Regulation and Gun Homicide in the U.S.

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Abstract: This study focuses on the effects of regulation on gun homicide in the United States. We gathered data on homicides and gun regulations in different states and performed tests to see whether gun regulation, in the form of mandatory permits and registration, had an effect on gun homicide rates. We obtained mixed results about the significance of effects of regulation on the gun homicide rate. In addition, we sought to produce a model for predicting gun homicide rates based on regulation as well as other influential factors.

1. Introduction

1.1 About this study

Gun control is a hotly debated issue in the United States. Some are of the opinion that the regulation of gun ownership reduces gun crime, while others believe that it has no significant effect. The goal of our study is twofold: to determine whether gun control laws, at the state level, have a significant effect on gun homicide in either direction.

In terms of regulation, we must consider two main types of restrictions that are used at the state level: mandatory permits for gun purchasing, and forced registration of guns.

Our goals in this study are to determine whether there is a significant effect on gun murder rates based on state regulations concerning permits or mandatory registration. We also aim to answer some related questions with our data, such as whether gun control increases non-gun murder. In addition, we will construct a model for predicting gun homicide rates based on the regulations in a state, as well as a number of other factors that can affect the gun homicide rate.

1.2 Permits and registration

Our study uses the terms “permit” and “registration.” A permit is a document that gives permission to an individual or organization to perform a certain act. For example, a state permit is required for selling alcohol. Permits are required in some states for ownership of firearms. This is done so that the state can regulate the gun market. Permits are considered beneficial by some, in that they may prevent weapons from falling into the hands of either those who would cause harm with them or not handle them responsibly. As a further example, a state permit is required to drive a car (a car license). If someone were to drive a car without proper knowledge, an accident may occur where a person could die, or at the least, property could become damaged. Permits, however, can restrict access to certain items (in the case of this study, firearms) to those who are trusted.

Gun registration is a voluntary process handled by the United States government that works on a federal level. The Gun Control Act of 1968 is the law that created gun registration, which is a process where the national government stores data on the firearms that a citizen owns. This involves submitting an official form to the government, which contains data such as the serial number of a firearm, the home address of the owner, and so on. Gun registration was created to help identify the owners of firearms when crimes are committed, and it can act as an additional barrier to obtaining a gun. Firearms registration is not mandatory at the federal level; however, some states mandate that their residents participate in the registration program if they purchase a gun.

1.3 Nature and source of data

Our data was obtained from several sources. Per-state homicide and crime data was obtained from the Federal Bureau of Investigation website. We obtained population figures and estimates, as well as urbanization and poverty data, from the United States Census Bureau website. Finally, we obtained information on existing regulations from the National Rifle Association website. All of this data is for the year 2008, except for the urbanization data, which is from 2000, but is still accurate enough to be acceptable for our purposes.

Due to insufficient reporting of homicide data, the state of Florida and the District of Columbia are omitted from our study.

Because of the low amounts of murders committed with shotguns, rifles, and guns classified in the "other" category, as well as because of the very restrictive legislation concerning these types of weapons, we decided to focus mainly on handguns for this study, as they are by far the most common type of gun used in homicides.

1.4 Considerations

This study focuses only on data from the year 2008. One of our original intentions in this study was to observe whether changes in gun regulations in a state would cause significant differences in homicide rates. However, there are several problems with this approach. First of all, changes in gun regulations are actually fairly uncommon, and as such, we could not find enough data points to make any reliable conclusions concerning such changes. Additionally, per-state homicide data in the same level of detail as used by this study for 2008 has not been available for very long, which would limit the time frame we could examine. Without enough data points or enough of a range, a study of changes in gun laws would not be very effective. Therefore, we will focus on comparing states in the year 2008, since comparing trends over time is not relevant to our study unless there have been many significant gun law changes that we can observe.

2. Methodology

2.1 Data format and preliminary observations

In order to perform the necessary calculations for this study, we used the R statistics software.

