Project Report for Applied Econometrics and Time Series Analysis

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DO MORE GUNS REDUCE CRIME?

The right-to-carry laws, or **shall-issue** laws, is one of the most hotly debated laws in America. A Shall-issue law is one that requires that governments issue concealed carry-handgun permits to any applicant who meets the following necessary criteria:

- The applicant must be an adult
- Applicant must have no significant criminal record and no history of mental illness
- Applicant must successfully complete a course in firearms safety training (if required by law)

If the above criteria are met, the applicant is eligible to be issued a handgun permit and is not required to demonstrate 'good cause'. This has sparked off a debate with some claiming that the move would make citizens better equipped to handle crime/ attacks and fend off potential attackers, while others feel that the move would make it easier for potential criminals to access weapons or that it may raise the number of accidental crimes.

Guns is a balanced panel of data on 50 US states, plus the District of Columbia (for a total of 51 "states"), by year for 1977 – 1999. Each observation is a given state in a given year. There is a total of 51 states × 23 years = 1173 observations.

Objective: To analyze historical data on crime in the U.S to answer the questions:

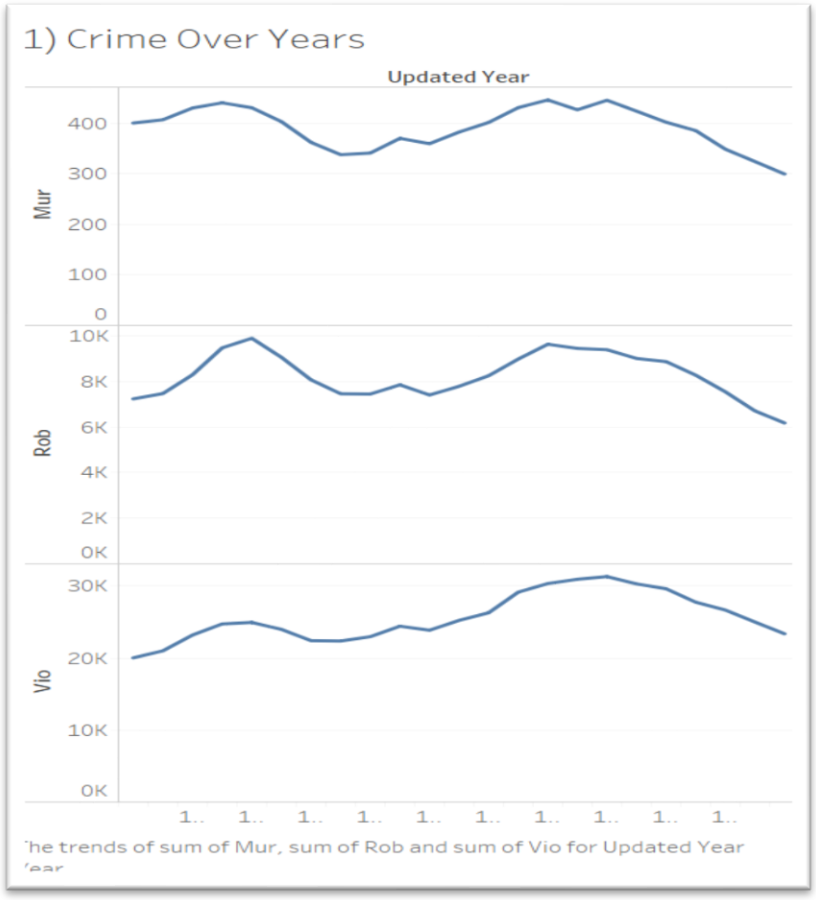
- ***"Do shall-issues law reduce crime-or not?"***
- ***"Does incarceration policy reduce crime-or not?"***

Variable	Definition
vio	violent crime rate (incidents per 100,000 members of the population)
rob	robbery rate (incidents per 100,000)
mur	murder rate (incidents per 100,000)
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)

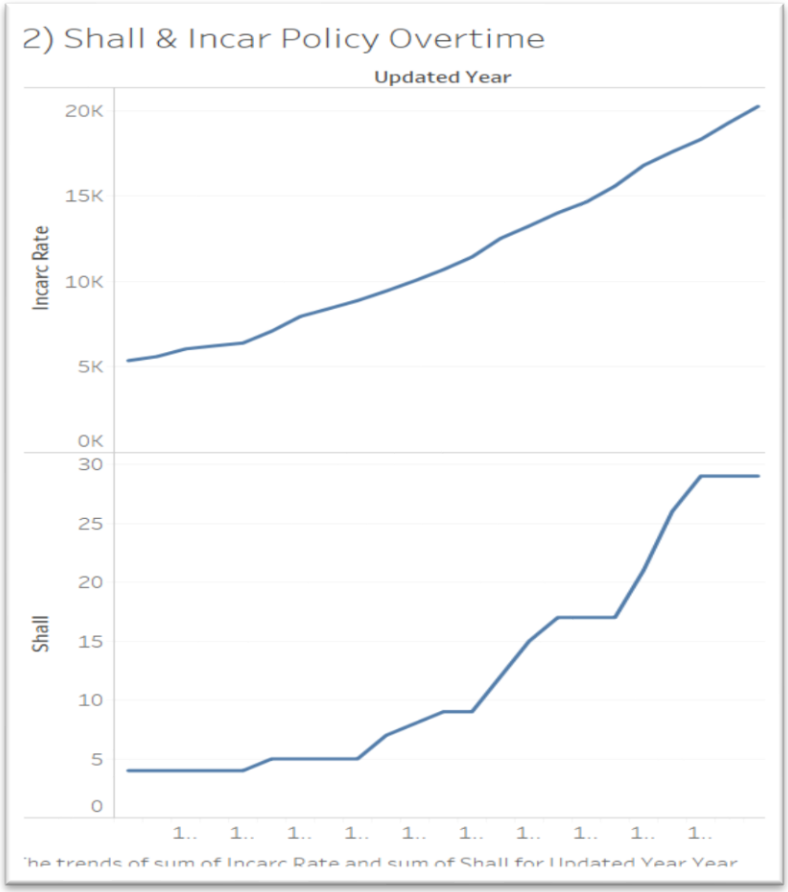
Before proceeding to answer the above question, it is important to do a quick exploratory data analysis to realize any trends or correlations that exist in the data.

- Graph 1 shows the crime-trend over the years. Murder rates and robbery rates follow a similar pattern over the years (relatively flat-trended), while violent-crime rate shows an upward trend.

- Of the 51 states, 29 adopted the shall-issue laws, while 22 never adopted them. (Graph 2)
- The incarceration rate shows a steady increase over the years. (Graph 2)



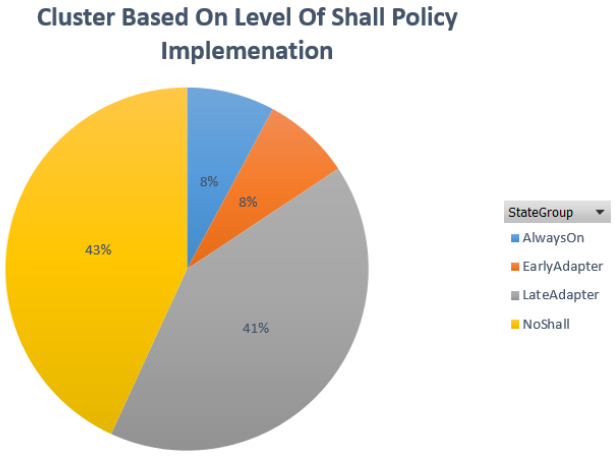
GRAPH 1



GRAPH 2

To better understand the trends within panel data, 50 States were clustered into 4 distinct groups based on the level of shall-policy implementations. The 4 clusters were:

