Statistical Methods for Discrete Response, Time Series, and Panel Data (W271): Lab 4

Heather Feinstein, Ryan Delgado, April Kim

Fall 2018

Instructions:

- **Due Date: 12/11/2018 (11:59 p.m. Pacific Time)**
- **Page limit of the pdf report: 20 (not include title and the table of content page**
- Use the margin, linespace, and font size specification below:
  - fontsize=11pt
  - margin=1in
  - line_spacing=single
- Submission:
  - Each group makes one submission to Github; please have one of your team members made the submission
  - Submit 2 files:
    1. A pdf file including the details of your analysis and all the R codes used to produce the analysis. Please do not suppress the codes in your pdf file.
    2. R markdown file used to produce the pdf file
  - Use the following file-naming convensation; fail to do so will receive 10% reduction in the grade:
    - FirstNameLastName1_FirstNameLastName2_FirstNameLastName3_LabNumber.fileExtension
    - For example, if you have three students in the group for Lab Z, and their names are Gerard Kelley, Steve Yang, and Jeffrey Yau, then you should name your file the following
      - GerardKelley_SteveYang_JeffreyYau_LabZ.Rmd
      - GerardKelley_SteveYang_JeffreyYau_LabZ.pdf
  - Although it sounds obvious, please write the name of each members of your group on page 1 of your pdf and Rmd files.
- This lab can be completed in a group of up to 3 students in your session. Students are encouraged to work in a group for the lab.
- For statistical methods that we cover in this course, use only the R libraries and functions that are covered in this course. If you use libraries and functions for statistical modeling that we have not covered, you have to provide (1) explanation of why such libraries and functions are used instead and (2) reference to the library documentation. Lacking the explanation and reference to the documentation will result in a score of zero for the corresponding question.
- Students are expected to act with regards to UC Berkeley Academic Integrity.

Description of the Lab

In this lab, you are asked to answer the question **"Do changes in traffic laws affect traffic fatalities?"** To do so, you will conduct the tasks specified below using the data set *driving.Rdata*, which includes 25 years of data that cover changes in various state drunk driving, seat belt, and speed limit laws.

Specifically, this data set contains data for the 48 continental U.S. states from 1980 through 2004. Various driving laws are indicated in the data set, such as the alcohol level at which drivers are considered legally intoxicated. There are also indicators for "per se" laws—where licenses can be revoked without a trial—and seat belt laws. A few economics and demographic variables are also included. The description of the each of the variables in the dataset is come with the dataste.

Exercises:

1. Load the data. Provide a description of the basic structure of the dataset, as we have done throughout the semester. Conduct a very thorough EDA, which should include both graphical and tabular techniques, on the dataset, including both the dependent variable *totfatrte* and the potential explanatory variables. You need to write a detailed narrative of your observations of your EDA. *Reminder: giving an "output dump" (i.e. providing a bunch of graphs and tables without description and hoping your audience will interpret them) will receive a zero in this exercise.*

```
# Insert the function to *tidy up* the code when they are printed out
library(knitr)
opts_chunk$set(tidy.opts=list(width.cutoff=60),tidy=TRUE)

# Load libraries
library(car)
```

```
## Loading required package: carData
```

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following object is masked from 'package:car':
##
##     recode
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(Hmisc)
```

```
## Loading required package: lattice
```

```
## Loading required package: survival
```

```
## Loading required package: Formula
```

```
## Loading required package: ggplot2
```

```
##
## Attaching package: 'Hmisc'
```

```
## The following objects are masked from 'package:dplyr':
```

```
##
##     src, summarize
```

```
## The following objects are masked from 'package:base':
##
##     format.pval, units
```

```
library(ggplot2)
library(lattice)
library(plm)
```

```
##
## Attaching package: 'plm'
```

```
## The following objects are masked from 'package:dplyr':
##
##     between, lag, lead
```

```
library(plyr)
```

```
## ------------------------------------------------------------------------------
```

```
## You have loaded plyr after dplyr - this is likely to cause problems.
## If you need functions from both plyr and dplyr, please load plyr first, then dplyr:
## library(plyr); library(dplyr)
```

```
## ------------------------------------------------------------------------------
```

```
##
## Attaching package: 'plyr'
```

```
## The following objects are masked from 'package:Hmisc':
##
##     is.discrete, summarize
```

```
## The following objects are masked from 'package:dplyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize
```