After gathering data and assembling it into a tabular format that was suitable for our study, we proceeded to test our primary hypotheses: whether permits being required for handgun purchases or mandatory handgun registration in a state has a significant effect on the number of handgun murders in that state. In order to prevent a bias toward small or large states, we used the proportion of handgun murders to the state's 2008 population estimate, rather than simply the number of handgun murders.

To understand the distribution of our data, we produced histograms of the handgun homicide data, both as a whole and when divided into groups. The group division was based on permit and registration regulations. All five histograms showed relative normality and no especially significant outliers (see Figures 1.1 – 1.5 in the appendix). A skew toward the right was visible in many of the histograms, though it was not especially strong. The state of North Dakota could be considered an outlier, with zero handgun murders in 2008, but we did not remove it from the dataset, as it did not strongly disturb any visible trends, nor would it be appropriate to remove it just because it did not fit an expected pattern.

Observing the means of the handgun murder proportion in different subsets provided us with the following information:

Permit required	No permit required	Mandatory reg.	Optional reg.
1.30E-005	2.11E-005	2.03E-005	1.90E-005

The states with a permit requirement for the purchasing of handguns had a noticeably different proportion of handgun murders to population, while there was a small reverse effect where registration was mandatory. Based on these means, we discovered which directions would be appropriate for one-sided testing.

2.2 Significance tests

Following these early observations, we moved on to the hypothesis tests. We divided the data into subsets where permits were required vs. not required, and where registration was mandatory vs. optional. We performed pairwise T-tests on the subsets to determine whether there was a significant difference in the mean handgun murder proportion between these groups at a 95% confidence level, which we shall discuss in the results section.

In addition, we performed significance tests on some secondary hypotheses. We wondered if a reduction in the handgun murder rate in states that have strict legislation would lead to a similar reduction in the overall murder rate, or whether a reduction in handgun murders would simply lead to more homicides being committed by other methods than with handguns. Again, we performed pairwise T-tests to determine whether there was a significant difference in the mean murder rate or non-gun murder rate based on the presence or lack of permit and registration restrictions at a 95% confidence level.

2.3 Building the regression model

After testing our hypotheses, we sought to build a model to describe the handgun murder rate (as a proportion to population) in a state based on a number of variables. From our data, the possible variables for such a model would include: permit requirement (as a factor); mandatory registration (as a factor); state population; state poverty rate; percentage of the state population in urbanized locations; and the overall violent crime rate in the state.

We began by making a linear regression model with handgun murder rate as the response variable and all of the previously mentioned possibilities as explanatory variables. We performed multivariate ANOVA tests to determine which explanatory variables were significant and which were not. We then removed the less significant variables in an attempt to refine the model and increase its explanatory power. Aside from this manual attempt, we also used stepwise regression techniques to see if R would be able to algorithmically produce a better model. Finally, we checked our resulting models to see if they could be transformed for better power, by performing residual analysis.

3. Results

3.1 Primary significance test results

Our main significance test was to determine whether there was a difference in handgun murder rate between states where permits or registration were required, and states where they were not required.

We first tested based on permit requirement. We suspected that the overall mean handgun homicide rate would be lower in states with the permit requirement, so we performed a one-sided T-test to see if this was the case. With the null hypothesis being that there was no difference between the means, and the alternative being that the mean in states with permit requirements was lower, our calculations gave us a P-value of 0.023, indicating that we can reject the null hypothesis at a 95% confidence level. Therefore, we obtained the statistically significant result that the requirement of permits for handgun purchases causes a reduction in the handgun homicide rate of a state.

We also wished to test for a similar significant difference in states where registration of handguns is mandatory, versus states where it is optional. From our earlier observation of the data, however, it did not seem that such an effect might necessarily be present. For this reason, we performed a two-sided T-test, with the null hypothesis predicting no difference in means based on the registration requirement, and the alternative hypothesis predicting a difference. Our results for this test give a P-value of 0.88. With such a large P-value, we fail to reject the null hypothesis.

No significant effect on the handgun homicide rate based on mandatory handgun registration is evident.

