, a briefly evaluation of the information quality was taken place, in order to understand what preparation and cleaning had to be done. The columns in both datasets were: ‘cod’, ‘nome’, ‘periodo’ and ‘valor’. The ‘cod’ column is irrelevant for this analysis as it is the state code, ‘nome’ (name) is the state name, ‘periodo’ (period) is the year and ‘valor’ (value) is the total number. After understanding each column and the data, it was decided to merge them into a one single dataset for better handling and visualization. For this project, some libraries had to be installed and are the following: dplyr, ggplot2, ggthemes, DataExplorer, Cairo, tidyverse, lubridate, grid and gridExtra. For full detailed information

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about all the coding and analysis please refer to the Appendix G – R Code.

The first step taken was ordering the datasets by the column ‘State’ in order to avoid mismatch when merging them both. Following that, columns in the two datasets had been renamed to English as: cod, Name, Year, TotalRate (for the ‘homicidios’ dataset and FirearmsRate (for the ‘homicidios-por-armas-de-fogo’ dataset). After the renaming step, the two datasets were merged into one with cbind function and then the irrelevant columns dropped, leaving us with only ‘State’, ‘Year’, ‘TotalRate’ and ‘FirearmsRate’. With the merge done, a new file was saved as ‘Homicides’.

The next step was to check if there were any homicide values of zero and trying to understand if they were really correct of in fact a missing value. There were 19 occurrences of missing values for some homicide rates in the state of TO (Tocantins). In order for the analysis to be precise, the median value of homicides in TO was calculated using the other values populated for this state and then inserted in the missing places. The median was selected instead of mean (average) in order to avoid outliers and make the analysis biased.

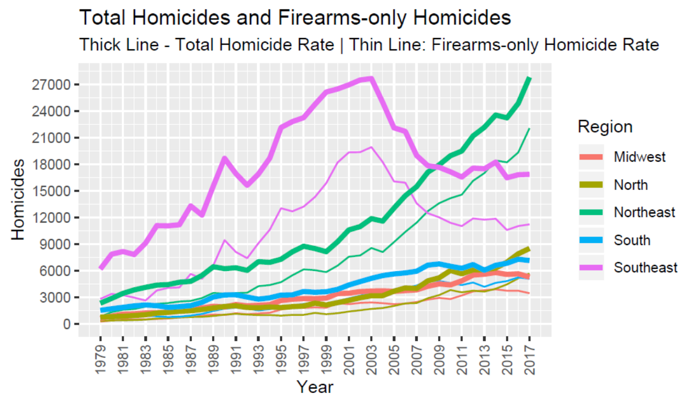
After these steps, the dataset is now cleaned, renamed, organized and has no missing values. The following step was to create subsets for the main five regions in Brazil (North, Northwest, Midwest, Southeast and South), totaling 26 states and 1 federal district. This allowed to have information by region-only, organized by State and Year. Following that, a matrix was created named ‘AllRegions’, containing all 5 regions and summing the homicide and firearms-only homicide rates per region. Then, another 5 subsets were created to separate each region from ‘AllRegions’ results.

With these subsets and matrixes, it was possible to create insights, plots and to extract relevant information from the file, which can be found below in the Insights and Analysis sector.

III. Insights and Analysis

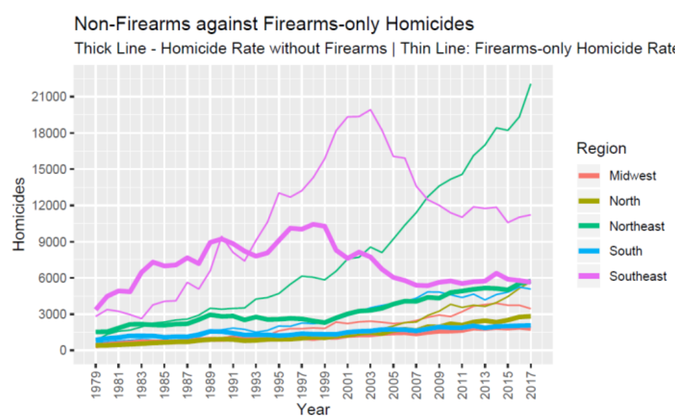
The analysis has started with a correlation and dependence test. This is a short but very important test in this case scenario. It was performed to understand the level of correlation between firearms-only homicides and total homicides. The correlation coefficient value of 0.9528805 was obtained. That means that the correlation dependence between firearms-only homicides and total homicides is very high and positively correlated. The increase of firearms-only homicides follows closely total homicides, indicating that when the homicide rates were increasing along the years, firearms homicides were also growing by almost the same rate, possibly varying on different states and regions.

In order to understand this relation deeper, a graphic was created to illustrate how they correlate to each other.



Higher resolution graphic can be found on Appendix A – Total Homicides and Firearms-only Homicides.

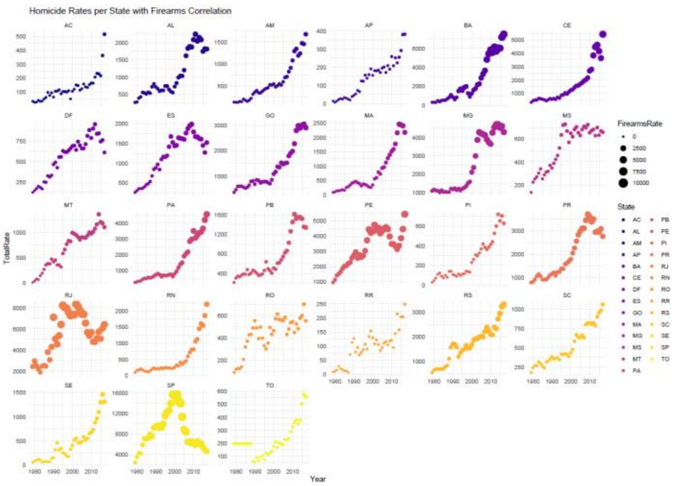
The graphic above shows us the total homicides compared with forearms-only homicides, organized by region and displayed yearly, from 1979 to 2017. As we can observe, the correlation between both is very high. The thicker line represents the total and the thinner firearms-only. When the total number of homicides rise, so does the firearms-only homicide rate and when it declines, so does firearms again, however the total homicides rate includes firearms homicides as well as all the other methods. In the following graphic we are able to see a similar plot but instead of total homicides vs firearms-only, it will be homicide rate without firearms compared with firearms-only, so we can have a better understanding of the real correlation of growth or decay, yearly.



