DO MORE GUNS AND /OR HIGHER INCARCERATION REDUCE CRIME?

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Report on Applied Econometrics And Time Series Analysis Spring 2018 Project

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Data Description & Data Analysis

The data provided (guns.dta) is panel in nature. It comprised of 50 states in United States of America and included District of Columbia tallying up to 51 states over a time period of 23 years (1977 - 1999). By looking at the data first, it looked like there were states missing with the states codes ‘3’, ‘4’, ‘14’ and ‘43’. Upon further investigation it was identified that these states codes do not exist. From basic understanding it looked like states with Shall law implemented would have lower violence rates. However, this was not the case, there were states with higher violence rate when Shall Law was implemented.

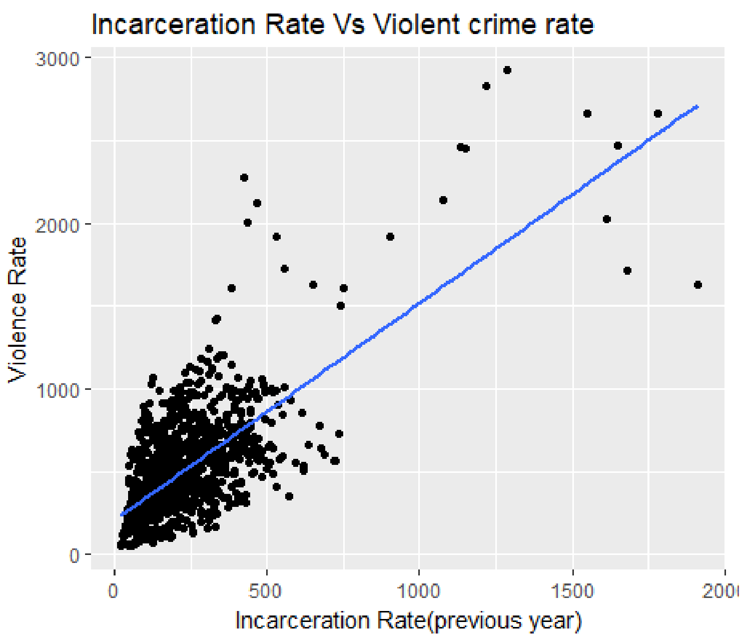
Analysis of the data throughout the project was performed using STATA, R and SAS programming.
Summary of the data –

```
      year            vio              mur              rob
 Min.   :77    Min.   :  47.0   Min.   : 0.200   Min.   :   6.4
 1st Qu.:82    1st Qu.: 283.1   1st Qu.: 3.700   1st Qu.:  71.1
 Median :88    Median : 443.0   Median : 6.400   Median : 124.1
 Mean   :88    Mean   : 503.1   Mean   : 7.665   Mean   : 161.8
 3rd Qu.:94    3rd Qu.: 650.9   3rd Qu.: 9.800   3rd Qu.: 192.7
 Max.   :99    Max.   :2921.8   Max.   :80.600   Max.   :1635.1

  incarc_rate         pb1064            pw1064          pm1029
 Min.   :  19.0   Min.   : 0.2482   Min.   :21.78   Min.   :12.21
 1st Qu.: 114.0   1st Qu.: 2.2022   1st Qu.:59.94   1st Qu.:14.65
 Median : 187.0   Median : 4.0262   Median :65.06   Median :15.90
 Mean   : 226.6   Mean   : 5.3362   Mean   :62.95   Mean   :16.08
 3rd Qu.: 291.0   3rd Qu.: 6.8507   3rd Qu.:69.20   3rd Qu.:17.53
 Max.   :1913.0   Max.   :26.9796   Max.   :76.53   Max.   :22.35

      pop             avginc           density             stateid
 Min.   : 0.4027   Min.   : 8.555   Min.   : 0.000707   Min.   : 1.00
 1st Qu.: 1.1877   1st Qu.:11.935   1st Qu.: 0.031911   1st Qu.:16.00
 Median : 3.2713   Median :13.402   Median : 0.081569   Median :29.00
 Mean   : 4.8163   Mean   :13.725   Mean   : 0.352038   Mean   :28.96
 3rd Qu.: 5.6856   3rd Qu.:15.271   3rd Qu.: 0.177718   3rd Qu.:42.00
 Max.   :33.1451   Max.   :23.647   Max.   :11.102116   Max.   :56.00
```

From the above statistics we get a vague idea of the range and level of data we are dealing with.

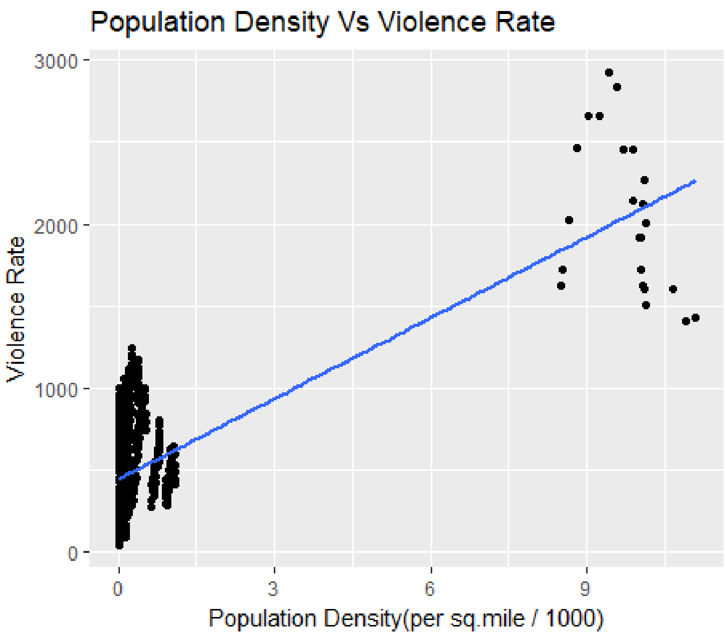
The following insights were found when we performed exploratory analysis on the data –

1. **Incarceration rate Vs violent crime rate**



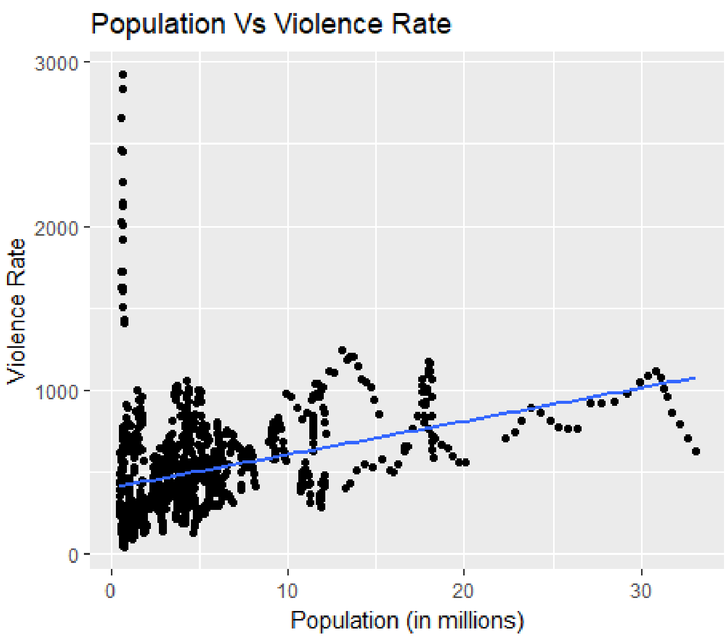
From the above graph it can be see that there is positive relationship between incarceration rate and violent crime rate (incidents per 100,000 members of the population). For majority of the cases, as crime rate increases incarceration rate also increases.

2. Population density Vs violent crime rate



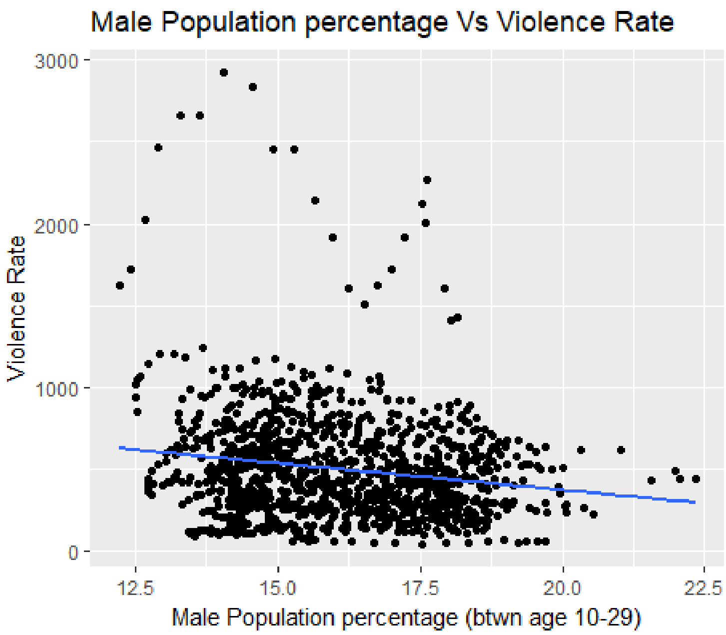
In the above graph violence rate is plotted against population density (population per square mile of land area, divided by 1000). Here as well, we could say there is positive trend between the 2 variables. Very high violent crime rate exists where the population density is also very high.

3. Population Vs violent crime rate



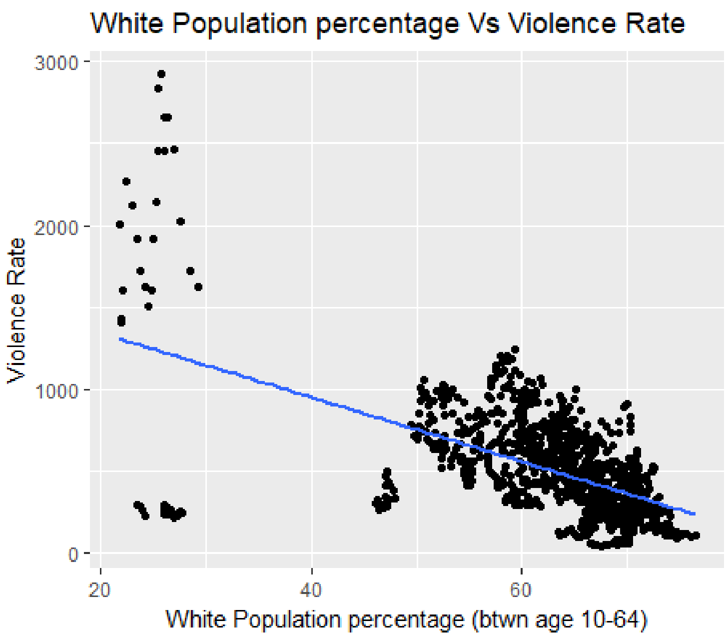
In the above graph violent crime rate is plotted against population. Crime rate increases as population increases. There a few states where violence rate is high even though population is less.

4. pm1029 vs violent crime rate



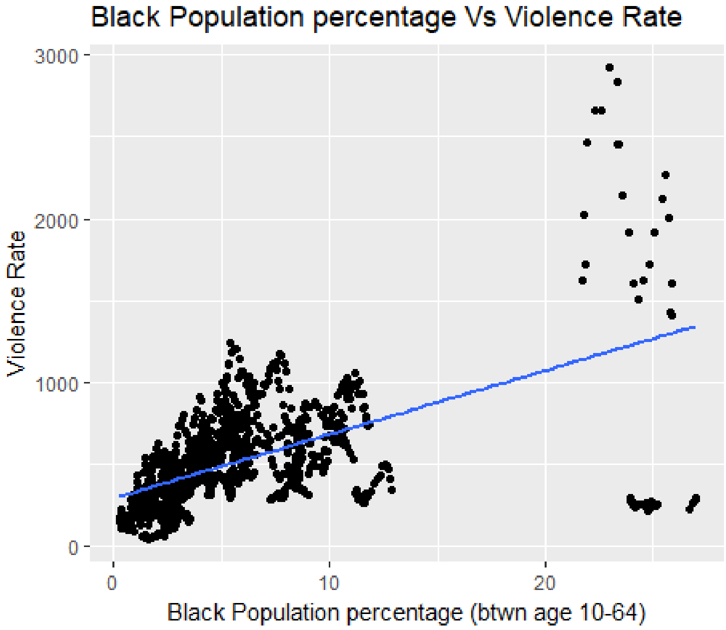
In the above graph violent crime rate is plotted against male population percentage in the age group of 10 to 29. The graph doesn't show a high correlation between these variables.

5. pw1064 Vs violent crime rate



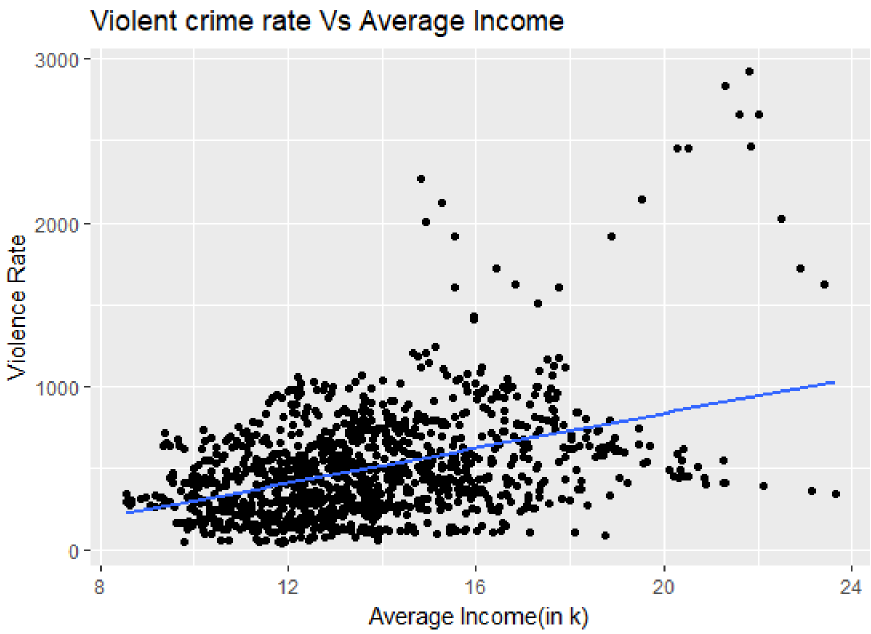
In the above graph violent crime rate is plotted against the white population percentage in the age bracket of 10 to 64. The graph shows that as the white population percentage is higher in that state, violent crime rate declines. This is a very interesting insight and an area we would love to dig deeper into.

