BUAN 6312.004

Applied Econometrics and Time Series Analysis

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Research Question

Do shall-issues law reduce crime or not?

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Contents

1. Abstract

The impact of guns on crime in America has triggered lot of public debate. Many strongly believe that state laws enabling citizens to carry concealed handguns had reduced crime. According to this view, gun control laws take away guns from law-abiding citizens, while would-be criminals ignore those leaving potential victims defenseless. Following this view, National Rifle Association (NRA) and many politicians across country advance the cause of greater freedom to carry guns.

As a result, many states in United States have passed **right-to-carry laws** (aka **shall-issue laws**). A shall-issue law is one that requires the governments to issue permits for carrying concealed handgun to any applicant who meets the necessary criteria. These criteria are:

a) Applicant must be an adult
b) Applicant must not have a significant criminal record
c) Applicant must not have a history of any mental illness
d) Applicant must successfully complete a course in firearms safety training (if required)

If these criteria are met, the granting authority has no discretion in the awarding of the licenses, and there is no requirement for the applicant to demonstrate "good cause".

In this study, we focus on the effects of shall-issue laws using historical data of 51 states followed over a period of 23 years. We run various models to interpret the trends showing the variation in crime rates before and after the introduction of the shall-law along with the effects of other factors like income, population, proportion of population that is white, black and young males. From the results we can infer that there is no significant effect of shall-issue law on crime rates.

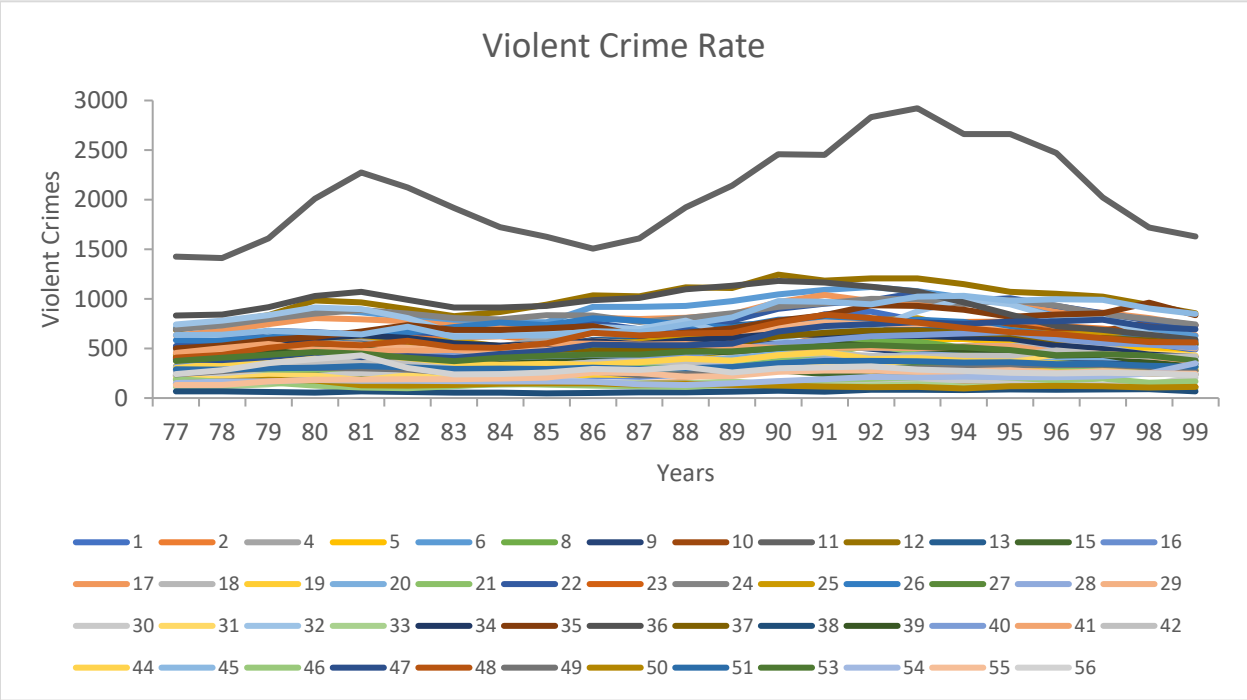
2. Data Description

We have balanced panel data available for 51 US states (including the District of Columbia), from 1977 to 1999 having data about violent crime rate (vio), robbery rate (rob), murder rate (mur), shall (shall-law indicator), incarceration rate (incarc_rate), per capita income (avginc), population (pop), population density (density), proportion of male youth aged 10 to 29 (pm1029), proportion of white adults aged 10 to 64 (pw1064), proportion of black adults aged 10 to 64 (pb1064). Following are the details of all variables available for 51 US states from 1977 to 1999.

Variable	Definition
vio	violent crime rate (incidents per 100,000 members of the population)
rob	robbery rate (incidents per 100,000 members of the population)
mur	murder rate (incidents per 100,000 members of the population)
shall	= 1 if the state has a shall-carry law in effect in that year = 0 otherwise
incarc_rate	incarceration rate in the state in the previous year (sentenced prisoners per 100,000 residents; value for the previous year)
density	population per square mile of land area, divided by 1000
avginc	real per capita personal income in the state, in thousands of dollars
pop	state population, in millions of people
pm1029	percent of state population that is male, ages 10 to 29
pw1064	percent of state population that is white, ages 10 to 64
pb1064	percent of state population that is black, ages 10 to 64
stateid	ID number of states (Alabama = 1, Alaska = 2, etc.)
year	Year (1977-1999)

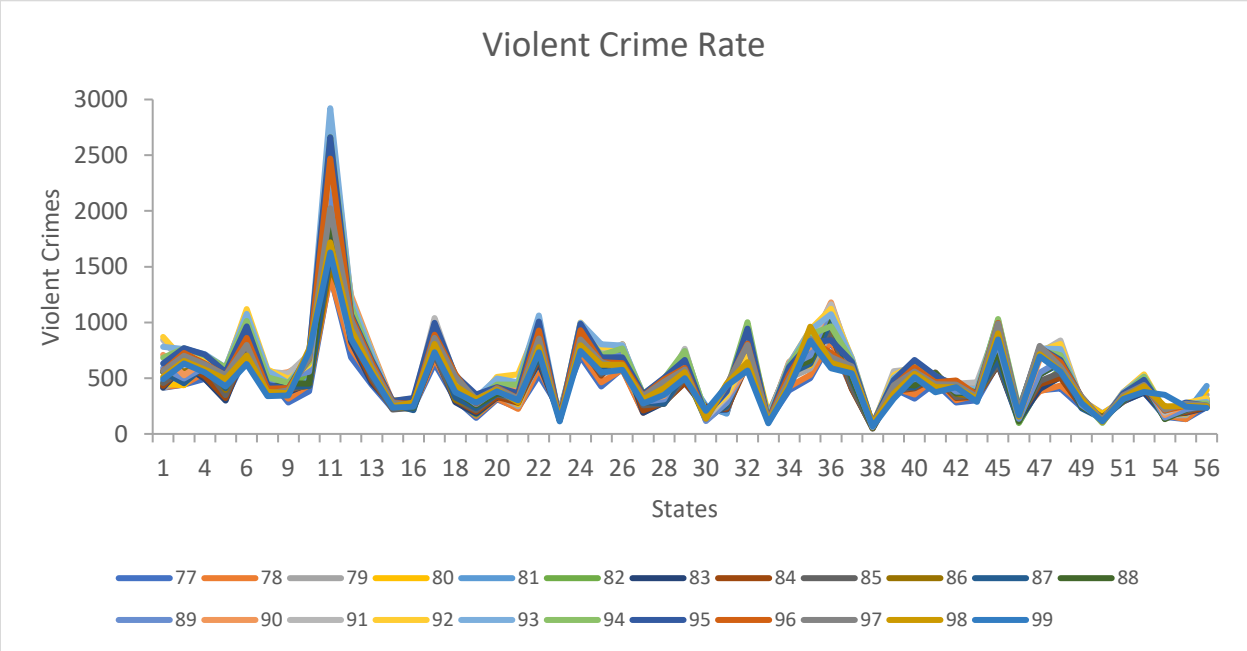
2.1. Trends in Violent Crimes

Violent Crime Rate for 51 States: State 11 has highest number of incidents and seems as outlier