1. No-Shall: 22 out of 51 states that never allowed the carry of concealed handgun.
2. Early-Adopter: 4 out of 51 states that decided to implement shall policy anytime between 1978 to 1999
3. Late- Adopter: 21 out of 5 states that decided to implement shall policy after 1989
4. Always-On: 4 out of 51 states that always allow the carry of concealed handgun



Among the 4 clusters:

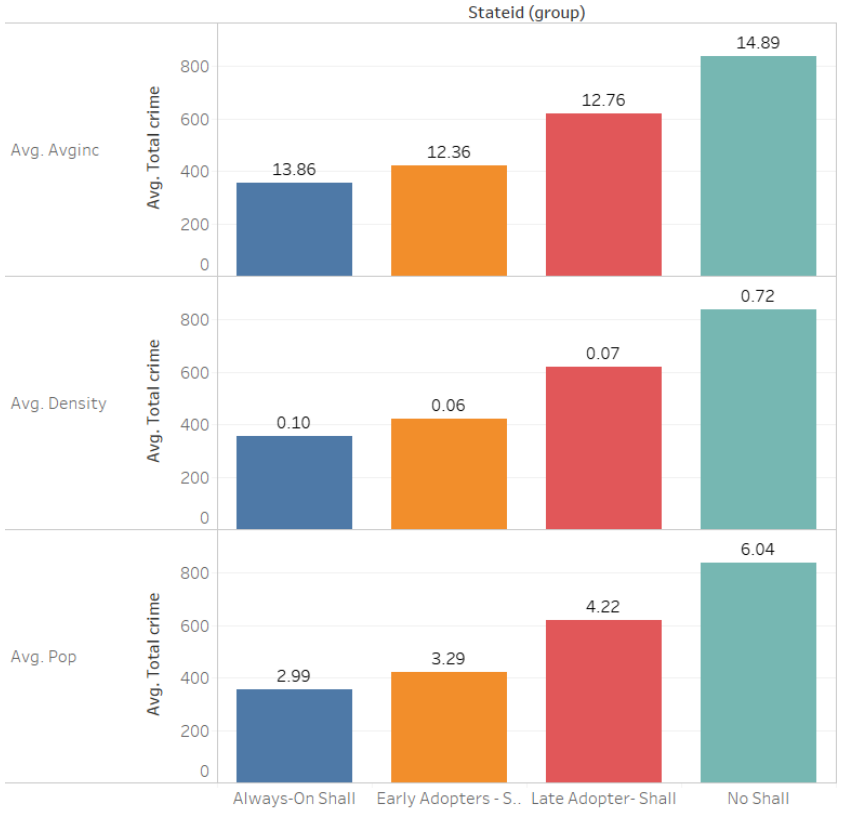
- No-Shall and Late-Adopter states had much higher crime incidents (across violence, murder, and robbery) compared to Early-Adopter and Always-On states. However, the difference between number of crimes in Always-On and Early-Adopter was not significantly (For example: an average of 4.1 vs 3.8 for murder). Same trend appeared between Late-Adopter and No-Shall. Therefore, it was implied that there were individual differences among 50 States that caused the variation in crime levels.

- No-Shall and Later-Adopter states also had higher incarceration rate compared to Early-Adopter and Always-On states. Implementing incarceration policy was expected to deter people from committing crimes. However, at the same time, higher incarceration might also be the result of increased crime. A simultaneous causality bias might be possible in this circumstance. As a result, the panel data might be inflicted with unobserved heterogeneity.

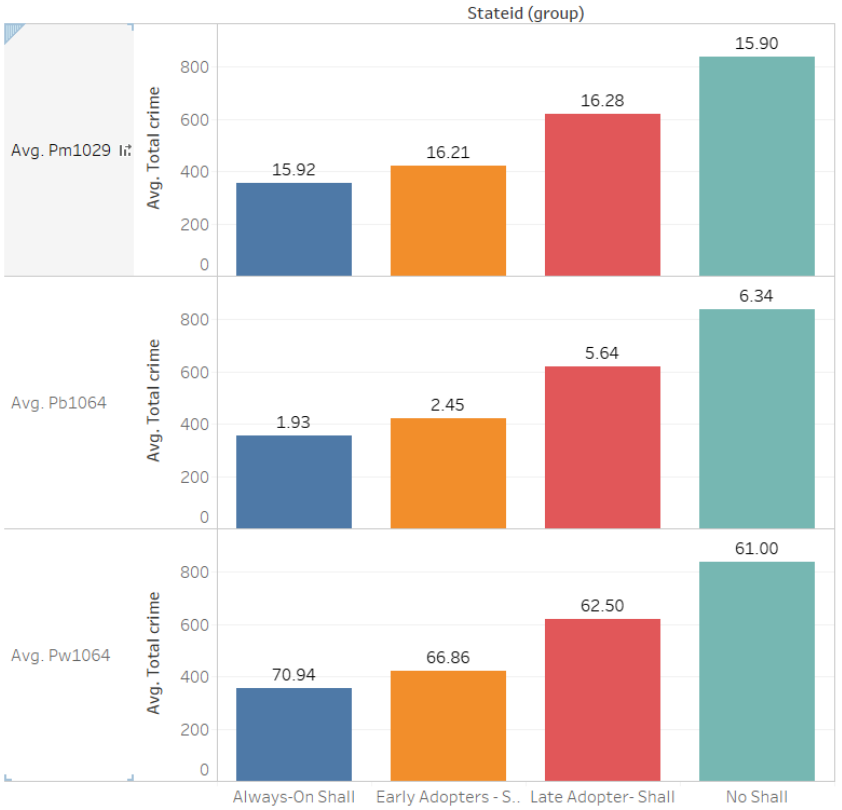
Trends in other demographic variables were also studied to get a better insight into the panel data. Specifically:

- Graph 3 showed in No-Shall and Late-Adopter states where crime level was high, demographic variables such as: “income level, density, and population” also tended to be upward. Therefore, it was speculated that the mentioned variables would have some effects on the crime level.

- Graph 4 showed that in No-Shall and Late-Adopter states where crime level was high, there was also a high percent male population. The high percent of black population and white population were just indication of high population. As a result, it was speculated that high level of male population would have some effects on the number of crime incidents.