```
load("driving.RData")

head(data)
```

```
##   year state sl55 sl65 sl70 sl75 slnone seatbelt minage zerotol gdl bac10
## 1 1980     1    1    0    0    0      0        0     18       0   0     1
## 2 1981     1    1    0    0    0      0        0     18       0   0     1
## 3 1982     1    1    0    0    0      0        0     18       0   0     1
## 4 1983     1    1    0    0    0      0        0     18       0   0     1
## 5 1984     1    1    0    0    0      0        0     18       0   0     1
## 6 1985     1    1    0    0    0      0        0     20       0   0     1
##   bac08 perse totfat nghtfat wkndfat totfatpvm nghtfatpvm wkndfatpvm
## 1     0     0    940     422     236      3.20      1.437      0.803
## 2     0     0    933     434     248      3.35      1.558      0.890
## 3     0     0    839     376     224      2.81      1.259      0.750
## 4     0     0    930     397     223      3.00      1.281      0.719
## 5     0     0    932     421     237      2.83      1.278      0.720
## 6     0     0    882     358     224      2.51      1.019      0.637
##   statepop totfatrte nghtfatrte wkndfatrte vehicmiles unem perc14_24
## 1  3893888     24.14      10.84       6.06   29.37500  8.8      18.9
```

```
## 2  3918520     24.07      11.08       6.33   27.85200 10.7      18.7
## 3  3925218     21.37       9.58       5.71   29.85765 14.4      18.4
## 4  3934109     23.64      10.09       5.67   31.00000 13.7      18.0
## 5  3951834     23.58      10.65       6.00   32.93286 11.1      17.6
## 6  3972527     22.20       9.01       5.64   35.13944  8.9      17.3
##   sl70plus sbprim sbsecon d80 d81 d82 d83 d84 d85 d86 d87 d88 d89 d90 d91
## 1        0      0       0   1   0   0   0   0   0   0   0   0   0   0   0
## 2        0      0       0   0   1   0   0   0   0   0   0   0   0   0   0
## 3        0      0       0   0   0   1   0   0   0   0   0   0   0   0   0
## 4        0      0       0   0   0   0   1   0   0   0   0   0   0   0   0
## 5        0      0       0   0   0   0   0   1   0   0   0   0   0   0   0
## 6        0      0       0   0   0   0   0   0   1   0   0   0   0   0   0
##   d92 d93 d94 d95 d96 d97 d98 d99 d00 d01 d02 d03 d04 vehicmilespc
## 1   0   0   0   0   0   0   0   0   0   0   0   0   0     7543.874
## 2   0   0   0   0   0   0   0   0   0   0   0   0   0     7107.785
## 3   0   0   0   0   0   0   0   0   0   0   0   0   0     7606.622
## 4   0   0   0   0   0   0   0   0   0   0   0   0   0     7879.802
## 5   0   0   0   0   0   0   0   0   0   0   0   0   0     8333.562
## 6   0   0   0   0   0   0   0   0   0   0   0   0   0     8845.614
```

```
describe(data)
```

```
## data
##
##  56  Variables      1200  Observations
## ---------------------------------------------------------------------------
## year
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       25    0.998     1992    8.327     1981     1982
##      .25      .50      .75      .90      .95
##     1986     1992     1998     2002     2003
##
## lowest : 1980 1981 1982 1983 1984, highest: 2000 2001 2002 2003 2004
## ---------------------------------------------------------------------------
## state
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       48        1    27.15     16.6     4.00     6.00
##      .25      .50      .75      .90      .95
##    15.75    27.50    39.25    47.00    49.00
##
## lowest :  1  3  4  5  6, highest: 47 48 49 50 51
## ---------------------------------------------------------------------------
## sl55
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       17    0.722   0.3533   0.4569        0        0
##      .25      .50      .75      .90      .95
##        0        0        1        1        1
##
## lowest : 0.000 0.011 0.044 0.049 0.083, highest: 0.542 0.583 0.750 0.917 1.000
## ---------------------------------------------------------------------------
## sl65
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       23    0.782   0.4399   0.4923        0        0
##      .25      .50      .75      .90      .95
##        0        0        1        1        1
```