Higher resolution graphic can be found on Appendix B – Non-Firearms Homicides against Firearms-only Homicides.

Now, with this graphic is easier to visualize that in some regions like Southeast and Northeast, the growth of firearms-only homicides is considerably higher than the homicides by other methods. The other regions present a constant slow growth correlation. It is important to highlight that there is a considerable drop in firearms homicides in the Southeast region after 2003, which is when the Disarmament Law was implemented in Brazil. The other regions, however, does not show any improvement and the Northeast region has a dramatic increase after 2003, being the highest index in the whole country. It is also safe to assume that firearms-only homicides are the most common method in all regions, surpassing all other types of homicides (that includes stabbing, strangulation, beat-to-death, etc. combined).

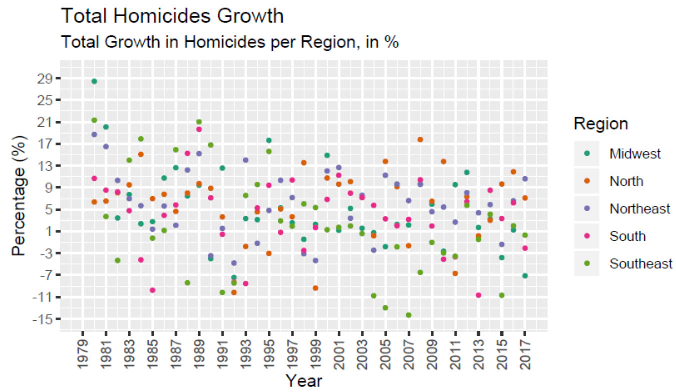
Another point to consider is that some states in Brazil are very populous and others not so much, so that might affect the regional results, which would probably be the case of Southeast region, which contains São Paulo and Rio de Janeiro states, both containing not only the biggest city in the whole Latin America but also Rio de Janeiro city, a notorious place for its favelas and violence. The next graphic addresses some information per state instead of region.



Higher resolution graphic can be found on Appendix C – Homicide Rates per State with Firearms Correlation.

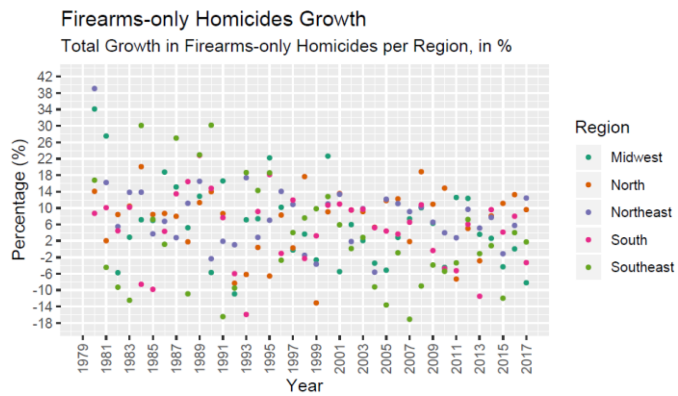
As we can observe above, this graphic shows the total homicides plotted, yearly. The circles (and their sizes) on the graphics represent the firearms homicides in correlation with the total rate, so we can understand the impact of firearms in the total rate as well as the 2003 Disarmament Law impact per state, if any. Some states like SP, RJ, PE, MT and RO seem to have had a decline in total homicide rates after 2003. While we can observe a lower homicide rate, the firearms rate seems to remain reasonably equal amongst them, indicating that maybe this decline might have no relation with the Disarmament Law. Some other states have rising homicides rate with also rising of firearms related incidents, like AL, AM, BA, CE, GO, MA, MG, PA, PB and RS. Some other states, although rising in homicides, seem to have no considerable rising in firearms-only incidents, like AC, AP, MS, RR, PI, SE, SC and TO. Lastly, some states seem to have a decline in total homicides, like DF, ES, PR, and SP.

A good way to understand better the current scenario is to calculate the average growth or decay, which would give us some number figures, therefore a more precise method of evaluation.



Higher resolution graphic can be found on Appendix D – Total Homicides Growth.

This graphic shows the percentage of growth or decay in the total homicide rates, where every rate is compared with the previous year. It is grouped and colored by region for better understanding.



Higher resolution graphic can be found on Appendix E – Firearms-only Homicides Growth.

The above graphic shows the percentage of growth or decay only for firearms related homicides, where every rate is compared with the previous year. It is also grouped and colored by region for better understanding. According to the graphics, the inconsistence of growth and/or decay between regions is constant, where some years they go up for a few percent and in some others, they go down. Considering the 2003 mark, it is also difficult to say that the Disarmament Law had any long-term impact in the rates.

	Region	Total Homicides Growth Difference (%)	Total Firearms-Only Homicides Growth Difference (%)
1	Midwest	2.57	3.64
2	North	-2.40	-4.10
3	Northeast	-0.83	0.12
4	Southeast	7.80	10.95
5	South	2.60	4.47

Higher resolution graphic can be found on Appendix F – Difference Between Growth Rates Before and After 2003.

Lastly, this small table brings information in regards to effects of the Disarmament Law. The numbers are the difference in percentage before and after 2003, divided by Total Homicides and Firearms-only Homicides. As we can see on the numbers, the Midwest, Northeast, Southeast and South regions have a positive percentage on the firearms-only homicides, meaning that comparing what the scenario was before 2003 and after, it has gotten worse. The North region, however, has improved slightly. In terms of total homicides, the North and Northeast had improved slightly where the Midwest, Southeast and South regions have gotten higher numbers. In order to calculate this table, all the regions were calculated yearly. The results per region are shown on the graphics above. The actual numbers for all regions are not being displayed in the report due to its size but they can be obtained by running the R code found in the Appendix G – R Code.

IV. Conclusion

It is difficult to draw a conclusion in this matter. While some states had shown a decrease of firearm homicides after the Disarmament Law, the rates tend to start going up again, with exception of São Paulo (SP) state but we cannot state that this is due to the implemented law. There are a lot of another external factors that might have affected this result, such as police enforcement changes, economic situation, politics and so on. This analysis is not taking into consideration any other possible factors that might impact homicide rates. More research has to be done in this matter in order to have deeper understanding on the subject. What are the direct and indirect influences on homicides? Education, economics, law enforcement, juridical system and more.