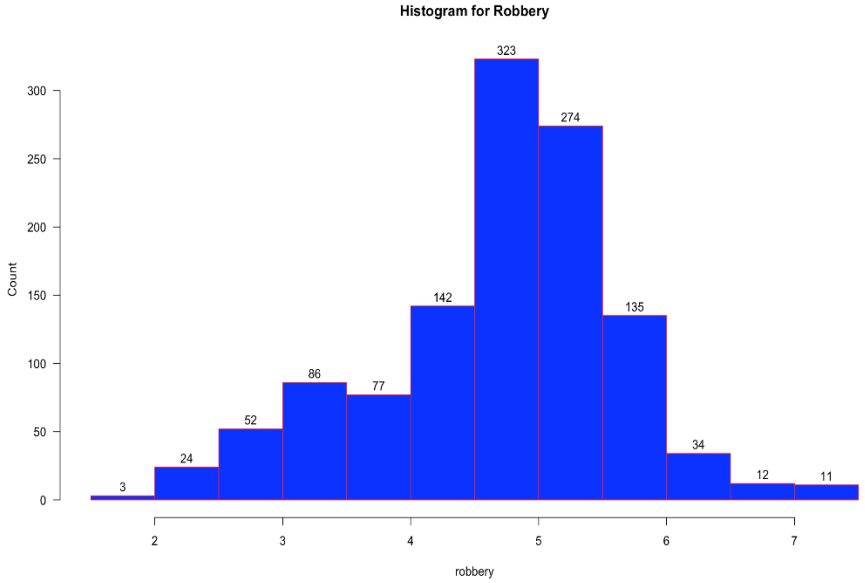
GRAPH 3

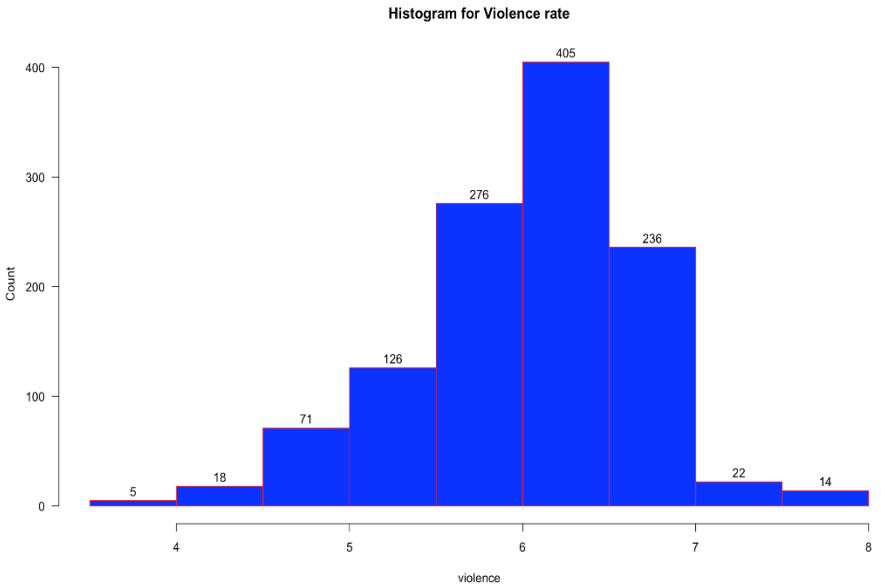


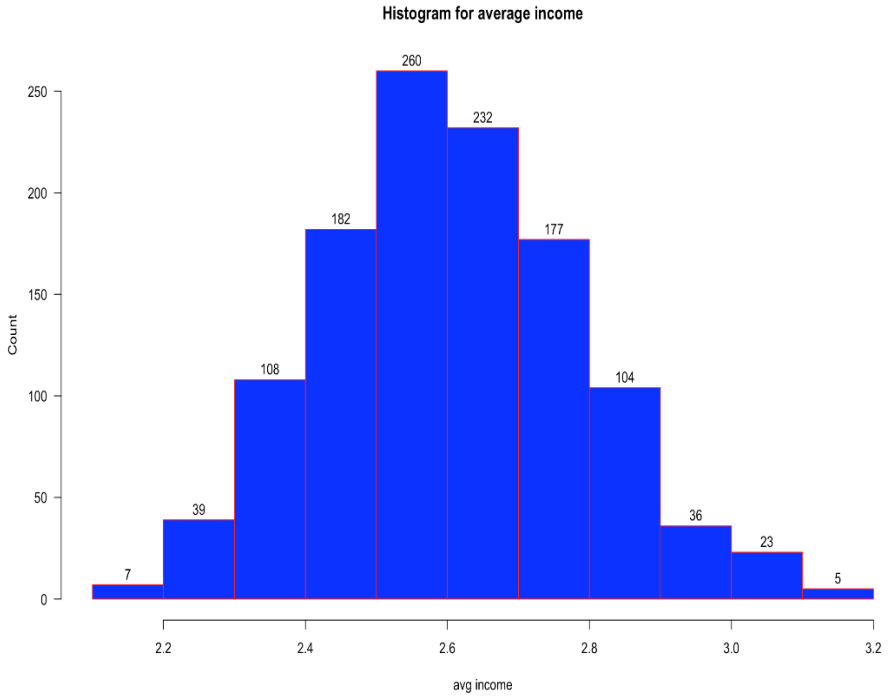
GRAPH 4

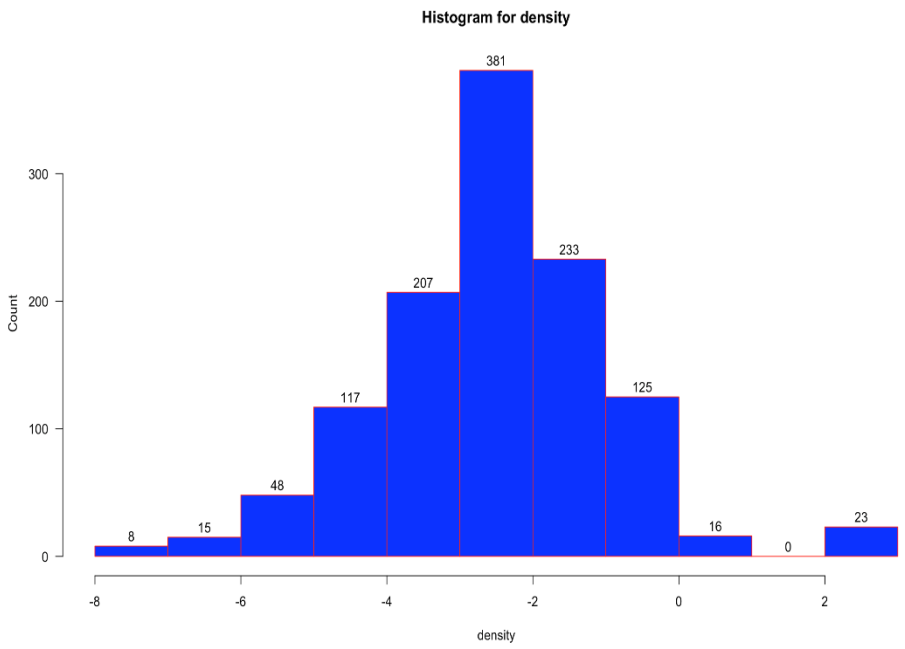
Note: Avg. Total Crime = Avg. (Violence crime + Murder crime + Robbery crime)

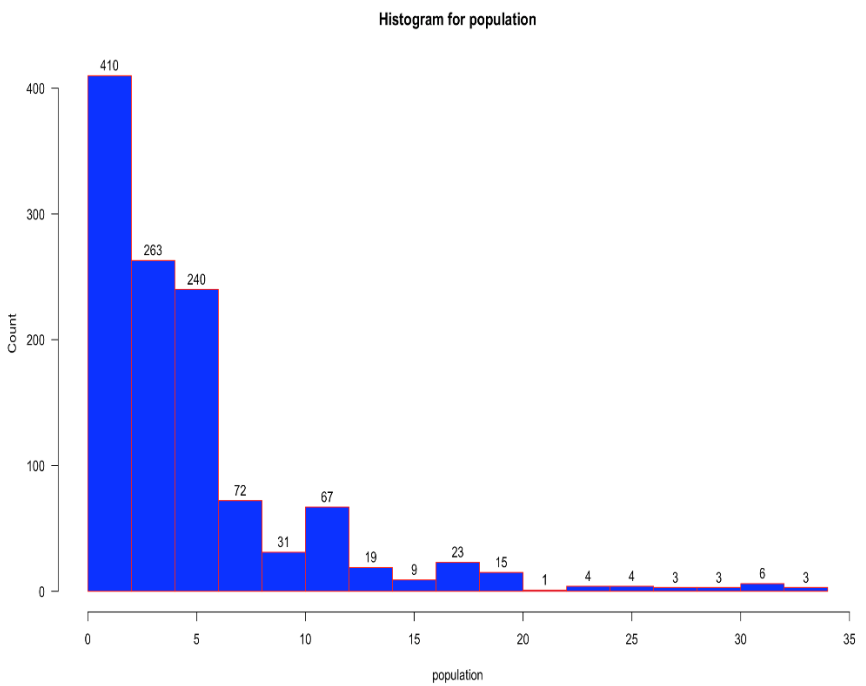
The following histogram plots helped reveal the distributions of the variables and the possible effects of outliers. Accordingly, certain variables were log-transformed to reduce their skewness and to make them more interpretable.