6. **pb1064 Vs violent crime rate**



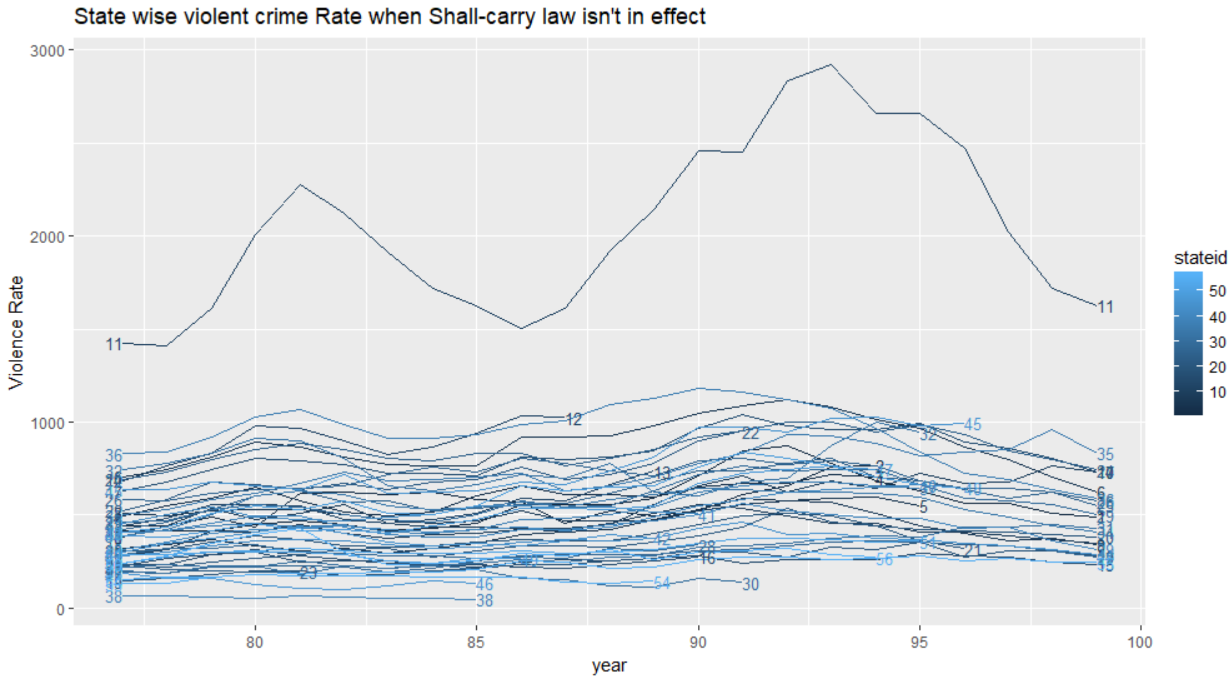
In the above graph, violent crime rate is plotted against black population percentage in the ages of 10 to 64. This is the exact opposite scenario of white population percentage vs violent crime rate (lateral flip in the graphs). This graph shows that as black population percentage increases, the violent crime rate seems to also increase. From economic theory the wages of black people when compared to white is comparatively lower, due to this they might be staying in a dangerous neighbourhood.

7. **Violent crime rate Vs average income**

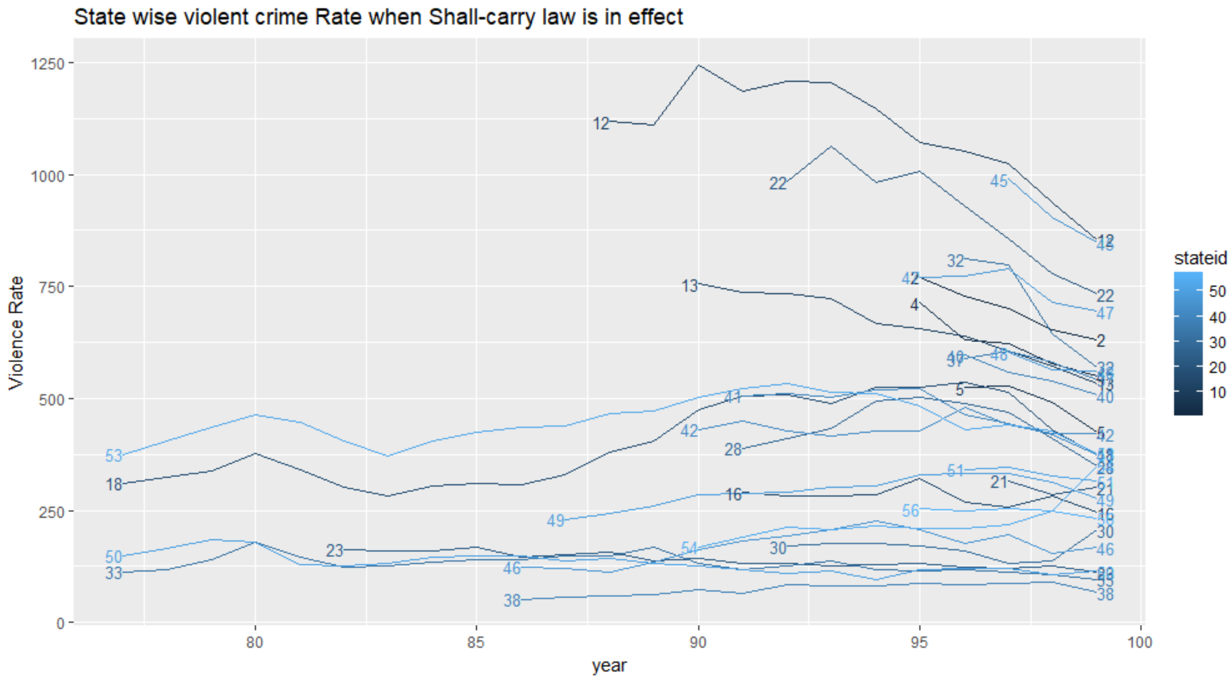


In the above graph violent crime rate is plotted against average per capita personal income of the state (in thousands of dollars). Here again we can observe that states with higher average per capita personal income have lower crime rates indicating that the neighbourhood is safer (people with higher pay wouldn't indulge in crime related activities) when compared to lower income states. However, some states with high average income seems to have higher violent crime rate. This maybe because richer people also face a risk of getting attacked.

8. Comparing state wise violent crime rate based on shall-carry law

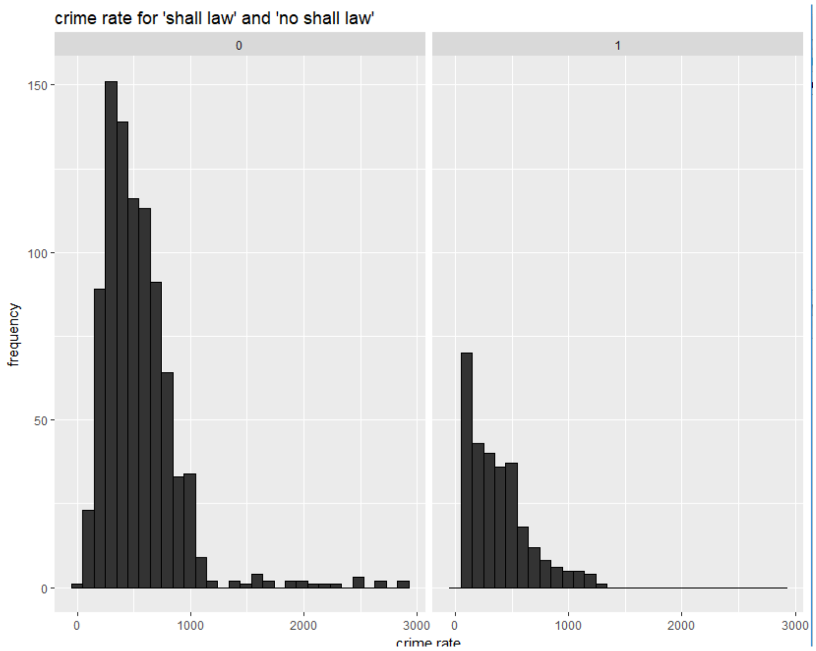


The above graph plots the state wise violent crime rate when Shall-carry law isn't in effect. The state id 11 (District of Columbia) seems to have an exceptionally high violent crime rate when compared to other states when the shall-carry law wasn't implied. State id 38 (North Dakota) seems to have the lowest violent crime rate even though data is available till 1985 only.



The above graph plots the state wise violent crime rate when Shall-carry law is in effect. Violent rate seems to be lesser in the states where shall-carry law is in effect. With the shall law implemented, Florida (12) seems to still have a high violent crime rate and North Dakota continues to have the least violent crime rate amongst all other states.

Now we shift our focus towards Shall Law. We have performed several comparison analyses of crime rate against shall law. Below are further insights specific to shall law –



Side by side comparison of violent crime rate when shall law was implemented and when it wasn't.

Violent Rate with respect to Shall law:

```
hr$shall: 0
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   47.0   315.0   478.4   542.2   676.4  2921.8
------------------------------------------------
hr$shall: 1
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   51.3   149.5   322.0   381.1   514.6  1244.3
```

Shall: 0, no shall law

Shall: 1, shall law present in the state

Murder Rate with respect to Shall law:

```
hr$shall: 0
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  0.700   4.200   7.400   8.429  10.400  80.600
------------------------------------------------
hr$shall: 1
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  0.200   2.300   4.600   5.284   7.300  20.300
```

Shall: 0, no shall law

Shall: 1, shall law present in the state

Robbery Rate with respect to Shall law:

```
hr$shall: 0
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
    6.4    85.9   133.8   182.3   210.6  1635.1
------------------------------------------------
hr$shall: 1
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
    6.4    23.3    86.6    97.9   141.4   416.8
```

Shall: 0, no shall law

Shall: 1, shall law present in the state

It looks like shall law does influence the respective crime rates. We see general drop in crime rates when shall law was implemented in the state

Hypothesis Testing on Shall Law

1. **Analysis of Average Violent Crime rates in Shall law states and states not having Shall law with T-test:**
   We conduct T-test to know if there is any difference between states having shall law and states that are not having shall law in average violent crime rate.

Hypothesis:

Ho: No difference between shall law states and no shall law states

Ha: Significant difference between average violent crime rate in shall law states and average violent crime rate in no shall law states

```
        Welch Two Sample t-test

data:  hr$vio by hr$shall
t = 8.2381, df = 613.37, p-value = 1.06e-15
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 122.7622 199.6115
sample estimates:
mean in group 0 mean in group 1 
       542.2377        381.0509 
```

We can see the p value is < 0.05, hence null hypothesis is rejected. We conclude that there is significant difference in the violent crime rate between states having shall law and states not having shall law.

2. **Analysis of Average Murder rates in Shall law states and states not having Shall law with T-test:**
   We conduct T-test to know if there is any difference between states having shall law and states that are not having shall law in average murder rate.

Hypothesis:

Ho: No difference between shall law states and no shall law states

Ha: Significant difference between average murder rate in shall law states and average murder crime rate in no shall law states

```
        Welch Two Sample t-test

data:  hr$mur by hr$shall
t = 8.9797, df = 1069.9, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 2.458192 3.832873
sample estimates:
mean in group 0 mean in group 1 
       8.429392        5.283860 
```

P-value is < 0.05, hence null hypothesis is rejected. We conclude that there is significant difference in the murder rate between states having shall law and states not having shall law.

3. **Analysis of Average Robbery rates in Shall law states and states not having Shall law with T-test:**
   We conduct T-test to know if there is any difference between states having shall law and states that are not having shall law in average robbery rate.

Hypothesis:

Ho: No difference between shall law states and no shall law states
Ha: Significant difference between average robbery rate in shall law states and average murder crime rate in no shall law states

```
        Welch Two Sample t-test

data:  hr$rob by hr$shall
t = 10.428, df = 1012.2, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  68.54833 100.32565
sample estimates:
mean in group 0 mean in group 1
       182.3356         97.8986
```

P-value is < 0.05, hence null hypothesis is rejected. We conclude that there is significant difference in the robbery rates between states having shall law and states not having shall law.

4. **Analysis of Average Incarceration Rates in Shall law states and states not having Shall law with T-test:**
   We conduct T-test to know if there is any difference between states having shall law and states that are not having shall law in average incarceration rate.

Hypothesis:

Ho: No difference between shall law states and no shall law states
Ha: Significant difference between average incarceration rate in shall law states and average murder crime rate in no shall law states

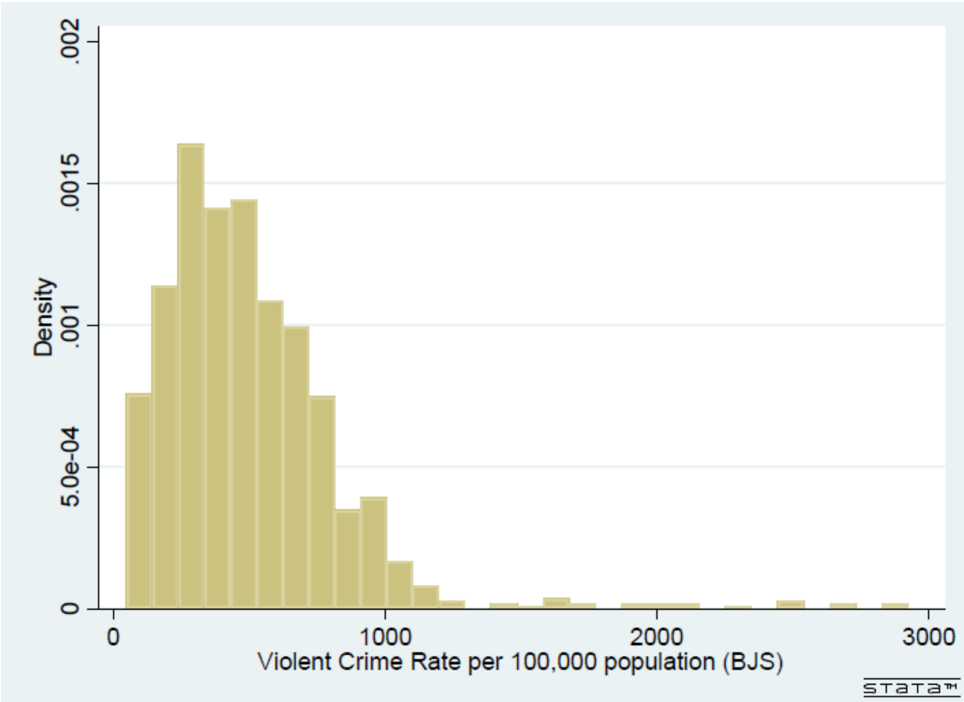
```
        Welch Two Sample t-test

data:  hr$incarc_rate by hr$shall
t = -1.5881, df = 564.91, p-value = 0.1128
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -39.518171   4.183724
sample estimates:
mean in group 0 mean in group 1
       222.2872        239.9544
```

The p-value is **not** < 0.05, hence null hypothesis is not rejected. There is no significant difference in average incarceration rate between states having shall law and states not having shall law

With a clearer picture and understanding of the data now, we performed regression models and compared how Shall law affects the crime rates. The below sections have various types of regression models and insights from these models. (at the end of the report, we have attached all the .do files written for this project)

Regression Analysis

To model the violent crime rate over the years we look at the distribution of violent crime rate and we plotted the histogram for the same. As seen in the graph the histogram is highly right skewed and therefore we take the log for the crime rate before modelling the data.



