Drunk driving laws impact on car fatalities

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Abstract

The objective is to determine how drunk law affects traffic fatalities. We proceed with a well-known postulate; a strict traffic rules reduces traffic fatality rate. Further diving deep into formulating a strict traffic rule involves socio-economic factors to be considered. Thus, we postulate a hypothesis that social mind set, and economical background has major role to play. So, alcohol involved vehicle fatality is the centre of our research. Panel data of 48 cross-section (U.S. states excluding the Hawaii and Alaska) annually for 1982 through 1988 is used to test our hypothesis. Religious congregation like Baptist and Mormon has been clubbed with social factors as we assume religious to be integrated part of social reforms and it does not fall in a separate space as per the US constitution. A fact check revealed Americans love to drive cars. But the question is - do they still opt to drive after alcohol consumption which pushed us to add dry counties data as people dwelling here are forced to drive to far off places seeking alcohol. Mandatory jail and community service are also the variables to be considered to understand the existing rules effect. We are generalizing our research to overall population as we did not find any significance confining to a single age group. This will be tested considering the minimum driving age. Per capita income and unemployment are the key factor determining the alcohol consumption. But mechanism behind the income and beer tax is still unknown. Future research could focus on unravelling the mechanism.

Variable selection

There are 39 features observed across 48 states from 1982 to 1988 which can be used to explain the alcohol involved vehicle fatality rate (AFR).

Features like Unemployment, beer tax and per capita personal income were chosen as to explain economic influence on the fatality rate. A holistic approach would say that unemployment and per capita income are related which may lead to exact collinearity but there are various factors influencing per capita income like unequal wealth distribution, skill and gender wage difference etc more than unemployment rate which makes them discrete. Correlation between them turned out to be -0.55 hence we use both the variables in our further analysis to determine which one has major impact. We believe increasing beer tax to lower alcohol consumption. Below graph proves that as unemployment decreases per capita income increases for the period 1982-1988.

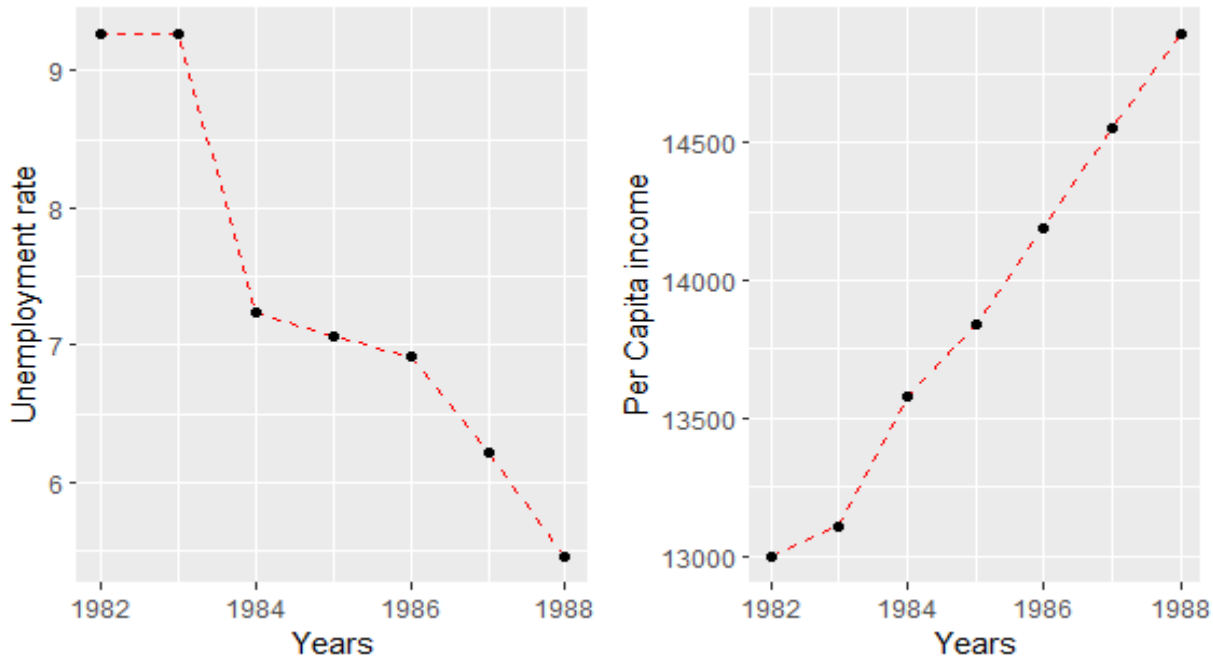

Figure 1

Religious belief and alcohol are connected as few religions abstain alcohol consumption. Mormon and southern Baptist's are believed to be teetotallers. Though they have disparate outlook on life, they seem to have a strict common policy to eschew alcohol which force us to consider one among them. Broadening the view for the entire population suggest us to include Per Capita Pure Alcohol Consumption.