3.2 Secondary significance test results

Next, we tested our hypotheses about handgun permits or registration affecting the overall murder rate in a state. With the null hypothesis indicating no difference based on permits, we obtained a P-value of 0.05 in a two-sided test. Given this result, we tried again with a one-sided test, with the alternative hypothesis that the murder rate was lower in states that required handgun permits. We obtained a P-value of 0.025, allowing us to reject the null hypothesis at a 95% confidence level. Therefore, we observe a significant reduction effect on the state-wide homicide rate when permits are required for handgun purchases.

Similarly, we performed a test for when registration is mandatory in a state. A two-sided test gave us a P-value of 0.57, so we were unable to reject the null hypothesis that there was no difference in the overall murder rate based on registration regulation.

Finally, we performed two more significance tests, to see if permits or registration had an effect on non-gun violence in a state. These tests returned P-values of 0.21 and 0.50, respectively, meaning that we could not determine any significant difference in either case.

3.3 Regression modeling results

Our next aim was to construct a regression model for handgun murder rates. Initially, we attempted to construct a model with all the relevant variables we had in our data. Performing ANOVA tests on this model gave us the following results:

```
Response: m.handgun.perpop
                   Df     Sum Sq    Mean Sq F value   Pr(>F)
handgun.permit      1 5.8980e-10 5.8980e-10  4.0229 0.051358 .
handgun.reg         1 7.7300e-11 7.7300e-11  0.5272 0.471828
pop                 1 8.8910e-10 8.8910e-10  6.0642 0.017979 *
poverty.rate        1 4.4760e-10 4.4760e-10  3.0529 0.087902 .
urban.pop           1 7.5960e-10 7.5960e-10  5.1809 0.027998 *
violent.crime.rate  1 1.4894e-09 1.4894e-09 10.1590 0.002711 **
```

These results show the handgun registration factor being very insignificant, which agrees with our earlier results from the significance tests. We then removed this factor, giving the following model:

```
Response: m.handgun.perpop
                   Df     Sum Sq    Mean Sq F value   Pr(>F)
handgun.permit      1 5.8980e-10 5.8980e-10  4.1004 0.049110 *
pop                 1 9.5940e-10 9.5940e-10  6.6700 0.013292 *
poverty.rate        1 4.5450e-10 4.5450e-10  3.1600 0.082537 .
urban.pop           1 7.5960e-10 7.5960e-10  5.2807 0.026491 *
violent.crime.rate  1 1.4622e-09 1.4622e-09 10.1653 0.002669 **
```

All of the terms in this model are somewhat significant. The R-squared value is 0.4059 for this model, indicating moderately strong explanatory power.

However, manual analysis does not necessarily produce the best model. Therefore, we used a stepwise regression selection algorithm to try to find a better model. The algorithm gave us the same model as our manual result, except with the population term removed. The ANOVA test for this model is as follows:

```
Response: m.handgun.perpop
                   Df     Sum Sq    Mean Sq F value   Pr(>F)   
handgun.permit      1 5.8980e-10 5.8980e-10  4.1902 0.046658 * 
poverty.rate        1 7.0590e-10 7.0590e-10  5.0151 0.030230 * 
urban.pop           1 1.3975e-09 1.3975e-09  9.9283 0.002926 **
violent.crime.rate  1 1.5241e-09 1.5241e-09 10.8279 0.001975 **
```

The R-squared value for this model is 0.4051, again indicating moderately strong explanatory power. Since it is comparable in power to our manually-produced model, and it contains fewer terms, we will choose this model over the other for simplicity and clarity.

We must also examine the model to ensure that we can use it. A plot of fitted versus residuals indicates that the residuals are fairly equal in variance (see Figure 2.1 in the appendix). The Q-Q normal plot of residuals is slightly curved away from the desired line shape (see Figure 2.2 in the appendix), indicating that the normality of the residuals is not very strong. This may be a weakness of our model due to the limited data available.

The Durbin-Watson test gives us a P-value of 0.84, so we fail to reject the hypothesis that rho = 0. This means that it is reasonably safe to assume that our residuals are independent.