```
##
## lowest : 0.000 0.016 0.083 0.167 0.208, highest: 0.951 0.956 0.958 0.989 1.000
## ---------------------------------------------------------------------------
## sl70
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       14    0.333    0.119   0.2098        0        0
##      .25      .50      .75      .90      .95
##        0        0        0        1        1
##
## Value      0.000 0.042 0.083 0.333 0.375 0.417 0.500 0.583 0.667 0.750
## Frequency   1048     1     2     1     1     3     2     1     2     2
## Proportion 0.873 0.001 0.002 0.001 0.001 0.002 0.002 0.001 0.002 0.002
##
## Value      0.792 0.833 0.984 1.000
## Frequency      2     2     1   132
## Proportion 0.002 0.002 0.001 0.110
## ---------------------------------------------------------------------------
## sl75
##        n  missing distinct     Info     Mean      Gmd
##     1200        0        9    0.231  0.08024   0.1477
##
## Value      0.000 0.083 0.333 0.500 0.583 0.625 0.667 0.750 1.000
## Frequency   1099     2     1     1     1     1     2     1    92
## Proportion 0.916 0.002 0.001 0.001 0.001 0.001 0.002 0.001 0.077
## ---------------------------------------------------------------------------
## slnone
##        n  missing distinct     Info     Mean      Gmd
##     1200        0        3    0.025 0.007569  0.01504
##
## Value      0.000 0.083 1.000
## Frequency   1190     1     9
## Proportion 0.992 0.001 0.008
## ---------------------------------------------------------------------------
## seatbelt
##        n  missing distinct     Info     Mean      Gmd
##     1200        0        3    0.848    1.116   0.9553
##
## Value          0     1     2
## Frequency    423   215   562
## Proportion 0.352 0.179 0.468
## ---------------------------------------------------------------------------
## minage
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       12    0.446     20.6   0.6886       18       19
##      .25      .50      .75      .90      .95
##       21       21       21       21       21
##
## Value       18.0  18.5  18.6  18.7  19.0  19.5  19.7  19.8  20.0  20.5
## Frequency     98     5     1     4    58     5     2     1    35     2
## Proportion 0.082 0.004 0.001 0.003 0.048 0.004 0.002 0.001 0.029 0.002
##
## Value       20.7  21.0
## Frequency      4   985
## Proportion 0.003 0.821
```

```
## ---------------------------------------------------------------------------
## zerotol
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       11    0.767   0.4519   0.4954        0        0
##      .25      .50      .75      .90      .95
##        0        0        1        1        1
##
## Value      0.000 0.083 0.167 0.250 0.333 0.417 0.500 0.583 0.667 0.750
## Frequency    636     1     2     6     2     3    17     5     2     1
## Proportion 0.530 0.001 0.002 0.005 0.002 0.002 0.014 0.004 0.002 0.001
##
## Value      1.000
## Frequency    525
## Proportion 0.438
## ---------------------------------------------------------------------------
## gdl
##        n  missing distinct     Info     Mean      Gmd
##     1200        0        8    0.449   0.1741   0.2877
##
## Value      0.000 0.167 0.250 0.500 0.670 0.750 0.833 1.000
## Frequency    981     1     2    14     1     1     1   199
## Proportion 0.818 0.001 0.002 0.012 0.001 0.001 0.001 0.166
## ---------------------------------------------------------------------------
## bac10
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       10    0.748   0.6231   0.4691        0        0
##      .25      .50      .75      .90      .95
##        0        1        1        1        1
##
## Value      0.000 0.250 0.333 0.417 0.500 0.583 0.667 0.750 0.833 1.000
## Frequency    424     4     4     1    28     4     8    13     3   711
## Proportion 0.353 0.003 0.003 0.001 0.023 0.003 0.007 0.011 0.002 0.592
## ---------------------------------------------------------------------------
## bac08
##        n  missing distinct     Info     Mean      Gmd
##     1200        0        8     0.54   0.2135   0.3358
##
## Value      0.000 0.250 0.333 0.417 0.500 0.667 0.750 1.000
## Frequency    921     9     5     4    19     1     2   239
## Proportion 0.768 0.008 0.004 0.003 0.016 0.001 0.002 0.199
## ---------------------------------------------------------------------------
## perse
##        n  missing distinct     Info     Mean      Gmd
##     1200        0        9     0.76   0.5471   0.4958
##
## Value      0.000 0.083 0.167 0.250 0.333 0.417 0.500 0.750 1.000
## Frequency    528     1     1     4     2     2    16     1   645
## Proportion 0.440 0.001 0.001 0.003 0.002 0.002 0.013 0.001 0.538
## ---------------------------------------------------------------------------
## totfat
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      834        1    900.7    827.9    110.0    143.9
##      .25      .50      .75      .90      .95
##    310.0    676.0   1099.5   1646.1   2841.6
```