Graph 2.1.1 - Violent Crime Rate for 51 States (Violent Crime Incidents per 100,000 Members of Population v/s Years)

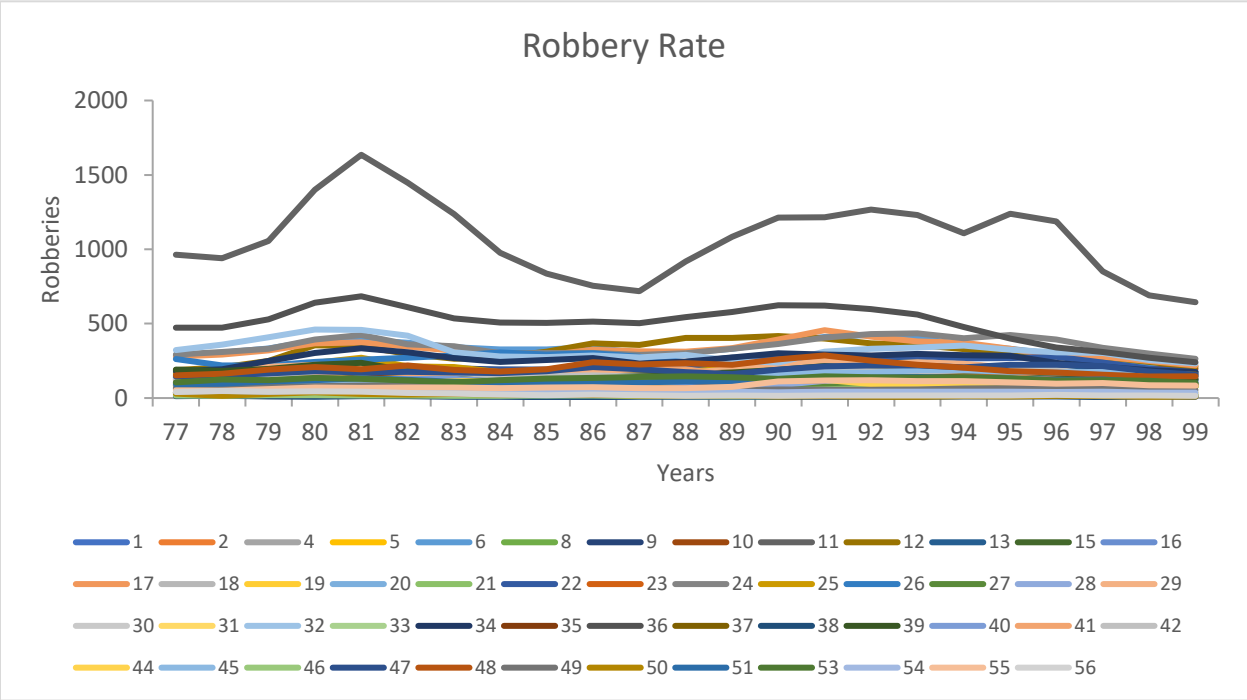
Violent Crime Rate for 23 Years: State 11 has highest number of incidents and seems as outlier



Graph 2.1.2 - Violent Crime Rate for 23 Years (Violent Crime Incidents per 100,000 Members of Population v/s States)

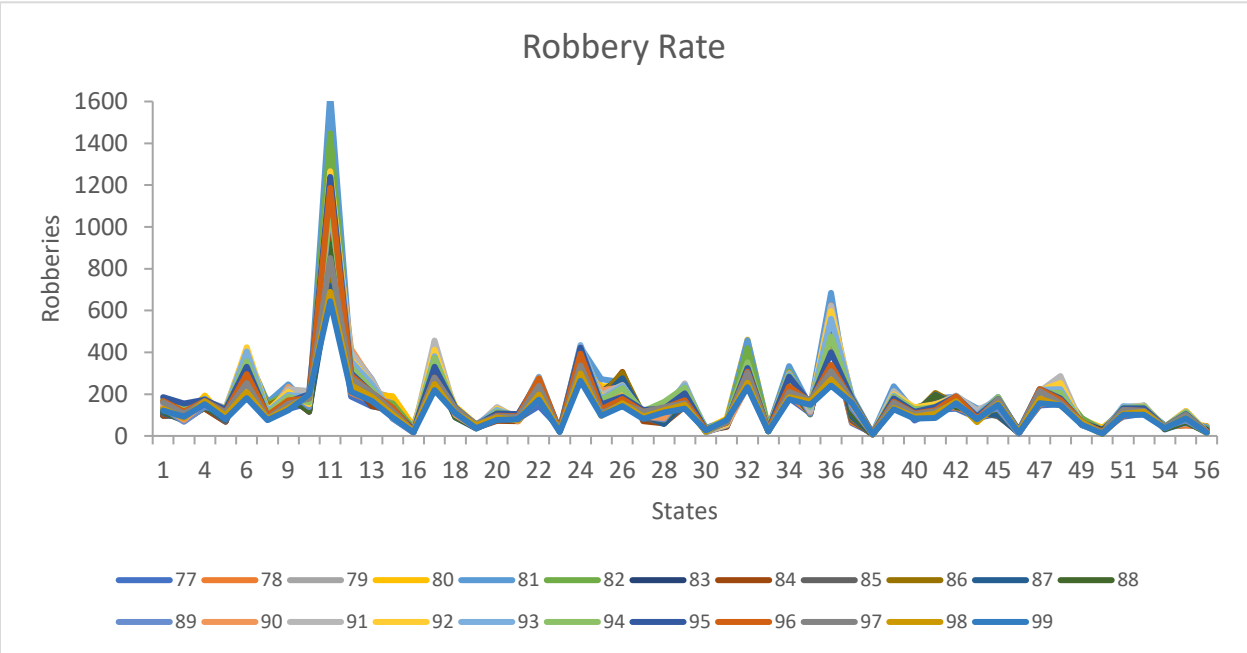
2.2. Trends in Robberies

Robbery Rate for 51 States: State 11 has highest number of incidents and seems as an outlier



Graph 2.2.1 - Robbery Rate for 51 States (Robbery Incidents per 100,000 Members of Population v/s Years)

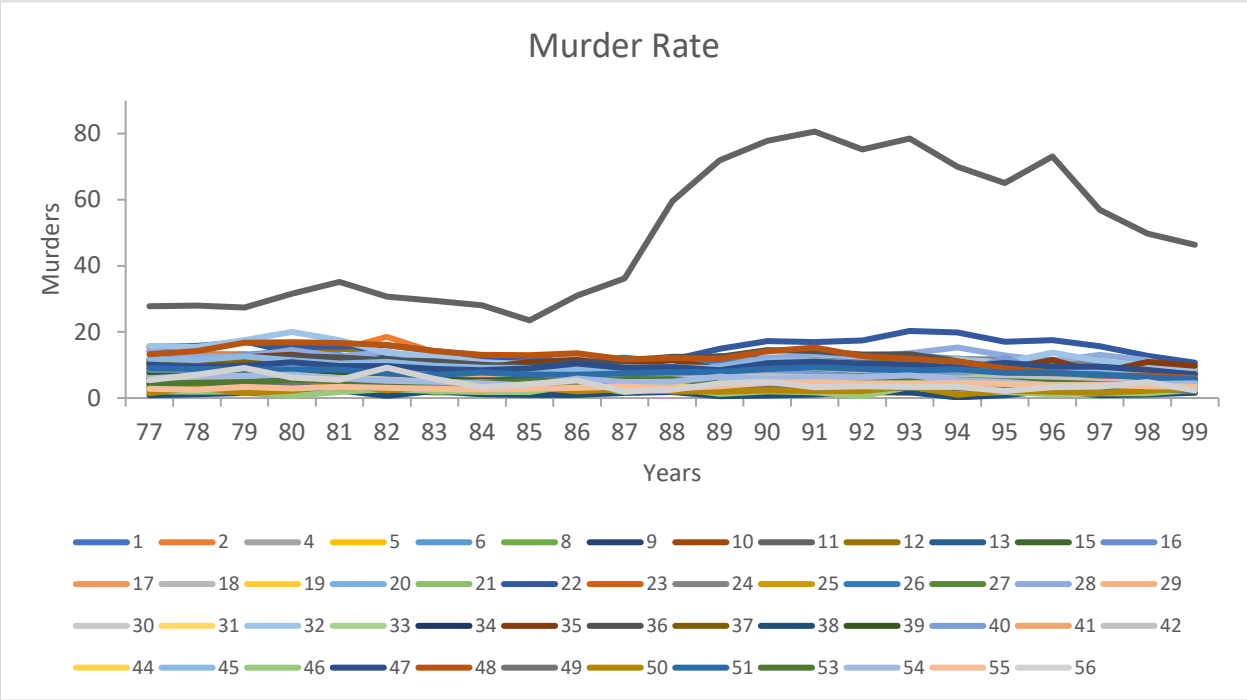
Robbery Rate for 23 Years: State 11 has highest number of incidents and seems as an outlier