We can also construct an LR plot to look for influential outliers. In doing so, we determined that none of the few potential outliers were influential enough to require removal.

Overall, we can claim that the model is fairly robust. The weak normality of the residuals, however, is a potential problem.

The final model equation is as follows (where “permit” is a factor that is 0 if permits are not required in a state and 1 if they are):

```
      handgun murders / population = -2.118e-05 + -7.427e-06(permit) + 1.430e-04(poverty rate) + 2.866e-05(urban population rate) + 1.302e-03(violent crime rate)
```

This equation can be used to predict the handgun murder rate in a hypothetical state based on the variables of permit requirement for purchase, poverty rate, urbanization rate, and overall violent crime rate.

4. Conclusion

We have determined several notable results through our testing. A state requirement for a permit to purchase a handgun results in significantly less handgun-related homicides. It also produces a significant reduction in overall homicides, though this may largely be *because* of the reduction in handgun-related homicides. This agrees with our inability to find any significant change in non-gun homicide in states where permits are not required for handgun purchases.

We did not, however, find any significant change in handgun homicide rates when a state enforces handgun registration. Our other related tests showed no significant changes based on mandatory registration, either.

We were also able to construct a model that has moderately strong explanatory power in predicting handgun murder rates. The model relies heavily on the permit laws in the state, as well as poverty rate, urbanization percentage, and violent crime rate, all of which significantly influence the handgun murder rate in our model.

In summary, we recommend that states require permits for handgun purchases in order to reduce homicide rates, while we find no reason to enforce handgun registration. In addition, we acknowledge the importance of poverty rate, urbanization, and overall violent crime statistics in determining the handgun murder rate.

5. Acknowledgments

We would like to thank our Intermediate Statistics professor, Ionut Florescu, for providing us with education and experience in the application of statistical methods. Likewise, we would like to thank our teaching assistant for the course, Forrest Levin.

We would also like to thank the developers and maintainers of the R software package, which has made the production of this study possible.

6. References

Federal Bureau of Investigation:
Homicide by state, 2008. http://www.fbi.gov/ucr/cius2008/data/table_20.html
Violent crime by state, 2008. http://www.fbi.gov/ucr/cius2008/data/table_05.html

Census Bureau:
Population by state, 2008. http://www.census.gov/popest/states/NST-ann-est.html
Poverty by state, 2008. http://www.census.gov/prod/2009pubs/acsbr08-1.pdf
Urbanization, 2000. http://www.census.gov/compendia/statab/2010/tables/10s0029.xls