```
##
## lowest :   63   69   74   75   76, highest: 5253 5392 5412 5496 5504
## ---------------------------------------------------------------------------
## nghtfat
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      659        1    427.3    407.5     49.0     67.0
##      .25      .50      .75      .90      .95
##    139.8    316.0    518.2    806.0   1472.0
##
## lowest :   26   27   28   29   30, highest: 2595 2678 2699 2751 2918
## ---------------------------------------------------------------------------
## wkndfat
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      464        1    222.3    211.7     26.0     34.0
##      .25      .50      .75      .90      .95
##     70.0    163.0    277.0    435.2    752.0
##
## lowest :   10   11   12   14   15, highest: 1310 1312 1352 1443 1499
## ---------------------------------------------------------------------------
## totfatpvm
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      359        1    2.122   0.8305    1.130    1.260
##      .25      .50      .75      .90      .95
##    1.578    2.020    2.500    3.177    3.500
##
## lowest : 0.780 0.800 0.810 0.820 0.830, highest: 5.000 5.056 5.300 5.400 5.700
## ---------------------------------------------------------------------------
## nghtfatpvm
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      791        1    0.999    0.459   0.4799   0.5529
##      .25      .50      .75      .90      .95
##   0.6848   0.9130   1.2110   1.6051   1.8061
##
## lowest : 0.270 0.337 0.356 0.363 0.369, highest: 2.780 2.789 2.815 2.828 3.003
## ---------------------------------------------------------------------------
## wkndfatpvm
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      624        1   0.5255   0.2595   0.2409   0.2719
##      .25      .50      .75      .90      .95
##   0.3410   0.4770   0.6420   0.8684   0.9990
##
## lowest : 0.114 0.120 0.159 0.169 0.174, highest: 1.450 1.480 1.528 1.557 1.675
## ---------------------------------------------------------------------------
## statepop
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0     1200        1  5329896  5257972   635665   782739
##      .25      .50      .75      .90      .95
##  1641938  3700425  6069563 11864108 17594606
##
## lowest :   453401   458377   459260   465098   466251
## highest: 33871648 34600463 35001986 35484453 35894000
## ---------------------------------------------------------------------------
## totfatrte
##        n  missing distinct     Info     Mean      Gmd      .05      .10
```

```
##     1200        0      916        1    18.92    7.032    9.578   11.458
##      .25      .50      .75      .90      .95
##   14.377   18.435   22.773   26.790   29.895
##
## lowest :  6.20  6.47  6.55  6.75  6.76, highest: 42.31 43.22 46.51 52.18 53.32
## ------------------------------------------------------------------------------
## nghtfatrte
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      750        1    8.796    3.544    4.249    5.170
##      .25      .50      .75      .90      .95
##    6.338    8.420   10.650   12.752   14.271
##
## lowest :  2.66  2.84  2.90  3.20  3.22, highest: 23.68 24.90 25.87 27.25 29.60
## ------------------------------------------------------------------------------
## wkndfatrte
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      547        1    4.606    1.973    2.140    2.569
##      .25      .50      .75      .90      .95
##    3.240    4.390    5.680    6.860    7.830
##
## lowest :  1.18  1.38  1.42  1.50  1.57, highest: 12.35 13.27 13.71 13.83 14.43
## ------------------------------------------------------------------------------
## vehicmiles
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0     1191        1    46.32    44.33    6.162    7.360
##      .25      .50      .75      .90      .95
##   14.574   33.863   58.639   97.933  129.236
##
## lowest :   3.70270   3.83500   3.96296   4.15929   4.25000
## highest: 307.62292 311.49606 321.10239 324.23077 329.60001
## ------------------------------------------------------------------------------
## unem
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0      112        1    5.951    2.235      3.2      3.7
##      .25      .50      .75      .90      .95
##      4.5      5.6      7.0      8.6      9.9
##
## lowest :  2.2  2.3  2.4  2.5  2.6, highest: 14.2 14.4 15.0 15.5 18.0
## ------------------------------------------------------------------------------
## perc14_24
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       87        1    15.33    2.116     12.6     13.2
##      .25      .50      .75      .90      .95
##     13.9     14.9     16.6     18.2     18.9
##
## lowest : 11.7 11.8 11.9 12.0 12.1, highest: 19.9 20.0 20.1 20.2 20.3
## ------------------------------------------------------------------------------
## sl70plus
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0       15    0.515   0.2068   0.3283        0        0
##      .25      .50      .75      .90      .95
##        0        0        0        1        1
##
## Value      0.000 0.042 0.083 0.333 0.375 0.417 0.500 0.583 0.625 0.667
```

```
## Frequency    938     1     5     1     1     3     3     2     1     3
## Proportion 0.782 0.001 0.004 0.001 0.001 0.002 0.002 0.002 0.001 0.002
##
## Value      0.750 0.792 0.833 0.984 1.000
## Frequency      3     2     2     1   234
## Proportion 0.002 0.002 0.002 0.001 0.195
## ---------------------------------------------------------------------------
## sbprim
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.441      215   0.1792   0.2944
##
## ---------------------------------------------------------------------------
## sbsecon
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.747      562   0.4683   0.4984
##
## ---------------------------------------------------------------------------
## d80
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ---------------------------------------------------------------------------
## d81
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ---------------------------------------------------------------------------
## d82
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ---------------------------------------------------------------------------
## d83
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ---------------------------------------------------------------------------
## d84
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ---------------------------------------------------------------------------
## d85
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ---------------------------------------------------------------------------
## d86
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ---------------------------------------------------------------------------
## d87
##        n  missing distinct     Info      Sum     Mean      Gmd
```