Graph 2.2.2 - Robbery Rate for 23 Years (Robbery Incidents per 100,000 Members of Population v/s States)

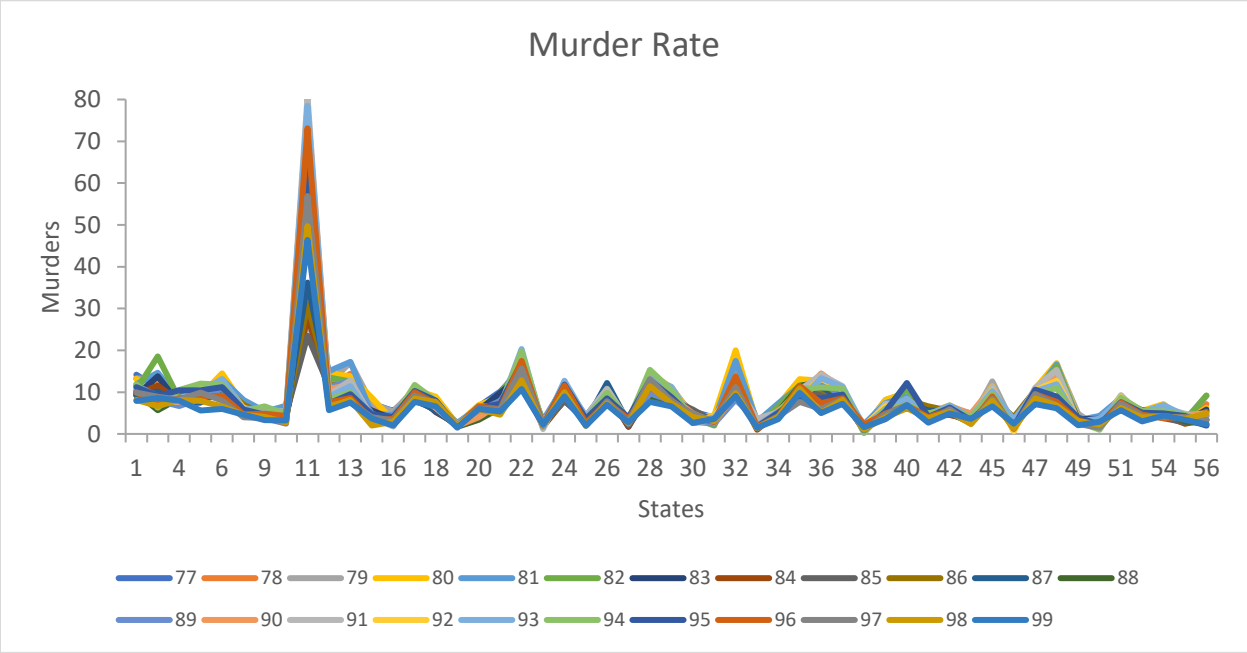
2.3. Trends in Murders

Murder Rate for 51 States: State 11 has highest number of incidents and seems as an outlier



Graph 2.3.1 - Murder Rate for 51 States (Murder Incidents per 100,000 Members of Population v/s Years)

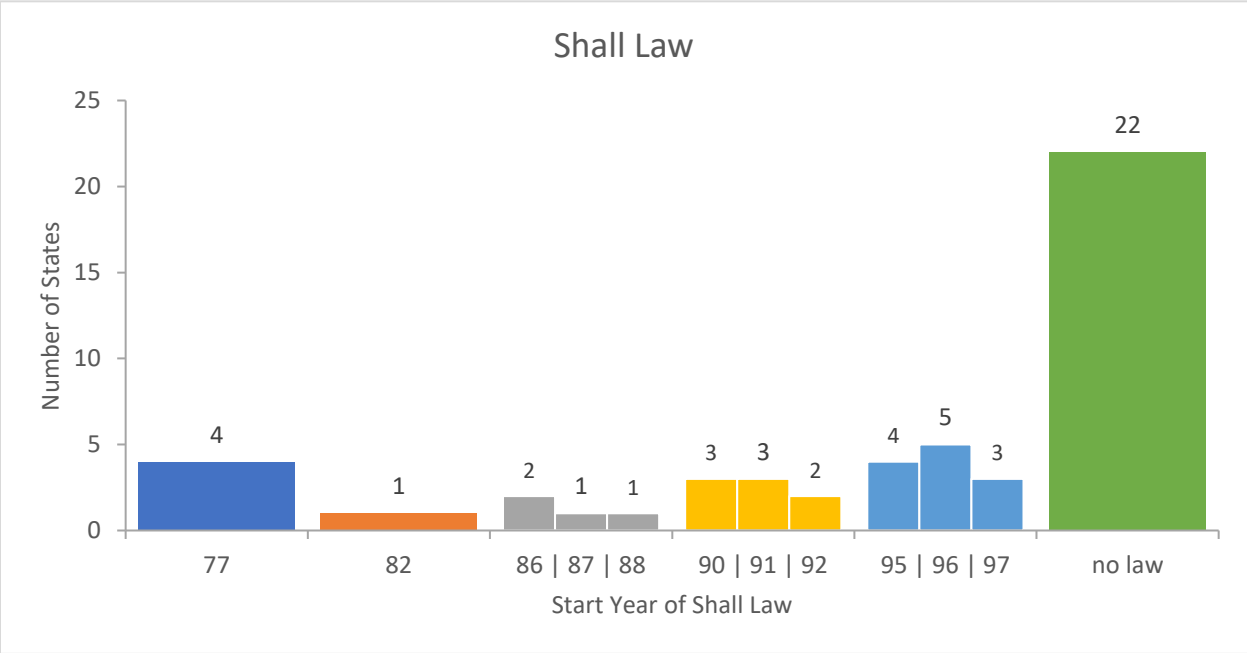
Murder Rate for 23 Years: State 11 has highest number of incidents and seems as an outlier



Graph 2.3.2 - Murder Rate for 23 Years (Murder Incidents per 100,000 Members of Population v/s States)

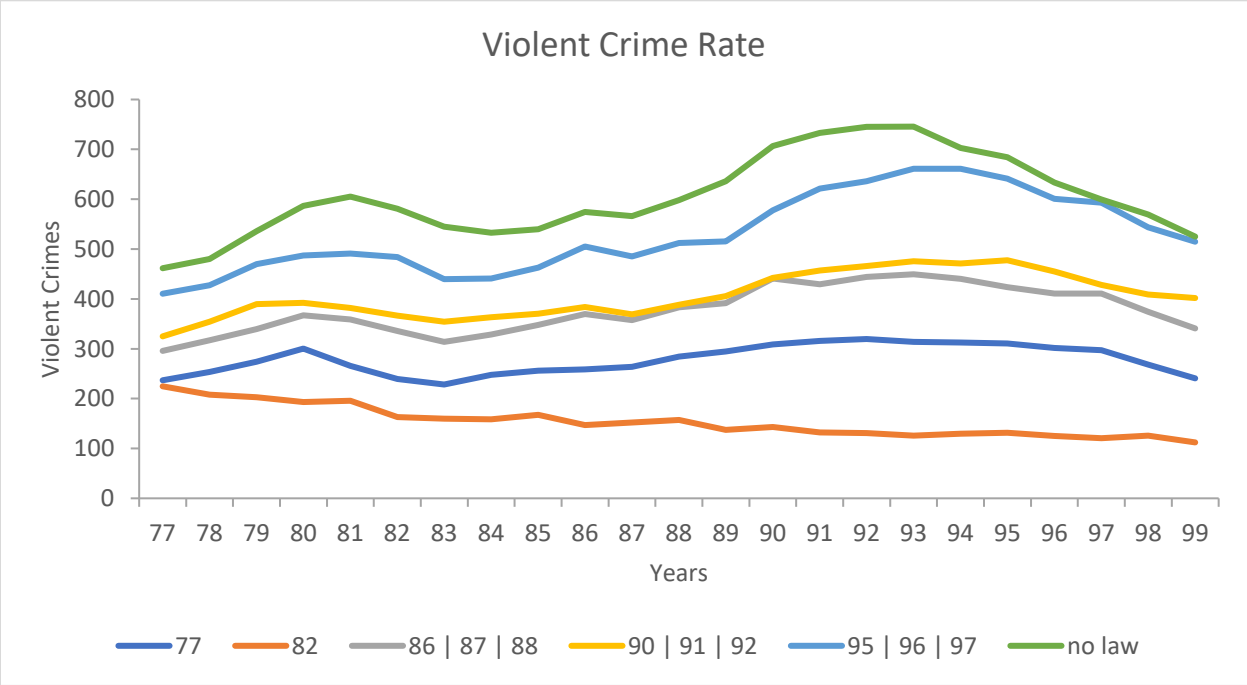
2.4. States with Shall Law

Number of States with Shall Law: 22 states do not have shall-law in entire observation period