National Rifle Association:
Gun law summary. http://www.nraila.org/GunLaws/

7. Appendix: Graphs

Fig. 1.1

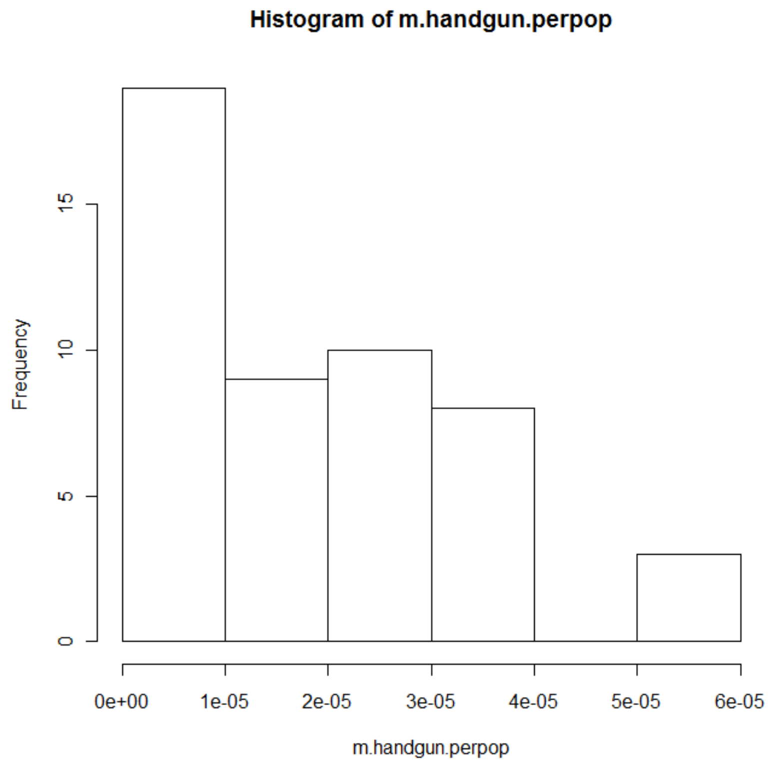


Fig. 1.2

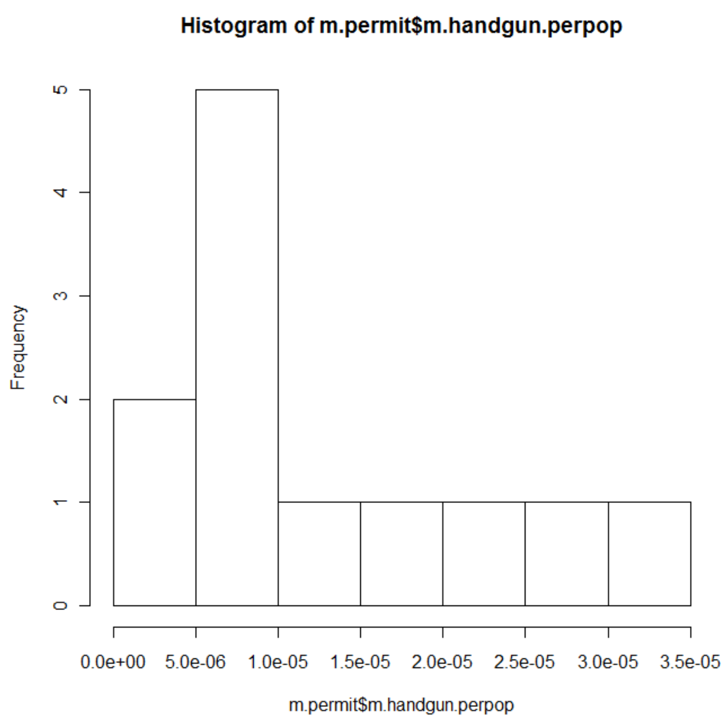
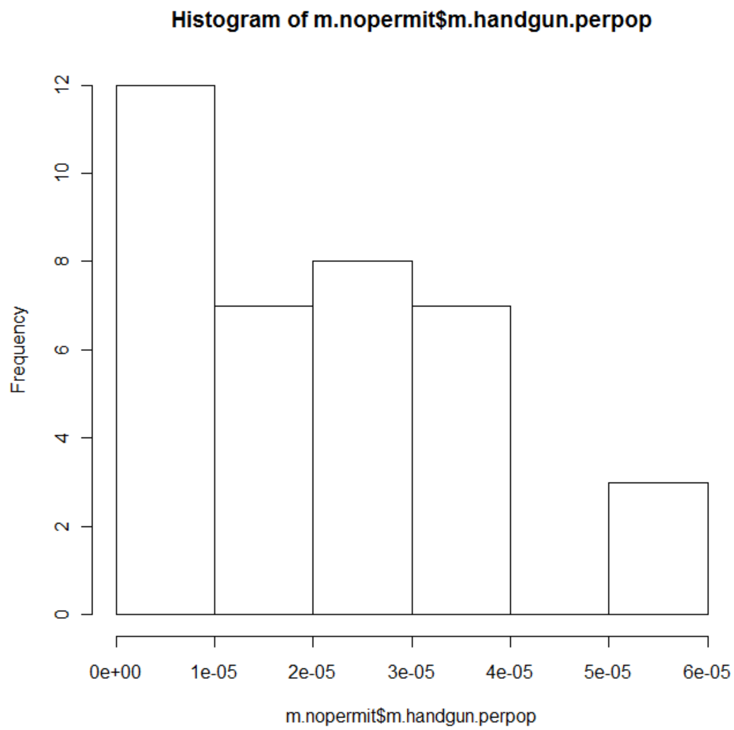
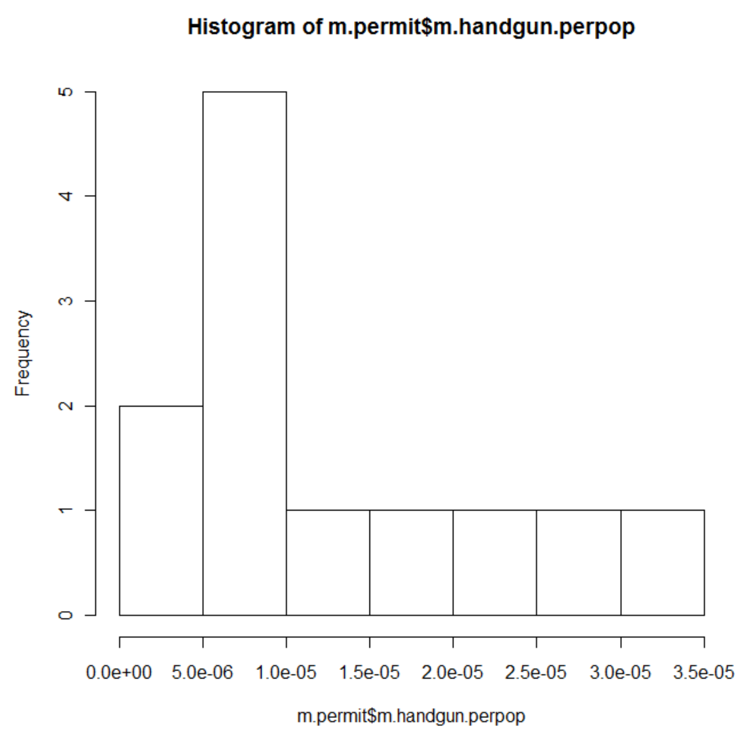