Before we blindly go ahead and run models on the data, our main focus was on finding extent up to which shall law has an impact on the violent crime rate. By the help of a covariance matrix we found variables that are correlated to each other.

```
. corr vio mur rob incarc_rate pb1064 pw1064 pm1029 pop avginc density
(obs=1,173)
```

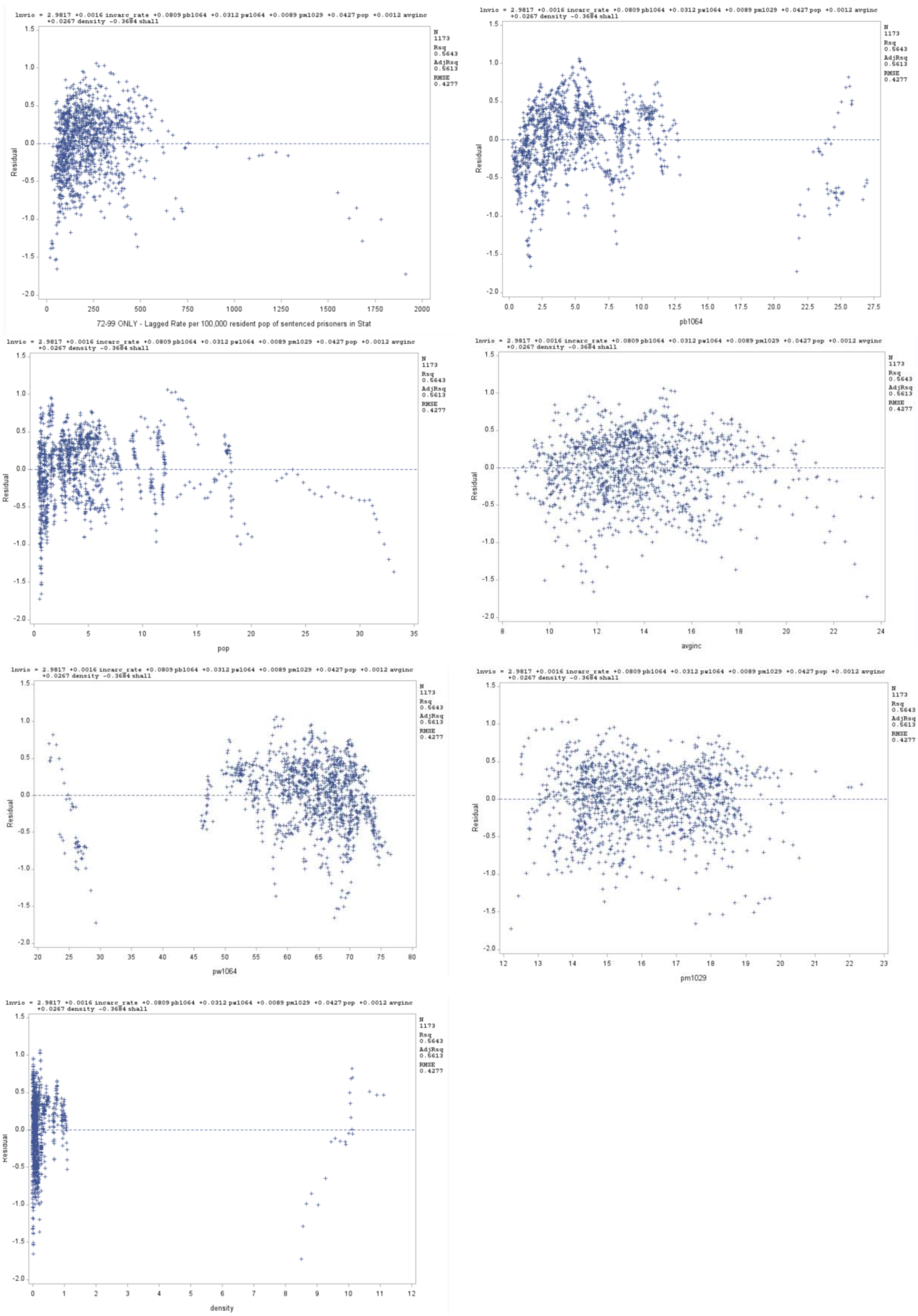
	vio	mur	rob	incarc~e	pb1064	pw1064	pm1029	pop	avginc	density
vio	1.0000									
mur	0.8265	1.0000								
rob	0.9071	0.7976	1.0000							
incarc_rate	0.7027	0.7096	0.5668	1.0000						
pb1064	0.5698	0.6018	0.5812	0.5308	1.0000					
pw1064	-0.5730	-0.6154	-0.5842	-0.5271	-0.9820	1.0000				
pm1029	-0.1696	0.0150	-0.0860	-0.4463	0.0162	-0.0126	1.0000			
pop	0.3190	0.0999	0.3172	0.0953	0.0581	-0.0654	-0.0975	1.0000		
avginc	0.4080	0.2206	0.4148	0.4615	0.2627	-0.1912	-0.5279	0.2152	1.0000	
density	0.6647	0.7486	0.7818	0.5593	0.5432	-0.5551	-0.0637	-0.0780	0.3433	1.0000

From the above matrix we can see that robbery rate is highly correlated to violent crime rate and murder rate is also highly correlated to violent crime rate.

We regressed only violent crime rate against shall law to see the effect of shall law on violent crime rate not considering any other factor playing its part. As expected the model fit of the model was very bad, had an R-square value of 0.08. Shall law was highly significant, and the model interpreted that if the state employed shall law the violent crime rate would decrease by 44.2% when compared to shall law not being implemented. This result is bogus because a lot of other significant variables were residing in the error term & had a clear case of omitted variable bias.

1. Pooled OLS Model

Ignoring the panel nature of the data, change in crime rate across different states was checked by using pooled OLS regression. Before running the model, we did check for heteroskedasticity in the data. While the residuals plot didn't give much information w.r.t presence of heteroscedasticity (function of variance was unknown, so WLS didn't in solving for heteroskedasticity), as a safe practice we used cluster robust standard errors under the assumption that heteroskedasticity exists.



Above graphs shows the residual plots of individual variables plotted against residual

```
. reg lnvio incarc_rate pb1064 pw1064 pm1029 pop avginc density shall, vce(cluster state)

Linear regression                               Number of obs     =      1,173
                                                F(8, 50)          =      62.13
                                                Prob > F          =     0.0000
                                                R-squared         =     0.5643
                                                Root MSE          =     .42769

                                  (Std. Err. adjusted for 51 clusters in stateid)
```

lnvio	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
incarc_rate	.0016126	.0005999	2.69	0.010	.0004076	.0028177
pb1064	.0808526	.0713875	1.13	0.263	-.0625334	.2242386
pw1064	.0312005	.03409	0.92	0.364	-.0372713	.0996723
pm1029	.0088709	.0340964	0.26	0.796	-.0596137	.0773554
pop	.0427098	.011729	3.64	0.001	.0191515	.0662681
avginc	.0012051	.0240808	0.05	0.960	-.0471626	.0495728
density	.0266885	.0414909	0.64	0.523	-.0566485	.1100255
shall	-.3683869	.113937	-3.23	0.002	-.5972361	-.1395378
_cons	2.981738	2.166513	1.38	0.175	-1.369831	7.333307

We observe that the crime rate is decreases by 36.84% for those states who have the shall law implemented as compared to the other states where the shall law is not implemented. Also, we can observe that if the incarceration rate increases by 1 unit the crime rate also increases by 0.16%. We observed that the impact of shall law on violent crime rate decreased from 44% to 36.8%. population, incarc_rate and shall law are highly significant variables. The least square estimators are no longer efficient.

Interaction terms where created and tested with the model. These interaction terms were highly insignificant and didn't add value into the model. Thus, they were exempted from the final model which was to be regressed.

The least square estimators are no longer BLUE as they are inefficient. We move ahead with panel effect modelling.

2. Fixed Effects Model

Since it is panel data, we perform panel regression. There are 3 ways of doing it – least square dummy variable estimator, fixed effects estimator & random effects estimator. Least square dummy variable estimator is not feasible because we create a dummy variable for every observation, i.e. 1173 dummy variables. So, we go ahead with Fixed Effects estimator.

To check the within effects we perform the Fixed Effects panel regression. We observe that the impact of crime rate on violent crime rate drastically goes down to 4.61% for those states who have the shall law implemented as compared to the other states where the shall law is not implemented. The incarceration rate has become an insignificant variable and does not have a very high impact on the crime rate.

The population variables (pm1029, pw1064 & pb1064) have become significant variables. At this point, it looks like Fixed Effects model does a great job in capturing the unobserved heterogeneity which Pooled OLS failed to do so. From the fixed effects model, it can be interpreted that when shall law is in effect, the violent crime rate decreases by 4.61% when compared to shall law not in effect.

```
. xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe vce(cluster stateid)

Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.2178                                         min =         23
     between = 0.0033                                         avg =       23.0
     overall = 0.0001                                         max =         23

                                                F(8,50)           =      34.10
corr(u_i, Xb)  = -0.3687                        Prob > F          =     0.0000

                                (Std. Err. adjusted for 51 clusters in stateid)
```

lnvio	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
incarc_rate	-.000071	.0002504	-0.28	0.778	-.0005739	.0004318
pb1064	.1042804	.0326849	3.19	0.002	.0386308	.1699301
pw1064	.0408611	.0134585	3.04	0.004	.0138289	.0678932
pm1029	-.0502725	.0206949	-2.43	0.019	-.0918394	-.0087057
avginc	-.0092037	.0129649	-0.71	0.481	-.0352445	.016837
pop	.0115247	.014224	0.81	0.422	-.0170452	.0400945
density	-.1722901	.1376129	-1.25	0.216	-.4486936	.1041135
shall	-.0461415	.0417616	-1.10	0.275	-.1300223	.0377392
_cons	3.866017	.7701057	5.02	0.000	2.319214	5.412819
sigma_u	.68024951					
sigma_e	.16072287					
rho	.94712779	(fraction of variance due to u_i)				

3. Random Effects Model

To observe both within and between effects we now perform the Random Effects Panel Regression. We observe that the violent crime rate decreases by 6.96% for those states who have the shall law implemented as compared to the other states where the shall law is not implemented. Population related variables are highly significant. Shall law is significant at 90% confidence interval not at 95%.

```
. xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, re cluster(stateid)

Random-effects GLS regression                   Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.2044                                         min =         23
     between = 0.4908                                         avg =       23.0
     overall = 0.4591                                         max =         23

                                                Wald chi2(8)      =     167.14
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

                                (Std. Err. adjusted for 51 clusters in stateid)
```

lnvio	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
incarc_rate	.0001888	.0001877	1.01	0.314	-.0001791	.0005567
pb1064	.1067022	.0270973	3.94	0.000	.0535924	.1598119
pw1064	.0400716	.0127282	3.15	0.002	.0151248	.0650184
pm1029	-.0375292	.0180436	-2.08	0.038	-.072894	-.0021643
avginc	-.0105112	.0117802	-0.89	0.372	-.0335999	.0125775
pop	.0225755	.0116369	1.94	0.052	-.0002323	.0453833
density	.0661588	.0437925	1.51	0.131	-.0196729	.1519905
shall	-.069609	.038845	-1.79	0.073	-.1457438	.0065258
_cons	3.525463	.7786851	4.53	0.000	1.999268	5.051658
sigma_u	.33790775					
sigma_e	.16072287					
rho	.81550462	(fraction of variance due to u_i)				

To decide which is the better model between Fixed Effects and Random Effects model, we perform the Hausman Test. This test compares the coefficient estimates from the Random Effects model to those from the Fixed Effects model.

```
. quietly xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe

. estimates store fe

. quietly xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, re

. estimates store re

. hausman fe re
```

	Coefficients (b) fe	Coefficients (B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
incarc_rate	-.000071	.0001888	-.0002598	.0000635
pb1064	.1042804	.1067022	-.0024217	.011767
pw1064	.0408611	.0400716	.0007895	.
pm1029	-.0502725	-.0375292	-.0127434	.0021099
avginc	-.0092037	-.0105112	.0013075	.0006269
pop	.0115247	.0225755	-.0110508	.0059821
density	-.1722901	.0661588	-.2384489	.0763882
shall	-.0461415	-.069609	.0234675	.

```
                   b = consistent under Ho and Ha; obtained from xtreg
      B = inconsistent under Ha, efficient under Ho; obtained from xtreg

   Test:  Ho:  difference in coefficients not systematic

                 chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                         =        31.86
               Prob>chi2 =       0.0001
               (V_b-V_B is not positive definite)
```

According to the Chi Square statistic and the P-value we will have to reject the Null Hypothesis of no endogeneity. We conclude that the Fixed Effects model is a better model for this analysis. From the Hausman test it is established that the Fixed effects model is better than Random Effects model (Random Effects model also risks the occurrence of endogeneity). We go ahead and perform entity fixed effects model and time fixed effects model.

4. **Entity Fixed Effects Model**

Here in this model, each state has an intercept of its own.

```
. reg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.stateid
```

Source	SS	df	MS
Model	459.854887	58	7.92853254
Residual	28.7766714	1,114	.025831841
Total	488.631558	1,172	.416921125

Number of obs	=	1,173
F(58, 1114)	=	306.93
Prob > F	=	0.0000
R-squared	=	0.9411
Adj R-squared	=	0.9380
Root MSE	=	.16072

lnvio	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
incarc_rate	-.000071	.0000936	-0.76	0.448	-.0002547	.0001126
pb1064	.1042804	.0177564	5.87	0.000	.0694407	.1391201
pw1064	.0408611	.0050745	8.05	0.000	.0309044	.0508177
pm1029	-.0502725	.0064037	-7.85	0.000	-.0628373	-.0377078
avginc	-.0092037	.0059083	-1.56	0.120	-.0207963	.0023889
pop	.0115247	.0087239	1.32	0.187	-.0055924	.0286417
density	-.1722901	.0850362	-2.03	0.043	-.3391392	-.0054409
shall	-.0461415	.0188668	-2.45	0.015	-.08316	-.009123
stateid						
2	.0559649	.0727213	0.77	0.442	-.0867213	.198651
4	.2404116	.0887689	2.71	0.007	.0662385	.4145848
5	-.1272757	.0664795	-1.91	0.056	-.2577149	.0031635
6	.2442405	.2304245	1.06	0.289	-.2078744	.6963554
8	-.1050866	.1121747	-0.94	0.349	-.3251842	.1150109
9	-.0955651	.1348337	-0.71	0.479	-.3601218	.1689916
10	.0975979	.0767356	1.27	0.204	-.0529647	.2481605
11	2.759405	.7797288	3.54	0.000	1.229502	4.289307
12	.6771463	.1135223	5.96	0.000	.4544047	.8998878
13	.0225319	.0538476	0.42	0.676	-.0831224	.1281861
15	-1.127962	.2590434	-4.35	0.000	-1.63623	-.6196937
16	-.5029989	.1220814	-4.12	0.000	-.7425344	-.2634634
17	.4085668	.1072083	3.81	0.000	.1982138	.6189197
18	-.2056563	.1110607	-1.85	0.064	-.4235679	.0122553
19	-.62914	.1277561	-4.92	0.000	-.8798097	-.3784703
20	-.180834	.1015614	-1.78	0.075	-.3801071	.0184391
21	-.4255548	.1049019	-4.06	0.000	-.6313824	-.2197272
22	.3685392	.057251	6.44	0.000	.2562073	.4808711
23	-1.131981	.1330361	-8.51	0.000	-1.39301	-.8709513
24	.3961276	.0592262	6.69	0.000	.2799202	.512335
25	.2869058	.1489839	1.93	0.054	-.005415	.5792265
26	.2449163	.0991731	2.47	0.014	.0503291	.4395035
27	-.5760094	.1251856	-4.60	0.000	-.8216356	-.3303833
28	-.392985	.0771168	-5.10	0.000	-.5442955	-.2416745
29	.1455349	.0922059	1.58	0.115	-.0353819	.3264516
30	-.9910133	.1051692	-9.42	0.000	-1.197365	-.7846612
31	-.4432373	.11437	-3.88	0.000	-.6676422	-.2188325
32	.3226112	.0865611	3.73	0.000	.15277	.4924524
33	-1.277052	.139976	-9.12	0.000	-1.551698	-1.002406
34	.1222139	.1265728	0.97	0.334	-.126134	.3705618
35	.3817845	.0768095	4.97	0.000	.2310769	.5324921
36	.4354412	.1459921	2.98	0.003	.1489906	.7218917
37	-.0965572	.0549367	-1.76	0.079	-.2043483	.0112339
38	-1.843342	.111446	-16.54	0.000	-2.06201	-1.624675
39	-.1884885	.1257346	-1.50	0.134	-.4351919	.0582149
40	-.0411461	.0684913	-0.60	0.548	-.1755325	.0932403
41	.0049471	.1153633	0.04	0.966	-.2214067	.2313009
42	-.3249639	.1370178	-2.37	0.018	-.593806	-.0561218
44	-.1003761	.1577365	-0.64	0.525	-.4098703	.209118
45	.334051	.0576949	5.79	0.000	.2208482	.4472539
46	-1.024605	.0989142	-10.36	0.000	-1.218684	-.8305256
47	.0446805	.0720137	0.62	0.535	-.0966174	.1859784
48	.0526546	.1451395	0.36	0.717	-.2321229	.3374321
49	-.3039108	.1136771	-2.67	0.008	-.526956	-.0808655
50	-1.254522	.1352965	-9.27	0.000	-1.519987	-.9890573
51	-.6017665	.0614983	-9.79	0.000	-.7224321	-.4811009
53	-.1321725	.1036698	-1.27	0.203	-.3355826	.0712377
54	-.9691482	.122316	-7.92	0.000	-1.209144	-.7291524
55	-.7812224	.1174512	-6.65	0.000	-1.011673	-.5507718
56	-.4804004	.121985	-3.94	0.000	-.7197467	-.2410541
cons	4.036775	.3893662	10.37	0.000	3.272801	4.800749

Shall law is significant and indicates a 4.6% drop in violent crime rate when shall law is present.