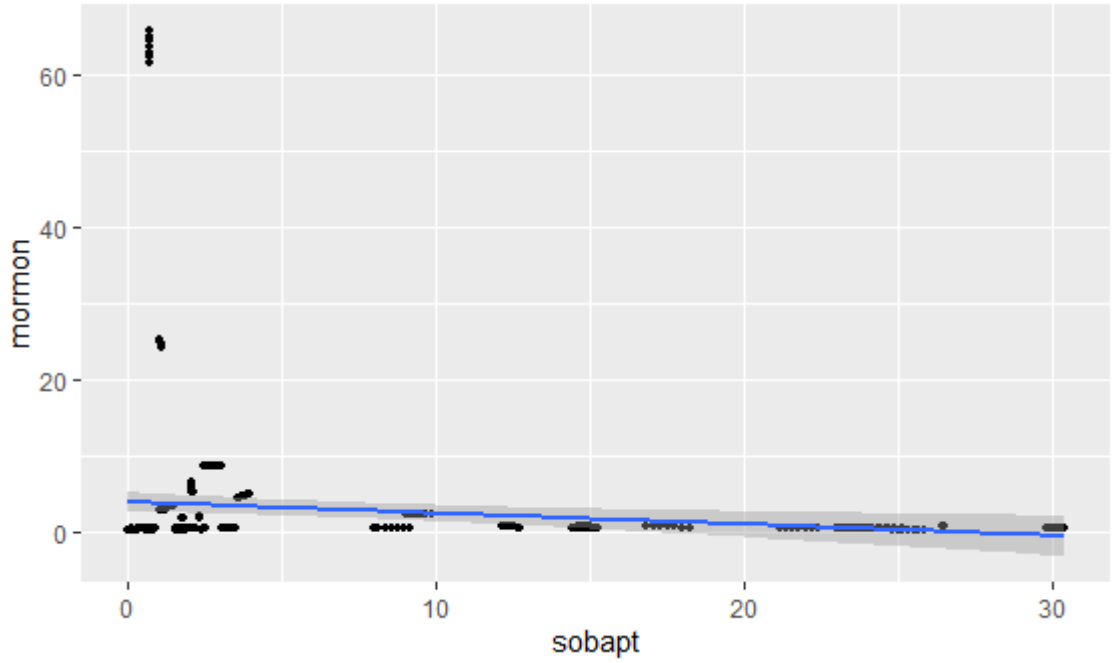

Figure 2

Figure 2 shows relation between Mormon and sobapt. The line looks to have no practical slope indicating no relation.

A presumption of “stricter traffic rules makes us safe” always triggers the debate on how strict the rule should be whether a jail sentence or mandatory community service. Both categorical data can be used to determine which among them has more weightage.