Fig. 1.3



Histogram of m.nopermit$m.handgun.perpop
Frequency
0
2
4
6
8
10
12
0e+00
1e-05
2e-05
3e-05
4e-05
5e-05
6e-05
m.nopermit$m.handgun.perpop

Fig. 1.4



Histogram of m.permit$m.handgun.perpop
Frequency
0
1
2
3
4
5
0.0e+00
5.0e-06
1.0e-05
1.5e-05
2.0e-05
2.5e-05
3.0e-05
3.5e-05
m.permit$m.handgun.perpop

Fig. 1.5

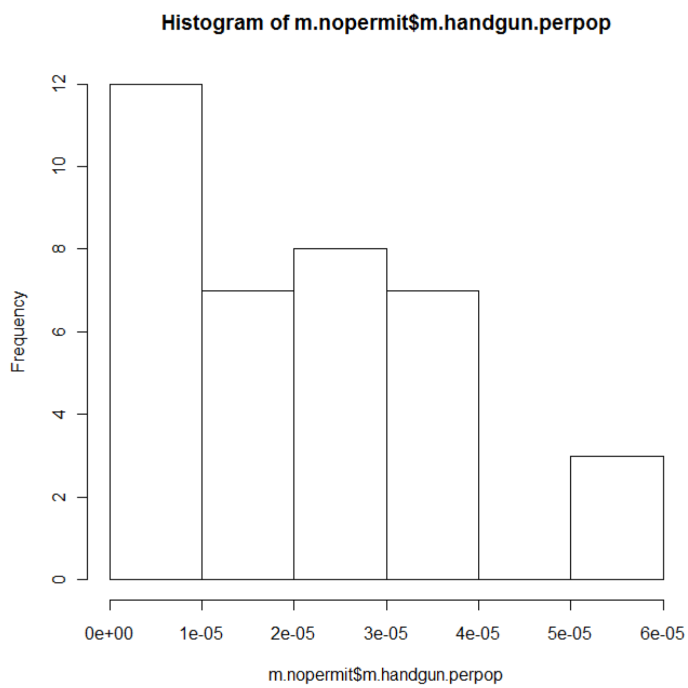

Histogram of m.nopermit$m.handgun.perpop
Frequency
0
2
4
6
8
10
12
0e+00
1e-05
2e-05
3e-05
4e-05
5e-05
6e-05
m.nopermit$m.handgun.perpop