Unfortunately, the homicide rates are very high and still rising and it is improbable that the scenario will change in the short term.

References

[1] Legislação [Internet]. Portal da Câmara dos Deputados. [cited 2019Nov29]. Available from: https://www2.camara.leg.br/legin/fed/lei/2003/lei-10826-22-dezembro-2003-490580-publicacaooriginal-1-pl.html

[2] Estatuto do Desarmamento [Internet]. Wikipedia. Wikimedia Foundation; 2019 [cited 2019Nov29]. Available from: https://pt.wikipedia.org/wiki/Estatuto_do_Desarmamento

[3] United Nations. Brazil: Crime situation, including organized crime; police and state response, including effectiveness; state protection for witnesses and victims of crime (2009-Oct. 2012) [Internet]. Refworld. [cited 2019Nov29]. Available from: https://www.refworld.org/docid/50bf2c812.html

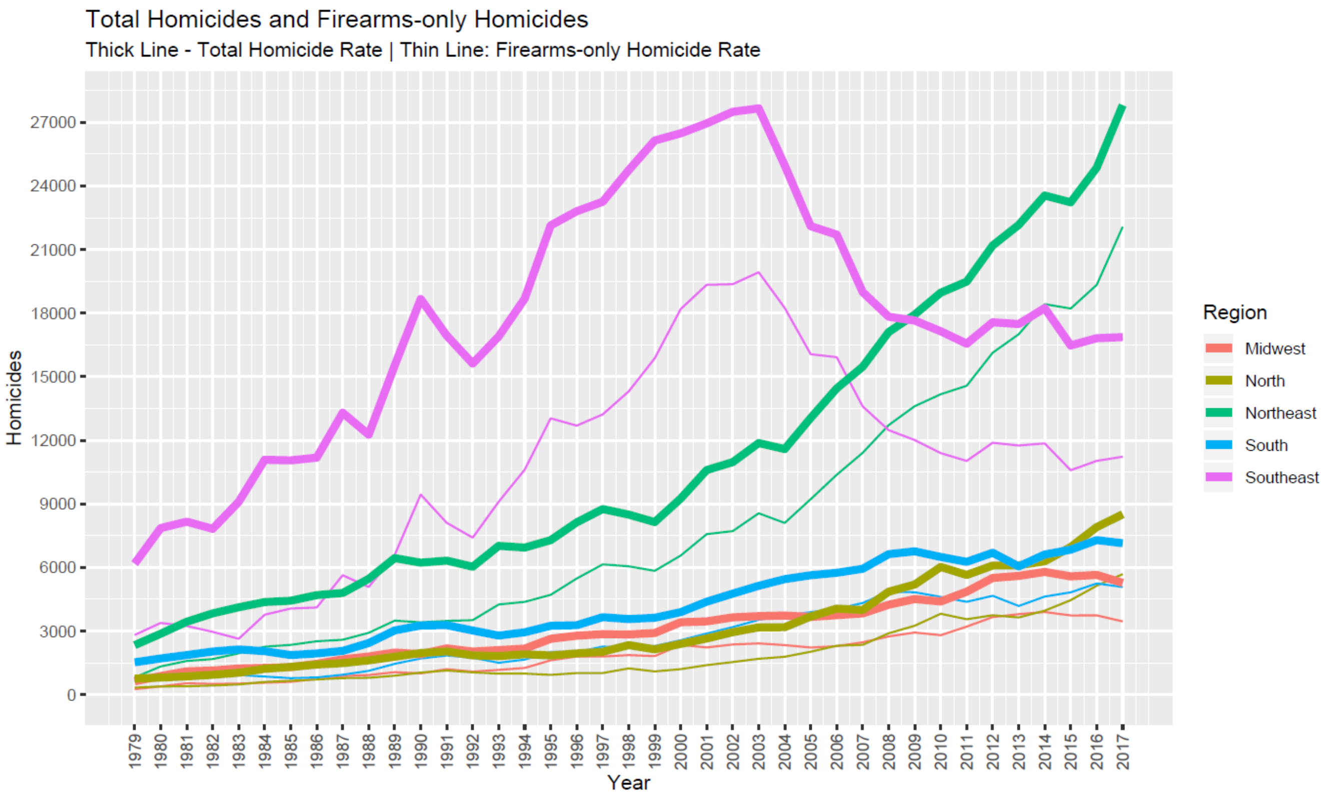
[4] Brazil suffers record murder tally in 2017, ahead of election [Internet]. Reuters. Thomson Reuters; 2018 [cited 2019Nov29]. Available from: https://www.reuters.com/article/us-brazil-violence-murder/brazil-suffers-record-murder-tally-in-2017-ahead-of-election-idUSKBN1KU2R5

[5] Atlas da Violencia: Homicidios Total - Mapa [Internet]. ipea. [cited 2019Dec11]. Available from: http://www.ipea.gov.br/atlasviolencia/dados-series/17