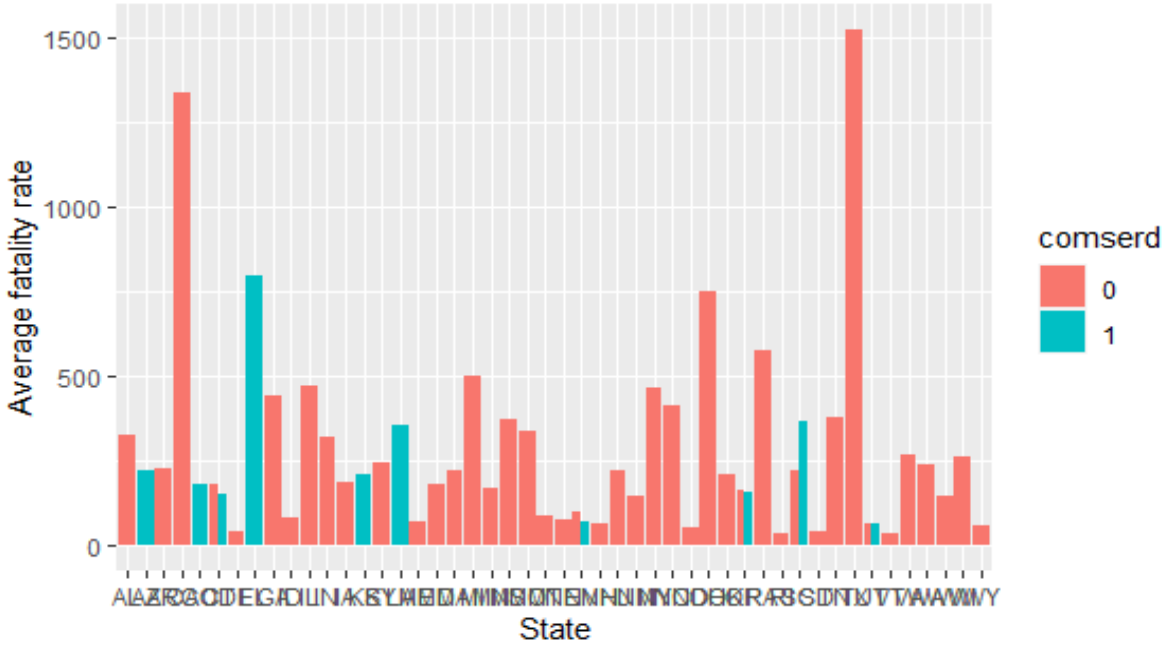

Figure 3

A bar plot of VFR in each state with jail and community service gives us an idea on how VFR is varying. Figure 3 clearly shows a high VFR for states with no community service. Few states from 1982-1988 had toggled on having community service which makes our study interesting.

Similar plot was done for jail in Figure 4. States which alternated between jail and no jail shows a higher VFR for no jail period. Obviously as expected higher VFR are seen among states with no jail sentence.

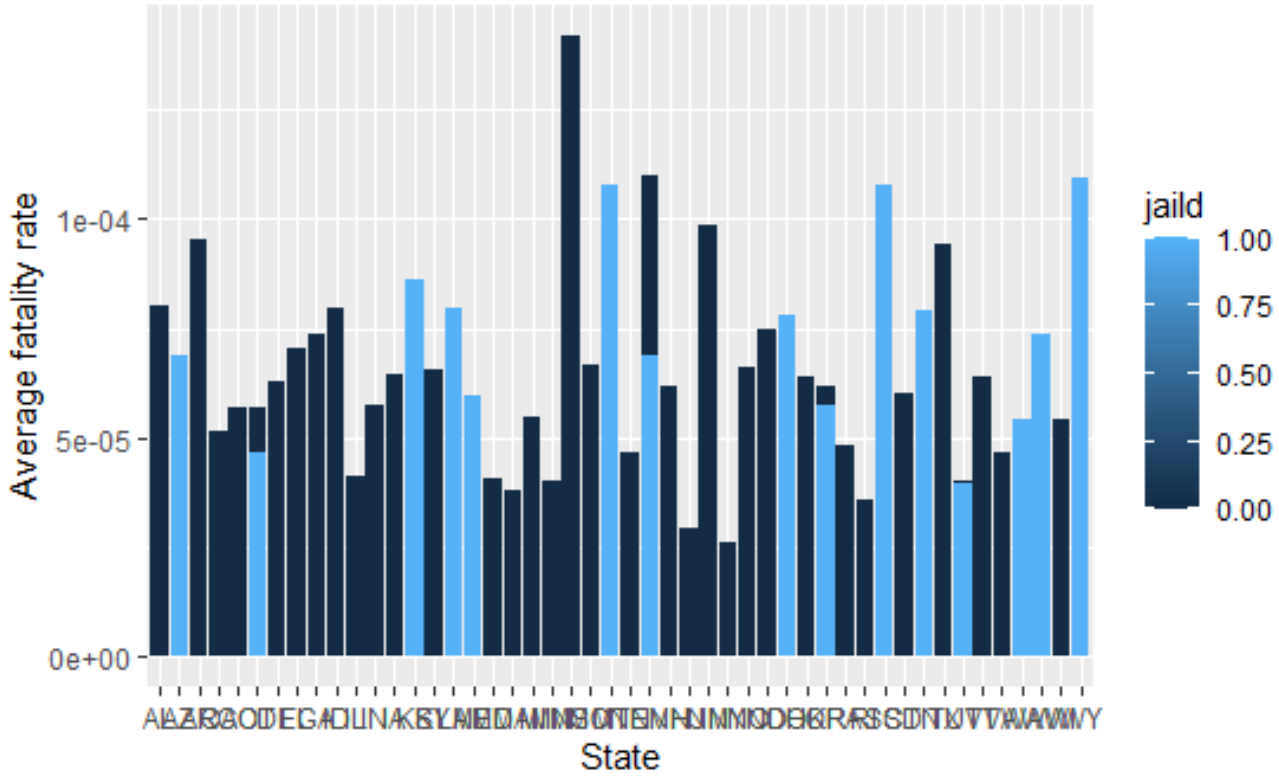

Figure 4

The dependent variable alcohol involved vehicle fatality rate in short AFR helps to broaden our research on overall population (no age dependency) and its factors influencing vehicle fatality. Fatality rate fluctuates over period, it has hit minimum in the year 1985,1987 and 1988 which makes us to look for factor which are time variant. Similarly, California, Texas, Florida and Ohio have high fatality rates sparking the curiosity to know more about factors affecting entity but are constant over time. Please note fatality rates are high in the states known for the pro-active night life.