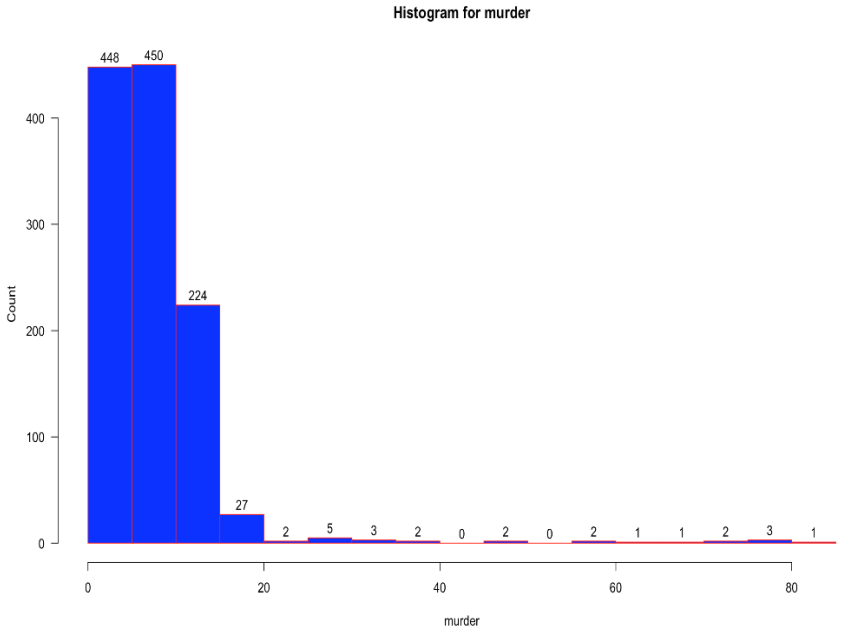


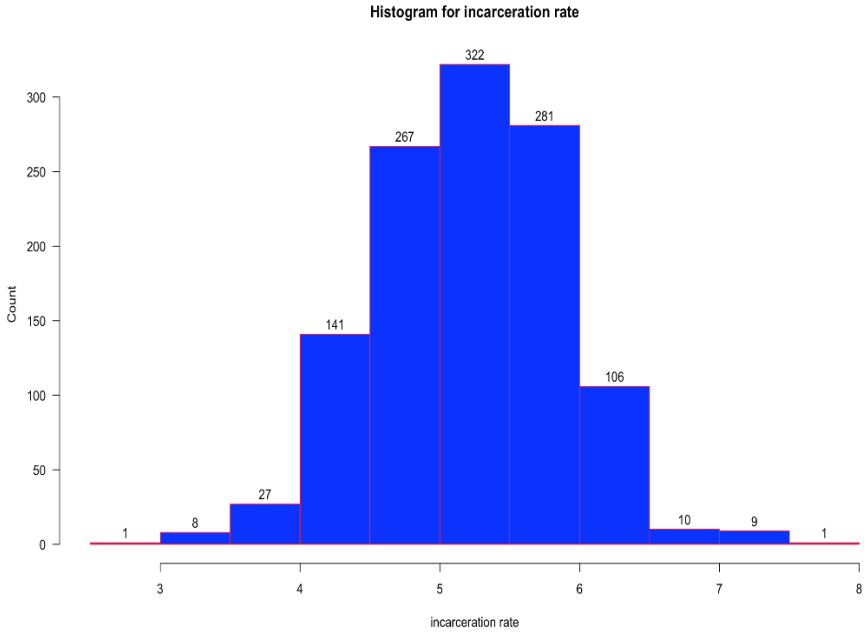


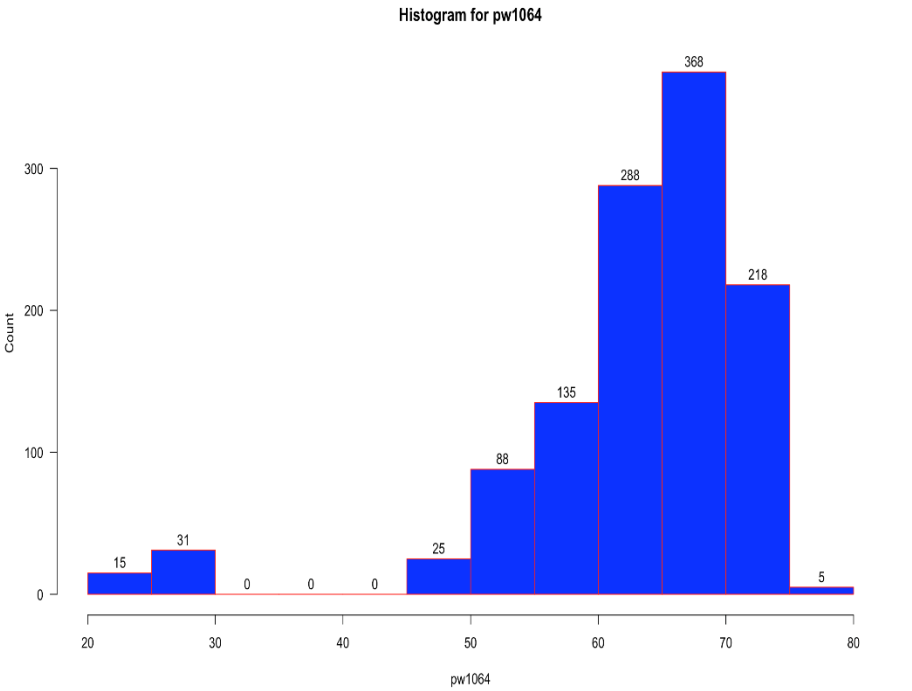



Histogram for density
Count
density
0
100
200
300
-8
-6
-4
-2
0
2
8
15
48
117
207
381
233
125
16
0
23