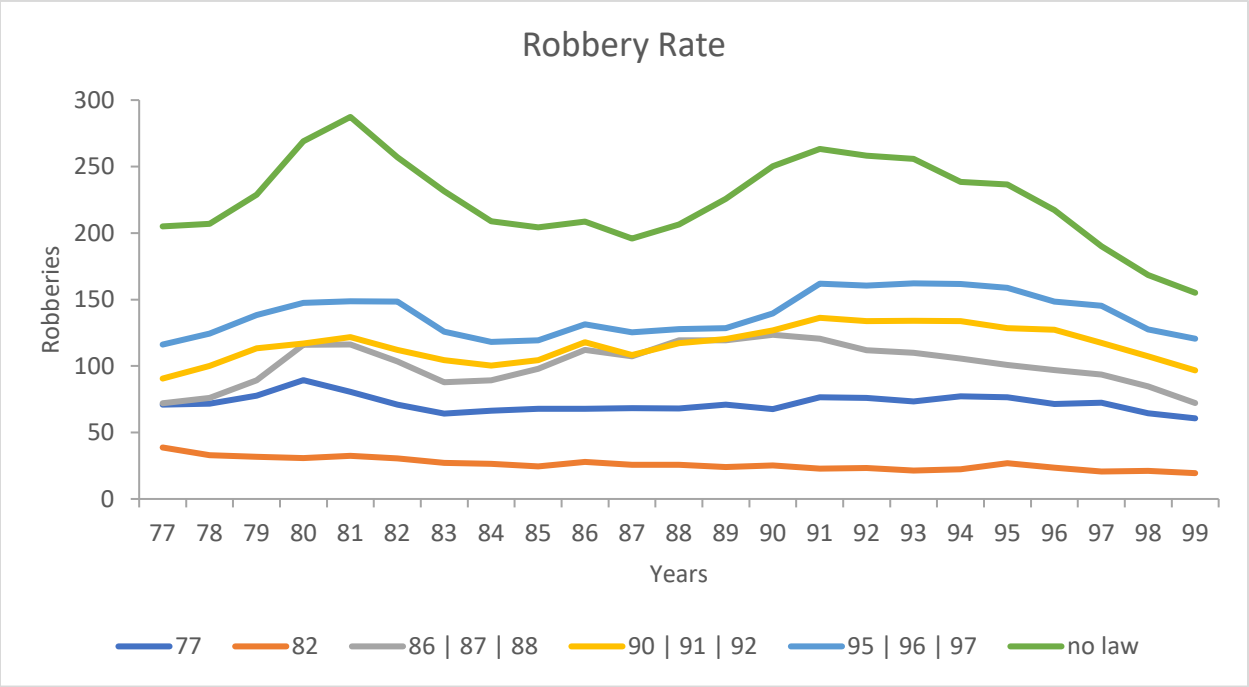
Graph 2.4.1 - Shall Law States (Number of States v/s Start Year of Shall Law)

Violent Crime Rate in Shall Law States: Early shall-law adopting states have less violent crimes



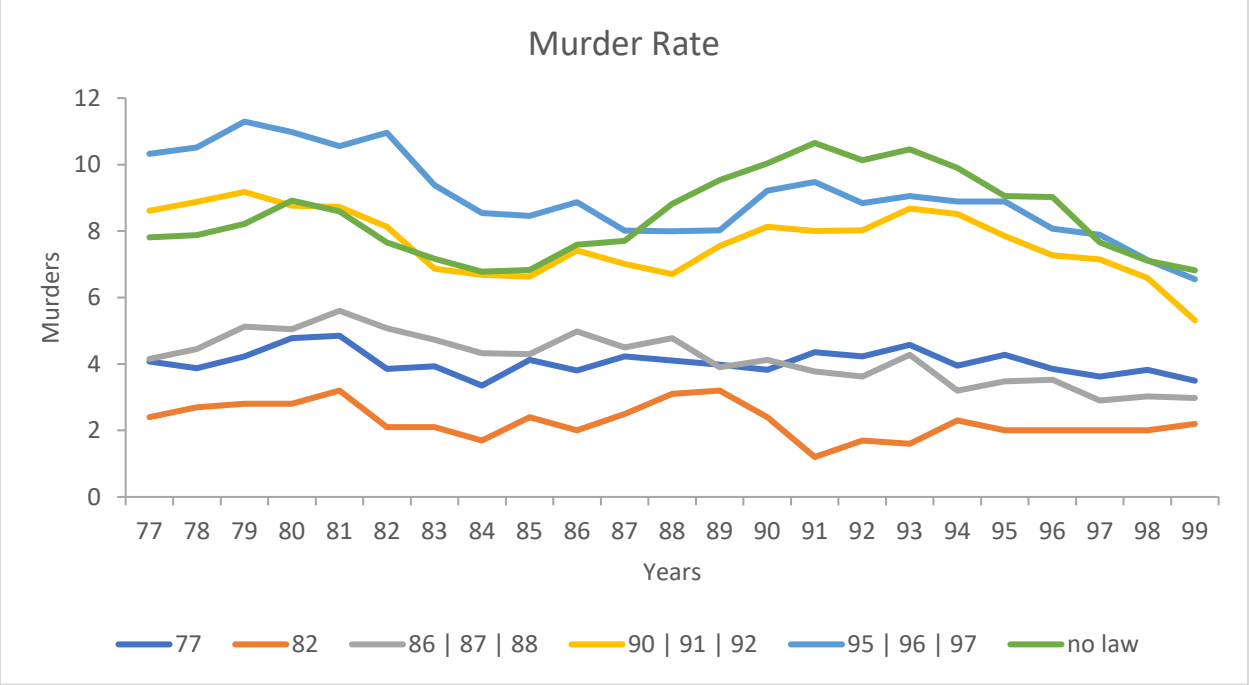
Graph 2.4.2 - Average Violent Crime Rate in States with Shall Law and without Shall Law

Robbery Rate in Shall Law States: Early shall-law adopting states have less robbery incidents



Graph 2.4.3 - Average Robbery Rate in States with Shall Law and without Shall Law

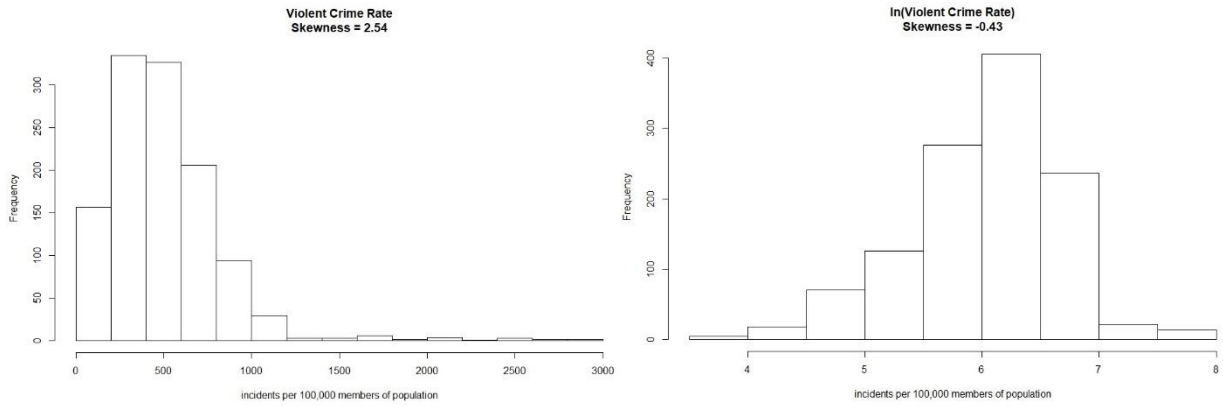
Murder Rate in Shall Law States: Early shall-law adopting states have less murder incidents