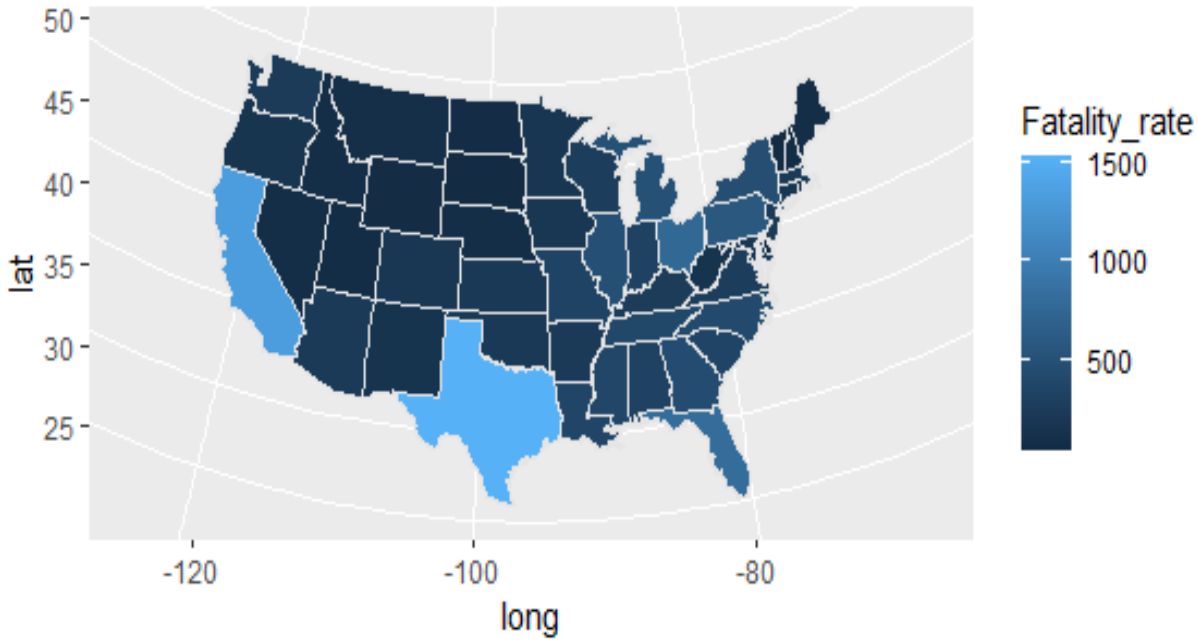

Figure 5

Descriptive Stats

```
    spircons          unrate          perinc          beertax           mormon       
Min.   :0.790   Min.   : 2.400   Min.   : 9514   Min.   :0.04331   Min.   : 0.1000  
1st Qu.:1.300   1st Qu.: 5.475   1st Qu.:12086   1st Qu.:0.20885   1st Qu.: 0.2722  
Median :1.670   Median : 7.000   Median :13763   Median :0.35259   Median : 0.3931  
Mean   :1.754   Mean   : 7.347   Mean   :13880   Mean   :0.51326   Mean   : 2.8019  
3rd Qu.:2.013   3rd Qu.: 8.900   3rd Qu.:15175   3rd Qu.:0.65157   3rd Qu.: 0.6293  
Max.   :4.900   Max.   :18.000   Max.   :22193   Max.   :2.72076   Max.   :65.9165  

      dry               yngdrv            jaild           comserd          aidall       
Min.   : 0.00000   Min.   :0.07314   Min.   :0.0000   Min.   :0.0000   Min.   :  24.6  
1st Qu.: 0.00000   1st Qu.:0.17037   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:  90.5  
Median : 0.08681   Median :0.18539   Median :0.0000   Median :0.0000   Median : 211.6  
Mean   : 4.26707   Mean   :0.18593   Mean   :0.2806   Mean   :0.1851   Mean   : 293.3  
3rd Qu.: 2.42481   3rd Qu.:0.20219   3rd Qu.:1.0000   3rd Qu.:0.0000   3rd Qu.: 364.0  
Max.   :45.79210   Max.   :0.28163   Max.   :1.0000   Max.   :1.0000   Max.   :2094.9  
                                     NA's   :1        NA's   :1                        

     miles        
Min.   :  3993  
1st Qu.: 11692  
Median : 28484  
Mean   : 37101  
3rd Qu.: 44140  
Max.   :241575  
```

Figure 6

The above figure shows the summary of the all the variables under consideration. A value is missing in the jaild and comserd for California which makes the data unbalanced. Observing the trend over the years for California missing value can be replaced with 0 which makes it balanced. Below figure shows correlation and histogram of all the variables. Per capita income and unemployment rate are highly negatively correlated among other pairs. Dependent variable aidall and indepent variables miles, dry, beertax are left skewed.