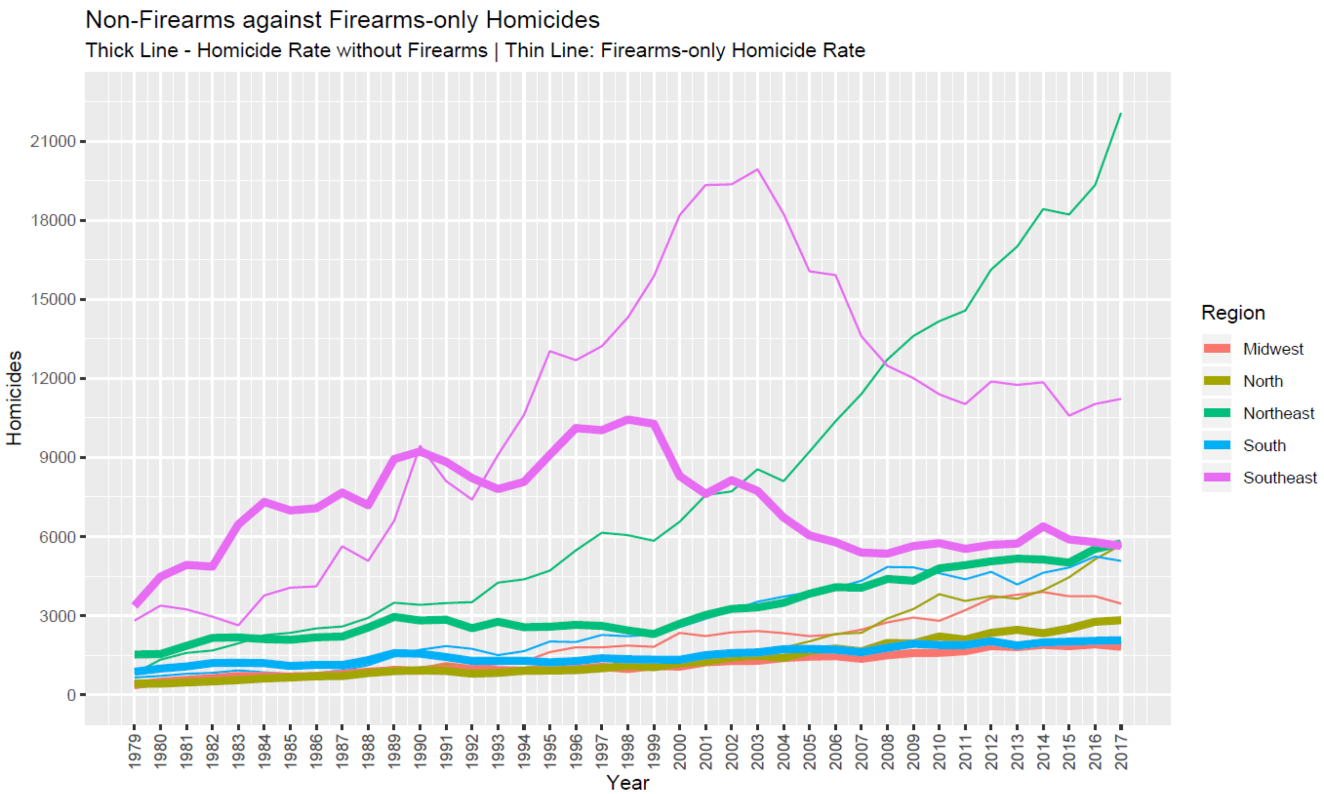
[6] Atlas da Violencia: Homicidios Armas Fogo - Mapa [Internet]. ipea. [cited 2019Dec11]. Available from: http://www.ipea.gov.br/atlasviolencia/dados-series/31

APPENDIX

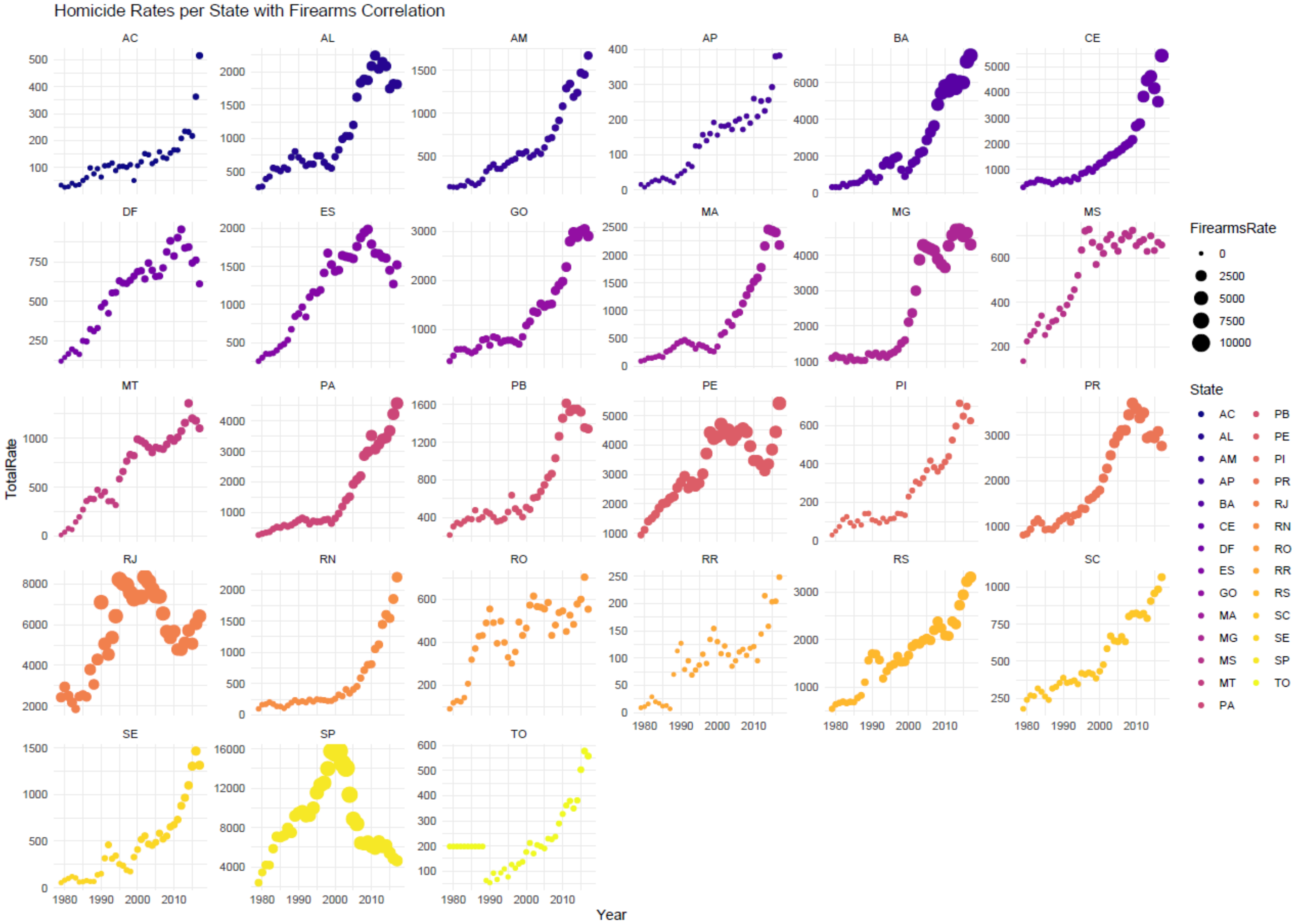
Appendix A - Total Homicides and Firearms-only Homicides