5. **Time Fixed Effects Model**

In order to observe the Shall law effect on the crime rate over the years we perform Time Fixed Effects Panel Regression.

```
. xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.year, fe vce(cluster stateid)

Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.4180                                         min =         23
     between = 0.0419                                         avg =       23.0
     overall = 0.0009                                         max =         23

                                                F(30,50)          =      56.86
corr(u_i, Xb)  = -0.2929                        Prob > F          =     0.0000

                                (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnvio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |    .000076   .0002079     0.37   0.716    -.0003416    .0004935
      pb1064 |   .0291862   .0495407     0.59   0.558    -.0703192    .1286916
      pw1064 |   .0092501   .0237564     0.39   0.699    -.0384659    .0569662
      pm1029 |   .0733254   .0524733     1.40   0.168    -.0320704    .1787211
      avginc |   .0009587   .0164931     0.06   0.954    -.0321688    .0340861
         pop |  -.0047544   .0152294    -0.31   0.756    -.0353436    .0258347
     density |   -.091555   .1238622    -0.74   0.463    -.3403396    .1572296
       shall |  -.0279935   .0407168    -0.69   0.495    -.1097757    .0537886
             |
        year |
         78  |   .0585261   .0161556     3.62   0.001     .0260767    .0909755
         79  |   .1639486   .0244579     6.70   0.000     .1148233    .2130738
         80  |   .2170759   .0334184     6.50   0.000     .1499531    .2841987
         81  |   .2172551   .0391956     5.54   0.000     .1385284    .2959819
         82  |   .1946328   .0465743     4.18   0.000     .1010856      .28818
         83  |    .158645   .0593845     2.67   0.010     .0393676    .2779223
         84  |   .1929883   .0770021     2.51   0.015     .0383251    .3476515
         85  |   .2444764   .0922217     2.65   0.011     .0592438    .4297091
         86  |   .3240904   .1089181     2.98   0.004     .1053219    .5428589
         87  |    .324365   .1249881     2.60   0.012      .073319    .5754111
         88  |   .3867412   .1397074     2.77   0.008     .1061305    .6673518
         89  |   .4422143   .1535358     2.88   0.006     .1338286    .7505999
         90  |   .5430478   .1960859     2.77   0.008     .1491976     .936898
         91  |   .5959456   .2040685     2.92   0.005     .1860618    1.005829
         92  |   .6275171   .2170306     2.89   0.006     .1915982    1.063436
         93  |   .6497414   .2246177     2.89   0.006     .1985834    1.100899
         94  |   .6354187   .2332437     2.72   0.009     .1669349    1.103903
         95  |   .6276831   .2423607     2.59   0.013     .1408874    1.114479
         96  |   .5713423   .2534067     2.25   0.029       .06236    1.080325
         97  |   .5501153   .2613516     2.10   0.040     .0251751    1.075055
         98  |   .4932904   .2746546     1.80   0.079    -.0583697     1.04495
         99  |   .4328776   .2862197     1.51   0.137    -.1420117    1.007767
             |
       _cons |   3.765525   1.152108     3.27   0.002     1.451448    6.079603
-------------+----------------------------------------------------------------
     sigma_u |  .6663043
     sigma_e |  .1400264
         rho |  .95770338   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

The effect of shall law on violent crime rate further decreases. The violent crime rate decreases by 2.79% for those states who have the shall law implemented as compared to the other states where the shall law is not implemented. From 1983-1995 shows a major trend with an increase in the magnitude of the coefficients. And after 1996 we see a drop till 1999.

Furthermore, to check if there is any trend effect we perform a hypothesis test. This hypothesis test checks for the joint significance of time effects

Hypothesis:

H0: Year78=year79=year80………=year99=0

H1: Atleast one of the year estimator is not equal to 0

```
.   testparm i.year

 ( 1)  78.year = 0
 ( 2)  79.year = 0
 ( 3)  80.year = 0
 ( 4)  81.year = 0
 ( 5)  82.year = 0
 ( 6)  83.year = 0
 ( 7)  84.year = 0
 ( 8)  85.year = 0
 ( 9)  86.year = 0
 (10)  87.year = 0
 (11)  88.year = 0
 (12)  89.year = 0
 (13)  90.year = 0
 (14)  91.year = 0
 (15)  92.year = 0
 (16)  93.year = 0
 (17)  94.year = 0
 (18)  95.year = 0
 (19)  96.year = 0
 (20)  97.year = 0
 (21)  98.year = 0
 (22)  99.year = 0

       F( 22,    50) =   21.62
            Prob > F =    0.0000
```

The F-stat value obtained is 21.62 and the P-value is approximately 0. We can now reject the null hypothesis and conclude that there is a joint significance of time effect.

By performing the series of regression exercise we can conclude that time fixed effect is the most credible model as it uses the entire data to estimate the significance of shall law on crime rate.

6. Fixed Effect Regression on Murder & Robbery rate

Further analyzing the effect of shall law we model the murder and the robbery rate using the Fixed Effects panel regression.

```
. xtreg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe cluster(stateid)

Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.1528                                         min =         23
     between = 0.2221                                         avg =       23.0
     overall = 0.1846                                         max =         23

                                                F(8,50)           =     156.39
corr(u_i, Xb)  = -0.8961                        Prob > F          =     0.0000

                              (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |    -.00036   .0004231    -0.85   0.399    -.0012099    .0004899
      pb1064 |   .0307009   .0781245     0.39   0.696    -.1262169    .1876186
      pw1064 |   .0103313   .0128776     0.80   0.426    -.0155341    .0361967
      pm1029 |   .0392384   .0215964     1.82   0.075    -.0041394    .0826161
      avginc |   .0243114   .0156779     1.55   0.127    -.0071786    .0558013
         pop |  -.0257054   .0203457    -1.26   0.212    -.0665709    .0151602
     density |  -.6707132   .3957745    -1.69   0.096     -1.46565    .1242232
       shall |    -.06081   .0369632    -1.65   0.106    -.1350527    .0134327
       _cons |   .4600088   .8425884     0.55   0.588     -1.23238    2.152397
-------------+----------------------------------------------------------------
     sigma_u |    1.36035
     sigma_e |  .21942693
         rho |  .97464151   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

We observe that the murder rate is going down by 6.1% for those states who have the shall law implemented as compared to the other states where the shall law is not implemented. Shall law is not a significant variable.

```
. xtreg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.year, fe cluster(stateid)

Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.2905                                         min =         23
     between = 0.1945                                         avg =       23.0
     overall = 0.1413                                         max =         23

                                                F(30,50)          =      81.49
corr(u_i, Xb)  = -0.8336                        Prob > F          =     0.0000

                                (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |  -.0001164   .0003631    -0.32   0.750    -.0008457    .0006129
      pb1064 |   .0219833   .0758151     0.29   0.773    -.1302958    .1742624
      pw1064 |  -.0004893   .0201044    -0.02   0.981    -.0408701    .0398915
      pm1029 |   .0691941   .0417945     1.66   0.104    -.0147526    .1531408
      avginc |   .0566492   .0165554     3.42   0.001     .0233967    .0899017
         pop |  -.0320769   .0209819    -1.53   0.133    -.0742202    .0100664
     density |  -.5442635   .3192203    -1.70   0.094    -1.185436    .0969093
       shall |  -.0149524   .0382403    -0.39   0.697    -.0917603    .0618556
             |
        year |
         78  |  -.0007195   .0322722    -0.02   0.982    -.0655401    .0641011
         79  |   .0592481   .0311141     1.90   0.063    -.0032465    .1217427
         80  |   .0901814    .041058     2.20   0.033     .0077139    .1726489
         81  |   .1021543   .0510636     2.00   0.051     -.00041     .2047186
         82  |   .0224098   .0581861     0.39   0.702    -.0944604    .1392799
         83  |  -.0314385   .0640621    -0.49   0.626    -.1601111    .0972341
         84  |  -.1359192    .071662    -1.90   0.064    -.2798565    .0080181
         85  |  -.0866144   .0856965    -1.01   0.317    -.2587409    .0855122
         86  |  -.0122752   .0927286    -0.13   0.895    -.1985262    .1739758
         87  |  -.0290338   .0999408    -0.29   0.773    -.2297707    .1717032
         88  |  -.0174594   .1196893    -0.15   0.885    -.2578626    .2229437
         89  |  -.0145617   .1321034    -0.11   0.913    -.2798993    .2507759
         90  |    .059998   .1649718     0.36   0.718    -.2713577    .3913537
         91  |   .1053071   .1754909     0.60   0.551    -.2471767    .4577909
         92  |   .0681002   .1828352     0.37   0.711    -.2991352    .4353355
         93  |   .1544297   .1898113     0.81   0.420    -.2268176     .535677
         94  |   .0442648   .1971908     0.22   0.823    -.3518047    .4403342
         95  |   .0556601   .1989082     0.28   0.781    -.3438588     .455179
         96  |   -.015709   .2125365    -0.07   0.941    -.4426011    .4111831
         97  |  -.1221824   .2186706    -0.56   0.579    -.5613952    .3170304
         98  |  -.1863381   .2332966    -0.80   0.428    -.6549281    .2822519
         99  |  -.2554286   .2420434    -1.06   0.296     -.741587    .2307298
             |
       _cons |   .1882653   1.056771     0.18   0.859    -1.934322    2.310853
-------------+----------------------------------------------------------------
     sigma_u |  1.1362086
     sigma_e |  .20281999
         rho |  .96911961   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

From the time fixed effects model, we can see that the model has improved. The murder rate is decreases by 1.4% now for those states who have the shall law implemented as compared to the other states where the shall law is not implemented. Shall law is not a significant variable.

```
. xtreg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe cluster(stateid)

Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.0366                                         min =         23
     between = 0.0531                                         avg =       23.0
     overall = 0.0521                                         max =         23

                                                F(8,50)           =       2.86
corr(u_i, Xb)  = -0.0859                        Prob > F          =     0.0108

                                (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |  -.0000763    .000321    -0.24   0.813    -.0007211    .0005685
      pb1064 |   .1115421   .0511546     2.18   0.034      .008795    .2142891
      pw1064 |   .0271807   .0164344     1.65   0.104    -.0058286    .0601901
      pm1029 |   .0111817   .0290976     0.38   0.702    -.0472626     .069626
      avginc |  -.0175195   .0220352    -0.80   0.430    -.0617784    .0267395
         pop |   .0163332   .0275874     0.59   0.556    -.0390778    .0717441
     density |  -.1860917   .1663413    -1.12   0.269     -.520198    .1480147
       shall |  -.0078189   .0551653    -0.14   0.888    -.1186217    .1029838
       _cons |   2.445723   1.012584     2.42   0.019     .4118887    4.479557
-------------+----------------------------------------------------------------
     sigma_u |   .9174441
     sigma_e |  .21514885
         rho |  .94787229   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Also, the robbery rate is going down by 0.78% for those states who have the shall law implemented as compared to the other states where the shall law is not implemented. Shall law is not a significant variable.

```
. xtreg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.year, fe cluster(stateid)

Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.2359                                         min =         23
     between = 0.1358                                         avg =       23.0
     overall = 0.1362                                         max =         23

                                                F(30,50)          =      40.77
corr(u_i, Xb)  = 0.1441                         Prob > F          =     0.0000

                                (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |   .0000314   .0003477     0.09   0.928     -.000667    .0007297
      pb1064 |   .0141078   .0840609     0.17   0.867    -.1547335    .1829491
      pw1064 |  -.0128322   .0327626    -0.39   0.697    -.0786379    .0529734
      pm1029 |   .1046049    .072997     1.43   0.158    -.0420138    .2512236
      avginc |   .0143569   .0247676     0.58   0.565    -.0353903     .064104
         pop |   .0000164   .0259374     0.00   0.999    -.0520805    .0521133
     density |  -.0447449   .1982135    -0.23   0.822    -.4428684    .3533786
       shall |   .0268298   .0521753     0.51   0.609    -.0779673    .1316269
             |
        year |
          78 |   .0328497   .0216897     1.51   0.136    -.0107154    .0764148
          79 |   .1375917    .032117     4.28   0.000     .0730828    .2021006
          80 |    .243408    .045464     5.35   0.000     .1520908    .3347251
          81 |   .2737088   .0508793     5.38   0.000     .1715147     .375903
          82 |     .21599   .0644109     3.35   0.002     .0866168    .3453632
          83 |   .1208158   .0867066     1.39   0.170    -.0533395    .2949711
          84 |    .078831   .1064308     0.74   0.462    -.1349416    .2926036
          85 |   .1131495   .1272629     0.89   0.378    -.1424655    .3687645
          86 |   .1895678   .1521449     1.25   0.219    -.1160242    .4951598
          87 |   .1572151   .1688872     0.93   0.356    -.1820049     .496435
          88 |   .1927596   .1878849     1.03   0.310    -.1846184    .5701376
          89 |   .2487313   .2140573     1.16   0.251    -.1812154    .6786781
          90 |   .3509806   .2668617     1.32   0.194     -.185027    .8869881
          91 |   .4668537   .2791767     1.67   0.101    -.0938891    1.027596
          92 |   .4633221   .2951262     1.57   0.123    -.1294562      1.0561
          93 |   .4796983   .3082342     1.56   0.126    -.1394084    1.098805
          94 |   .4943754   .3234124     1.53   0.133    -.1552175    1.143968
          95 |   .4940171   .3338462     1.48   0.145    -.1765328    1.164567
          96 |   .4341625   .3504351     1.24   0.221    -.2697072    1.138032
          97 |   .3652393   .3581743     1.02   0.313     -.354175    1.084654
          98 |   .2677144   .3690383     0.73   0.472    -.4735208     1.00895
          99 |   .1894683   .3845414     0.49   0.624    -.5829059    .9618425
             |
       _cons |    3.27912   1.676644     1.96   0.056     -.088518    6.646759
-------------+----------------------------------------------------------------
     sigma_u |  .88484023
     sigma_e |  .19352746
         rho |  .95434775   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

The robbery rate now decreases by 2.6% for those states who have the shall law implemented as compared to the other states where the shall law is not implemented. Shall law is not a significant variable. For both murder & robbery rate, time effects is significant.

7. Non – Linear Regression in Fixed Effects Model

```
Call:
plm(formula = vio ~ incarc_rate + incarc_sq + pb1064 + pw1064 +
    pm1029 + pm1029sq + pop + avginc + avgincsq + density + shall,
    data = data2, index = c("stateid", "year"), method = "within")

Balanced Panel: n = 51, T = 23, N = 1173

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-707.0787  -46.2730   -3.2072   45.0785  795.3026