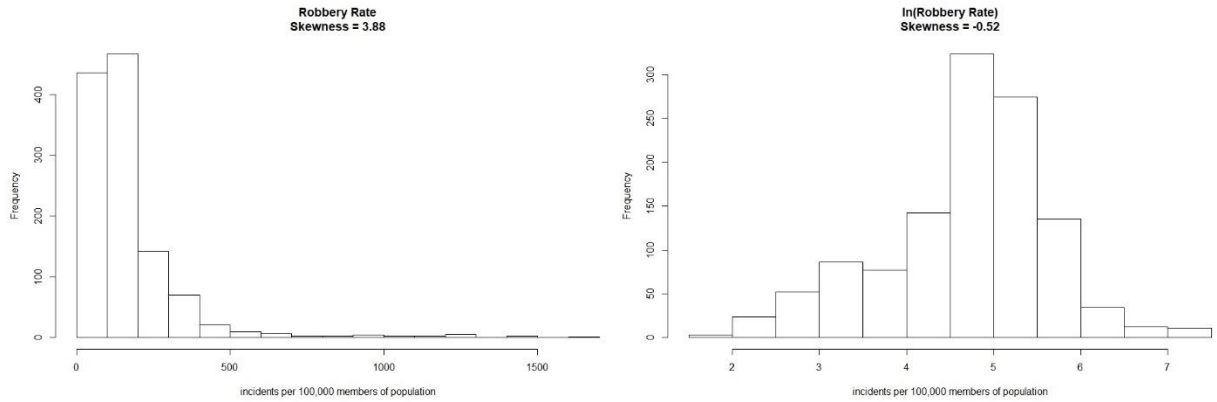
Graph 2.4.4 - Average Murder Rate in States with Shall Law and without Shall Law

2.5. Skewness

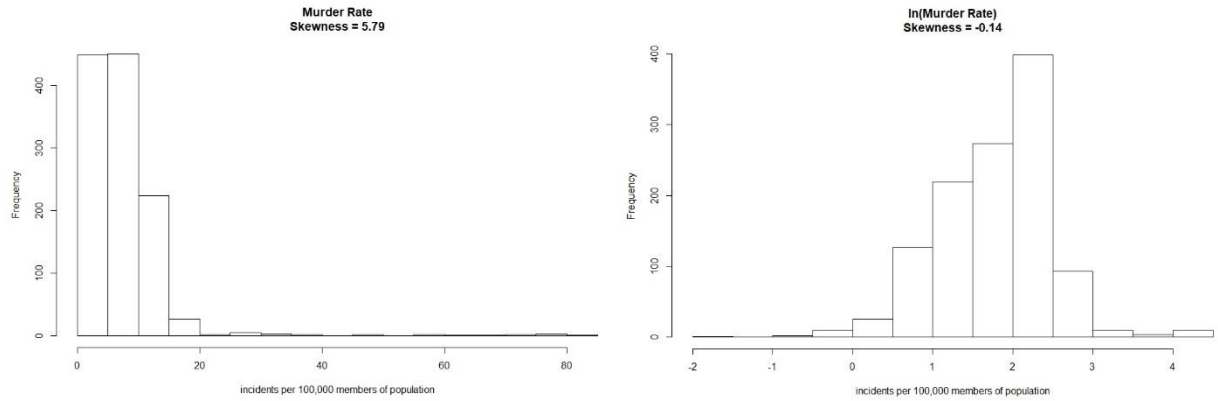
All 3 dependent variables (Violent Crime Rate, Robbery Rate and Murder Rate) are highly skewed due to outlier state 11, and hence it is better to use their logarithmic values to reduce skewness.



Graph 2.5.1 - Frequency Distribution of Violent Crime Rate (skewness = 2.54) and its Natural Logarithm (skewness = -0.43)



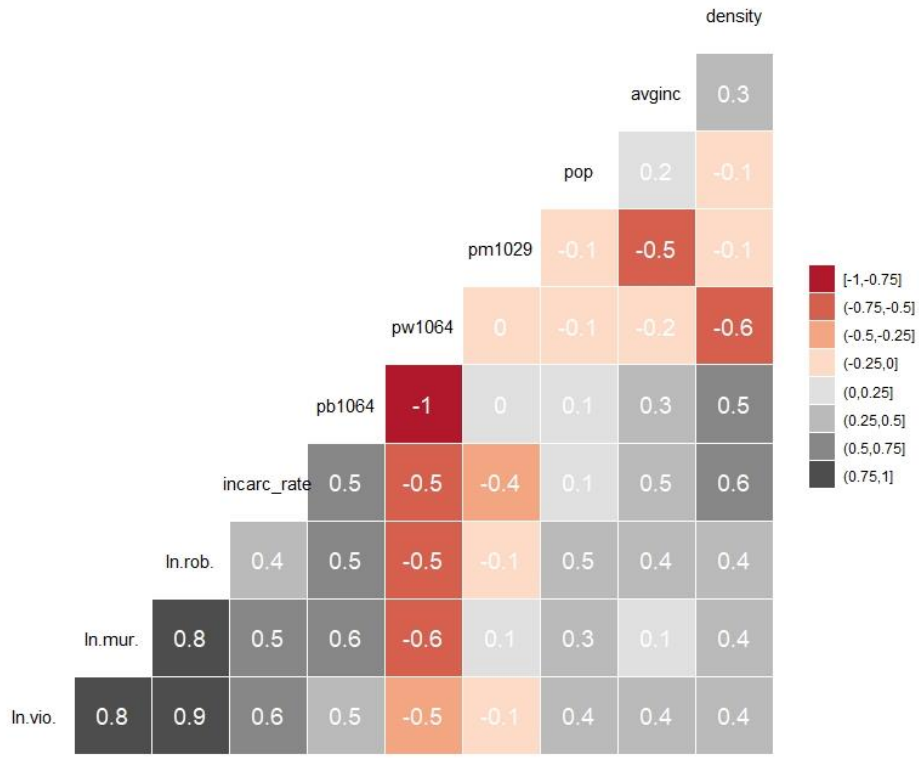
Graph 2.5.2 - Frequency Distribution of Robbery Rate (skewness = 3.88) and its Natural Logarithm (skewness = -0.52)



Graph 2.5.2 - Frequency Distribution of Murder Rate (skewness = 5.79) and its Natural Logarithm (skewness = -0.14)

2.6. Correlation

Following is correlation plot among independent variables and dependent variables logarithms. Grey color box indicates a positive correlation and Red color box indicates a negative correlation.



Graph 2.6 - Correlation between all Independent Variables and Logarithms of Dependent Variables

Violent Crime Rate, Robbery Rate and Murder Rate are highly correlated as we expect in general. The variables *density*, *pb1064*, *pw1064* and *incarc_rate* have moderate correlation with others. From the above correlation matrix, we can see that the variables *pb1064* and *pw1064* have very high negative correlation with each other as expected since both variables are complementary. The remaining variables *pm1029*, *pop* and *avginc* do not have significant correlation with others.