```
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d88
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d89
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d90
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d91
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d92
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d93
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d94
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d95
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d96
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d97
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d98
```

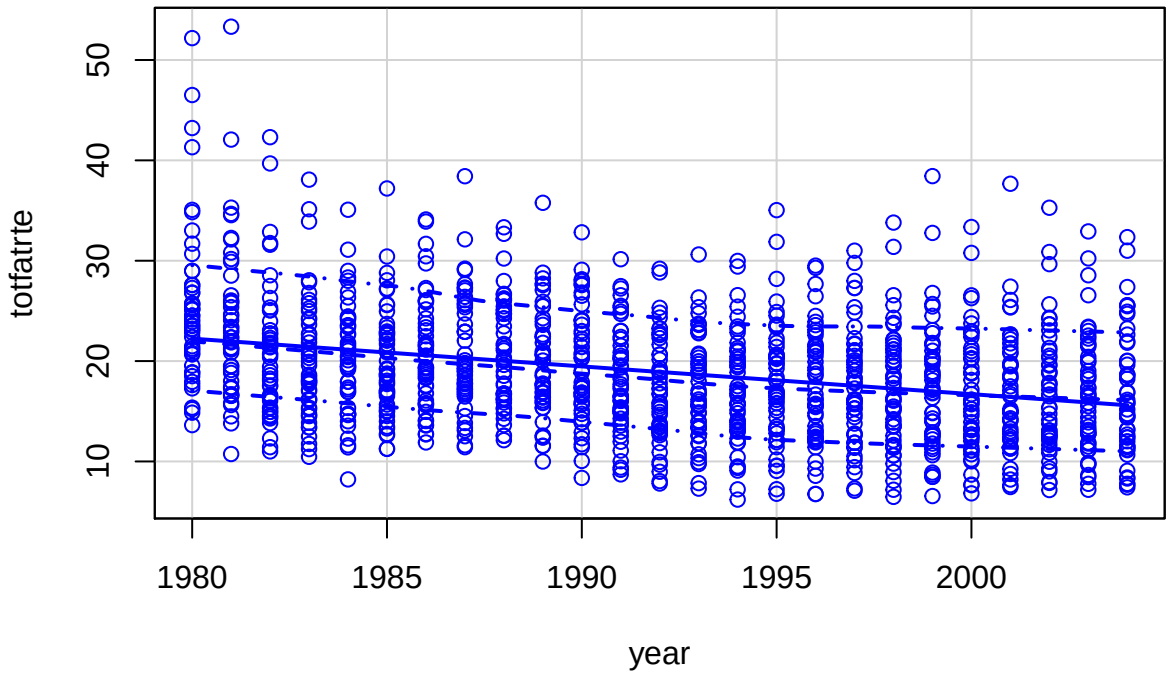
```
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d99
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d00
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d01
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d02
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d03
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## d04
##        n  missing distinct     Info      Sum     Mean      Gmd
##     1200        0        2    0.115       48     0.04  0.07686
##
## ------------------------------------------------------------------------
## vehicmilespc
##        n  missing distinct     Info     Mean      Gmd      .05      .10
##     1200        0     1200        1     9129     2014     6573     6968
##      .25      .50      .75      .90      .95
##     7788     9013    10327    11348    12197
##
## lowest :  4372.046  4504.285  4569.239  4735.135  4918.824
## highest: 16373.844 17440.082 18093.619 18276.135 18390.080
## ------------------------------------------------------------------------
```