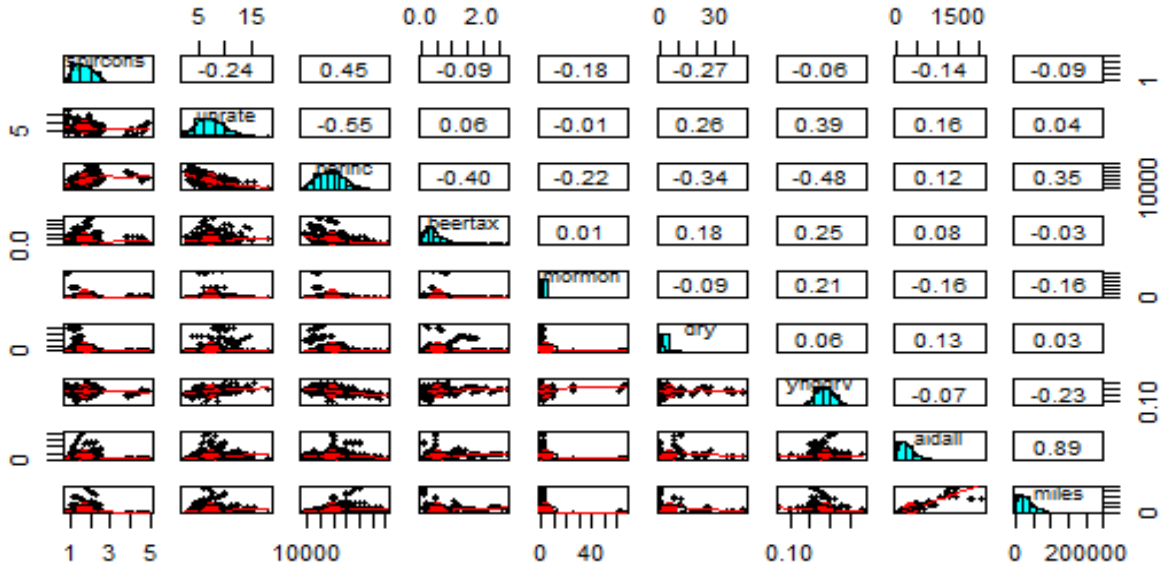

Figure 7

Regression Models

Before regression we take logs for few variables to allow for an easier interpretation and comparison of the sizes of the estimated coefficients.

Pooled regression

Running an Ordinary least square ignoring the panel structure of the data gives us significant result. The expect socio-economic factors like unemployment rate and spirit consumption to have a positive effect on the alcohol involved vehicle fatality rate whereas per capita income to have a negative impact.

Few factors like per capita income, unemployment rate, Jail and southern Baptist change over the time and geographic areas. Income of an individual varies with the place they live because it is dependent on the economic factor of a state.

```
Pooling Model

Call:
plm(formula = log(aidall) ~ unrate + sobapt + log(miles) + jaild +
    log(spircons) + log(perinc), data = p.sample, model = "pooling")

Balanced Panel: n = 48, T = 7, N = 336

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-1.4496092 -0.1816206 -0.0065881  0.1543889  0.7737508

Coefficients:
                Estimate Std. Error t-value  Pr(>|t|)
(Intercept)    3.7923839  1.7658457  2.1476 0.0324732 *
unrate         0.0288097  0.0081460  3.5367 0.0004634 ***
sobapt         0.0083085  0.0020689  4.0159 7.340e-05 ***
log(miles)     0.9787163  0.0243488 40.1956 < 2.2e-16 ***
jaild1         0.1363771  0.0337685  4.0386 6.697e-05 ***
log(spircons)  0.2052238  0.0583223  3.5188 0.0004945 ***
log(perinc)   -0.9272169  0.2003317 -4.6284 5.310e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    295.24
Residual Sum of Squares: 22.902
R-Squared:      0.92243
Adj. R-Squared: 0.92101
F-statistic: 652.041 on 6 and 329 DF, p-value: < 2.22e-16
```

Figure 8

Summary of the model shows unrate, sobapt, miles and spircons to have a positive effect on AVF rate. Increase in the per capita alcohol consumption decreases the AVF which is contradicting our prediction. The model explains 92.10 % of the variation and all the variables are significant at 5%.