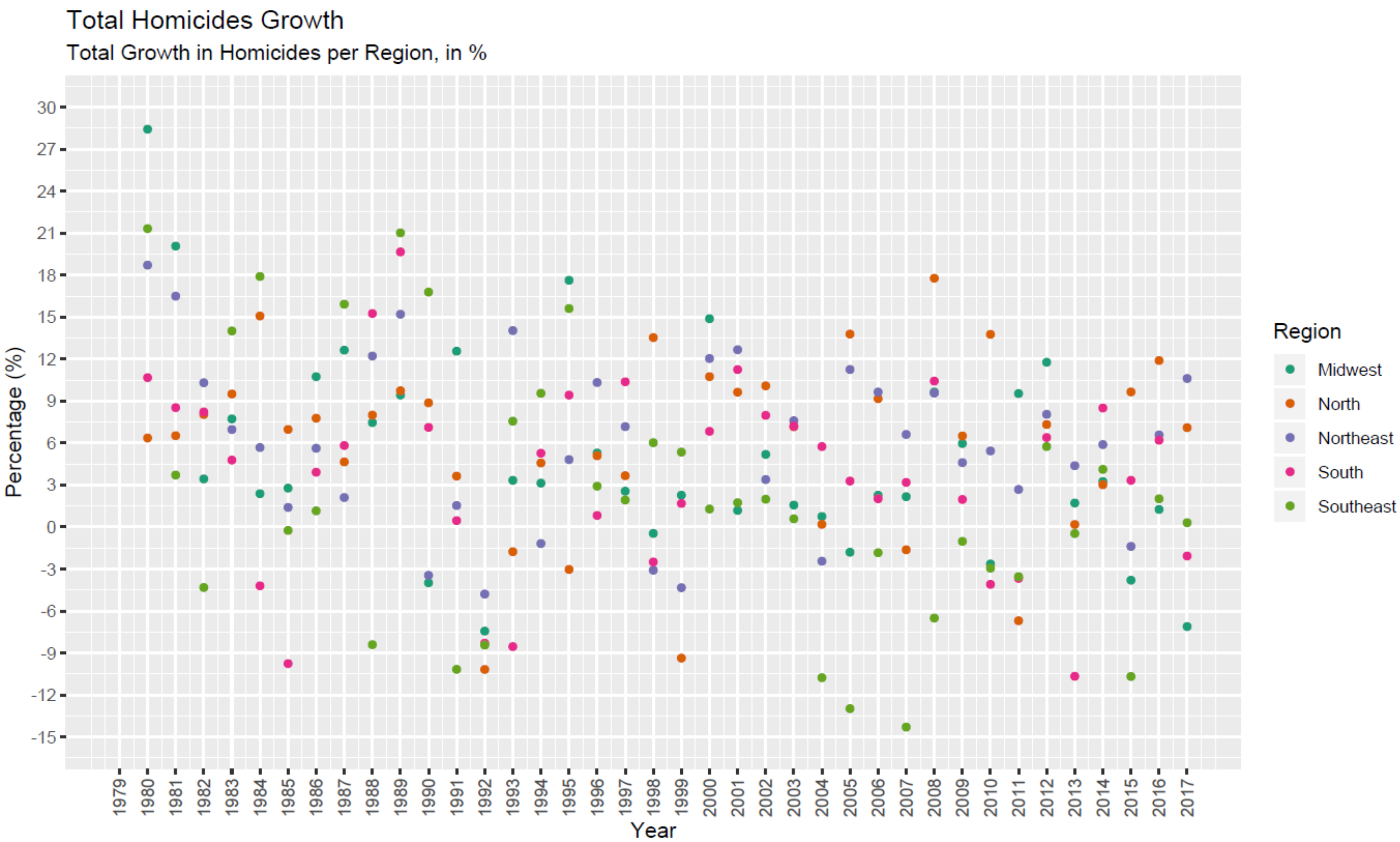
Appendix B - Non-Firearms Homicides against Firearms-only Homicides



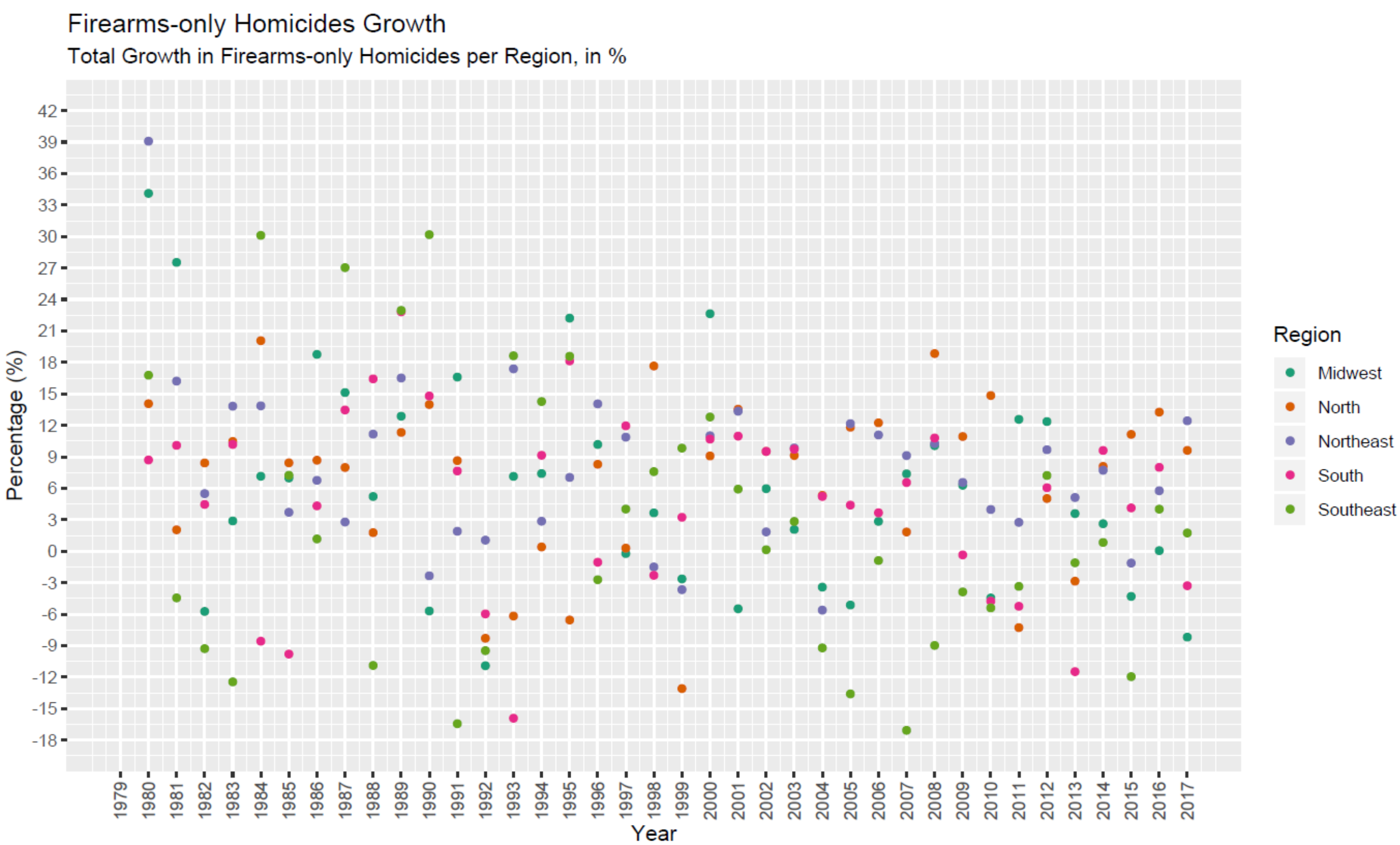
Appendix C - Homicide Rates per State with Firearms Correlation