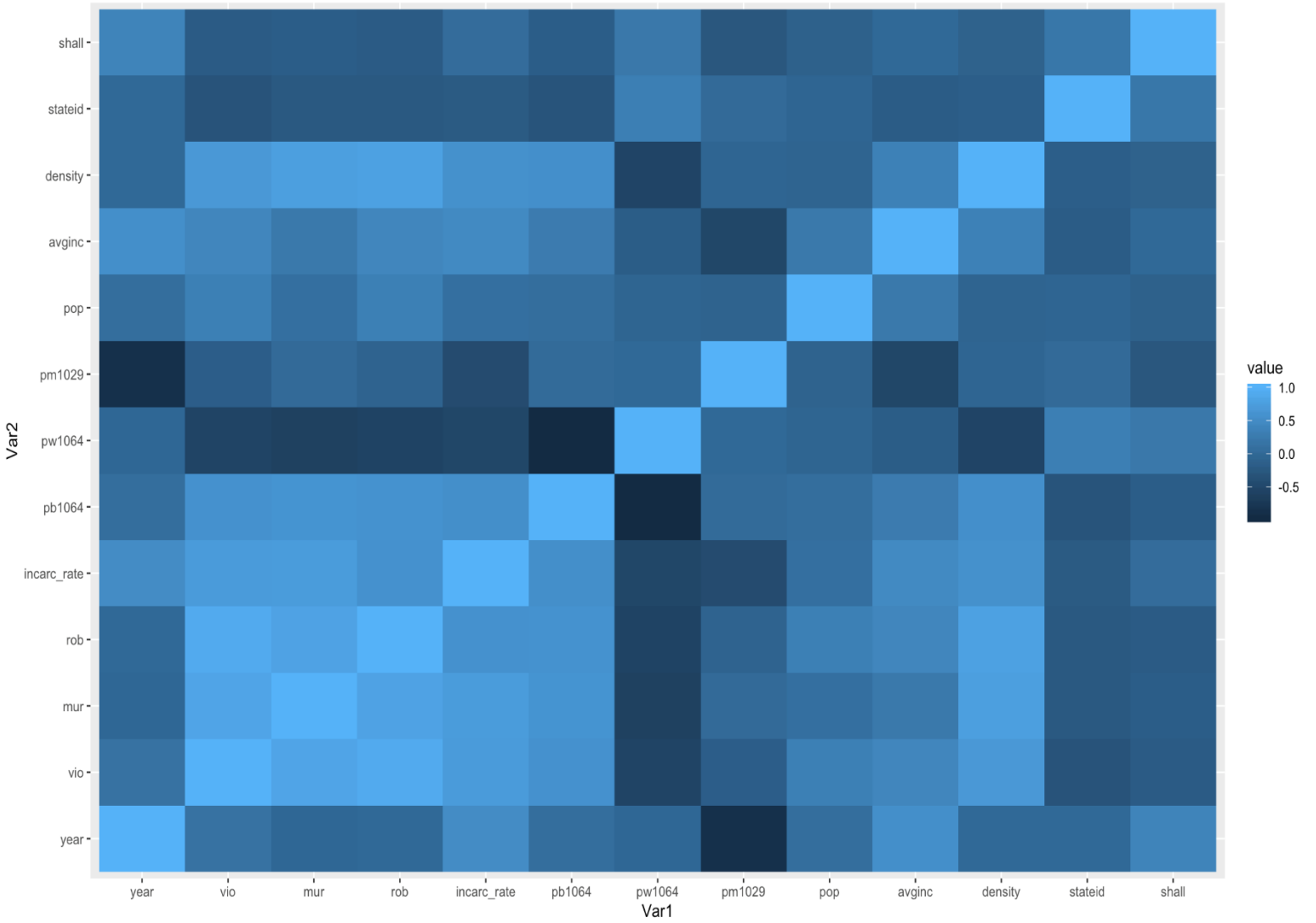

Histogram for population
Count
population
0
100
200
300
400
0
5
10
15
20
25
30
35
410
263
240
72
31
67
19
9
23
15
1
4
4
3
3
6
3


Histogram for murder
Count
murder
0
100
200
300
400
0
20
40
60
80
448
450
224
27
2
5
3
2
0
2
0
2
1
1
2
3
1


Histogram for incarceration rate
Count
incarceration rate
0
50
100
150
200
250
300
3
4
5
6
7
8
1
8
27
141
267
322
281
106
10
9
1



We have also looked at the correlation matrix to be aware of highly correlated variables, if any. This will be an easy reference to investigate, if a collinearity problem were to be detected.


shall
stateid
density
avginc
pop
pm1029
pw1064
pb1064
incarc_rate
rob
mur
vio
year
Var2
year
vio
mur
rob
incarc_rate
pb1064
pw1064
pm1029
pop
avginc
density
stateid
shall
Var1
value
1.0
0.5
0.0
-0.5

	vio	*mur*	*rob*	*incarc_rate*	*pb1064*	*pw1064*	*pm1029*	*pop*	*avginc*	*density*	*shall*
vio	1.00										
mur	0.83	1.00									
rob	0.91	0.80	1.00								
incarc_rate	0.70	0.71	0.57	1.00							
pb1064	0.57	0.60	0.58	0.53	1.00						
pw1064	(0.57)	(0.62)	(0.58)	(0.53)	**(0.98)**	1.00					
pm1029	(0.17)	0.01	(0.09)	(0.45)	0.02	(0.01)	1.00				
pop	0.32	0.10	0.32	0.10	0.06	(0.07)	(0.10)	1.00			
avginc	0.41	0.22	0.41	0.46	0.26	(0.19)	(0.53)	0.22	1.00		
density	0.66	0.75	0.78	0.56	0.54	(0.56)	(0.06)	(0.08)	0.34	1.00	
shall	(0.21)	(0.18)	(0.21)	0.04	(0.18)	0.21	(0.28)	(0.12)	(0.00)	(0.11)	1.00

We shall now proceed with detailed analysis of our panel dataset, to fulfill the stated objective. We have conducted Entity Fixed effects modeling and Time-fixed effects modeling for violent-crime rate, murder rate and robbery-rates as dependent variables separately.

Hausmann Tests were conducted in each case to check the presence of endogeneity and to conclude the requirement/ non-requirement of random-effects model for each analysis.

The models, their analysis, and conclusions have been elaborated below:

METHODOLOGY

- Run Pooled OLS model, Entity- Fixed Effect model, Time-Effect-FE model for 3 dependent variables: Violence, Murder, Robbery Crime
- Perform log transformation on the following variables to improve model accuracy: Violence, Murder, Robber, Incarceration Rate, Population, Average Income, and Density.

RESULTS

❖ **Findings on Violence Crime**

➢ The result showed that States with active shall-policy would witness a decrease in violence crime by 25%. The effect was significant at 99% confidence level.

➢ We initially expected incarceration policy would help decrease violence crime in local areas. However, the Pooled OLS model showed contradicting outcome. Implementing incarceration policy would lead to a surge in violence crime by 66% compared to when the policy was not enforced.

➢ The assumption of Pooled OLS Model where there would be no unobserved heterogeneity across all 51 entities was violated, since the huge effect of shall policy from the model did not align with real-life observation. Therefore, Pooled OLS was not recommended to use.

➢ The unreliable results might be influenced by difference between the States in terms of other government policies, cultural practices, or unemployment rate. The mentioned factors could be omitted from the model leading to upward bias. As a result, it was necessary for the model to consider unobserved heterogeneity.

1. Pooled OLS Model

```
. reg log_vio log_incar pb1064 pw1064 pm1029 log_pop log_inc log_dens shall
```

Source	SS	df	MS	Number of obs	=	1,173
				F(8, 1164)	=	326.48
Model	337.999141	8	42.2498926	Prob > F	=	0.0000
Residual	150.632417	1,164	.129409293	R-squared	=	0.6917
				Adj R-squared	=	0.6896
Total	488.631558	1,172	.416921125	Root MSE	=	.35974

log_vio	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_incar	.6641384	.0246988	26.89	0.000	.6156793	.7125975
pb1064	-.0108803	.0142213	-0.77	0.444	-.0387826	.017022
pw1064	-.006234	.0069759	-0.89	0.372	-.0199207	.0074527
pm1029	.1299967	.0098634	13.18	0.000	.1106447	.1493487
log_pop	.1626314	.0121509	13.38	0.000	.1387913	.1864714
log_inc	.616552	.0879788	7.01	0.000	.4439372	.7891668
log_dens	.0637798	.0092361	6.91	0.000	.0456586	.0819011
shall	-.250214	.0275038	-9.10	0.000	-.3041765	-.1962515
_cons	-.6248042	.465095	-1.34	0.179	-1.537323	.2877141