Fig. 2.1

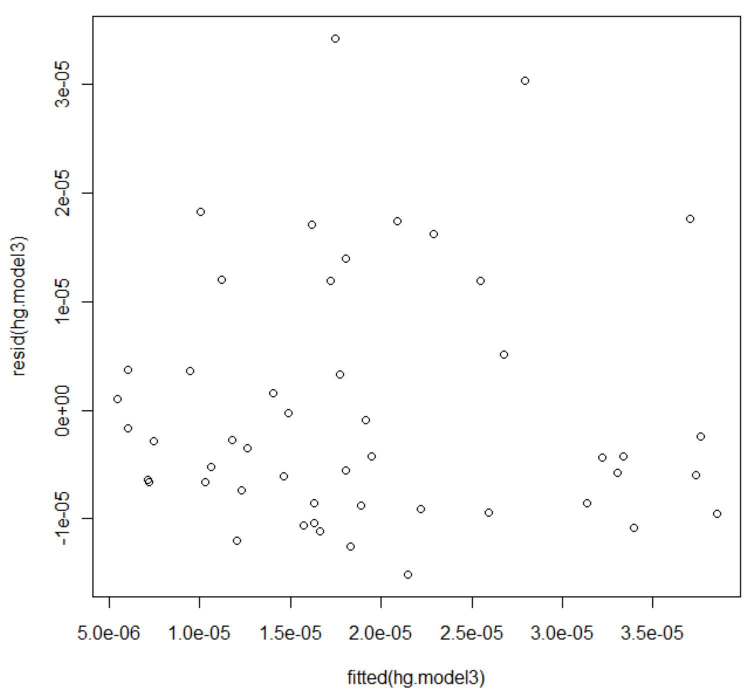
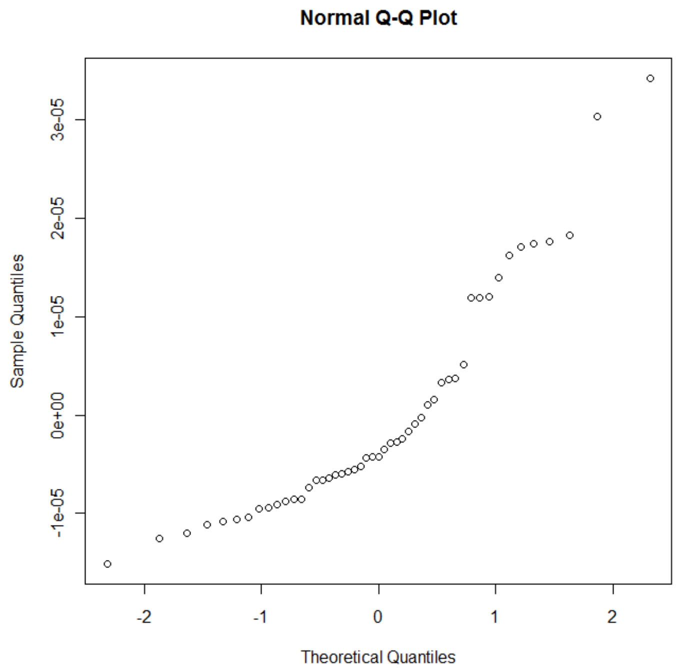

resid(hg.model3)
-1e-05
0e+00
1e-05
2e-05
3e-05
5.0e-06
1.0e-05
1.5e-05
2.0e-05
2.5e-05
3.0e-05
3.5e-05
fitted(hg.model3)

Fig. 2.2


Normal Q-Q Plot
Sample Quantiles
3e-05
2e-05
1e-05
0e+00
-1e-05
-2
-1
0
1
2
Theoretical Quantiles