Appendix D - Total Homicides Growth



Appendix E - Firearms-only Homicides Growth



Appendix F - Difference Between Growth Rates Before and After 2003

	Region	Total Homicides Growth Difference (%)	Total Firearms-Only Homicides Growth Difference (%)
1	Midwest	2.57	3.64
2	North	-2.40	-4.10
3	Northeast	-0.83	0.12
4	Southeast	7.80	10.95
5	South	2.60	4.47

Appendix G - R Code

```
###### Required Libraries ######

# Installing
install.packages('dplyr')
install.packages('ggplot2')
install.packages('ggthemes')
install.packages('DataExplorer')
install.packages('Cairo')
install.packages('tidyverse', dependencies=T)
install.packages('lubridate')
install.packages('gridExtra')
install.packages('grid')

# Running
library('dplyr')
library('ggplot2')
library('ggthemes')
library('DataExplorer')
library('Cairo')
library('tidyverse')
library('lubridate')
library('gridExtra')
library('grid')

###### Setting working directory ######
setwd("C:/Users/%username%/Desktop")

###### Opening the databases ######
total <- read.csv(file="homicidios.csv", head=TRUE, sep=",")
armas <- read.csv(file="homicidios-por-armas-de-fogo.csv", head=TRUE, sep=",")


###### > CLEANING DATASET < ######

###### First Look ######
head(Homicides)
nrow(Homicides)
summary(Homicides)

###### Ordering Columns by State ######
total <- total[order(total[,'nome']), ]
armas <- armas[order(armas[,'nome']), ]
```

```
###### Renaming columns ######
total <- total %>% rename('cod1' = 'cod', 'State' = 'nome', 'Year' = 'período', 'TotalRate' = 'valor')
armas <- armas %>% rename('cod2' = 'cod', 'Name2' = 'nome', 'Year2' = 'período', 'FirearmsRate' = 'valor')

###### Binding Datasets Together ######
combined <- cbind(total, armas)
print(combined)

###### Dropping Irrelevant Columns ######
Homicides <- select (combined,-c(cod1, cod2, Name2, Year2))
head(Homicides)

###### Saving Merged Files ######
write.csv(Homicides, file="Homicides.csv", row.names=FALSE)

###### Checking 'Zero' Values ######
Homicides[Homicides$TotalRate == 0,]
Homicides[Homicides$FirearmsRate == 0,]

###### Subseting TO State to Calculate Median From Populated Values ######
TOstateTotal <- Homicides$TotalRate[c(1025:1053)]
print(TOstateTotal)
TOstateArms <- Homicides$FirearmsRate[c(1025:1053)]
print(TOstateArms)

###### Calculating mMdian Number for TO State [Total and Firearms Rates] ######
ArmsMedian <- median(TOstateArms)
TotalMedian <- median(TOstateTotal)

###### Replacing 0 values from TO state to TO Median value ######
Homicides$TotalRate[c(1015:1024)] <- TotalMedian
Homicides$FirearmsRate[c(1015:1024)] <- ArmsMedian

###### Saving Cleaned Unique Dataset to Store Changes ######
write.csv(Homicides, file="Homicides.csv", row.names=FALSE)

###### Creating Regional Subsets ######
# States by Region
North <- subset(Homicides, State == 'AM' | State == 'RR'| State == 'AP' | State == 'PA' | State == 'TO' | State == 'RO' | State ==
'AC')
Northeast <- subset(Homicides, State == 'MA' | State == 'PI'| State == 'CE' | State == 'RN' | State == 'PE' | State == 'PB' | State ==
'SE' | State == 'AL' | State == 'BA')
Midwest <- subset(Homicides, State == 'MT' | State == 'MS'| State == 'GO'| State == 'DF')
Southeast <- subset(Homicides, State == 'SP' | State == 'RJ'| State == 'ES'| State == 'MG')
South <- subset(Homicides, State == 'PR' | State == 'RS'| State == 'SC')

# Regions by State
AllRegions <- Homicides %>%
  mutate(Region = case_when(
    State == 'AM' | State == 'RR'| State == 'AP' | State == 'PA' | State == 'TO' | State == 'RO' | State == 'AC' ~ "North",
    State == 'MA' | State == 'PI'| State == 'CE' | State == 'RN' | State == 'PE' | State == 'PB' | State == 'SE' | State == 'AL' | State ==
'BA' ~ "Northeast",
    State == 'SP' | State == 'RJ'| State == 'ES'| State == 'MG' ~ 'Southeast',
    State == 'PR' | State == 'RS'| State == 'SC' ~ 'South',
    State == 'MT' | State == 'MS'| State == 'GO'| State == 'DF' ~ "Midwest")) %>%
  group_by(Region, Year) %>%
  summarize(TotalHomicides = sum(TotalRate), FirearmsHomicides = sum(FirearmsRate))
```

```
# Total Yearly by Region
NorthTotal <- subset(AllRegions, Region == 'North')
NortheastTotal <- subset(AllRegions, Region == 'Northeast')
MidwestTotal <- subset(AllRegions, Region == 'Midwest')
SoutheastTotal <- subset(AllRegions, Region == 'Southeast')
SouthTotal <- subset(AllRegions, Region == 'South')


###### > INSIGHTS AND ANALYSIS < ######

###### Insight 1 ######

# Correlation Between Total Homicides and Firearms Homicides
HomicidesCorrelation <- cor(Homicides$TotalRate,Homicides$FirearmsRate)
print(HomicidesCorrelation)


###### Insight 2 ######

# Plot 1 - Total Homicides and Firearms-only Homicides Compared
PLOT1 <- ggplot(AllRegions, aes(x = Year, y = TotalHomicides, color = Region)) +
  geom_line(aes(x=Year,y=FirearmsHomicides))+