Coefficients:
               Estimate  Std. Error t-value  Pr(>|t|)
incarc_rate  2.0549e-01  9.1159e-02  2.2542  0.024380 *
incarc_sq   -6.4995e-05  6.7489e-05 -0.9630  0.335733
pb1064       1.0067e+01  1.1382e+01  0.8845  0.376635
pw1064       1.9847e+00  3.3996e+00  0.5838  0.559477
pm1029       5.5114e+01  3.7273e+01  1.4786  0.139519
pm1029sq    -1.9934e+00  1.0967e+00 -1.8177  0.069387 .
pop          8.6504e+00  5.2552e+00  1.6461  0.100032
avginc       9.8069e+01  1.6465e+01  5.9561 3.463e-09 ***
avgincsq    -3.1518e+00  5.3066e-01 -5.9395 3.820e-09 ***
density     -3.0984e+02  7.0666e+01 -4.3846 1.272e-05 ***
shall       -3.2899e+01  1.1578e+01 -2.8416  0.004571 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    13576000
Residual Sum of Squares: 10308000
R-Squared:      0.24073
Adj. R-Squared: 0.19904
F-statistic: 32.0225 on 11 and 1111 DF, p-value: < 2.22e-16
```

In the above model we have added incarc_sq (square term of the variable "incarc_rate", incarceration rate), pm1029sq (square term of the variable "pm1029", male population percentage), and avgincsq(square term of the variable "avginc", average income). Adding non-linear terms has made the variable "shall" significant in the model but made the male population percentage and white people population percentage insignificant. This model doesn't seem to improve the model when compared to the model without non-linear terms.

Conclusion

After running a series of regression models, we have got a much better picture on the effect of shall law on crime rate. From our best model we saw that implementation of shall law reduces the crime rate by just 2.7% and is insignificant. This value is pretty low from a world point of view.

The above achieved result tells us that there is no significant impact of shall law on crime rate.

Limitations

There might be few cases which is preventing us from thoroughly validating our model. 3 main cases are –

1. Heteroskedasticity: Apart from the investigation performed on the data for identifying heteroskedasticity, a clear culprit variable couldn't be identified. The graphs didn't depict much and also no knowledge about the function of variance hampered from employing Weighted Least Squares. To mitigate the risk of heteroskedasticity affecting our models, precaution was taken by using robust cluster standard errors.
2. Omitted variable bias: There might have been few variables which might not have been provided for analysis. These omitted variables could explain the effect the shall law on violent crime rate to a better extent. Due to this there could be omitted variable bias which can affect our models. Few omitted variables could be policies that vary between states and over time which help in governing the shall laws.
3. Simultaneous Causality: We sensed the presence of simultaneous causality bias in the data. Let's look into it – violent crime rate/ incarceration rate. This can be looked in two ways. If the incarceration rate at a place is high i.e. more number of law offenders are getting prisoned, then this instills a fear in the public and would in turn reduce the crime rate in that particular area. Another way of looking at this is, if the crime rate of a place is exceedingly high then the law enforces (police/ government) would deploy more squad of police and tighten the security. By doing so the incarceration would also increase. Another case of simultaneous causality could be between crime rate and shall law. If the crime rates at a particular state has always been low, then there wouldn't be a need to implement a concealed weapon law to reduce the crime. Also, if there is a high crime rate at a state over a long period of time, this would force the policy makers to introduce shall law in that state.

* from this page onwards, the report contains all the code which was written for this project*

-- BEGIN OF ALL DO FILES --

R Code

```
library(readstata13)
library(ggplot2)
library(dplyr)
library(directlabels)
data1<-read.dta13("guns.dta")
data2<- data1

# plots
attach(data2)
s<- ggplot(data = data2,aes(y=vio))

# Scatter plots

s+ geom_point(aes(x=avginc)) +geom_smooth(aes(x=avginc),method="lm", se=F)+
  labs(title="Violent crime rate Vs Average Income",
      y="Violence Rate",
      x="Average Income(in k)")

s+ geom_point(aes(x=incarc_rate)) +geom_smooth(aes(x=incarc_rate),method="lm", se=F)+
  labs(title="Incarceration Rate Vs Violent crime rate",
      y="Violence Rate",
      x="Incarceration Rate(previous year)")


s+ geom_point(aes(x=density)) +geom_smooth(aes(x=density),method="lm", se=F)+
  labs(title="Population Density Vs Violence Rate",
      y="Violence Rate",
      x="Population Density(per sq.mile / 1000)")

s+ geom_point(aes(x=pop)) +geom_smooth(aes(x=pop),method="lm", se=F)+
  labs(title="Population Vs Violence Rate",
      y="Violence Rate",
      x="Population (in millions)")

s+ geom_point(aes(x=pm1029)) +geom_smooth(aes(x=pm1029),method="lm", se=F)+
  labs(title="Male Population percentage Vs Violence Rate",
      y="Violence Rate",
      x="Male Population percentage (btwn age 10-29)")

s+ geom_point(aes(x=pw1064)) +geom_smooth(aes(x=pw1064),method="lm", se=F)+
  labs(title="White Population percentage Vs Violence Rate",
      y="Violence Rate",
      x="White Population percentage (btwn age 10-64)")

s+ geom_point(aes(x=pb1064)) +geom_smooth(aes(x=pb1064),method="lm", se=F)+
  labs(title="Black Population percentage Vs Violence Rate",
      y="Violence Rate",
      x="Black Population percentage (btwn age 10-64)")

# State wise plots

shall0=filter(data2, shall == 0)
shall1=filter(data2, shall == 1)
p0<-ggplot(data=shall0)
p1<-ggplot(data=shall1)
p0+geom_line(aes(x=year,y=vio,group = stateid,color=stateid))+
  geom_dl(aes(label = stateid,x=year,y=vio,group = stateid,color=stateid), method = list(dl.combine("first.points",
"last.points"), cex = 0.8))+
  labs(title="State wise violent crime Rate when Shall-carry law isn't in effect",
      y="Violence Rate")
p1+geom_line(aes(x=year,y=vio,group = stateid,color=stateid))+
  geom_dl(aes(label = stateid,x=year,y=vio,group = stateid,color=stateid), method = list(dl.combine("first.points",
"last.points"), cex = 0.8))+
  labs(title="State wise violent crime Rate when Shall-carry law is in effect",
      y="Violence Rate")

# Non-Linear Fixel Effect Model
data2$incarc_sq <- data2$incarc_rate*data2$incarc_rate
```

```
data2$pm1029sq <- data2$pm1029 * data2$pm1029
data2$avgincsq <- data2$avginc * data2$avginc
nl_model <- plm(vio ~ incarc_rate + incarc_sq +  pb1064 + pw1064 + pm1029 + pm1029sq + pop + avginc + avgincsq + density + shall,data = data2,method = 'within',index = c("stateid","year")  )
summary(nl_model)

install.packages('ggplot2')
library(ggplot2)
library(dplyr)
library(tidyr)
library(haven)

setwd("C:/Users/BHARGAV/Desktop/Econometrics/project/project")
hr <-read_dta('guns.dta')
hr$rob
summary(hr)

p <- ggplot(aes(x=vio),data = hr)+
  geom_histogram(color="black", fill="gray20", bins=30)+
  labs(title="crime rate for 'shall law' and 'no shall law'", x="crime rate", y="frequency")
p1= p+ facet_wrap(~shall)
p1

by(hr$vio, hr$shall, summary)
by(hr$mur, hr$shall, summary)
by(hr$rob, hr$shall, summary)


t.test(hr$vio~hr$shall)
t.test(hr$mur~hr$shall)
t.test(hr$rob~hr$shall)

by(hr$vio, hr$stateid, summary)
summary(hr$incarc_rate)
by(hr$incarc_rate, hr$shall, summary)
t.test(hr$incarc_rate~hr$shall)
```

STATA DO FILE WITH OUTPUTS

```
use "H:\econ\project\guns.dta", clear
des
summ
histogram vio

use guns.dta
describe

/* create log variable for vio */
gen lnvio = log(vio)

/* correlation matrix */
corr vio mur rob incarc_rate pb1064 pw1064 pm1029 pop avginc density
/* (obs=1,173)

             |      vio      mur      rob incarc~e   pb1064   pw1064   pm1029      pop   avginc  density
-------------+------------------------------------------------------------------------------------------
         vio |   1.0000
         mur |   0.8265   1.0000
         rob |   0.9071   0.7976   1.0000
 incarc_rate |   0.7027   0.7096   0.5668   1.0000
      pb1064 |   0.5698   0.6018   0.5812   0.5308   1.0000
      pw1064 |  -0.5730  -0.6154  -0.5842  -0.5271  -0.9820   1.0000
      pm1029 |  -0.1696   0.0150  -0.0860  -0.4463   0.0162  -0.0126   1.0000
         pop |   0.3190   0.0999   0.3172   0.0953   0.0581  -0.0654  -0.0975   1.0000
      avginc |   0.4080   0.2206   0.4148   0.4615   0.2627  -0.1912  -0.5279   0.2152   1.0000
     density |   0.6647   0.7486   0.7818   0.5593   0.5432  -0.5551  -0.0637  -0.0780   0.3433   1.0000

 From the matrix we cab see that mur & rob are highlu correlated to vio variable. We'll have to skip these variables while performing regression. */

/* let us check how only the shall_law has an impact on vio rate */
```

```
reg lnvio shall
/*
    Source |       SS           df       MS      Number of obs   =     1,173
-------------+----------------------------------   F(1, 1171)      =    111.08
     Model |  42.3348289         1  42.3348289   Prob > F        =    0.0000
  Residual |  446.29673     1,171  .381124449   R-squared       =    0.0866
-------------+----------------------------------   Adj R-squared   =    0.0859
     Total |  488.631558     1,172  .416921125   Root MSE        =    .61735

------------------------------------------------------------------------------
     lnvio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     shall |  -.4429646   .0420294   -10.54   0.000     -.525426   -.3605032
     _cons |   6.134919    .020717   296.13   0.000     6.094272    6.175566
------------------------------------------------------------------------------

We can see that, when shall law is implemented in a state, the violence rate drops by 44.2% */

/* since we are employing regression on panel data, it is advised to use robust standard errors */
reg lnvio shall, vce(robust)
/*
Linear regression                               Number of obs     =      1,173
                                                F(1, 1171)        =      86.86
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0866
                                                Root MSE          =     .61735

------------------------------------------------------------------------------
             |               Robust
     lnvio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     shall |  -.4429646   .0475283    -9.32   0.000    -.5362148   -.3497144
     _cons |   6.134919   .0193039   317.81   0.000     6.097045    6.172793
------------------------------------------------------------------------------

We can observe changes in the t-values & standard errors but coefficients remain same. */
/* let us go ahead and regress a pooled OLS model with robust standard errors */
Adding the interaction term doesn't improve the fit of the model. Hence we'll go ahead the model without the interaction
term */
/* Since it is panel data the least square estimators are not efficient. This is due to the fact that there can be unobserved
heterogeneity.
 We'll go ahead and create a fixed effect model & interpret the fixed effect estimators. We can do this in two ways - dummy
variable creation or
 fixed effect estimator. since N is large it isn't feasible to do so. Let's go ahead with fixed effect estimator.
 We have to let Stata know that we are dealing with panel data -*/
 xtset stateid year
/*       panel variable:  stateid (strongly balanced)
        time variable:  year, 77 to 99
                delta:  1 unit */
/* since it is a balanced panel data, it makes sense to use fixed effect over random effects */
xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe cluster(stateid)
/*
Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.2178                                         min =         23
     between = 0.0033                                         avg =       23.0
     overall = 0.0001                                         max =         23

                                                F(8,50)           =      34.10
corr(u_i, Xb)  = -0.3687                        Prob > F          =     0.0000

                               (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
     lnvio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |   -.000071   .0002504    -0.28   0.778    -.0005739    .0004318
      pb1064 |   .1042804   .0326849     3.19   0.002     .0386308    .1699301
```

```
     pw1064 |  .0408611  .0134585    3.04  0.004    .0138289   .0678932
     pm1029 |  -.0502725  .0206949   -2.43  0.019   -.0918394  -.0087057
     avginc |  -.0092037  .0129649   -0.71  0.481   -.0352445    .016837
        pop |   .0115247   .014224    0.81  0.422   -.0170452   .0400945
    density |  -.1722901  .1376129   -1.25  0.216   -.4486936   .1041135
      shall |  -.0461415  .0417616   -1.10  0.275   -.1300223   .0377392
      _cons |   3.866017  .7701057    5.02  0.000    2.319214   5.412819
-------------+----------------------------------------------------------------
    sigma_u |  .68024951
    sigma_e |  .16072287
        rho |  .94712779   (fraction of variance due to u_i)
------------------------------------------------------------------------------ */
/* we can have 2 more variations for fixed effects. entity fixed & time fixed effects. We'll good ahead with both */
/* fixed entity fixed effect. create dummy variable for state */
reg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.stateid
/*
      Source |       SS           df       MS      Number of obs   =     1,173
-------------+----------------------------------   F(58, 1114)     =    306.93
       Model |  459.854887        58  7.92853254   Prob > F        =    0.0000
    Residual |  28.7766714     1,114  .025831841   R-squared       =    0.9411
-------------+----------------------------------   Adj R-squared   =    0.9380
       Total |  488.631558     1,172  .416921125   Root MSE        =    .16072

------------------------------------------------------------------------------
       lnvio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |   -.000071   .0000936    -0.76   0.448    -.0002547    .0001126
      pb1064 |   .1042804   .0177564     5.87   0.000     .0694407    .1391201
      pw1064 |   .0408611   .0050745     8.05   0.000     .0309044    .0508177
      pm1029 |  -.0502725   .0064037    -7.85   0.000    -.0628373   -.0377078
      avginc |  -.0092037   .0059083    -1.56   0.120    -.0207963    .0023889
         pop |   .0115247   .0087239     1.32   0.187    -.0055924    .0286417
     density |  -.1722901   .0850362    -2.03   0.043    -.3391392   -.0054409
       shall |  -.0461415   .0188668    -2.45   0.015      -.08316    -.009123
             |
     stateid |
          2  |   .0559649   .0727213     0.77   0.442    -.0867213     .198651
          4  |   .2404116   .0887689     2.71   0.007     .0662385    .4145848
          5  |  -.1272757   .0664795    -1.91   0.056    -.2577149    .0031635
          6  |   .2442405   .2304245     1.06   0.289    -.2078744    .6963554
          8  |  -.1050866   .1121747    -0.94   0.349    -.3251842    .1150109
          9  |  -.0955651   .1348337    -0.71   0.479    -.3601218    .1689916
         10  |   .0975979   .0767356     1.27   0.204    -.0529647    .2481605
         11  |   2.759405   .7797288     3.54   0.000     1.229502    4.289307
         12  |   .6771463   .1135223     5.96   0.000     .4544047    .8998878
         13  |   .0225319   .0538476     0.42   0.676    -.0831224    .1281861
         15  |  -1.127962   .2590434    -4.35   0.000     -1.63623   -.6196937
         16  |  -.5029989   .1220814    -4.12   0.000    -.7425344   -.2634634
         17  |   .4085668   .1072083     3.81   0.000     .1982138    .6189197
         18  |  -.2056563   .1110607    -1.85   0.064    -.4235679    .0122553
         19  |    -.62914   .1277561    -4.92   0.000    -.8798097   -.3784703
         20  |   -.180834   .1015614    -1.78   0.075    -.3801071    .0184391
         21  |  -.4255548   .1049019    -4.06   0.000    -.6313824   -.2197272
         22  |   .3685392    .057251     6.44   0.000     .2562073    .4808711
         23  |  -1.131981   .1330361    -8.51   0.000     -1.39301   -.8709513
         24  |   .3961276   .0592262     6.69   0.000     .2799202     .512335
         25  |   .2869058   .1489839     1.93   0.054     -.005415    .5792265
         26  |   .2449163   .0991731     2.47   0.014     .0503291    .4395035
         27  |  -.5760094   .1251856    -4.60   0.000    -.8216356   -.3303833
         28  |   -.392985   .0771168    -5.10   0.000    -.5442955   -.2416745
         29  |   .1455349   .0922059     1.58   0.115    -.0353819    .3264516
         30  |  -.9910133   .1051692    -9.42   0.000    -1.197365   -.7846612
         31  |  -.4432373     .11437    -3.88   0.000    -.6676422   -.2188325
         32  |   .3226112   .0865611     3.73   0.000       .15277    .4924524
         33  |  -1.277052    .139976    -9.12   0.000    -1.551698   -1.002406
         34  |   .1222139   .1265728     0.97   0.334     -.126134    .3705618
         35  |   .3817845   .0768095     4.97   0.000     .2310769    .5324921
         36  |   .4354412   .1459921     2.98   0.003     .1489906    .7218917
         37  |  -.0965572   .0549367    -1.76   0.079    -.2043483    .0112339
         38  |  -1.843342    .111446   -16.54   0.000     -2.06201   -1.624675
```