Heteroskedasticity test

We further test for heteroskedasticity in the pooled model

H0 : Homoskedasticity

H1 : Heteroskedasticity

```
        studentized Breusch-Pagan test

data:  c
BP = 13.227, df = 6, p-value = 0.03957
```

With 5 % significance level we fail to reject the null hypothesis. The model has exogeneity.

Test for serial correlation

```
        Breusch-Godfrey/Wooldridge test for serial correlation in panel models

data:  log(aidall) ~ unrate + sobapt + log(miles) + jaild + log(spircons) +     log(perinc)
chisq = 115.86, df = 7, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

They seem to have serial correlation in the panel data. So, we use robust standard error.

With Robust standard errors

```
t test of coefficients:

               Estimate Std. Error t value Pr(>|t|)
(Intercept)    3.7923839  3.4870361  1.0876  0.27758
unrate         0.0288097  0.0141693  2.0332  0.04283 *
sobapt         0.0083085  0.0044338  1.8739  0.06183 .
log(miles)     0.9787163  0.0437736 22.3586  < 2e-16 ***
jaild1         0.1363771  0.0606447  2.2488  0.02519 *
log(spircons)  0.2052238  0.1039150  1.9749  0.04911 *
log(perinc)   -0.9272169  0.3912414 -2.3699  0.01837 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 9

Robust standard errors are large compared to pooled model standard errors. There is no change in the coefficients but all of them become significant at 10%.

Fixed effect model

Completely ignoring time and entity factor, and considering it as a normal data will not help us make any conclusion. We require the study of variance within an entity (states) over a period. Time invariant variables are not considered as they will be dropped during the fixed effect model formation.

Let's start with variables from different aspects like per capita income from economic prospective, southern Baptist from religious and spirit consumption from social behaviour.

```
Oneway (individual) effect Within Model

Call:
plm(formula = log(aidall) ~ log(perinc) + sobapt + log(spircons),
    data = p.sample, model = "within")

Balanced Panel: n = 48, T = 7, N = 336

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-1.0466180 -0.0818519 -0.0041023  0.0814007  0.5633863

Coefficients:
              Estimate Std. Error t-value  Pr(>|t|)
log(perinc)   0.377590   0.216409  1.7448   0.08210 .
sobapt       -0.100851   0.050061 -2.0146   0.04489 *
log(spircons) 0.785318   0.141472  5.5510 6.499e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    8.4781
Residual Sum of Squares: 7.5243
R-Squared:      0.1125
Adj. R-Squared: -0.043204
F-statistic: 12.042 on 3 and 285 DF, p-value: 1.9128e-07
```

Figure 10

As we expected perinc (per capita income) and spiricons (Per Capita Pure Alcohol Consumption) increases the AVF and increase in the sobapt (Southern Baptist community) decreases AVF. All the coefficients are significant.

Auto accidents are the leading cause of death for teens ages 15 to 20. This raises a question does mlda (minimum driving age) has any relation with AVF. Each state has different age standard which changed over a period. It helps us analyse its effect.

```
Oneway (individual) effect within Model

Call:
plm(formula = log(aidall) ~ log(perinc) + sobapt + log(spircons) +
    mlda, data = p.sample, model = "within")

Balanced Panel: n = 48, T = 7, N = 336

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-1.0444e+00 -8.3704e-02 -1.1242e-05  8.1032e-02  5.7056e-01

Coefficients:
                      Estimate Std. Error t-value  Pr(>|t|)
log(perinc)           0.460944   0.242130  1.9037   0.05800 .
sobapt               -0.099943   0.051977 -1.9228   0.05554 .
log(spircons)         0.800982   0.153817  5.2074 3.766e-07 ***
mlda18.5              0.189901   0.119145  1.5939   0.11212
mlda19                0.146350   0.078736  1.8587   0.06414 .
mlda19.1599998474121  0.034293   0.191186  0.1794   0.85778
mlda19.25             0.104667   0.145834  0.7177   0.47354
mlda19.5              0.107316   0.137032  0.7831   0.43422
mlda19.6700000762939  0.111459   0.100871  1.1050   0.27015
mlda20                0.173799   0.088828  1.9566   0.05141 .
mlda20.25             0.185445   0.193623  0.9578   0.33903
mlda20.3299999237061  0.085357   0.146445  0.5829   0.56047
mlda20.5             -0.028416   0.099749 -0.2849   0.77596
mlda21                0.124378   0.079478  1.5649   0.11875
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    8.4781
Residual Sum of Squares: 7.2465
R-Squared:      0.14527
Adj. R-Squared: -0.045018
F-statistic: 3.32634 on 14 and 274 DF, p-value: 6.0655e-05
```

Figure 11

Results show that mlda 19 and 20 are significant at 10%. Setting minimum driving age to above 20 might decrease AVF. The intermittent values between 18-19 and 19-20 are not significant because we see very few values pertaining to this category.