  geom_line(size = 2) +
  ylab('Homicides') +
  scale_x_continuous(breaks = seq(1979, 2017, 1),
                     limits=c(1979, 2017)) +
  scale_y_continuous(breaks = seq(0, 28000, 3000),
                     limits=c(0, 28000)) +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5)) + # angled year text
  ggtitle("Total Homicides and Firearms-only Homicides", subtitle = "Thick Line - Total Homicide Rate | Thin Line: Firearms-only Homicide Rate")

# Saving Plot 1
ggsave(PLOT1, filename = "plot1.pdf",
       width = 10, height = 6, device = cairo_pdf)

# Plot 2 - Non-Firearms against Firearms-only Homicides Compared
PLOT2 <- ggplot(AllRegions, aes(x = Year, y = TotalHomicides-FirearmsHomicides, color = Region)) +
  geom_line(aes(x=Year,y=FirearmsHomicides))+
  geom_line(size = 2) +
  ylab('Homicides') +
  scale_x_continuous(breaks = seq(1979, 2017, 1),
                     limits=c(1979, 2017)) +
  scale_y_continuous(breaks = seq(0, 22500, 3000),
                     limits=c(0, 22500)) +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5)) + # angled year text
  ggtitle("Non-Firearms against Firearms-only Homicides", subtitle = "Thick Line - Homicide Rate without Firearms | Thin Line: Firearms-only Homicide Rate")

# Saving Plot 2
ggsave(PLOT2, filename = "plot2.pdf",
       width = 10, height = 6, device = cairo_pdf)
```

```
###### Insight 3 ######

# Plot 3 - Correlation plot between Total Rate and Firearms
PLOT3 <- ggplot(Homicides) +
  aes(x = Year, y = TotalRate, colour = State, size = FirearmsRate) +
  geom_point() +
  scale_color_viridis_d(option = "plasma") +
  theme_minimal() +
  facet_wrap(vars(State), scales = "free_y") +
  ggtitle("Homicide Rates per State with Firearms Correlation")

# Saving plot 3
ggsave(PLOT3, filename = "plot3.pdf",
       width = 14, height = 10, device = cairo_pdf)

###### Insight 4 ######

# Percentage Growth by Region and mean calculation before and after 2003

## MIDWEST ##

# Midwest Total
MWHomicidesGrowth = MidwestTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = TotalHomicides - lag(TotalHomicides),
         Rate_percent = (Diff_growth / Diff_year)/TotalHomicides * 100)
# Mean Total Growth Before and After 2003
MWTB2003 <- mean(MWHomicidesGrowth$Rate_percent[MWHomicidesGrowth$Year>=1988 & MWHomicidesGrowth$Year<=2002])
MWTA2003 <- mean(MWHomicidesGrowth$Rate_percent[MWHomicidesGrowth$Year>=2003 & MWHomicidesGrowth$Year<=2017])
# Midwest Firearms Only
MWFirearmsGrowth = MidwestTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = FirearmsHomicides - lag(FirearmsHomicides),
         Rate_percent = (Diff_growth / Diff_year)/FirearmsHomicides * 100)
# Mean Firearms Growth Before and After 2003
MWFB2003 <- mean(MWFirearmsGrowth$Rate_percent[MWFirearmsGrowth$Year>=1988 & MWFirearmsGrowth$Year<=2002])
MWFA2003 <- mean(MWFirearmsGrowth$Rate_percent[MWFirearmsGrowth$Year>=2003 & MWFirearmsGrowth$Year<=2017])

## NORTH ##

# North Total
NOHomicidesGrowth = NorthTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = TotalHomicides - lag(TotalHomicides),
         Rate_percent = (Diff_growth / Diff_year)/TotalHomicides * 100)
# Mean Total Growth Before and After 2003
NOTB2003 <- mean(NOHomicidesGrowth$Rate_percent[NOHomicidesGrowth$Year>=1988 & NOHomicidesGrowth$Year<=2002])
NOTA2003 <- mean(NOHomicidesGrowth$Rate_percent[NOHomicidesGrowth$Year>=2003 & NOHomicidesGrowth$Year<=2017])
# North Firearms Only
NOFirearmsGrowth = NorthTotal %>%
  arrange(Year) %>%
```

```
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = FirearmsHomicides - lag(FirearmsHomicides),
         Rate_percent = (Diff_growth / Diff_year)/FirearmsHomicides * 100)
# Mean Firearms Growth Before and After 2003
NOFB2003 <- mean(NOFirearmsGrowth$Rate_percent[NOFirearmsGrowth$Year>=1988 & NOFirearmsGrowth$Year<=2002])
NOFA2003 <- mean(NOFirearmsGrowth$Rate_percent[NOFirearmsGrowth$Year>=2003 & NOFirearmsGrowth$Year<=2017])

## NORTHEAST ##

# Northeast Total
NEHomicidesGrowth = NortheastTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = TotalHomicides - lag(TotalHomicides),
         Rate_percent = (Diff_growth / Diff_year)/TotalHomicides * 100)
# Mean Total Growth Before and After 2003
NETB2003 <- mean(NEHomicidesGrowth$Rate_percent[NEHomicidesGrowth$Year>=1988 &
NEHomicidesGrowth$Year<=2002])
NETA2003 <- mean(NEHomicidesGrowth$Rate_percent[NEHomicidesGrowth$Year>=2003 &
NEHomicidesGrowth$Year<=2017])
# Northeast Firearms Only
NEFirearmsGrowth = NortheastTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = FirearmsHomicides - lag(FirearmsHomicides),
         Rate_percent = (Diff_growth / Diff_year)/FirearmsHomicides * 100)
# Mean Firearms Growth Before and After 2003
NEFB2003 <- mean(NEFirearmsGrowth$Rate_percent[NEFirearmsGrowth$Year>=1988 & NEFirearmsGrowth$Year<=2002])