3. Regression Models

3.1. Violent Crime Rate

Linear Regression:

We start with a normal linear regression without any corrections for the robust standard errors

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

Source	SS	df	MS	Number of obs	=	1,173
				F(8, 1164)	=	188.41
Model	275.712977	8	34.4641221	Prob > F	=	0.0000
Residual	212.918581	1,164	.182919743	R-squared	=	0.5643
				Adj R-squared	=	0.5613
Total	488.631558	1,172	.416921125	Root MSE	=	.42769

lnvio	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.shall	-.3683869	.0325674	-11.31	0.000	-.4322844	-.3044895
incarc_rate	.0016126	.0001072	15.05	0.000	.0014024	.0018229
avginc	.0012051	.0077802	0.15	0.877	-.0140597	.01647
density	.0266885	.013168	2.03	0.043	.0008527	.0525242
pop	.0427098	.0025588	16.69	0.000	.0376894	.0477303
pb1064	.0808526	.0166514	4.86	0.000	.0481825	.1135227
pw1064	.0312005	.0083776	3.72	0.000	.0147636	.0476374
pm1029	.0088709	.0107737	0.82	0.410	-.0122671	.0300089
_cons	2.981738	.5433938	5.49	0.000	1.915598	4.047879

```
. estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(43)     =    454.02
         Prob > chi2  =    0.0000
```

White test revealed that residuals are heteroskedastic, hence we estimate robust standard errors

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

Linear regression

				Number of obs	=	1,173
				F(8, 1164)	=	95.67
				Prob > F	=	0.0000
				R-squared	=	0.5643
				Root MSE	=	.42769

lnvio	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.shall	-.3683869	.0347879	-10.59	0.000	-.436641	-.3001329
incarc_rate	.0016126	.0001807	8.92	0.000	.0012581	.0019672
avginc	.0012051	.0072778	0.17	0.869	-.013074	.0154842
density	.0266885	.0143494	1.86	0.063	-.0014651	.054842
pop	.0427098	.0031466	13.57	0.000	.0365361	.0488836
pb1064	.0808526	.0199924	4.04	0.000	.0416274	.1200778
pw1064	.0312005	.0097271	3.21	0.001	.012116	.0502851
pm1029	.0088709	.0120604	0.74	0.462	-.0147917	.0325334
_cons	2.981738	.6090198	4.90	0.000	1.786839	4.176638

Pooled OLS (with robust errors):

Pooled OLS with robust standard errors for heteroskedasticity and auto correlation within states

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

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)
------------------------------------------------------------------------------
             |               Robust
       lnvio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     1.shall |  -.3683869    .113937    -3.23   0.002    -.5972361   -.1395378
incarc_rate  |   .0016126   .0005999     2.69   0.010     .0004076    .0028177
      avginc |   .0012051   .0240808     0.05   0.960    -.0471626    .0495728
     density |   .0266885   .0414909     0.64   0.523    -.0566485    .1100255
         pop |   .0427098    .011729     3.64   0.001     .0191515    .0662681
      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
       _cons |   2.981738   2.166513     1.38   0.175    -1.369831    7.333307
------------------------------------------------------------------------------
```

Model Interpretations:

➔ According to linear and pooled models, all variables except *shall* account for raising crimes

➔ States with shall-law in effect have 36.84% less violent crimes than states without shall-law

➔ In pooled model, variables with 1% significance are *shall*, *incarceration rate* and *population*

Fixed Effects (without robust errors):

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

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(8,1114)         =      38.77
corr(u_i, Xb)  = -0.3687                        Prob > F          =     0.0000

------------------------------------------------------------------------------
       lnvio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     1.shall |  -.0461415   .0188668    -2.45   0.015      -.08316   -.009123
 incarc_rate |   -.000071   .0000936    -0.76   0.448    -.0002547    .0001126
      avginc |  -.0092037   .0059083    -1.56   0.120    -.0207963    .0023889
     density |  -.1722901   .0850362    -2.03   0.043    -.3391392   -.0054409
         pop |   .0115247   .0087239     1.32   0.187    -.0055924    .0286417
      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
       _cons |   3.866017   .3847716    10.05   0.000     3.111058    4.620975
-------------+----------------------------------------------------------------
     sigma_u |  .68024951
     sigma_e |  .16072287
         rho |  .94712779   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(50, 1114) = 142.57                     Prob > F = 0.0000
```

Random Effects (without robust errors):

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

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)       =      337.19
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =      0.0000
```

lnvio	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.shall	-.069609	.0190835	-3.65	0.000	-.107012	-.032206
incarc_rate	.0001888	.0000687	2.75	0.006	.0000541	.0003235
avginc	-.0105112	.0058749	-1.79	0.074	-.0220258	.0010034
density	.0661588	.037363	1.77	0.077	-.0070713	.1393889
pop	.0225755	.0063498	3.56	0.000	.0101301	.035021
pb1064	.1067022	.0132976	8.02	0.000	.0806394	.1327649
pw1064	.0400716	.0050987	7.86	0.000	.0300783	.050065
pm1029	-.0375292	.0060462	-6.21	0.000	-.0493794	-.0256789
_cons	3.525463	.3874011	9.10	0.000	2.766171	4.284755
sigma_u	.33790775					
sigma_e	.16072287					
rho	.81550462	(fraction of variance due to u_i)				

Huasman Test:

```
. hausman fe_vio re_vio
```

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

```
                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)
```

Model Interpretations:

➔ From above test, we say that estimates of fixed and random effects are significantly different

➔ Both Fixed/Random effects indicate that shall-law reduces violent crimes with 5% significance

Entity Fixed Effects (with robust errors):

```
. xtreg lnvio i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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)
```

lnvio	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.shall	-.0461415	.0417616	-1.10	0.275	-.1300223	.0377392
incarc_rate	-.000071	.0002504	-0.28	0.778	-.0005739	.0004318
avginc	-.0092037	.0129649	-0.71	0.481	-.0352445	.016837
density	-.1722901	.1376129	-1.25	0.216	-.4486936	.1041135
pop	.0115247	.014224	0.81	0.422	-.0170452	.0400945
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
_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)				

Entity Fixed and Time Fixed Effects (with robust errors):

```
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)
```

lnvio	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.shall	-.0279935	.0407168	-0.69	0.495	-.1097757	.0537886
incarc_rate	.000076	.0002079	0.37	0.716	-.0003416	.0004935
avginc	.0009587	.0164931	0.06	0.954	-.0321688	.0340861
density	-.091555	.1238622	-0.74	0.463	-.3403396	.1572296
pop	-.0047544	.0152294	-0.31	0.756	-.0353436	.0258347
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
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)				

Time Fixed Effects Significance:

```
. 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
```

Random Effects (with robust errors):

```
. xtreg lnvio i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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]
-------------+----------------------------------------------------------------
      1.shall |   -.069609   .038845    -1.79   0.073    -.1457438    .0065258
incarc_rate |    .0001888   .0001877     1.01   0.314    -.0001791    .0005567
      avginc |   -.0105112   .0117802    -0.89   0.372    -.0335999    .0125775
     density |    .0661588   .0437925     1.51   0.131    -.0196729    .1519905
         pop |    .0225755   .0116369     1.94   0.052    -.0002323    .0453833
      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
       _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)
------------------------------------------------------------------------------
```

Model Interpretations:

➔ The joint significance test in Time Fixed model shows that at least one estimate is significant

➔ After obtaining robust errors, both models estimates for shall-law became insignificant at 5%

3.2. Robbery Rate

Linear Regression:

We start with a normal linear regression without any corrections for the robust standard errors

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

Source	SS	df	MS	Number of obs	=	1,173
				F(8, 1164)	=	214.83
Model	636.767797	8	79.5959747	Prob > F	=	0.0000
Residual	431.265325	1,164	.370502857	R-squared	=	0.5962
				Adj R-squared	=	0.5934
Total	1068.03312	1,172	.91129106	Root MSE	=	.60869

lnrob	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.shall	-.5288202	.0463499	-11.41	0.000	-.619759	-.4378815
incarc_rate	.0010057	.0001525	6.59	0.000	.0007065	.0013049
avginc	.0407325	.0110728	3.68	0.000	.0190076	.0624574
density	.0905048	.0187407	4.83	0.000	.0537353	.1272742
pop	.0778176	.0036417	21.37	0.000	.0706726	.0849627
pb1064	.1021881	.0236982	4.31	0.000	.0556921	.1486841
pw1064	.0275209	.011923	2.31	0.021	.0041279	.0509138
pm1029	.0272565	.0153331	1.78	0.076	-.0028271	.05734
_cons	.9041383	.7733572	1.17	0.243	-.6131918	2.421468

```
. estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(43)     =    468.81
         Prob > chi2  =    0.0000
```

White test revealed that residuals are heteroskedastic, hence we estimate robust standard errors

```
. reg lnrob i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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

lnrob	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.shall	-.5288202	.0510021	-10.37	0.000	-.6288865	-.4287539
incarc_rate	.0010057	.0001869	5.38	0.000	.0006391	.0013724
avginc	.0407325	.0092722	4.39	0.000	.0225404	.0589246
density	.0905048	.0153545	5.89	0.000	.0603792	.1206303
pop	.0778176	.0054853	14.19	0.000	.0670554	.0885799
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
_cons	.9041383	.8893029	1.02	0.310	-.8406777	2.648954