Assessing the rules already in effect would help us explore the possibility to amend the rule. Mandatory jail and community services are the categorical values which are expected to contain alcohol involved driving law. The question is - do these consequences really refrain people from drink and drive. Another important variable is beer tax, it certainly has a major impact on the consumption. That is increase in the price would reduce its consumption. But we can see that beer tax varies from 0.043331 to 2.72076 with an average of 0.3525 which makes it cheap in most of the states when compared cost of a case of beer during 1982 - 1987. We can test the possibility of increasing beer tax for each state over a period and study whether it lowers the consumption which reduces the AFR. We can also try unemployment instead of per capita income.

```
plm(formula = log(aidall) ~ unrate + sobapt + log(beertax) +
    +log(spircons) + jaild + comserd + mlda, data = p.sample,
    model = "within")

Balanced Panel: n = 48, T = 7, N = 336

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-1.02468829 -0.07380798  0.00075284  0.07764712  0.58189769

Coefficients:
                          Estimate Std. Error t-value  Pr(>|t|)
unrate                  -0.0226716  0.0071497 -3.1710  0.001694 **
sobapt                  -0.1152310  0.0508769 -2.2649  0.024309 *
log(beertax)             0.1036384  0.1050408  0.9866  0.324695
log(spircons)            0.7880307  0.1476773  5.3362 2.007e-07 ***
jaild1                   0.2767731  0.1227857  2.2541  0.024988 *
comserd1                -0.3286852  0.1436108 -2.2887  0.022865 *
mlda18.5                 0.2001755  0.1185666  1.6883  0.092505 .
mlda19                   0.1507189  0.0781771  1.9279  0.054910 .
mlda19.1599998474121     0.0224235  0.1885806  0.1189  0.905437
mlda19.25                0.0820307  0.1456250  0.5633  0.573696
mlda19.5                 0.1026438  0.1352800  0.7588  0.448661
mlda19.6700000762939     0.0998576  0.0995627  1.0030  0.316774
mlda20                   0.1674357  0.0867334  1.9305  0.054593 .
mlda20.25                0.1892436  0.1911298  0.9901  0.322993
mlda20.3299999237061     0.0951026  0.1451630  0.6551  0.512931
mlda20.5                -0.0454970  0.0981912 -0.4634  0.643485
mlda21                   0.1139407  0.0785005  1.4515  0.147807
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    8.4781
Residual Sum of Squares: 6.9689
R-Squared:      0.17801
Adj. R-Squared: -0.016111
F-statistic: 3.45226 on 17 and 271 DF, p-value: 8.0557e-06
```

Figure 12

Output show that beer tax has a positive effect (which was not expected) and is not significant. Drunk law like Community service reduced the AFR by 32% in comparison with the states with no community service. Unfortunately, a strict law like mandatory jail has a positive effect. Both the coefficients are significant at 5%. So, final model includes per capita income, southern Baptist, per capita alcohol consumption, Jail, Community service and minimum driving age. So, we roll back to previous model. Below is the finalized model.

```
Call:
plm(formula = log(aidall) ~ log(perinc) + sobapt + +log(spircons) +
    jaild + comserd + mlda, data = p.sample, model = "within")

Balanced Panel: n = 48, T = 7, N = 336

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-1.04297712 -0.08074000  0.00089202  0.07839395  0.57223780

Coefficients:
                          Estimate Std. Error t-value  Pr(>|t|)
log(perinc)              0.492823   0.244181  2.0183   0.04454 *
sobapt                  -0.096159   0.051856 -1.8544   0.06477 .
log(spircons)            0.796316   0.153062  5.2026 3.874e-07 ***
jaild1                   0.267977   0.123817  2.1643   0.03131 *
comserd1                -0.290755   0.143679 -2.0236   0.04398 *
mlda18.5                 0.185713   0.119501  1.5541   0.12133
mlda19                   0.146019   0.078352  1.8636   0.06345 .
mlda19.1599998474121     0.032811   0.190227  0.1725   0.86319
mlda19.25                0.097187   0.147014  0.6611   0.50913
mlda19.5                 0.105251   0.136347  0.7719   0.44082
mlda19.6700000762939     0.109395   0.100380  1.0898   0.27676
mlda20                   0.173764   0.088400  1.9657   0.05035 .
mlda20.25                0.182243   0.192785  0.9453   0.34534
mlda20.3299999237061     0.088220   0.146394  0.6026   0.54726
mlda20.5                -0.029750   0.099262 -0.2997   0.76463
mlda21                   0.121376   0.079127  1.5339   0.12621
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    8.4781
Residual Sum of Squares: 7.1215
R-Squared:      0.16002
Adj. R-Squared: -0.034538
F-statistic: 3.23851 on 16 and 272 DF, p-value: 3.7858e-05
```