2. Entity Fixed Effect Model

- In Entity Fixed Effect model, States which implemented shall policy were able to decrease violence crime by 3.9%
- The effect of incarceration policy on violence crime was minimal at 0.07%, which did not show significant impact.
- Variables such as: population, income, and density showed insignificant influence on violence crime since their p-values were much higher than significance level at 5%.
- Even though, Entity-Fixed Effect did solve unobserved heterogeneity problem in Pooled OLS, the model still ignored the potential changes in violence crime across the years.

```
. xtreg log_vio log_incar pb1064 pw1064 pm1029 log_pop log_inc log_dens shall, fe

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

R-sq:                                           Obs per group:
     within  = 0.2201                                         min =          23
     between = 0.0096                                         avg =        23.0
     overall = 0.0104                                         max =          23

                                                F(8,1114)          =       39.30
corr(u_i, Xb)  = -0.9018                        Prob > F           =      0.0000

------------------------------------------------------------------------------
     log_vio |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   log_incar |  -.0719767   .0278179    -2.59   0.010    -.1265581   -.0173952
      pb1064 |   .0933273   .0152817     6.11   0.000     .0633431    .1233115
      pw1064 |   .0397041   .0052568     7.55   0.000     .0293897    .0500186
      pm1029 |  -.0600557   .0083853    -7.16   0.000    -.0765084   -.0436029
     log_pop |  -1.017077   1.455481    -0.70   0.485    -3.872871    1.838717
     log_inc |   .1071861   .0863504     1.24   0.215    -.0622417    .2766139
    log_dens |   .8696474   1.472712     0.59   0.555    -2.019955     3.75925
       shall |  -.039219    .0191353    -2.05   0.041    -.0767642   -.0016737
       _cons |   7.412193   5.308396     1.40   0.163    -3.003388    17.82777
-------------+----------------------------------------------------------------
     sigma_u |  1.4556259
     sigma_e |  .16048693
         rho |  .98799029   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(50, 1114) = 94.69                     Prob > F = 0.0000
```

3. Time Fixed Effect Model

- An F-test was conducted to determine whether violence crime was influenced over the years. The test result showed significant effect results at 99% confidence level.

```
( 1)  d77 = 0
( 2)  d78 = 0
( 3)  d79 = 0
( 4)  d80 = 0
( 5)  d81 = 0
( 6)  d82 = 0
( 7)  d83 = 0
( 8)  d84 = 0
( 9)  d85 = 0
(10)  d86 = 0
(11)  d87 = 0
(12)  d88 = 0
(13)  d89 = 0
(14)  d90 = 0
(15)  d91 = 0
(16)  d92 = 0
(17)  d93 = 0
(18)  d94 = 0
(19)  d95 = 0
(20)  d96 = 0
(21)  d97 = 0
(22)  d98 = 0
(23)  o.d99 = 0
      Constraint 23 dropped

      F( 22,  1092) =   18.03
           Prob > F =    0.0000
```

- In Time-Fixed Effect Model, shall-policy implementation decreased violence crime by 2.3%. However, its effect was insignificant at 5% significance level.

- The impact of incarceration policy on violence crime (at 0.097% reduction rate) was also minimal.

- According to the model result, demographic variable "pm1029" had great effect on violence crime. Specifically, when pm1029 increased by 1%, violence crime would go up by 7.5%.

log_vio	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_incar	-.0974403	.0282725	-3.45	0.001	-.1529149	-.0419657
pb1064	-.0107897	.0192508	-0.56	0.575	-.0485624	.026983
pw1064	-.0022356	.0072098	-0.31	0.757	-.0163823	.0119111
pm1029	.0751388	.0148364	5.06	0.000	.0460278	.1042498
log_pop	.9923086	1.317948	0.75	0.452	-1.593688	3.578305
log_inc	.2151159	.0974623	2.21	0.028	.0238814	.4063504
log_dens	-1.226726	1.334911	-0.92	0.358	-3.846006	1.392554
shall	-.0233768	.017304	-1.35	0.177	-.0573297	.010576
d77	-.605799	.1068217	-5.67	0.000	-.8153981	-.3962
d78	-.5471158	.101879	-5.37	0.000	-.7470165	-.347215
d79	-.4286484	.098841	-4.34	0.000	-.6225881	-.2347087
d80	-.3605878	.0980204	-3.68	0.000	-.5529174	-.1682582
d81	-.3544642	.0948857	-3.74	0.000	-.5406431	-.1682854
d82	-.3617006	.0908778	-3.98	0.000	-.5400154	-.1833857
d83	-.3887045	.0857372	-4.53	0.000	-.5569328	-.2204761
d84	-.3579931	.0793649	-4.51	0.000	-.513718	-.2022682
d85	-.3056261	.0746338	-4.10	0.000	-.452068	-.1591841
d86	-.2241027	.0696793	-3.22	0.001	-.3608232	-.0873823
d87	-.2201839	.0651538	-3.38	0.001	-.3480247	-.0923432
d88	-.1541368	.0604567	-2.55	0.011	-.2727611	-.0355124
d89	-.094503	.0562773	-1.68	0.093	-.2049269	.015921
d90	.0431711	.0447964	0.96	0.335	-.0447257	.1310679
d91	.1079641	.0421593	2.56	0.011	.0252416	.1906865
d92	.1453423	.0386601	3.76	0.000	.0694859	.2211987
d93	.1757429	.0365823	4.80	0.000	.1039633	.2475225
d94	.1677484	.0341359	4.91	0.000	.100769	.2347278
d95	.1702824	.0319483	5.33	0.000	.1075954	.2329694
d96	.1218765	.0301324	4.04	0.000	.0627526	.1810004
d97	.1061023	.0287698	3.69	0.000	.0496519	.1625526
d98	.0535332	.0277378	1.93	0.054	-.0008922	.1079587
d99	0	(omitted)				
_cons	.920053	4.79769	0.19	0.848	-8.49368	10.33379
sigma_u	2.0386539					
sigma_e	.13882927					
rho	.995384	(fraction of variance due to u_i)				

F test that all u_i=0: F(50, 1092) = 112.02 Prob > F = 0.0000

4. Hausmann Test - Endogeneity Problem Detection

- The Hausmann Test revealed that the null hypothesis would be rejected. As a result, it was concluded that the assumption of no endogeneity was incorrect.

- From the findings, Random-Effect Model would not be suitable due to endogeneity problem. In addition, the panel data comprised of information across all 50 States, not random samples. As a result, running Random-Effect Model would not be recommended.

```
. hausman Random_Vio Entity_FE_Vio
```

	Coefficients (b) Random_Vio	(B) Entity_FE_~o	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
log_incar	-.0004565	-.0719767	.0715201	.0032698
pb1064	.1086669	.0933273	.0153395	.
pw1064	.036811	.0397041	-.0028931	.0010286
pm1029	-.0303625	-.0600557	.0296931	.
log_pop	.151121	-1.017077	1.168198	.
log_inc	.0855652	.1071861	-.0216209	.0111817
log_dens	.0330983	.8696474	-.8365491	.
shall	-.0708977	-.039219	-.0316787	.0026694

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)
= 195.17
Prob>chi2 = 0.0000
(V_b-V_B is not positive definite)

5. Model Comparison

- In summary, Pooled OLS Model's result was unreliable as it did not capture within-state differences. *Due to this fatal flaws, Pooled OLS Model would not be conducted to study the effect of shall policy and incarceration policy on Robbery & Murder Crime*

- Time Fixed-Effect Model was more accurate than Entity Fixed-Effect Model as it captured the trend of violence crimes over the years.

Variable	Pooled_OLS~o	Entity_FE_~o	Time_FE_Vio
log_incar	0.664***	-0.072**	-0.097***
pb1064	-0.011	0.093***	-0.011
pw1064	-0.006	0.040***	-0.002
pm1029	0.130***	-0.060***	0.075***
log_pop	0.163***	-1.017	0.992
log_inc	0.617***	0.107	0.215*
log_dens	0.064***	0.870	-1.227
shall	-0.250***	-0.039*	-0.023

❖ Findings on Robbery Crime

1. Entity Fixed-Effect Model

- The model showed that shall policy had insignificant effect on robbery. As a result, it was concluded that allowing the carry of concealed handgun did not deter robbery crime.