Pooled OLS (with robust errors):

Pooled OLS with robust standard errors for heteroskedasticity and auto correlation within states

```
. reg lnrob i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, vce(cluster stateid)

Linear regression                               Number of obs     =      1,173
                                                F(8, 50)          =      27.22
                                                Prob > F          =     0.0000
                                                R-squared         =     0.5962
                                                Root MSE          =     .60869

                                    (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnrob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     1.shall |  -.5288202   .1608765    -3.29   0.002    -.8519501   -.2056903
incarc_rate |   .0010057   .0006401     1.57   0.122    -.0002799    .0022914
      avginc |   .0407325   .0281568     1.45   0.154     -.015822     .097287
     density |   .0905048   .0459796     1.97   0.055     -.001848    .1828576
         pop |   .0778176   .0225194     3.46   0.001     .0325862    .1230491
      pb1064 |   .1021881   .0894076     1.14   0.259    -.0773923    .2817686
      pw1064 |   .0275209   .0450088     0.61   0.544     -.062882    .1179237
      pm1029 |   .0272565   .0417254     0.65   0.517    -.0565515    .1110645
       _cons |   .9041383     3.0615     0.30   0.769    -5.245065    7.053341
------------------------------------------------------------------------------
```

Model Interpretations:

➔ According to linear & pooled models, all variables except *shall* account for more robberies

➔ States with shall-law in effect have 52.88% less robberies than the states without shall-law

➔ In the pooled model, variables with 1% significance are only *shall* and *population* variables

Fixed Effects (without robust errors):

```
. xtreg lnrob i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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]
-------------+----------------------------------------------------------------
     1.shall |  -.0078189   .0252557    -0.31   0.757    -.0573731    .0417352
incarc_rate |  -.0000763   .0001253    -0.61   0.542    -.0003222    .0001695
      avginc |  -.0175195    .007909    -2.22   0.027    -.0330377   -.0020012
     density |  -.1860917   .1138322    -1.63   0.102    -.4094413     .037258
         pop |   .0163332   .0116781     1.40   0.162    -.0065803    .0392466
      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
       _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
```

Random Effects (without robust errors):

```
. xtreg lnrob i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, re

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)       =       99.59
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =      0.0000
```

lnrob	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.shall	-.0411192	.0255899	-1.61	0.108	-.0912745	.0090362
incarc rate	.0001735	.0000931	1.86	0.062	-9.02e-06	.000356
avginc	-.0152975	.0078914	-1.94	0.053	-.0307643	.0001693
density	.0997518	.0527672	1.89	0.059	-.0036699	.2031735
pop	.0405861	.0087624	4.63	0.000	.0234121	.05776
pb1064	.1074485	.0181757	5.91	0.000	.0718247	.1430723
pw1064	.0282639	.0068389	4.13	0.000	.0148598	.041668
pm1029	.0252997	.0081299	3.11	0.002	.0093654	.041234
_cons	1.8759	.52089	3.60	0.000	.8549742	2.896826
sigma_u	.48469008					
sigma_e	.21514885					
rho	.83539542	(fraction of variance due to u_i)				

Huasman Test:

```
. hausman fe_rob re_rob
```

	Coefficients (b) fe_rob	(B) re_rob	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
1.shall	-.0078189	-.0411192	.0333002	.
incarc_rate	-.0000763	.0001735	-.0002498	.0000838
avginc	-.0175195	-.0152975	-.002222	.0005277
density	-.1860917	.0997518	-.2858435	.1008633
pop	.0163332	.0405861	-.0242529	.00772
pb1064	.1115421	.1074485	.0040936	.0153173
pw1064	.0271807	.0282639	-.0010832	.
pm1029	.0111817	.0252997	-.014118	.002718

```
                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)
```

Model Interpretations:

➔ From above test, we say that estimates of fixed and random effects are significantly different

➔ Both Fixed/Random effects indicate shall-law reduce robberies but its estimate is insignificant

Entity Fixed Effects (with robust errors):

```
. xtreg lnrob i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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]
-------------+----------------------------------------------------------------
     1.shall |  -.0078189   .0551653    -0.14   0.888    -.1186217    .1029838
incarc_rate |  -.0000763    .000321    -0.24   0.813    -.0007211    .0005685
      avginc |  -.0175195   .0220352    -0.80   0.430    -.0617784    .0267395
     density |  -.1860917   .1663413    -1.12   0.269     -.520198    .1480147
         pop |   .0163332   .0275874     0.59   0.556    -.0390778    .0717441
      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
       _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)
------------------------------------------------------------------------------
```

Entity Fixed and Time Fixed Effects (with robust errors):

```
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]
-------------+----------------------------------------------------------------
     1.shall |   .0268298   .0521753     0.51   0.609    -.0779673    .1316269
incarc_rate |   .0000314   .0003477     0.09   0.928     -.000667    .0007297
      avginc |   .0143569   .0247676     0.58   0.565    -.0353903     .064104
     density |  -.0447449   .1982135    -0.23   0.822    -.4428684    .3533786
         pop |   .0000164   .0259374     0.00   0.999    -.0520805    .0521133
      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
             |
        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)
------------------------------------------------------------------------------
```

Time Fixed Effects Significance:

```
. 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
```

Random Effects (with robust errors):

```
. xtreg lnrob i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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]
-------------+----------------------------------------------------------------
      1.shall |  -.0411192   .0529293    -0.78   0.437    -.1448586    .0626203
 incarc_rate |   .0001735   .0002507     0.69   0.489    -.0003179    .0006649
      avginc |  -.0152975   .0199351    -0.77   0.443    -.0543697    .0237747
     density |   .0997518   .0479974     2.08   0.038     .0056786    .1938251
         pop |   .0405861   .0244303     1.66   0.097    -.0072964    .0884686
      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
       _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)
------------------------------------------------------------------------------
```

Model Interpretations:

➔ The joint significance test in Time Fixed model shows that at least one estimate is significant

➔ After obtaining robust errors, both models estimates for shall-law became insignificant at 5%

3.3. Murder Rate

Linear Regression:

We start with a normal linear regression without any corrections for the robust standard errors

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

Source	SS	df	MS		
Model	351.342396	8	43.9177995	Number of obs	= 1,173
Residual	228.559518	1,164	.196356974	F(8, 1164)	= 223.66
				Prob > F	= 0.0000
Total	579.901914	1,172	.494796855	R-squared	= 0.6059
				Adj R-squared	= 0.6032
				Root MSE	= .44312

lnmur	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.shall	-.3131735	.0337424	-9.28	0.000	-.3793763	-.2469707
incarc_rate	.002097	.000111	18.89	0.000	.0018791	.0023148
avginc	-.0772578	.0080609	-9.58	0.000	-.0930733	-.0614422
density	.0396669	.0136431	2.91	0.004	.012899	.0664348
pop	.0416175	.0026511	15.70	0.000	.0364159	.0468191
pb1064	.1307641	.0172521	7.58	0.000	.0969153	.1646128
pw1064	.0470796	.0086798	5.42	0.000	.0300497	.0641094
pm1029	.0655308	.0111624	5.87	0.000	.0436301	.0874314
_cons	-2.485593	.5629989	-4.41	0.000	-3.5902	-1.380987

```
. estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(43)     =    317.00
         Prob > chi2  =    0.0000
```

White test revealed that residuals are heteroskedastic, hence we estimate robust standard errors

```
. reg lnmur i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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

lnmur	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.shall	-.3131735	.0357019	-8.77	0.000	-.3832208	-.2431262
incarc_rate	.002097	.0001544	13.58	0.000	.0017941	.0023999
avginc	-.0772578	.0087513	-8.83	0.000	-.0944278	-.0600878
density	.0396669	.0117541	3.37	0.001	.0166054	.0627284
pop	.0416175	.0035077	11.86	0.000	.0347355	.0484995
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
_cons	-2.485593	.6149912	-4.04	0.000	-3.692209	-1.278978

Pooled OLS (with robust errors):

Pooled OLS with robust standard errors for heteroskedasticity and auto correlation within states

```
. reg lnmur i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, vce(cluster stateid)

Linear regression                               Number of obs     =      1,173
                                                F(8, 50)          =     138.04
                                                Prob > F          =     0.0000
                                                R-squared         =     0.6059
                                                Root MSE          =     .44312