Figure 13

Random Effect model

So far, we tried to explore variance within each state. Further considering both within and between variation of each state we build random effect model. Variables used in the finalized fixed effect model are used.

```
Call:
plm(formula = log(aidall) ~ log(perinc) + sobapt + +log(spircons) +
    jaild + comserd + mlda, data = p.sample, model = "random")

Balanced Panel: n = 48, T = 7, N = 336

Effects:
                  var std.dev share
idiosyncratic 0.02618 0.16181 0.049
individual    0.50570 0.71113 0.951
theta: 0.9143

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-1.049426 -0.079855  0.007803  0.103232  0.527648

Coefficients:
                          Estimate Std. Error z-value  Pr(>|z|)
(Intercept)             -0.261673   2.288639 -0.1143 0.9089718
log(perinc)              0.503839   0.235299  2.1413 0.0322523 *
sobapt                   0.042502   0.011329  3.7518 0.0001756 ***
log(spircons)            0.603615   0.141724  4.2591 2.053e-05 ***
jaild1                   0.193604   0.117822  1.6432 0.1003438
comserd1                -0.200638   0.136878 -1.4658 0.1426965
mlda18.5                 0.194644   0.125634  1.5493 0.1213100
mlda19                   0.123141   0.081883  1.5039 0.1326160
mlda19.1599998474121     0.022235   0.200393  0.1110 0.9116518
mlda19.25                0.095839   0.154424  0.6206 0.5348483
mlda19.5                 0.033150   0.142661  0.2324 0.8162523
mlda19.6700000762939     0.085341   0.105270  0.8107 0.4175453
mlda20                   0.163237   0.091753  1.7791 0.0752247 .
mlda20.25                0.195321   0.202604  0.9641 0.3350197
mlda20.3299999237061     0.045859   0.153663  0.2984 0.7653686
mlda20.5                -0.053436   0.103702 -0.5153 0.6063556
mlda21                   0.102536   0.082578  1.2417 0.2143507
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    10.583
Residual Sum of Squares: 9.3041
R-Squared:      0.12088
Adj. R-Squared: 0.076791
Chisq: 43.8646 on 16 DF, p-value: 0.00020681
```

Figure 14

In the random effect model perinc, sobapt, spricons and mlda20 are significant but sobapt has a positive effect which indicates the change in sign compared to fixed effect model. Theta is 91.43% indicating most of the variation is from the individual. This suggests that variables like active social life preference in pub, alcohol consumption after a hard day etc which surely affects AVF are captured under error term. But what if random error term is correlated with independent variables. People with hard day (random error) pockets more money (perinc – independent variable) tend to have a drink in the evening (spircons – independent variable). Thus, even though it can be capture in the random error, this error can be correlated with one of the independent variable which makes the model biased and inconsistent. We shall have a Hausman test to confirm for endogeneity.

Hausman Test

```
        Hausman Test

data:  log(aidall) ~ log(perinc) + sobapt + +log(spircons) + jaild +  ...
chisq = 12.136, df = 16, p-value = 0.7346
alternative hypothesis: one model is inconsistent
```

We confirm the presence of endogeneity in the model. Hence, we prefer fixed effect model over random effect model.

Conclusion

The analysis of How drunk driving laws affect traffic deaths has been the topic of study. However, the more the topic is disaggregated, the more discussion it provokes. Surely alcohol involved vehicle fatality rate is influenced by the social, economic and cultural factors. Per capita income has a positive effect but it's not wise to lower the income to reduce the fatality rate because it has adverse effect on other factors like unemployment, purchasing power etc which in turn destroys harmony in the society.

Further research can be done to study the factors affecting per capita alcohol consumption as it has significant effect. Drinking is a pervasive and deep-rooted culture of American life. Alcoholic beverages have been widely consumed throughout American history an attempt to prohibit alcohol through amendment has failed multiple times. Steady increase in the alcohol consumption is alarming and its high time to look for an alternate solution.

Law in place like mandatory community service helps lower the AFR. But a jail term which appears to be intimidating, has shown increase in the AFR. Each state is unique, laws pertaining alcohol must be customized to its need. Few countries have fines proportionate to income for example – 20% of the income as fine and a suspension of driving licence permanently which proved to be working.