- However, implementing incarceration policy revealed to decrease level of robbery. 1% increase in incarceration would lead to 0.129% decrease in robbery incidents

- Other demographic factors such as: *pb1064, pw1064, pop, and density* also made a significant impact in reducing robbery.

```
. xtreg log_rob log_incar pb1064 pw1064 pm1029 log_pop log_inc log_dens shall, fe

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

R-sq:                                           Obs per group:
     within  = 0.0704                                         min =          23
     between = 0.0655                                         avg =        23.0
     overall = 0.0624                                         max =          23

                                                F(8,1114)          =       10.55
corr(u_i, Xb)  = -0.9965                        Prob > F           =      0.0000

------------------------------------------------------------------------------
     log_rob |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   log_incar |  -.2194706   .0366321    -5.99   0.000    -.2913463   -.1475948
     pb1064 |   .1117079   .0201238     5.55   0.000     .0722231    .1511926
     pw1064 |   .0362451   .0069225     5.24   0.000     .0226625    .0498277
     pm1029 |  -.0141734   .0110422    -1.28   0.200    -.0358392    .0074925
    log_pop |  -7.309897   1.916654    -3.81   0.000    -11.07056   -3.549237
    log_inc |   .1181901   .1137108     1.04   0.299    -.1049214    .3413015
   log_dens |    7.53175   1.939345     3.88   0.000     3.726569    11.33693
      shall |  -.0226663   .0251983    -0.90   0.369    -.0721078    .0267753
      _cons |   29.93769   6.990375     4.28   0.000     16.22191    43.65348
-------------+----------------------------------------------------------------
    sigma_u |  10.941568
    sigma_e |  .21133763
        rho |  .99962707   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(50, 1114) = 99.24                     Prob > F = 0.0000
```

2. Time Fixed Effect Model

- An F-test was conducted to determine whether there was a significant change of robbery level over the years. The result confirmed the notion. There was time effect on the variation of robbery

```
( 1)  d77 = 0
( 2)  d78 = 0
( 3)  d79 = 0
( 4)  d80 = 0
( 5)  d81 = 0
( 6)  d82 = 0
( 7)  o.d83 = 0
( 8)  d84 = 0
( 9)  d85 = 0
(10)  d86 = 0
(11)  d87 = 0
(12)  d88 = 0
(13)  d89 = 0
(14)  d90 = 0
(15)  d91 = 0
(16)  d92 = 0
(17)  d93 = 0
(18)  d94 = 0
(19)  d95 = 0
(20)  d96 = 0
(21)  d97 = 0
(22)  d98 = 0
(23)  d99 = 0
      Constraint 7 dropped

      F( 22,  1092) =   13.96
           Prob > F =    0.0000
```

- In Time Fixed Effect model, shall policy again showed no significant impact on robbery.
- An 1% increase in incarceration would lead to a 0.215% decrease in robbery
- *Male population* revealed to affected robbery level significantly. Specially, a 1% decrease in male population age 10-26 would reduce robbery by almost 10%.
- Robbery crimes tended to increase over time, especially from 1983 onwards. Especially, robbery peaked from 1996 to 1999.

corr(u_i, Xb) = -0.9741 Prob > F = 0.0000

log_rob	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_incar	-.2157874	.0384035	-5.62	0.000	-.2911404	-.1404344
pb1064	-.0079249	.026149	-0.30	0.762	-.0592328	.043383
pw1064	-.0158479	.0097934	-1.62	0.106	-.0350639	.003368
pm1029	.0993936	.0201527	4.93	0.000	.0598512	.138936
log_pop	-2.729072	1.790212	-1.52	0.128	-6.241715	.7835719
log_inc	.6088091	.1323862	4.60	0.000	.349049	.8685692
log_dens	2.815311	1.813252	1.55	0.121	-.7425414	6.373164
shall	.0087874	.0235046	0.37	0.709	-.0373319	.0549067
d77	-.1890711	.0486635	-3.89	0.000	-.2845556	-.0935867
d78	-.1672227	.0452557	-3.70	0.000	-.2560207	-.0784246
d79	-.045395	.0427403	-1.06	0.288	-.1292574	.0384674
d80	.0785264	.0416428	1.89	0.060	-.0031824	.1602353
d81	.1127817	.0399433	2.82	0.005	.0344073	.1911561
d82	.081389	.0381504	2.13	0.033	.0065326	.1562453
d83	0	(omitted)				
d84	-.0543896	.0387195	-1.40	0.160	-.1303626	.0215835
d85	-.0216548	.0412383	-0.53	0.600	-.10257	.0592604
d86	.0573019	.0451343	1.27	0.205	-.0312579	.1458617
d87	.0295724	.0495192	0.60	0.551	-.0675912	.126736
d88	.0678316	.0548003	1.24	0.216	-.0396942	.1753573
d89	.1268553	.0601357	2.11	0.035	.0088607	.2448498
d90	.2497605	.0734363	3.40	0.001	.1056683	.3938526
d91	.3826061	.0777602	4.92	0.000	.2300298	.5351824
d92	.3822642	.0834256	4.58	0.000	.2185716	.5459568
d93	.4060304	.0874478	4.64	0.000	.2344457	.5776152
d94	.4233977	.0924189	4.58	0.000	.2420591	.6047363
d95	.4351475	.0972926	4.47	0.000	.2442458	.6260491
d96	.3843262	.1021164	3.76	0.000	.1839597	.5846928
d97	.3192357	.1067117	2.99	0.003	.1098525	.5286189
d98	.2216634	.11205	1.98	0.048	.0018057	.441521
d99	.1475085	.1164597	1.27	0.206	-.0810015	.3760186
_cons	13.62581	6.504961	2.09	0.036	.8621736	26.38944
sigma_u	4.0446212					
sigma_e	.18857632					
rho	.99783092	(fraction of variance due to u_i)				

F test that all u_i=0: F(50, 1092) = 98.84 Prob > F = 0.0000

3. Hausman Test – Endogeneity Problem Detection

- Based on Hausman test, there was endogeneity in one of the variables at 10% significance level. The finding was alarming, thus running Random-Effect Model would not be suggested.

```
. hausman Random_Rob Entity_FE_Rob
```

	Coefficients (b) Random_Rob	(B) Entity_FE_~b	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
log_incar	-.1402204	-.2194706	.0792502	.0017998
pb1064	.1242713	.1117079	.0125635	.
pw1064	.0312081	.0362451	-.005037	.0011296
pm1029	.0157303	-.0141734	.0299037	.
log_pop	.3404792	-7.309897	7.650376	.
log_inc	.1840321	.1181901	.065842	.0083059
log_dens	.1519547	7.53175	-7.379795	.
shall	-.0538091	-.0226663	-.0311428	.0022552

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)
= 14.46
Prob>chi2 = 0.0706
(V_b-V_B is not positive definite)

4. Model Comparison

- In both Entity Fixed-Effect and Time Fixed-Effect model, allowing the carry of concealed handgun did not reduce robbery rate.
- As Time Fixed Effect were able to capture the changes of robbery over time, it was the preferred model.
- In Time Fixed Effect mode, factors that could diminish robbery incidents were to: incarceration rate, male population within the age of 10-29, and average income level.