```
desc
```

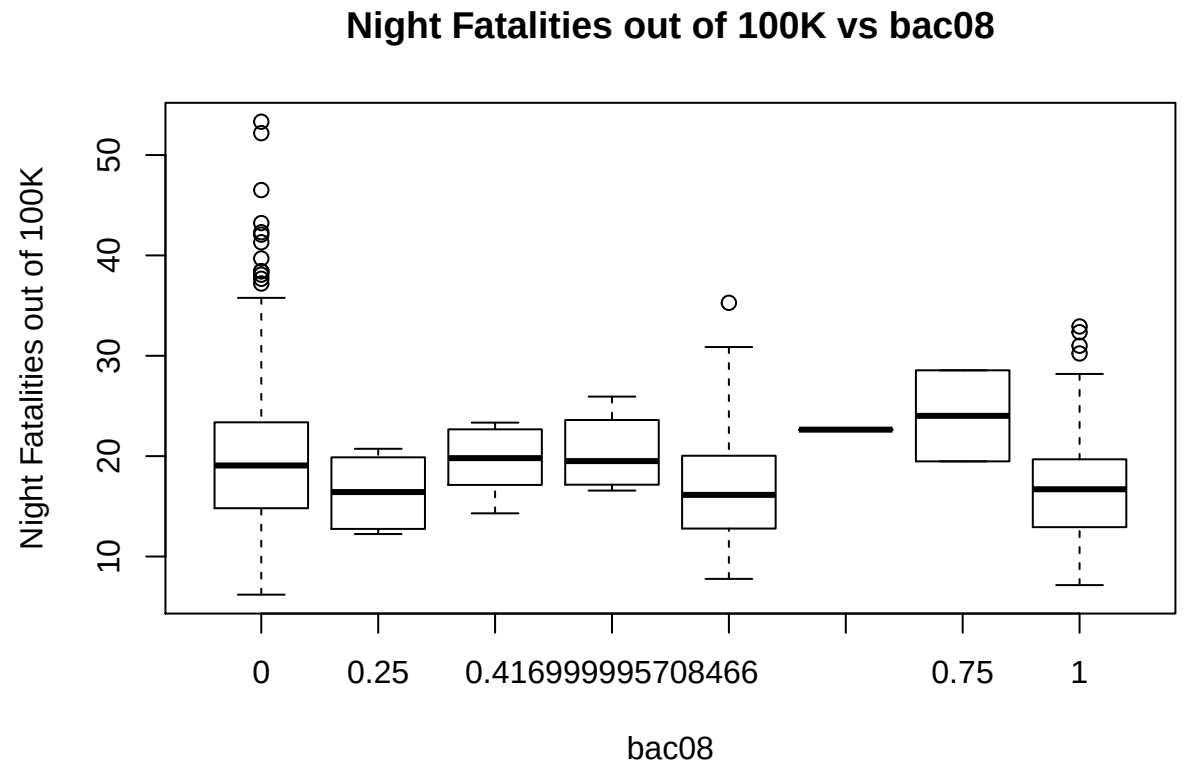
```
##        variable                                          label
## 1          year                                1980 through 2004
## 2         state            48 continental states, alphabetical
## 3          sl55                                speed limit == 55
## 4          sl65                                speed limit == 65
## 5          sl70                                speed limit == 70
## 6          sl75                                speed limit == 75
## 7        slnone                                   no speed limit
## 8      seatbelt     =0 if none, =1 if primary, =2 if secondary
```

```
## 9        minage                            minimum drinking age
## 10      zerotol                              zero tolerance law
## 11          gdl                    graduated drivers license law
## 12        bac10                          blood alcohol limit .10
## 13        bac08                          blood alcohol limit .08
## 14        perse administrative license revocation (per se law)
## 15       totfat                         total traffic fatalities
## 16      nghtfat                      total nighttime fatalities
## 17      wkndfat                         total weekend fatalities
## 18    totfatpvm          total fatalities per 100 million miles
## 19   nghtfatpvm      nighttime fatalities per 100 million miles
## 20   wkndfatpvm        weekend fatalities per 100 million miles
## 21     statepop                                  state population
## 22    totfatrte         total fatalities per 100,000 population
## 23   nghtfatrte     nighttime fatalities per 100,000 population
## 24   wkndfatrte        weekend accidents per 100,000 population
## 25   vehicmiles                vehicle miles traveled, billions
## 26         unem                      unemployment rate, percent
## 27    perc14_24           percent population aged 14 through 24
## 28     sl70plus                               sl70 + sl75 + slnone
## 29       sbprim                      =1 if primary seatbelt law
## 30      sbsecon                    =1 if secondary seatbelt law
## 31          d80                                =1 if year == 1980
## 32          d81
## 33          d82
## 34          d83
## 35          d84
## 36          d85
## 37          d86
## 38          d87
## 39          d88
## 40          d89
## 41          d90
## 42          d91
## 43          d92
## 44          d93
## 45          d94
## 46          d95
## 47          d96
## 48          d97
## 49          d98
## 50          d99
## 51          d00
## 52          d01
## 53          d02
## 54          d03
## 55          d04                                =1 if year == 2004
## 56 vehicmilespc
```

```
scatterplot(totfatrte ~ year, boxplots = TRUE, data = data)
```




```
boxplot(totfatrte ~ bac08, data = data, main = "Night Fatalities out of 100K vs bac08",
    xlab = "bac08", ylab = "Night Fatalities out of 100K")
```