```
         39  |  -.1884885   .1257346    -1.50   0.134    -.4351919    .0582149
         40  |  -.0411461   .0684913    -0.60   0.548    -.1755325    .0932403
         41  |   .0049471   .1153633     0.04   0.966    -.2214067    .2313009
         42  |  -.3249639   .1370178    -2.37   0.018     -.593806   -.0561218
         44  |  -.1003761   .1577365    -0.64   0.525    -.4098703     .209118
         45  |    .334051   .0576949     5.79   0.000     .2208482    .4472539
         46  |  -1.024605   .0989142   -10.36   0.000    -1.218684   -.8305256
         47  |   .0446805   .0720137     0.62   0.535    -.0966174    .1859784
         48  |   .0526546   .1451395     0.36   0.717    -.2321229    .3374321
         49  |  -.3039108   .1136771    -2.67   0.008     -.526956   -.0808655
         50  |  -1.254522   .1352965    -9.27   0.000    -1.519987   -.9890573
         51  |  -.6017665   .0614983    -9.79   0.000    -.7224321   -.4811009
         53  |  -.1321725   .1036698    -1.27   0.203    -.3355826    .0712377
         54  |  -.9691482    .122316    -7.92   0.000    -1.209144   -.7291524
         55  |  -.7812224   .1174512    -6.65   0.000    -1.011673   -.5507718
         56  |  -.4804004    .121985    -3.94   0.000    -.7197467   -.2410541
             |
       _cons |   4.036775   .3893662    10.37   0.000     3.272801    4.800749
------------------------------------------------------------------------------ */

/* the estimate on shall law hasnt changed. let's go with time-fixed effect */
xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.year, fe cluster(stateid)
/*
Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.4180                                         min =         23
     between = 0.0419                                         avg =       23.0
     overall = 0.0009                                         max =         23

                                                F(30,50)          =      56.86
corr(u_i, Xb)  = -0.2929                        Prob > F          =     0.0000

                               (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnvio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |    .000076   .0002079     0.37   0.716    -.0003416    .0004935
      pb1064 |   .0291862   .0495407     0.59   0.558    -.0703192    .1286916
      pw1064 |   .0092501   .0237564     0.39   0.699    -.0384659    .0569662
      pm1029 |   .0733254   .0524733     1.40   0.168    -.0320704    .1787211
      avginc |   .0009587   .0164931     0.06   0.954    -.0321688    .0340861
         pop |  -.0047544   .0152294    -0.31   0.756    -.0353436    .0258347
     density |   -.091555   .1238622    -0.74   0.463    -.3403396    .1572296
       shall |  -.0279935   .0407168    -0.69   0.495    -.1097757    .0537886
             |
        year |
         78  |   .0585261   .0161556     3.62   0.001     .0260767    .0909755
         79  |   .1639486   .0244579     6.70   0.000     .1148233    .2130738
         80  |   .2170759   .0334184     6.50   0.000     .1499531    .2841987
         81  |   .2172551   .0391956     5.54   0.000     .1385284    .2959819
         82  |   .1946328   .0465743     4.18   0.000     .1010856      .28818
         83  |    .158645   .0593845     2.67   0.010     .0393676    .2779223
         84  |   .1929883   .0770021     2.51   0.015     .0383251    .3476515
         85  |   .2444764   .0922217     2.65   0.011     .0592438    .4297091
         86  |   .3240904   .1089181     2.98   0.004     .1053219    .5428589
         87  |    .324365   .1249881     2.60   0.012      .073319    .5754111
         88  |   .3867412   .1397074     2.77   0.008     .1061305    .6673518
         89  |   .4422143   .1535358     2.88   0.006     .1338286    .7505999
         90  |   .5430478   .1960859     2.77   0.008     .1491976     .936898
         91  |   .5959456   .2040685     2.92   0.005     .1860618    1.005829
         92  |   .6275171   .2170306     2.89   0.006     .1915982    1.063436
         93  |   .6497414   .2246177     2.89   0.006     .1985834    1.100899
         94  |   .6354187   .2332437     2.72   0.009     .1669349    1.103903
         95  |   .6276831   .2423607     2.59   0.013     .1408874    1.114479
         96  |   .5713423   .2534067     2.25   0.029       .06236    1.080325
         97  |   .5501153   .2613516     2.10   0.040     .0251751    1.075055
         98  |   .4932904   .2746546     1.80   0.079    -.0583697     1.04495
```

```
      99  |   .4328776   .2862197     1.51   0.137    -.1420117    1.007767
             |
       _cons  |   3.765525   1.152108     3.27   0.002     1.451448    6.079603
-------------+----------------------------------------------------------------
     sigma_u  |    .6663043
     sigma_e  |    .1400264
         rho  |   .95770338   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

we can see that effect of shall law has decreased more. this model can be better because it explained for a lot of unobserved characteristics */

/* we can check if the years are jointly significant ot not
H0: effects of all time effects = 0
H1: effect not equal to 0 at least for 1 year */

```
 testparm i.year
/*
 ( 1)  78.year = 0
 ( 2)  79.year = 0
 ( 3)  80.year = 0
 ( 4)  81.year = 0
 ( 5)  82.year = 0
 ( 6)  83.year = 0
 ( 7)  84.year = 0
 ( 8)  85.year = 0
 ( 9)  86.year = 0
 (10)  87.year = 0
 (11)  88.year = 0
 (12)  89.year = 0
 (13)  90.year = 0
 (14)  91.year = 0
 (15)  92.year = 0
 (16)  93.year = 0
 (17)  94.year = 0
 (18)  95.year = 0
 (19)  96.year = 0
 (20)  97.year = 0
 (21)  98.year = 0
 (22)  99.year = 0

       F( 22,    50) =   21.62
            Prob > F =    0.0000 */
```

/* Yes, the time effects are jointly statistically significant */
/* Also, the effect on shall law drops even more. so, this model can be utilized to explain about the data. hence, we prefer a model with both entity & time effect*/

```
/* random effects model */
xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, re cluster(stateid)
/*
Random-effects GLS regression                   Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.2044                                         min =         23
     between = 0.4908                                         avg =       23.0
     overall = 0.4591                                         max =         23

                                                Wald chi2(8)      =     167.14
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

                               (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnvio |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |   .0001888   .0001877     1.01   0.314    -.0001791    .0005567
      pb1064 |   .1067022   .0270973     3.94   0.000     .0535924    .1598119
      pw1064 |   .0400716   .0127282     3.15   0.002     .0151248    .0650184
      pm1029 |  -.0375292   .0180436    -2.08   0.038     -.072894   -.0021643
      avginc |  -.0105112   .0117802    -0.89   0.372    -.0335999    .0125775
```

```
         pop |   .0225755   .0116369     1.94   0.052    -.0002323    .0453833
     density |   .0661588   .0437925     1.51   0.131    -.0196729    .1519905
       shall |   -.069609    .038845    -1.79   0.073    -.1457438    .0065258
       _cons |   3.525463   .7786851     4.53   0.000     1.999268    5.051658
-------------+----------------------------------------------------------------
     sigma_u |  .33790775
     sigma_e |  .16072287
         rho |  .81550462   (fraction of variance due to u_i)
------------------------------------------------------------------------------ */

/* test for endogienty - Hausman test */
quietly xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe
estimates store fe
quietly xtreg lnvio incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, re
estimates store re
hausman fe re

/*

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
 incarc_rate |    -.000071     .0001888       -.0002598        .0000635
      pb1064 |    .1042804     .1067022       -.0024217         .011767
      pw1064 |    .0408611     .0400716        .0007895               .
      pm1029 |   -.0502725    -.0375292       -.0127434        .0021099
      avginc |   -.0092037    -.0105112        .0013075        .0006269
         pop |    .0115247     .0225755       -.0110508        .0059821
     density |   -.1722901     .0661588       -.2384489        .0763882
       shall |   -.0461415     -.069609        .0234675               .
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from xtreg
           B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       31.86
                Prob>chi2 =      0.0001
                (V_b-V_B is not positive definite)  */

/* reject null and conclude at least 1 has endogeneity. from the differences we can suspect density is an endogenous
variable */

/* ------------------- END of vio variable ------------------ */
/* ------------------- BEGIN of rob variable ---------------- */
use guns.dta
describe

/* create log variable for mur */
gen lnrob = log(rob)

/* let us check how only the shall_law has an impact on mur rate */
reg lnrob shall
/*
      Source |       SS           df       MS      Number of obs   =     1,173
-------------+----------------------------------   F(1, 1171)      =    160.90
       Model |  129.02655         1   129.02655   Prob > F        =    0.0000
    Residual |  939.006572     1,171  .801884349   R-squared       =    0.1208
-------------+----------------------------------   Adj R-squared   =    0.1201
       Total |  1068.03312     1,172   .91129106   Root MSE        =    .89548

------------------------------------------------------------------------------
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       shall |  -.7733207   .0609644   -12.68   0.000    -.8929323   -.6537091
       _cons |   4.873051   .0300503   162.16   0.000     4.814093     4.93201
------------------------------------------------------------------------------
```

```
We can see that, when shall law is implemented in a state, the violence rate drops by 77.3% */

/* since we are employing regression on panel data, it is advised to use robust standard errors */
reg lnrob shall, vce(robust)
/*

Linear regression                    Number of obs     =      1,173
                                F(1, 1171)       =     124.66
                                Prob > F         =     0.0000
                                R-squared        =     0.1208
                                Root MSE         =     .89548

------------------------------------------------------------------------------
             |               Robust
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       shall |  -.7733207   .0692623   -11.17   0.000    -.9092128   -.6374286
       _cons |   4.873051   .0279093   174.60   0.000     4.818293    4.927809
------------------------------------------------------------------------------

We can observe changes in the t-values & standard errors but coeffiecnts remain same. */

/* let us go ahead and regress a pooled OLS model with robust standard errors
From the above model, we have to remove mur rob variables since they are highly correlated to vio, remodelling - */
reg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, vce(robust)
/*

Linear regression                    Number of obs     =      1,173
                                F(8, 1164)       =     144.90
                                Prob > F         =     0.0000
                                R-squared        =     0.5962
                                Root MSE         =     .60869

------------------------------------------------------------------------------
             |               Robust
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |   .0010057   .0001869     5.38   0.000     .0006391    .0013724
      pb1064 |   .1021881   .0265948     3.84   0.000     .0500091    .1543672
      pw1064 |   .0275209   .0135419     2.03   0.042     .0009515    .0540902
      pm1029 |   .0272565   .0149995     1.82   0.069    -.0021726    .0566856
      avginc |   .0407325   .0092722     4.39   0.000     .0225404    .0589246
         pop |   .0778176   .0054853    14.19   0.000     .0670554    .0885799
     density |   .0905048   .0153545     5.89   0.000     .0603792    .1206303
       shall |  -.5288202   .0510021   -10.37   0.000    -.6288865   -.4287539
       _cons |   .9041383   .8893029     1.02   0.310    -.8406777    2.648954
------------------------------------------------------------------------------

we can see that contribution of shall law towards vio rate has decreased. Now vio rate is reduced by 31% when a shall law was introduced. */
/* Since it is panel data the least square estimators are not efficient. This is due to the fact that there can be unobserved heterogeneity.
 We'll go ahead and create a fixed effect model & interpret the fixed effect estimators. We can do this in two ways - dummy variable creation or
 fixed effect estimator. since N is large it isn't feasible to do so. Let's go ahead with fixed effect estimator.
 We have to let Stata know that we are dealing with panel data -*/
 xtset stateid year
/*       panel variable:  stateid (strongly balanced)
        time variable:  year, 77 to 99
                delta:  1 unit */
/* since it is a balanced panel data, it makes sense to use fixed effect over random effects */
xtreg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe
/*Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51

R-sq:                                           Obs per group:
     within  = 0.0366                                         min =         23
     between = 0.0531                                         avg =       23.0
     overall = 0.0521                                         max =         23
```

```
                                F(8,1114)       =      5.29
corr(u_i, Xb)  = -0.0859                    Prob > F        =    0.0000

------------------------------------------------------------------------------
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |  -.0000763   .0001253    -0.61   0.542    -.0003222    .0001695
      pb1064 |   .1115421   .0237693     4.69   0.000     .0649045    .1581796
      pw1064 |   .0271807   .0067929     4.00   0.000     .0138525     .040509
      pm1029 |   .0111817   .0085722     1.30   0.192    -.0056378    .0280012
      avginc |  -.0175195    .007909    -2.22   0.027    -.0330377   -.0020012
         pop |   .0163332   .0116781     1.40   0.162    -.0065803    .0392466
     density |  -.1860917   .1138322    -1.63   0.102    -.4094413     .037258
       shall |  -.0078189   .0252557    -0.31   0.757    -.0573731    .0417352
       _cons |   2.445723   .5150678     4.75   0.000     1.435111    3.456335
-------------+----------------------------------------------------------------
     sigma_u |   .9174441
     sigma_e |  .21514885
         rho |  .94787229   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(50, 1114) = 164.06               Prob > F = 0.0000
We can see that the coeffecitent of shall rate has reduced considerably. If there is unobserved heterogeniety, we can make
our model robust to these effects as well - */
xtreg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe cluster(stateid)
/* Fixed-effects (within) regression             Number of obs     =      1,173
Group variable: stateid                          Number of groups  =         51

R-sq:                                            Obs per group:
     within  = 0.0366                                         min =         23
     between = 0.0531                                         avg =       23.0
     overall = 0.0521                                         max =         23

                                F(8,50)         =      2.86
corr(u_i, Xb)  = -0.0859                    Prob > F        =    0.0108

                              (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |  -.0000763    .000321    -0.24   0.813    -.0007211    .0005685
      pb1064 |   .1115421   .0511546     2.18   0.034      .008795    .2142891
      pw1064 |   .0271807   .0164344     1.65   0.104    -.0058286    .0601901
      pm1029 |   .0111817   .0290976     0.38   0.702    -.0472626     .069626
      avginc |  -.0175195   .0220352    -0.80   0.430    -.0617784    .0267395
         pop |   .0163332   .0275874     0.59   0.556    -.0390778    .0717441
     density |  -.1860917   .1663413    -1.12   0.269     -.520198    .1480147
       shall |  -.0078189   .0551653    -0.14   0.888    -.1186217    .1029838
       _cons |   2.445723   1.012584     2.42   0.019     .4118887    4.479557
-------------+----------------------------------------------------------------
     sigma_u |   .9174441
     sigma_e |  .21514885
         rho |  .94787229   (fraction of variance due to u_i)
------------------------------------------------------------------------------ */
/* we can have 2 more variations for fixed effects. entity fixed & time fixed effects. We'll good ahead with both */
/* fixed entity fixed effect. create dummy variable for state */
reg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.stateid
/*      Source |       SS           df       MS      Number of obs   =     1,173
-------------+----------------------------------   F(58, 1114)     =    378.61
       Model |  1016.46714        58  17.5252956   Prob > F        =    0.0000
    Residual |  51.5659789     1,114  .04628903   R-squared       =    0.9517
-------------+----------------------------------   Adj R-squared   =    0.9492
       Total |  1068.03312     1,172  .91129106   Root MSE        =    .21515

------------------------------------------------------------------------------
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |  -.0000763   .0001253    -0.61   0.542    -.0003222    .0001695
      pb1064 |   .1115421   .0237693     4.69   0.000     .0649045    .1581796
```

```
   pw1064 |  .0271807  .0067929    4.00  0.000    .0138525    .040509
   pm1029 |  .0111817  .0085722    1.30  0.192   -.0056378   .0280012
   avginc |  -.0175195   .007909   -2.22  0.027   -.0330377  -.0020012
      pop |  .0163332  .0116781    1.40  0.162   -.0065803   .0392466
  density |  -.1860917  .1138322   -1.63  0.102   -.4094413    .037258
    shall |  -.0078189  .0252557   -0.31  0.757   -.0573731   .0417352
          |
  stateid |
       2  |  -.2524599  .0973471   -2.59  0.010   -.4434642  -.0614555
       4  |  .4998573   .118829    4.21  0.000    .2667034   .7330112
       5  |  -.0886909  .0889917   -1.00  0.319    -.263301   .0859193
       6  |  .6758399  .3084537    2.19  0.029    .0706242   1.281056
       8  |  .1977714  .1501607    1.32  0.188   -.0968584   .4924011
       9  |  .8646919  .1804928    4.79  0.000    .5105477   1.218836
      10  |  .3987445  .1027208    3.88  0.000    .1971965   .6002924
      11  |  3.271549   1.04377    3.13  0.002    1.223571   5.319526
      12  |  1.103328  .1519646    7.26  0.000    .8051586   1.401497
      13  |  .3174942  .0720822    4.40  0.000     .176062   .4589264
      15  |  -1.003273  .3467639   -2.89  0.004   -1.683657  -.3228892
      16  |   -1.1913  .1634222   -7.29  0.000    -1.51195  -.8706501
      17  |  1.026567  .1435125    7.15  0.000    .7449816   1.308152
      18  |  .1770861  .1486694    1.19  0.234   -.1146175   .4687897
      19  |  -.5782475  .1710185   -3.38  0.001   -.9138022  -.2426929
      20  |  .1063569  .1359533    0.78  0.434   -.1603965   .3731104
      21  |  -.1137133  .1404251   -0.81  0.418   -.3892408   .1618142
      22  |  .4261722   .076638    5.56  0.000    .2758012   .5765433
      23  |  -1.121693  .1780864   -6.30  0.000   -1.471115  -.7722701
      24  |  .9937587  .0792821   12.53  0.000    .8381997   1.149318
      25  |  .7654727  .1994347    3.84  0.000    .3741627   1.156783
      26  |  .7157619  .1327564    5.39  0.000    .4552811   .9762426
      27  |  .1243381  .1675775    0.74  0.458   -.2044651   .4531412
      28  |  -.5037359   .103231   -4.88  0.000    -.706285  -.3011868
      29  |  .6637821  .1234298    5.38  0.000     .421601   .9059632
      30  |  -1.19872  .1407829   -8.51  0.000    -1.47495  -.9224906
      31  |  -.2888544  .1530994   -1.89  0.059     -.58925   .0115413
      32  |  1.156535  .1158735    9.98  0.000    .9291797    1.38389
      33  |  -1.056983  .1873764   -5.64  0.000   -1.424634  -.6893328
      34  |  1.014261  .1694344    5.99  0.000    .6818145   1.346708
      35  |  .2376604  .1028197    2.31  0.021    .0359183   .4394024
      36  |  1.326163  .1954298    6.79  0.000    .9427105   1.709615
      37  |  -.163333    .07354   -2.22  0.027   -.3076256  -.0190404
      38  |  -2.21564  .1491853  -14.85  0.000   -2.508356  -1.922924
      39  |  .5056484  .1683125    3.00  0.003    .1754032   .8358935
      40  |  .0443993  .0916846    0.48  0.628   -.1354947   .2242933
      41  |  .5380183   .154429    3.48  0.001    .2350138   .8410229
      42  |  .4905667  .1834165    2.67  0.008     .130686   .8504475
      44  |  .3712608  .2111512    1.76  0.079   -.0430381   .7855597
      45  |  -.1018475  .0772322   -1.32  0.188   -.2533845   .0496896
      46  |  -1.616425  .1324097  -12.21  0.000   -1.876225  -1.356624
      47  |   .512852  .0963999    5.32  0.000    .3237061   .7019979
      48  |  .4202159  .1942884    2.16  0.031    .0390035   .8014283
      49  |  -.2693639  .1521718   -1.77  0.077   -.5679395   .0292117
      50  |  -1.559857  .1811122   -8.61  0.000   -1.915216  -1.204497
      51  |  -.1249104  .0823236   -1.52  0.129   -.2864373   .0366164
      53  |  .2616721  .1387758    1.89  0.060   -.0106193   .5339635
      54  |  -.7122682  .1637362   -4.35  0.000   -1.033534  -.3910021
      55  |  -.0994233   .157224   -0.63  0.527   -.4079118   .2090653
      56  |  -1.283712  .1632931   -7.86  0.000   -1.604108  -.9633148
          |
    _cons |  2.373892  .5212183    4.55  0.000    1.351212   3.396572
------------------------------------------------------------------------------ */
/* the estimate on shall law hasnt changed. let's go with time-fixed effect */
xtreg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.year, fe cluster(stateid)
/* Fixed-effects (within) regression             Number of obs     =      1,173
Group variable: stateid                          Number of groups  =         51
R-sq:                                            Obs per group:
     within  = 0.2359                                          min =         23
     between = 0.1358                                          avg =       23.0
     overall = 0.1362                                          max =         23
```

```
                        F(30,50)        =     40.77
corr(u_i, Xb)  = 0.1441                   Prob > F        =    0.0000

                      (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |             Robust
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |   .0000314   .0003477     0.09   0.928     -.000667    .0007297
      pb1064 |   .0141078   .0840609     0.17   0.867    -.1547335    .1829491
      pw1064 |  -.0128322   .0327626    -0.39   0.697    -.0786379    .0529734
      pm1029 |   .1046049    .072997     1.43   0.158    -.0420138    .2512236
      avginc |   .0143569   .0247676     0.58   0.565    -.0353903     .064104
         pop |   .0000164   .0259374     0.00   0.999    -.0520805    .0521133
     density |  -.0447449   .1982135    -0.23   0.822    -.4428684    .3533786
       shall |   .0268298   .0521753     0.51   0.609    -.0779673    .1316269
             |
        year |
         78  |   .0328497   .0216897     1.51   0.136    -.0107154    .0764148
         79  |   .1375917    .032117     4.28   0.000     .0730828    .2021006
         80  |    .243408    .045464     5.35   0.000     .1520908    .3347251
         81  |   .2737088   .0508793     5.38   0.000     .1715147     .375903
         82  |     .21599   .0644109     3.35   0.002     .0866168    .3453632
         83  |   .1208158   .0867066     1.39   0.170    -.0533395    .2949711
         84  |    .078831   .1064308     0.74   0.462    -.1349416    .2926036
         85  |   .1131495   .1272629     0.89   0.378    -.1424655    .3687645
         86  |   .1895678   .1521449     1.25   0.219    -.1160242    .4951598
         87  |   .1572151   .1688872     0.93   0.356    -.1820049     .496435
         88  |   .1927596   .1878849     1.03   0.310    -.1846184    .5701376
         89  |   .2487313   .2140573     1.16   0.251    -.1812154    .6786781
         90  |   .3509806   .2668617     1.32   0.194     -.185027    .8869881
         91  |   .4668537   .2791767     1.67   0.101    -.0938891    1.027596
         92  |   .4633221   .2951262     1.57   0.123    -.1294562      1.0561
         93  |   .4796983   .3082342     1.56   0.126    -.1394084    1.098805
         94  |   .4943754   .3234124     1.53   0.133    -.1552175    1.143968
         95  |   .4940171   .3338462     1.48   0.145    -.1765328    1.164567
         96  |   .4341625   .3504351     1.24   0.221    -.2697072    1.138032
         97  |   .3652393   .3581743     1.02   0.313     -.354175    1.084654
         98  |   .2677144   .3690383     0.73   0.472    -.4735208     1.00895
         99  |   .1894683   .3845414     0.49   0.624    -.5829059    .9618425
             |
       _cons |    3.27912   1.676644     1.96   0.056     -.088518    6.646759
-------------+----------------------------------------------------------------
     sigma_u |  .88484023
     sigma_e |  .19352746
         rho |  .95434775   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

we can see that effect of shall law has decreaed more. this model can be better because it explanied for a lot of unobserved characterisics */

/* we can check if the years are jointly significant ot not
 H0: effects of all time effects = 0
 H1: effect not equal to 0 atleast for 1 year */