                                    (Std. Err. adjusted for 51 clusters in stateid)
------------------------------------------------------------------------------
             |               Robust
       lnmur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     1.shall |  -.3131735   .0990416    -3.16   0.003    -.5121045   -.1142425
incarc_rate |    .002097   .0004603     4.56   0.000     .0011723    .0030216
      avginc |  -.0772578    .027044    -2.86   0.006    -.1315773   -.0229382
     density |   .0396669    .039893     0.99   0.325    -.0404606    .1197944
         pop |   .0416175    .011926     3.49   0.001     .0176633    .0655717
      pb1064 |   .1307641   .0611915     2.14   0.038     .0078573    .2536709
      pw1064 |   .0470796   .0285914     1.65   0.106    -.0103479     .104507
      pm1029 |   .0655308   .0361641     1.81   0.076     -.007107    .1381685
       _cons |  -2.485593   1.992083    -1.25   0.218    -6.486809    1.515622
------------------------------------------------------------------------------
```

Model Interpretations:

➔ According to linear & pooled models, all variables except *shall* & *avginc* increase murders

➔ States with shall-law in effect have 31.32% less murders than the states without shall-law

➔ In pooled model, all the variables except density, pw1064 & pm1029 are significant at 5%

Fixed Effects (without robust errors):

```
. xtreg lnmur i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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]
-------------+----------------------------------------------------------------
     1.shall |    -.06081   .0257579    -2.36   0.018    -.1113495   -.0102704
incarc_rate |    -.00036   .0001278    -2.82   0.005    -.0006107   -.0001093
      avginc |   .0243114   .0080663     3.01   0.003     .0084846    .0401382
     density |  -.6707132   .1160957    -5.78   0.000     -.898504   -.4429224
         pop |  -.0257054   .0119103    -2.16   0.031    -.0490745   -.0023363
      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
       _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
```

Random Effects (without robust errors):

```
. xtreg lnmur i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, re

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)       =      169.92
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =      0.0000
```

lnmur	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1.shall	-.1153705	.0268844	-4.29	0.000	-.1680629	-.062678
incarc_rate	.0004438	.0000925	4.80	0.000	.0002625	.000625
avginc	.0093982	.0081589	1.15	0.249	-.0065929	.0253893
density	.0163429	.0381659	0.43	0.669	-.0584609	.0911467
pop	.0029126	.0072821	0.40	0.689	-.01136	.0171851
pb1064	.0512656	.0168244	3.05	0.002	.0182903	.0842409
pw1064	.0069318	.0071688	0.97	0.334	-.0071188	.0209824
pm1029	.0734716	.0084037	8.74	0.000	.0570007	.0899426
_cons	-.3301384	.536504	-0.62	0.538	-1.381667	.7213902
sigma_u	.30755149					
sigma_e	.21942693					
rho	.66267693	(fraction of variance due to u_i)				

Huasman Test:

```
. hausman fe_mur re_mur
```

	(b) fe_mur	(B) re_mur	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
1.shall	-.06081	-.1153705	.0545605	.
incarc_rate	-.00036	.0004438	-.0008037	.0000882
avginc	.0243114	.0093982	.0149132	.
density	-.6707132	.0163429	-.6870561	.1096429
pop	-.0257054	.0029126	-.0286179	.0094248
pb1064	.0307009	.0512656	-.0205648	.017453
pw1064	.0103313	.0069318	.0033995	.
pm1029	.0392384	.0734716	-.0342333	.0024109

```
                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)
```

Model Interpretations:

➔ From above test, we say that estimates of fixed and random effects are significantly different

➔ Both Fixed/Random effects indicate that shall-law reduces murder rates with 5% significance

Entity Fixed Effects (with robust errors):

```
. xtreg lnmur i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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]
-------------+----------------------------------------------------------------
     1.shall |    -.06081   .0369632    -1.65   0.106    -.1350527    .0134327
incarc_rate |    -.00036   .0004231    -0.85   0.399    -.0012099    .0004899
      avginc |   .0243114   .0156779     1.55   0.127    -.0071786    .0558013
     density |  -.6707132   .3957745    -1.69   0.096     -1.46565    .1242232
         pop |  -.0257054   .0203457    -1.26   0.212    -.0665709    .0151602
      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
       _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)
------------------------------------------------------------------------------
```

Entity Fixed and Time Fixed Effects (with robust errors):

```
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]
-------------+----------------------------------------------------------------
     1.shall |  -.0149524   .0382403    -0.39   0.697    -.0917603    .0618556
incarc_rate |  -.0001164   .0003631    -0.32   0.750    -.0008457    .0006129
      avginc |   .0566492   .0165554     3.42   0.001     .0233967    .0899017
     density |  -.5442635   .3192203    -1.70   0.094    -1.185436    .0969093
         pop |  -.0320769   .0209819    -1.53   0.133    -.0742202    .0100664
      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
             |
        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)
------------------------------------------------------------------------------
```

Time Fixed Effects Significance:

```
. 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
```

Random Effects (with robust errors):

```
. xtreg lnmur i.shall incarc_rate avginc density pop pb1064 pw1064 pm1029, 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]
-------------+----------------------------------------------------------------
      1.shall |  -.1153705    .039896    -2.89   0.004    -.1935652   -.0371757
incarc_rate |   .0004438   .0004395     1.01   0.313    -.0004176    .0013051
      avginc |   .0093982   .0149265     0.63   0.529    -.0198572    .0386535
     density |   .0163429    .067886     0.24   0.810    -.1167113    .1493971
         pop |   .0029126   .0114322     0.25   0.799    -.0194941    .0253193
      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
       _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)
------------------------------------------------------------------------------
```

Model Interpretations:

➔ The joint significance test in Time Fixed model shows that at least one estimate is significant

➔ After obtaining robust errors, fixed effects estimates for shall-law became insignificant at 5%

4. Models Interpretation

4.1. Conclusions

Pooled OLS: According to Pooled OLS, states with shall-law in effect have 37% less crime rate, 53% less robbery rate and 31% less murder rate when compared to states without shall-law. Pooled OLS model does not account for entity fixed effects or time fixed effects and treats panel data as cross-sectional data. Hence, pooled regression model is not the best model. Estimated coefficients of *shall* variable in pooling models shows a large and significant effect on violent crime rate, murder rate and robbery rate. However, we cannot rely on this model and these effects disappear in fixed effects models as it accounts for the variations within states and time.

Fixed Effects: According to both Fixed Effects models (Entity Fixed and Entity-Time Fixed), the estimates for shall variable are insignificant and does not give enough evidence that shall-law has significant effect on violent crime rate, robbery rate and murder rate. When compared to Pooled OLS model, Fixed Effects is more reliable as it accounts for the variations within states and time. However, fixed effects model has certain limitations when we do not capture all important variables that vary across states and could have significant impact on the crime rates. An example for such variables could be the strength of police force in a state or arrest probability.

Random Effects: According to the Random Effects model, the estimates for shall variable are insignificant and does not give enough evidence that shall-law has significant effect on violent crime rate and robbery rate. But estimates for shall-law has a significant effect on murder rate. With Hausman tests, we rejected null hypothesis and concluded that fixed and random effects estimates are significantly different and random effects estimates are inconsistent & inefficient. But the Fixed Effects model estimates are consistent but not efficient which could be corrected. Hence, its better to rely on the Fixed Effects model when compared to the Random Effects model.

4.2. Limitations

Omitted Variable Bias: There could be omitted variables in the regression that vary between states and time. Effects of these variables cannot be captured by Fixed Effects regression model. For example, variable like police force density could lead to a decrease in crime rates and omitting such variables could introduce bias into the regression which cannot be dealt by the Fixed Effects.

Simultaneous Causality Bias: Including variables like incarceration rate into the model has the potential of introducing simultaneous causality bias. Increase in incarceration rate could lead to a decline of violent crime rate, robbery rate and murder rate. However, high increase in these crime rates could make authorities to tighten the laws and focus on increasing incarceration rate. Crime and Incarceration rates affect each other and could lead to a simultaneous causality bias.

5. References

https://cran.r-project.org/web/packages/plm/vignettes/plmPackage.html

https://stats.idre.ucla.edu/stata/examples/eacspd/econometric-analysis-of-cross-section-and-panel-data-by-jeffrey-m-wooldridgechapter-10-basic-linear-unobserved-effects-panel-data-models/