```
# bac08 + bac10 + perse + sbprim + sbsecon + sl70plus + gdl
# +perc14_24 + gdl + perc14_24 + unem + vehicmilespc,
# data=data)
```

2. How is the our dependent variable of interest *totfatrte* defined? What is the average of this variable in each of the years in the time period covered in this dataset? Estimate a linear regression model of

totfatrte on a set of dummy variables for the years 1981 through 2004. What does this model explain? Describe what you find in this model. Did driving become safer over this period? Please provide a detailed explanation.

totfatrte is defined as "nighttime fatalities per 100,000 population"

```
ddply(data, .(year), summarize, Total = mean(totfatrte))
```

```
##    year    Total
## 1  1980 25.49458
## 2  1981 23.67021
## 3  1982 20.94250
## 4  1983 20.15292
## 5  1984 20.26750
## 6  1985 19.85146
## 7  1986 20.80042
## 8  1987 20.77479
## 9  1988 20.89167
## 10 1989 19.77229
## 11 1990 19.50521
## 12 1991 18.09479
## 13 1992 17.15792
## 14 1993 17.12771
## 15 1994 17.15521
## 16 1995 17.66854
## 17 1996 17.36938
## 18 1997 17.61062
## 19 1998 17.26542
## 20 1999 17.25042
## 21 2000 16.82562
## 22 2001 16.79271
## 23 2002 17.02958
## 24 2003 16.76354
## 25 2004 16.72896
```

```
mod1 <- lm(totfatrte ~ factor(year), data = data)
summary(mod1)
```

```
##
## Call:
## lm(formula = totfatrte ~ factor(year), data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -12.9302  -4.3468  -0.7305   3.7488  29.6498
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)        25.4946     0.8671  29.401  < 2e-16 ***
## factor(year)1981   -1.8244     1.2263  -1.488 0.137094
## factor(year)1982   -4.5521     1.2263  -3.712 0.000215 ***
## factor(year)1983   -5.3417     1.2263  -4.356 1.44e-05 ***
## factor(year)1984   -5.2271     1.2263  -4.263 2.18e-05 ***
## factor(year)1985   -5.6431     1.2263  -4.602 4.64e-06 ***
## factor(year)1986   -4.6942     1.2263  -3.828 0.000136 ***
## factor(year)1987   -4.7198     1.2263  -3.849 0.000125 ***
```

```
## factor(year)1988  -4.6029     1.2263  -3.754 0.000183 ***
## factor(year)1989  -5.7223     1.2263  -4.666 3.42e-06 ***
## factor(year)1990  -5.9894     1.2263  -4.884 1.18e-06 ***
## factor(year)1991  -7.3998     1.2263  -6.034 2.14e-09 ***
## factor(year)1992  -8.3367     1.2263  -6.798 1.68e-11 ***
## factor(year)1993  -8.3669     1.2263  -6.823 1.43e-11 ***
## factor(year)1994  -8.3394     1.2263  -6.800 1.66e-11 ***
## factor(year)1995  -7.8260     1.2263  -6.382 2.51e-10 ***
## factor(year)1996  -8.1252     1.2263  -6.626 5.25e-11 ***
## factor(year)1997  -7.8840     1.2263  -6.429 1.86e-10 ***
## factor(year)1998  -8.2292     1.2263  -6.711 3.01e-11 ***
## factor(year)1999  -8.2442     1.2263  -6.723 2.77e-11 ***
## factor(year)2000  -8.6690     1.2263  -7.069 2.67e-12 ***
## factor(year)2001  -8.7019     1.2263  -7.096 2.21e-12 ***
## factor(year)2002  -8.4650     1.2263  -6.903 8.32e-12 ***
## factor(year)2003  -8.7310     1.2263  -7.120 1.88e-12 ***
## factor(year)2004  -8.7656     1.2263  -7.148 1.54e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6.008 on 1175 degrees of freedom
## Multiple R-squared:  0.1276, Adjusted R-squared:  0.1098
## F-statistic: 7.164 on 24 and 1175 DF,  p-value: < 2.2e-16
```

This model suggests that driving got safer over the time period as each year has an increasing beta and all years are significant after 1981.

3. Expand your model in *Exercise 2* by adding variables *bac08, bac10, perse, sbprim, sbsecon, sl70plus, gdl, perc14_24, unem, vehicmilespc*, and perhaps *transformations of some or all of these variables*. Please explain carefully your rationale, which should be based on your EDA, behind any transformation you made. If no transformation is made, explain why transformation is not needed. How are the variables *bac8* and *bac10* defined? Interpret the coefficients on *bac8* and *bac10*. Do *per se laws* have a negative effect on the fatality rate? What about having a primary seat belt law? (Note that if a law was enacted sometime within a year the fraction of the year is recorded in place of the zero-one indicator.)