```
 testparm i.year
/*  ( 1)  78.year = 0
 ( 2)  79.year = 0
 ( 3)  80.year = 0
 ( 4)  81.year = 0
 ( 5)  82.year = 0
 ( 6)  83.year = 0
 ( 7)  84.year = 0
 ( 8)  85.year = 0
 ( 9)  86.year = 0
 (10)  87.year = 0
 (11)  88.year = 0
 (12)  89.year = 0
 (13)  90.year = 0
 (14)  91.year = 0
 (15)  92.year = 0
 (16)  93.year = 0
```

```
 (17)  94.year = 0
 (18)  95.year = 0
 (19)  96.year = 0
 (20)  97.year = 0
 (21)  98.year = 0
 (22)  99.year = 0

       F( 22,    50) =   25.86
            Prob > F =    0.0000 */
/* Yes, the time effects are jointly statistically significant */
/* Also, the effect on shall law drops even more. so this model can be utlized to explain about the data.  hence we prefer a
model with both entity & time effect*/
/* random effects model */
xtreg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, re cluster(stateid)
/* Random-effects GLS regression                   Number of obs     =      1,173
Group variable: stateid                        Number of groups  =         51
R-sq:                                          Obs per group:
     within  = 0.0269                                         min =         23
     between = 0.5183                                         avg =       23.0
     overall = 0.4910                                         max =         23

                                                Wald chi2(8)      =      83.85
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

                               (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnrob |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |   .0001735   .0002507     0.69   0.489    -.0003179    .0006649
      pb1064 |   .1074485   .0337729     3.18   0.001     .0412548    .1736422
      pw1064 |   .0282639   .0162546     1.74   0.082    -.0035945    .0601223
      pm1029 |   .0252997   .0259436     0.98   0.329    -.0255489    .0761483
      avginc |  -.0152975   .0199351    -0.77   0.443    -.0543697    .0237747
         pop |   .0405861   .0244303     1.66   0.097    -.0072964    .0884686
     density |   .0997518   .0479974     2.08   0.038     .0056786    .1938251
       shall |  -.0411192   .0529293    -0.78   0.437    -.1448586    .0626203
       _cons |     1.8759   1.025224     1.83   0.067    -.1335014    3.885301
-------------+----------------------------------------------------------------
     sigma_u |  .48469008
     sigma_e |  .21514885
         rho |  .83539542   (fraction of variance due to u_i)
------------------------------------------------------------------------------ */
/* test for endogienty - Hausman test */
quietly xtreg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe
estimates store fe
quietly xtreg lnrob incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, re
estimates store re
hausman fe re
/*                ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
 incarc_rate |   -.0000763     .0001735       -.0002498        .0000838
      pb1064 |    .1115421     .1074485        .0040936        .0153173
      pw1064 |    .0271807     .0282639       -.0010832               .
      pm1029 |    .0111817     .0252997        -.014118         .002718
      avginc |   -.0175195    -.0152975        -.002222        .0005277
         pop |    .0163332     .0405861       -.0242529          .00772
     density |   -.1860917     .0997518       -.2858435        .1008633
       shall |   -.0078189    -.0411192        .0333002               .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       26.94
                Prob>chi2 =      0.0007
```

```
(V_b-V_B is not positive definite) */
/* reject null and conclude at least 1 has endogeneity. from the differences we can suspect density is an endogenous
variable */
/* ------------------- END of rob variable ------------------ */
/* ------------------- BEGIN of mur variable ---------------- */
use guns.dta
describe
/* create log variable for mur */
gen lnmur = log(mur)
/* let us check how only the shall_law has an impact on mur rate */
reg lnmur shall
/*      Source |       SS           df       MS      Number of obs   =     1,173
-------------+----------------------------------   F(1, 1171)      =    106.51
       Model |  48.346582         1  48.346582   Prob > F        =    0.0000
    Residual |  531.555332     1,171  .45393282   R-squared       =    0.0834
-------------+----------------------------------   Adj R-squared   =    0.0826
       Total |  579.901914     1,172  .494796855   Root MSE        =    .67375

------------------------------------------------------------------------------
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       shall |  -.4733725   .0458686   -10.32   0.000    -.5633664   -.3833785
       _cons |   1.897556   .0226094    83.93   0.000     1.853196    1.941915
------------------------------------------------------------------------------
We can see that, when shall law is implemented in a state, the violence rate drops by 47.3% */
/* since we are employing regression on panel data, it is advised to use robust standard errors */
reg lnmur shall, vce(robust)
/* Linear regression                               Number of obs     =      1,173
                                                F(1, 1171)        =      95.12
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0834
                                                Root MSE          =     .67375

------------------------------------------------------------------------------
             |               Robust
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       shall |  -.4733725    .048536    -9.75   0.000    -.5685997   -.3781452
       _cons |   1.897556   .0219606    86.41   0.000     1.854469    1.940642
------------------------------------------------------------------------------
We can observe changes in the t-values & standard errors but coeffiecnts remain same. */
/* let us go ahead and regress a pooled OLS model with robust standard errors
From the above model, we have to remove mur rob variables since they are highly correlated to vio, remodelling - */
reg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, vce(robust)
/* Linear regression                               Number of obs     =      1,173
                                                F(8, 1164)        =     176.49
                                                Prob > F          =     0.0000
                                                R-squared         =     0.6059
                                                Root MSE          =     .44312
------------------------------------------------------------------------------
             |               Robust
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |    .002097   .0001544    13.58   0.000     .0017941    .0023999
      pb1064 |   .1307641    .018782     6.96   0.000     .0939137    .1676145
      pw1064 |   .0470796   .0090873     5.18   0.000     .0292502    .0649089
      pm1029 |   .0655308   .0136782     4.79   0.000     .0386941    .0923674
      avginc |  -.0772578   .0087513    -8.83   0.000    -.0944278   -.0600878
         pop |   .0416175   .0035077    11.86   0.000     .0347355    .0484995
     density |   .0396669   .0117541     3.37   0.001     .0166054    .0627284
       shall |  -.3131735   .0357019    -8.77   0.000    -.3832208   -.2431262
       _cons |  -2.485593   .6149912    -4.04   0.000    -3.692209   -1.278978
------------------------------------------------------------------------------
we can see that contribution of shall law towards mur rate has decreased. Now mur rate is reduced by 31% when a shall
law was introduced. */
/* Since it is panel data the least square estimators are not efficient. This is due to the fact that there can be unobserved
heterogeneity.
 We'll go ahead and create a fixed effect model & interpret the fixed effect estimators. We can do this in two ways - dummy
variable creation or
 fixed effect estimator. since N is large it isn't feasible to do so. Let's go ahead with fixed effect estimator.
```

```
 We have to let stata know that we are dealing with panel data -*/
 xtset stateid year
/*       panel variable:  stateid (strongly balanced)
        time variable:  year, 77 to 99
                delta:  1 unit */
/* since it is a balanced panel data, it makes sense to use fixed effect over random effects */
xtreg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe
/* Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51
R-sq:                                           Obs per group:
     within  = 0.1528                                         min =         23
     between = 0.2221                                         avg =       23.0
     overall = 0.1846                                         max =         23

                                                F(8,1114)         =      25.12
corr(u_i, Xb)  = -0.8961                        Prob > F          =     0.0000