Variable	Entity_FE_~b	Time_FE_Rob
log_incar	-0.219***	-0.216***
pb1064	0.112***	-0.008
pw1064	0.036***	-0.016
pm1029	-0.014	0.099***
log_pop	-7.310***	-2.729
log_inc	0.118	0.609***
log_dens	7.532***	2.815
shall	-0.023	0.009

❖ Findings on Murder rate

1. Entity Fixed-Effect Model

- Both shall and incarceration rate had significant impact on murder rate.
- Specifically, implementing shall-policy would lead to a reduction in murder incidents by at least 7%. Additionally, an 1% increase in incarceration would reduce murder by 0.16%
- *Income and density* also showed to affect the murder rate considerably. The more crowded, the more likelihood that murder rate would increase. Same went for the effect of income on murder rate.

```
. xtreg log_mur log_incar pb1064 pw1064 pm1029 log_pop log_inc log_dens shall, fe

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

R-sq:                                           Obs per group:
     within  = 0.1609                                         min =         23
     between = 0.0047                                         avg =       23.0
     overall = 0.0043                                         max =         23

                                                F(8,1114)          =      26.69
corr(u_i, Xb)  = -0.9989                        Prob > F           =     0.0000

------------------------------------------------------------------------------
     log_mur |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   log_incar |  -.1677261   .0378538    -4.43   0.000    -.2419988   -.0934534
      pb1064 |  -.020617    .0207949    -0.99   0.322    -.0614185    .0201846
      pw1064 |   .0169534   .0071533     2.37   0.018     .0029178    .0309889
      pm1029 |   .0066707   .0114105     0.58   0.559    -.0157177    .0290591
     log_pop |  -9.983194   1.980572    -5.04   0.000    -13.86927   -6.097121
     log_inc |   .4594353   .1175029     3.91   0.000     .2288834    .6899872
    log_dens |   9.666306    2.00402     4.82   0.000     5.734227    13.59838
       shall |  -.0744373   .0260387    -2.86   0.004    -.1255277    -.023347
       _cons |   35.79388   7.223495     4.96   0.000     21.62069    49.96707
-------------+----------------------------------------------------------------
     sigma_u |  14.224331
     sigma_e |  .21838547
         rho |  .99976434   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(50, 1114) = 59.59                     Prob > F = 0.0000

. estimates store Entity_FE_Mur
```

2. Time Fixed-Effect Model

- An F-test was conducted to determine whether there was a significant change of murder rate over the years. The result confirmed the notion. There was time effect on the variation of murder incidents.

```
( 1)  d77 = 0
( 2)  d78 = 0
( 3)  d79 = 0
( 4)  d80 = 0
( 5)  d81 = 0
( 6)  d82 = 0
( 7)  o.d83 = 0
( 8)  d84 = 0
( 9)  d85 = 0
(10)  d86 = 0
(11)  d87 = 0
(12)  d88 = 0
(13)  d89 = 0
(14)  d90 = 0
(15)  d91 = 0
(16)  d92 = 0
(17)  d93 = 0
(18)  d94 = 0
(19)  d95 = 0
(20)  d96 = 0
(21)  d97 = 0
(22)  d98 = 0
(23)  d99 = 0
      Constraint 7 dropped

      F( 22,  1092) =    7.90
           Prob > F =    0.0000
```

- In Time Fixed Effect model, at 5% significant level shall policy did not affect murder rate
- On the other hand, a 1% increase in incarceration would reduce murder incidents by 0.1%
- *Density and male population* could make positive contribution in murder rate deduction.
- The result showed that 1% increase in the male population within age 10-20 would increase murder level by 0.066%. Additionally, 1% increase in density unit would also lead to a surge of 6.22% in murder rate.
- In terms of time effect, murder rate slowly increased with its peak in 1993. After that, it consistently declined onward.

```
                                                F(30,1092)        =     13.88
corr(u_i, Xb)  = -0.9973                        Prob > F          =     0.0000
```

log_mur	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_incar	-.1008015	.041721	-2.42	0.016	-.1826638	-.0189392
pb1064	-.0763267	.0284078	-2.69	0.007	-.1320668	-.0205866
pw1064	-.0104361	.0106394	-0.98	0.327	-.031312	.0104399
pm1029	.0667335	.0218936	3.05	0.002	.0237752	.1096918
log_pop	-6.618268	1.944858	-3.40	0.001	-10.43435	-2.802186
log_inc	.8795447	.1438223	6.12	0.000	.5973454	1.161744
log_dens	6.298871	1.96989	3.20	0.001	2.433674	10.16407
shall	-.0393914	.025535	-1.54	0.123	-.0894947	.0107119
d77	-.0334562	.0528672	-0.63	0.527	-.137189	.0702766
d78	-.0322368	.0491652	-0.66	0.512	-.1287056	.0642321
d79	.0430109	.0464324	0.93	0.354	-.0480959	.1341177
d80	.0933175	.0452401	2.06	0.039	.0045502	.1820848
d81	.1105017	.0433938	2.55	0.011	.025357	.1956464
d82	.0469159	.041446	1.13	0.258	-.0344069	.1282387
d83	0	(omitted)				
d84	-.1085351	.0420643	-2.58	0.010	-.191071	-.0259991
d85	-.0582942	.0448006	-1.30	0.193	-.1461992	.0296109
d86	.0189646	.0490332	0.39	0.699	-.0772454	.1151747
d87	.0072997	.0537969	0.14	0.892	-.0982574	.1128568
d88	.0261631	.0595342	0.44	0.660	-.0906512	.1429774
d89	.0352976	.0653305	0.54	0.589	-.0928899	.1634851
d90	.127694	.07978	1.60	0.110	-.0288456	.2842335
d91	.1845644	.0844775	2.18	0.029	.0188079	.3503209
d92	.1574701	.0906323	1.74	0.083	-.020363	.3353032
d93	.2525602	.095002	2.66	0.008	.0661531	.4389672
d94	.1500012	.1004024	1.49	0.135	-.0470023	.3470047
d95	.174963	.1056972	1.66	0.098	-.0324296	.3823557
d96	.1182881	.1109377	1.07	0.287	-.0993871	.3359632
d97	.0248569	.11593	0.21	0.830	-.2026137	.2523276
d98	-.0269131	.1217294	-0.22	0.825	-.2657631	.2119368
d99	-.0841967	.12652	-0.67	0.506	-.3324465	.1640531
_cons	23.14204	7.066889	3.27	0.001	9.275822	37.00826
sigma_u	9.2815763					
sigma_e	.20486641					
rho	.99951305	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(50, 1092) = 53.10                     Prob > F = 0.0000
```

3. Hausman Test – Endogeneity Problem Detection

- Based on Hausman test, there was endogeneity in one of the variables. As a result, running Random-Effect Model would not be suggested.

```
. hausman Random_Mur Entity_FE_Mur
```

	Coefficients (b) Random_Mur	(B) Entity_FE_~r	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
log_incar	.0031395	-.1677261	.1708656	.00785
pb1064	.0524531	-.020617	.0730701	.
pw1064	.0051365	.0169534	-.0118169	.0023179
pm1029	.0620493	.0066707	.0553786	.0003659
log_pop	.125005	-9.983194	10.1082	.
log_inc	.2500766	.4594353	-.2093587	.0269747
log_dens	.0065112	9.666306	-9.659794	.
shall	-.1123997	-.0744373	-.0379624	.0076552

```
                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)
                      =      221.42
            Prob>chi2 =      0.0000
            (V_b-V_B is not positive definite)
```

4. Model Comparison

- Both models showed that implementing incarceration would reduce murder rate significantly.
- Besides that, demographic variables such as: income and density would also affect murder incidents across 50 States.
- Among the 2 models, Time Fixed Effect was more preferred as it was able to capture the effect of time on murder rate variation across the panel data.

Variable	Entity_FE_~r	Time_FE_Mur
log_incar	-0.168***	-0.101*
pb1064	-0.021	-0.076**
pw1064	0.017*	-0.010
pm1029	0.007	0.067**
log_pop	-9.983***	-6.618***
log_inc	0.459***	0.880***
log_dens	9.666***	6.299**
shall	-0.074**	-0.039

CONCLUSIONS & IMPLICATIONS

We were able to conclude the following from our analysis:

- Both shall-issues and incarceration policy can reduce violent crime rates, but very minimally.
- Neither the implementation of shall-issue laws nor enforcing increased incarceration seemed to have any effect on robbery rates. However, the percentage of male population aged 10-29 did.
- Shall-issue laws had no significant effect on murder rates but implementing increased incarceration did reduce murder rates in the succeeding year.

LIMITATIONS

The main limitation of our analysis is that we have assumed a linear relationship between the dependent and the regressors. It is indeed possible that better estimates may have been possible by including quadratic terms or even interaction terms.