```
mod2 <- lm(totfatrte ~ factor(year) + bac08 + bac10 + perse +
    sbprim + sbsecon + sl70plus + gdl + perc14_24 + gdl + perc14_24 +
    unem + vehicmilespc, data = data)

summary(mod2)
```

```
##
## Call:
## lm(formula = totfatrte ~ factor(year) + bac08 + bac10 + perse +
##     sbprim + sbsecon + sl70plus + gdl + perc14_24 + gdl + perc14_24 +
##     unem + vehicmilespc, data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -14.9160  -2.7384  -0.2778   2.2859  21.4203
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)      -2.716e+00  2.476e+00  -1.097 0.272847
## factor(year)1981 -2.175e+00  8.276e-01  -2.629 0.008686 **
## factor(year)1982 -6.596e+00  8.534e-01  -7.729 2.33e-14 ***
```

```
## factor(year)1983 -7.397e+00  8.690e-01  -8.512  < 2e-16 ***
## factor(year)1984 -5.850e+00  8.763e-01  -6.676 3.79e-11 ***
## factor(year)1985 -6.483e+00  8.948e-01  -7.245 7.82e-13 ***
## factor(year)1986 -5.853e+00  9.307e-01  -6.289 4.52e-10 ***
## factor(year)1987 -6.367e+00  9.670e-01  -6.585 6.87e-11 ***
## factor(year)1988 -6.592e+00  1.014e+00  -6.502 1.17e-10 ***
## factor(year)1989 -8.071e+00  1.053e+00  -7.667 3.68e-14 ***
## factor(year)1990 -8.959e+00  1.077e+00  -8.319 2.46e-16 ***
## factor(year)1991 -1.107e+01  1.101e+00 -10.052  < 2e-16 ***
## factor(year)1992 -1.288e+01  1.123e+00 -11.473  < 2e-16 ***
## factor(year)1993 -1.273e+01  1.136e+00 -11.204  < 2e-16 ***
## factor(year)1994 -1.236e+01  1.157e+00 -10.685  < 2e-16 ***
## factor(year)1995 -1.195e+01  1.184e+00 -10.098  < 2e-16 ***
## factor(year)1996 -1.388e+01  1.223e+00 -11.343  < 2e-16 ***
## factor(year)1997 -1.426e+01  1.250e+00 -11.408  < 2e-16 ***
## factor(year)1998 -1.504e+01  1.265e+00 -11.886  < 2e-16 ***
## factor(year)1999 -1.509e+01  1.284e+00 -11.750  < 2e-16 ***
## factor(year)2000 -1.544e+01  1.305e+00 -11.831  < 2e-16 ***
## factor(year)2001 -1.618e+01  1.334e+00 -12.131  < 2e-16 ***
## factor(year)2002 -1.672e+01  1.348e+00 -12.406  < 2e-16 ***
## factor(year)2003 -1.702e+01  1.359e+00 -12.521  < 2e-16 ***
## factor(year)2004 -1.671e+01  1.387e+00 -12.049  < 2e-16 ***
## bac08            -2.498e+00  5.375e-01  -4.648 3.73e-06 ***
## bac10            -1.418e+00  3.963e-01  -3.577 0.000362 ***
## perse            -6.201e-01  2.982e-01  -2.079 0.037791 *
## sbprim           -7.533e-02  4.908e-01  -0.153 0.878032
## sbsecon           6.728e-02  4.293e-01   0.157 0.875492
## sl70plus          3.348e+00  4.452e-01   7.521 1.09e-13 ***
## gdl              -4.269e-01  5.269e-01  -0.810 0.417978
## perc14_24         1.416e-01  1.227e-01   1.154 0.248675
## unem              7.571e-01  7.791e-02   9.718  < 2e-16 ***
## vehicmilespc      2.925e-03  9.497e-05  30.804  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.046 on 1165 degrees of freedom
## Multiple R-squared:  0.6078, Adjusted R-squared:  0.5963
## F-statistic:  53.1 on 34 and 1165 DF,  p-value: < 2.2e-16
```

bac8 is blood alcohol limit .08 bac10 is blood alcohol limit .10

4. Reestimate the model from *Exercise 3* using a fixed effects (at the state level) model. How do the coefficients on *bac08, bac10, perse, and sbprim* compare with the pooled OLS estimates? Which set of estimates do you think is more reliable? What assumptions are needed in each of these models? Are these assumptions reasonable in the current context?

5. Would you perfer to use a random effects model instead of the fixed effects model you built in *Exercise 4*? Please explain.

6. Suppose that *vehicmilespc*, the number of miles driven per capita, increases by $1,000$. Using the FE estimates, what is the estimated effect on *totfatrte*? Please interpret the estimate.

7. If there is serial correlation or heteroskedasticity in the idiosyncratic errors of the model, what would be the consequences on the estimators and their standard errors?