------------------------------------------------------------------------------
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |    -.00036   .0001278    -2.82   0.005    -.0006107   -.0001093
      pb1064 |   .0307009   .0242419     1.27   0.206    -.0168641    .0782658
      pw1064 |   .0103313    .006928     1.49   0.136     -.003262    .0239246
      pm1029 |   .0392384   .0087427     4.49   0.000     .0220844    .0563923
      avginc |   .0243114   .0080663     3.01   0.003     .0084846    .0401382
         pop |  -.0257054   .0119103    -2.16   0.031    -.0490745   -.0023363
     density |  -.6707132   .1160957    -5.78   0.000     -.898504   -.4429224
       shall |    -.06081   .0257579    -2.36   0.018    -.1113495   -.0102704
       _cons |   .4600088   .5253095     0.88   0.381    -.5706989    1.490716
-------------+----------------------------------------------------------------
     sigma_u |    1.36035
     sigma_e |  .21942693
         rho |  .97464151   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(50, 1114) = 72.66                   Prob > F = 0.0000
We can see that the coeffecitent of shall rate has reduced considerably. If there is unobserved heterogeniety, we can make
our model robust to these effects as well - */
xtreg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe cluster(stateid)
/* Fixed-effects (within) regression               Number of obs     =      1,173
Group variable: stateid                         Number of groups  =         51
R-sq:                                           Obs per group:
     within  = 0.1528                                         min =         23
     between = 0.2221                                         avg =       23.0
     overall = 0.1846                                         max =         23
                                                F(8,50)           =     156.39
corr(u_i, Xb)  = -0.8961                        Prob > F          =     0.0000
                                 (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |    -.00036   .0004231    -0.85   0.399    -.0012099    .0004899
      pb1064 |   .0307009   .0781245     0.39   0.696    -.1262169    .1876186
      pw1064 |   .0103313   .0128776     0.80   0.426    -.0155341    .0361967
      pm1029 |   .0392384   .0215964     1.82   0.075    -.0041394    .0826161
      avginc |   .0243114   .0156779     1.55   0.127    -.0071786    .0558013
         pop |  -.0257054   .0203457    -1.26   0.212    -.0665709    .0151602
     density |  -.6707132   .3957745    -1.69   0.096     -1.46565    .1242232
       shall |    -.06081   .0369632    -1.65   0.106    -.1350527    .0134327
       _cons |   .4600088   .8425884     0.55   0.588     -1.23238    2.152397
-------------+----------------------------------------------------------------
     sigma_u |    1.36035
     sigma_e |  .21942693
         rho |  .97464151   (fraction of variance due to u_i)
------------------------------------------------------------------------------ */
/* we can have 2 more variations for fixed effects. entity fixed & time fixed effects. We'll good ahead with both */
/* fixed entity fixed effect. create dummy variable for state */
reg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.stateid
/*      Source |       SS           df       MS      Number of obs   =     1,173
-------------+----------------------------------   F(58, 1114)     =    188.45
```

```
       Model |  526.264844        58  9.07353179   Prob > F        =    0.0000
    Residual |  53.6370704     1,114  .048148178   R-squared       =    0.9075
-------------+----------------------------------   Adj R-squared   =    0.9027
       Total |  579.901914     1,172  .494796855   Root MSE        =    .21943

------------------------------------------------------------------------------
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |    -.00036   .0001278    -2.82   0.005    -.0006107   -.0001093
      pb1064 |   .0307009   .0242419     1.27   0.206    -.0168641    .0782658
      pw1064 |   .0103313    .006928     1.49   0.136     -.003262    .0239246
      pm1029 |   .0392384   .0087427     4.49   0.000     .0220844    .0563923
      avginc |   .0243114   .0080663     3.01   0.003     .0084846    .0401382
         pop |  -.0257054   .0119103    -2.16   0.031    -.0490745   -.0023363
     density |  -.6707132   .1160957    -5.78   0.000     -.898504   -.4429224
       shall |    -.06081   .0257579    -2.36   0.018    -.1113495   -.0102704
             |
     stateid |
          2  |  -.5647602   .0992828    -5.69   0.000    -.7595625   -.3699578
          4  |  -.2651784   .1211918    -2.19   0.029    -.5029684   -.0273885
          5  |   -.187964   .0907612    -2.07   0.039    -.3660462   -.0098819
          6  |   .5355069   .3145871     1.70   0.089    -.0817431    1.152757
          8  |  -.8074469   .1531466    -5.27   0.000    -1.107935   -.5069587
          9  |  -.6007435   .1840818    -3.26   0.001    -.9619296   -.2395574
         10  |   -.829185   .1047633    -7.91   0.000    -1.034741   -.6236295
         11  |    7.77904   1.064525     7.31   0.000      5.69034     9.86774
         12  |   .3369919   .1549863     2.17   0.030      .032894    .6410899
         13  |   .0527886   .0735155     0.72   0.473    -.0914558    .1970331
         15  |  -1.294748   .3536591    -3.66   0.000    -1.988661   -.6008354
         16  |  -1.280885   .1666717    -7.69   0.000    -1.607911   -.9538593
         17  |   .0662671   .1463662     0.45   0.651    -.2209174    .3534515
         18  |  -.3334492   .1516256    -2.20   0.028    -.6309531   -.0359453
         19  |  -1.739756   .1744191    -9.97   0.000    -2.081983   -1.397529
         20  |  -.7768745   .1386567    -5.60   0.000    -1.048932   -.5048169
         21  |  -.3966237   .1432174    -2.77   0.006    -.6776299   -.1156175
         22  |   .3453888   .0781619     4.42   0.000     .1920277    .4987499
         23  |  -1.633723   .1816275    -8.99   0.000    -1.990094   -1.277353
         24  |   .0639087   .0808585     0.79   0.429    -.0947435    .2225608
         25  |  -.8014337   .2034003    -3.94   0.000    -1.200525   -.4023427
         26  |   .0231729   .1353962     0.17   0.864    -.2424873    .2888331
         27  |  -1.525127   .1709097    -8.92   0.000    -1.860468   -1.189786
         28  |    .047795   .1052837     0.45   0.650    -.1587817    .2543717
         29  |  -.1471592   .1258841    -1.17   0.243    -.3941559    .0998375
         30  |  -1.159839   .1435823    -8.08   0.000    -1.441561   -.8781166
         31  |  -1.337181   .1561436    -8.56   0.000     -1.64355   -1.030812
         32  |  -.0583977   .1181776    -0.49   0.621    -.2902734     .173478
         33  |  -1.747664   .1911023    -9.15   0.000    -2.122625   -1.372703
         34  |   -.112379   .1728035    -0.65   0.516     -.451436     .226678
         35  |  -.2073594   .1048642    -1.98   0.048    -.4131129   -.0016058
         36  |   .4095608   .1993158     2.05   0.040     .0184842    .8006375
         37  |  -.1033656   .0750023    -1.38   0.168    -.2505274    .0437961
         38  |   -2.39921   .1521517   -15.77   0.000    -2.697746   -2.100673
         39  |  -.3293598   .1716592    -1.92   0.055    -.6661717     .007452
         40  |  -.3157795   .0935077    -3.38   0.001    -.4992506   -.1323084
         41  |  -.9237303   .1574997    -5.86   0.000     -1.23276   -.6147007
         42  |   -.299992   .1870636    -1.60   0.109    -.6670287    .0670447
         44  |  -.6714586   .2153498    -3.12   0.002    -1.093996   -.2489217
         45  |  -.1236207   .0787679    -1.57   0.117    -.2781709    .0309296
         46  |  -1.889717   .1350426   -13.99   0.000    -2.154683    -1.62475
         47  |  -.0904587   .0983168    -0.92   0.358    -.2833656    .1024483
         48  |    .380945   .1981517     1.92   0.055    -.0078475    .7697376
         49  |  -1.363478   .1551976    -8.79   0.000    -1.667991   -1.058966
         50  |  -1.650036   .1847135    -8.93   0.000    -2.012462   -1.287611
         51  |  -.3505359   .0839606    -4.18   0.000    -.5152746   -.1857972
         53  |  -.8461956   .1415353    -5.98   0.000    -1.123901   -.5684898
         54  |  -.6978991    .166992    -4.18   0.000    -1.025553   -.3702449
         55  |  -1.154587   .1603503    -7.20   0.000     -1.46921   -.8399648
         56  |  -1.145291   .1665401    -6.88   0.000    -1.472059   -.8185238
             |
       _cons |   .8937583   .5315823     1.68   0.093    -.1492571    1.936774
------------------------------------------------------------------------------ */
```

```
/* the estimate on shall law hasnt changed. let's go with time-fixed effect */
xtreg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall i.year, fe cluster(stateid)
/* Fixed-effects (within) regression              Number of obs     =      1,173
Group variable: stateid                      Number of groups  =         51
R-sq:                                Obs per group:
     within  = 0.2905                                    min =         23
     between = 0.1945                                      avg =       23.0
     overall = 0.1413                                    max =         23

                                    F(30,50)          =      81.49
corr(u_i, Xb)  = -0.8336                      Prob > F          =     0.0000

                              (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |  -.0001164   .0003631    -0.32   0.750    -.0008457    .0006129
      pb1064 |   .0219833   .0758151     0.29   0.773    -.1302958    .1742624
      pw1064 |  -.0004893   .0201044    -0.02   0.981    -.0408701    .0398915
      pm1029 |   .0691941   .0417945     1.66   0.104    -.0147526    .1531408
      avginc |   .0566492   .0165554     3.42   0.001     .0233967    .0899017
         pop |  -.0320769   .0209819    -1.53   0.133    -.0742202    .0100664
     density |  -.5442635   .3192203    -1.70   0.094    -1.185436    .0969093
       shall |  -.0149524   .0382403    -0.39   0.697    -.0917603    .0618556
             |
        year |
         78  |  -.0007195   .0322722    -0.02   0.982    -.0655401    .0641011
         79  |   .0592481   .0311141     1.90   0.063    -.0032465    .1217427
         80  |   .0901814    .041058     2.20   0.033     .0077139    .1726489
         81  |   .1021543   .0510636     2.00   0.051      -.00041    .2047186
         82  |   .0224098   .0581861     0.39   0.702    -.0944604    .1392799
         83  |  -.0314385   .0640621    -0.49   0.626    -.1601111    .0972341
         84  |  -.1359192    .071662    -1.90   0.064    -.2798565    .0080181
         85  |  -.0866144   .0856965    -1.01   0.317    -.2587409    .0855122
         86  |  -.0122752   .0927286    -0.13   0.895    -.1985262    .1739758
         87  |  -.0290338   .0999408    -0.29   0.773    -.2297707    .1717032
         88  |  -.0174594   .1196893    -0.15   0.885    -.2578626    .2229437
         89  |  -.0145617   .1321034    -0.11   0.913    -.2798993    .2507759
         90  |    .059998   .1649718     0.36   0.718    -.2713577    .3913537
         91  |   .1053071   .1754909     0.60   0.551    -.2471767    .4577909
         92  |   .0681002   .1828352     0.37   0.711    -.2991352    .4353355
         93  |   .1544297   .1898113     0.81   0.420    -.2268176     .535677
         94  |   .0442648   .1971908     0.22   0.823    -.3518047    .4403342
         95  |   .0556601   .1989082     0.28   0.781    -.3438588     .455179
         96  |   -.015709   .2125365    -0.07   0.941    -.4426011    .4111831
         97  |  -.1221824   .2186706    -0.56   0.579    -.5613952    .3170304
         98  |  -.1863381   .2332966    -0.80   0.428    -.6549281    .2822519
         99  |  -.2554286   .2420434    -1.06   0.296     -.741587    .2307298
             |
       _cons |   .1882653   1.056771     0.18   0.859    -1.934322    2.310853
-------------+----------------------------------------------------------------
     sigma_u |  1.1362086
     sigma_e |  .20281999
         rho |  .96911961   (fraction of variance due to u_i)
------------------------------------------------------------------------------
 we can see that effect of shall law has decreased more. this model can be better because it explained for a lot of
unobserved characteristics */
 /* we can check if the years are jointly significant ot not
  H0: effects of all time effects = 0
  H1: effect not equal to 0 at least for 1 year */
  testparm i.year
/*  ( 1)  78.year = 0
 ( 2)  79.year = 0
 ( 3)  80.year = 0
 ( 4)  81.year = 0
 ( 5)  82.year = 0
 ( 6)  83.year = 0
 ( 7)  84.year = 0
 ( 8)  85.year = 0
```

```
( 9)  86.year = 0
(10)  87.year = 0
(11)  88.year = 0
(12)  89.year = 0
(13)  90.year = 0
(14)  91.year = 0
(15)  92.year = 0
(16)  93.year = 0
(17)  94.year = 0
(18)  95.year = 0
(19)  96.year = 0
(20)  97.year = 0
(21)  98.year = 0
(22)  99.year = 0

      F( 22,    50) =   19.61
           Prob > F =    0.0000 */
/* Yes, the time effects are jointly statistically significant */
/* Also, the effect on shall law drops even more. so this model can be utlized to explain about the data.  hence we prefer a model with both entity & time effect*/
/* random effects model */
xtreg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, re cluster(stateid)
/* Random-effects GLS regression               Number of obs     =      1,173
Group variable: stateid                        Number of groups  =         51

R-sq:                                          Obs per group:
     within  = 0.0813                                         min =         23
     between = 0.4921                                         avg =       23.0
     overall = 0.4381                                         max =         23

                                               Wald chi2(8)      =     277.18
corr(u_i, X)   = 0 (assumed)                   Prob > chi2       =     0.0000

                               (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnmur |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 incarc_rate |   .0004438   .0004395     1.01   0.313    -.0004176    .0013051
      pb1064 |   .0512656   .0376346     1.36   0.173    -.0224967     .125028
      pw1064 |   .0069318   .0123563     0.56   0.575    -.0172861    .0311497
      pm1029 |   .0734716   .0229191     3.21   0.001     .0285511    .1183922
      avginc |   .0093982   .0149265     0.63   0.529    -.0198572    .0386535
         pop |   .0029126   .0114322     0.25   0.799    -.0194941    .0253193
     density |   .0163429    .067886     0.24   0.810    -.1167113    .1493971
       shall |  -.1153705    .039896    -2.89   0.004    -.1935652   -.0371757
       _cons |  -.3301384   .7279221    -0.45   0.650     -1.75684    1.096563
-------------+----------------------------------------------------------------
     sigma_u |  .30755149
     sigma_e |  .21942693
         rho |  .66267693   (fraction of variance due to u_i)
------------------------------------------------------------------------------ */
/* test for endogienty - Hausman test */
quietly xtreg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, fe
estimates store fe
quietly xtreg lnmur incarc_rate pb1064 pw1064 pm1029 avginc pop density shall, re
estimates store re
hausman fe re
/*               ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
 incarc_rate |     -.00036     .0004438       -.0008037        .0000882
      pb1064 |    .0307009     .0512656       -.0205648         .017453
      pw1064 |    .0103313     .0069318        .0033995               .
      pm1029 |    .0392384     .0734716       -.0342333        .0024109
      avginc |    .0243114     .0093982        .0149132               .
         pop |   -.0257054     .0029126       -.0286179        .0094248
     density |   -.6707132     .0163429       -.6870561        .1096429
       shall |     -.06081    -.1153705        .0545605               .
```

```
------------------------------------------------------------------------------
                  b = consistent under Ho and Ha; obtained from xtreg
        B = inconsistent under Ha, efficient under Ho; obtained from xtreg

   Test:  Ho:  difference in coefficients not systematic

            chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                    =      91.44
          Prob>chi2 =      0.0000
          (V_b-V_B is not positive definite) */

/* reject null and conclude at least 1 has endogeneity. from the differences we can suspect density is an endogenous
variable */
```

*************************** END OF STATA CODE ******************************
*************************** BEGIN OF SAS CODE ******************************

```
data guns;
infile "H:\econ\project\guns.dta" firstobs=2;
input year vio mur rob incarc_rate pbl064 pwl064 pml029 pop avginc density stateid shall;
run;

data guns;
set guns;
lnvio = log(vio);
run;

proc reg data=guns;
model lnvio = incarc_rate pb1064 pw1064 pm1029 pop avginc density shall;
plot residual.*incarc_rate;
plot residual.*pb1064;
plot residual.*pw1064;
plot residual.*pm1029;
plot residual.*pop;
plot residual.*avginc;
plot residual.*density;
run;
```

*************************** END OF SAS CODE ******************************

*************************** BEGIN OF REPORT ******************************