NEFA2003 <- mean(NEFirearmsGrowth$Rate_percent[NEFirearmsGrowth$Year>=2003 & NEFirearmsGrowth$Year<=2017])

## SOUTHEAST ##

# Southeast Total
SEHomicidesGrowth = SoutheastTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = TotalHomicides - lag(TotalHomicides),
         Rate_percent = (Diff_growth / Diff_year)/TotalHomicides * 100)
# Mean Total Growth Before and After 2003
SETB2003 <- mean(SEHomicidesGrowth$Rate_percent[SEHomicidesGrowth$Year>=1988 &
SEHomicidesGrowth$Year<=2002])
SETA2003 <- mean(SEHomicidesGrowth$Rate_percent[SEHomicidesGrowth$Year>=2003 &
SEHomicidesGrowth$Year<=2017])
# Southeast Firearms Only
SEFirearmsGrowth = SoutheastTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = FirearmsHomicides - lag(FirearmsHomicides),
         Rate_percent = (Diff_growth / Diff_year)/FirearmsHomicides * 100)
# Mean Firearms Growth Before and After 2003
SEFB2003 <- mean(SEFirearmsGrowth$Rate_percent[SEFirearmsGrowth$Year>=1988 & SEFirearmsGrowth$Year<=2002])
SEFA2003 <- mean(SEFirearmsGrowth$Rate_percent[SEFirearmsGrowth$Year>=2003 & SEFirearmsGrowth$Year<=2017])

## SOUTH ##

# South Total
SOHomicidesGrowth = SouthTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
         Diff_growth = TotalHomicides - lag(TotalHomicides),
```

```
        Rate_percent = (Diff_growth / Diff_year)/TotalHomicides * 100)
# Mean Total Growth Before and After 2003
SOTB2003 <- mean(SOHomicidesGrowth$Rate_percent[SOHomicidesGrowth$Year>=1988 & SOHomicidesGrowth$Year<=2002])
SOTA2003 <- mean(SOHomicidesGrowth$Rate_percent[SOHomicidesGrowth$Year>=2003 & SOHomicidesGrowth$Year<=2017])
# South Firearms Only
SOFirearmsGrowth = SouthTotal %>%
  arrange(Year) %>%
  mutate(Diff_year = Year - lag(Year),
        Diff_growth = FirearmsHomicides - lag(FirearmsHomicides),
        Rate_percent = (Diff_growth / Diff_year)/FirearmsHomicides * 100)
# Mean Firearms Growth Before and After 2003
SOFB2003 <- mean(SOFirearmsGrowth$Rate_percent[SOFirearmsGrowth$Year>=1988 & SOFirearmsGrowth$Year<=2002])
SOFA2003 <- mean(SOFirearmsGrowth$Rate_percent[SOFirearmsGrowth$Year>=2003 & SOFirearmsGrowth$Year<=2017])


# Creating Variables to Combine into a Dataframe for a Total
Region <- c('Midwest', 'North', 'Northeast', 'Southeast', 'South')
TotalGrowthDif <- c(MWTB2003-MWTA2003, NOTB2003-NOTA2003, NETB2003-NETA2003, SETB2003-SETA2003, SOTB2003-SOTA2003)
TotalGrowthDif <- round(TotalGrowthDif, digits = 2)
GunsGrowthDif <- c(MWFB2003-MWFA2003, NOFB2003-NOFA2003, NEFB2003-NEFA2003, SEFB2003-SEFA2003, SOFB2003-SOFA2003)
GunsGrowthDif <- round(GunsGrowthDif, digits = 2)

# Creating Dataframe with Results
GrowthDifferencePerRegion <- data.frame(Region,TotalGrowthDif,GunsGrowthDif)
colnames(GrowthDifferencePerRegion) <- c("Region", "Total Homicides\nGrowth Difference (%)",  "Total Firearms-Only Homicides\nGrowth Difference (%)")

# Ploting Results
GrowthDifferenceTable <- grid.table(GrowthDifferencePerRegion)

# Saving Table
ggsave(grid.table(GrowthDifferencePerRegion), filename="GrowthDifferencePerRegion.png")

# Combining all Firearm Growth Results
FirearmsGrowthAllRegions <- rbind(MWFirearmsGrowth, NOFirearmsGrowth, NEFirearmsGrowth, SOFirearmsGrowth, SEFirearmsGrowth)

# Combining all Total Growth Results
TotalGrowthAllRegions <- rbind(MWHomicidesGrowth, NOHomicidesGrowth, NEHomicidesGrowth, SOHomicidesGrowth, SEHomicidesGrowth)

# Plot 4 -  Firearms Growth Results

PLOT4 <- ggplot(FirearmsGrowthAllRegions) +
  aes(x = Year, y = Rate_percent, colour = Region) +
  geom_point(size = 1.5) +
  scale_x_continuous(breaks = seq(1979, 2017, 1),
                    limits=c(1979, 2017)) +
  scale_y_continuous(breaks = seq(-18, 42, 3),
                    limits=c(-18, 42)) +
  scale_color_brewer(palette = "Dark2") +
  labs(x = "Year", y = "Percentage (%)", title = "Firearms-only Homicides Growth", subtitle = "Total Growth in Firearms-only Homicides per Region, in %") +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5))

# Saving Plot 4
```

```
ggsave(PLOT4, filename = "plot4.pdf",
       width = 10, height = 6, device = cairo_pdf)

# Plot 5 - Total Growth Results

PLOT5 <- ggplot(TotalGrowthAllRegions) +
  aes(x = Year, y = Rate_percent, colour = Region) +
  geom_point(size = 1.5) +
  scale_x_continuous(breaks = seq(1979, 2017, 1),
                     limits=c(1979, 2017)) +
  scale_y_continuous(breaks = seq(-15, 30, 3),
                     limits=c(-15, 30)) +
  scale_color_brewer(palette = "Dark2") +
  labs(x = "Year", y = "Percentage (%)", title = "Total Homicides Growth", subtitle = "Total Growth in Homicides per Region, in
%") +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5))

# Saving Plot 5
ggsave(PLOT5, filename = "plot5.pdf",
       width = 10, height = 6, device = cairo_pdf)
```